1. Task Order Number : DM56 Revision: Date of Revision:
Title: Evaluation of the Long Term Durability of Polymer Composites

2. Purpose, Objective or Background of Work to be Performed:

As a part of the High Speed Research (HSR) program, the LaRC has been tasked to evaluate the long term durability of polymeric matrix composites (PMCs) after exposure to thermal/mechanical fatigue (TMF) environments expected on future high speed civil transport airframes. Exposure of some PMCs to TMF environments is already underway in Government-owned testing machines at LaRC. Portions of the material being exposed will be removed from test at various time intervals and cut into smaller specimens for residual mechanical property testing. The specific objective of the work is to determine the variation (if any) of mechanical properties of the materials as a function of exposure time. Maximum exposure times in the test program are expected to be at least 60,000 hours.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

(A) The Contractor shall maintain a log book documenting specimen exposure status, performance of the twenty Government-owned testing machines used for the long-term tests, and downtime required for calibrations, modifications, and repairs. The Contractor shall specify and direct the implementation of calibrations/repairs/modifications to the machines to assure maintenance of required testing capability. The Contractor shall produce a formal Contractor Report documenting the design and operation of the twenty-test-machine testing facility.

Deliverables (for part A)
1. Monthly informal status reports on specimen exposures and testing machine performance. Status reporting will include documentation of any load/temperature anomalies or any other deviations from the test plan.
2. Documentation of calibrations/repairs/modifications of the testing machines as these activities occur.
3. A formal Contractor Report documenting the design and operation of the testing facility.

Performance Standards (for part A)
MEETS:
- Adherence to schedule and cost
- Content of documentation (see deliverables)

(**B**) The Contractor shall plan and conduct mechanical property tests of PMC materials that are currently undergoing exposure to TMF environments. Planning shall include specification of specimen/fixture designs and specimen/fixture fabrication plans. The mechanical properties to be determined shall include unnotched tensile and compressive strengths and Young's moduli, and open-hole tensile and compressive strengths. Mechanical property testing shall include testing of IM7/K3B materials after 10,000 and 15,000 hours of compressive-stress exposure. All testing must conform to applicable ASTM and SACMA standards. The Contractor shall investigate an alternative test fixture that might improve the quality of data obtained in tests for unnotched compression strength by conducting trial tests and analyzing the results. The Contractor shall produce a formal Contractor Report documenting the residual property testing procedures and the data produced to date.

Deliverables (for part B)

1. Monthly informal status report on planning and testing activities.
2. Documentation of the test plans for the mechanical testing including specimen/ fixture designs and fabrication plans, instrumentation requirements, and data to be recorded. Delivery of documentation required before start of testing.
3. Documentation of the test data and data analysis. Delivery required by September 30, 2000.
4. A formal Contractor Report documenting the residual property testing procedures and the data produced to date.

Performance Standards (for part B)

MEETS:

- Adherence to schedule and cost
- Adherence to ASTM and SACMA standards
- Content of documentation (see deliverables)

EXCEEDS:

- Figures, photographs, and charts in documentation meet NASA publication standards

(C) The Contractor shall initiate new long-term durability tests according to the plan developed under Task Order DM03 (1997) as testing machines become available.

Deliverables

1. Monthly informal status report on testing activity.

Performance Standards (for part C)

MEETS:

- Adherence to schedule and cost

4. Government Furnished Items:
1. PMC test specimens for the testing programs. 2. Twenty servohydraulic testing machines equipped with elevated temperature test chambers for the long-term testing. (Machines located in B.1205 at LaRC.) 3. All additional testing apparatus, equipment, and hardware needed to conduct the testing programs. (Test equipment located in B.1205 at LaRC.)

5. Other information needed for performance of task.
Year 2000 Compliance: Any information technology (IT) provided under this task must be Year 2000 compliant. To ensure this result, the contractor shall provide documentation describing how the IT items demonstrate Year 2000 compliance.

6. Security clearance required for performance of work:
None

7. Period of Performance	
Planned start date: July 1, 1999	Expected completion date: September 30, 2000

8. NASA Technical Monitor: Edward P. Phillips
.M/S: 188E Phone: 757-864- 3488

1. Task Order Number and Title:	Number: DI21	Revision:	Date:
Title: Chemical Vapor Deposition Facility			

2. Purpose, Objective or Background of Work to be Performed:

The Chemical Vapor Deposition Facility for Reactor Characterization (CVDF) performs flow field measurements and analysis in support of the NASA Microgravity Sciences program and to foster the technology transfer of instrumentation techniques developed for NASA aerospace applications to the semiconductor and coatings industries.

3. Tasks, Deliverables and or Products, and performance measurements:

The contractor shall provide operation, system troubleshooting, facility configuration, test specimen installation and maintenance, and data analysis for the CVDF. The details of the tasks are described below:

3.1. Laser velocimetry of rectangular test vessel (CFDRC-1):
a) configure CVDF for LV analysis of rectangular test vessel (CFDRC-1) at selected angles;
b) configure and maintain CFDRC-1 test vessel for CVDF LV analysis of flow field;
c) measure CFDRC-1 flow field over a specified test matrix of primary flow angle, susceptor temperature, test gas, and total gas flow rate;
d) analyze flow field and correlate with CFD model and measurements of CFDRC-1 made by PIV and IR imaging;
e) resolve issues with past CVDF measurements and determine validity of past measurements.

Deliverables shall be the flow field data and its correlation to CFD model of this geometry and to PIV and IR imaging measurements of this vessel. Deliverables shall be in both electronic and graphic formats.

Minimum acceptable performance:
1) LV flow field measurement of test vessel from 2cm upstream of sled to trailing edge of susceptor for 600C susceptor temperature, 8 lpm flow rate, a selected vessel tilt angle, and a selected test gas mixture by 4/15/99.

To exceed minimum performance of the tasks above, the contractor can:
a) suggest alternative approaches that result in time and/or cost savings;
b) improve specified procedures and/or tools to increase productivity, accuracy, or reduce costs;
c) propose alternative technologies that will benefit the government in achieving the goals or the tasks included herein; or
d) achieve specified deliverables for additional elements of the test matrices.

4. Government Furnished Items: Solvent reservoirs, solvents, cleaning agents, test equipment, microbalances, data acquisition and control systems, data analysis systems, lasers, optical scanning systems, and other related supplies or instruments will be made available to the contractor from existing laboratory resources to enable fulfillment of contract objectives. These items will remain the property of NASA LaRC and will be used solely for the purposes outlined in this task order. All work is performed in NASA LaRC Buildings 1202 and 1299 on a non-interference basis.

5. Other information needed for performance of task.

6. Security clearance required for performance of work:
After-hours access to facility is required. Some test specimens to be examined in CVDF shall be of a proprietary nature. Information pertaining to and/or derived from such specimens shall be handled so as to maintain the proprietary status.

7. Period of Performance	
Planned start date: July ~~1,~~ 1998	Expected completion date: June 30, 1999

8. NASA Technical Monitor: Ivan O. Clark	
.M/S: 473	Phone: (804) 864-1500

1. Task Order Number and Title Number: DF10 Revision: 1 Date: 10-28-96
Tittle: F-16XL Supersonic Laminar Flow Control Flight Experiment Data Analysis

2. Background: Under a cooperative program involving NASA and US Industry, the High Speed Research (HSR) Program is developing advanced technologies for application to a possible High Speed Civil Transport (HSCT). Supersonic laminar flow control (SLFC) is one of those advanced technologies, offering large reductions in viscous drag which translates to benefits in aircraft weight reduction, fuel savings, smaller engines and both takeoff noise and emissions reductions. To demonstrate the feasibility of achieving extensive laminar flow on a highly swept wing at supersonic speeds, an SLFC flight experiment on a modified F-16XL is being conducted by a NASA/Industry team under the HSR Program. The flight testing is currently being conducted at NASA Dryden Flight Research Center (DFRC), Edwards AFB, California. The objective of this task is to support the flight experiment by performing flight data analysis, interpreting sensor readings, providing inputs for flight planning, and creating key plots of measured parameters.

3. Subtask Descriptions:

1. The Contractor shall perform flight data interpretation and analysis on approximately 25 flights. Data to be analyzed consists of wing surface pressures, suction flow rates and high frequency hot film sensors and microphones. The required output is determination of the state of the boundary layer flow on the wing surface (laminar, transitional or turbulent) and plots of measured parameters which indicate the aerodynamic performance of the test surface panel installed on the F-16XL wing. The Contractor shall compare data at similar test points to ensure data consistency and repeatability. Within 8 hours after each flight, NASA DFRC compiles the time history data on the DFRC Flight Data Acquisition System (FDAS). From the FDAS, NASA DFRC creates (about 16 hours after the flight) time averaged data for each test point and posts this in an electronic data base file. The Contractor shall access the FDAS time history data and the time averaged data base using NASA provided computers and software.

The contractor shall be required to travel occasionally to NASA DFRC to review data results to date, present conclusions, and provide inputs for future flight planning (see section 5 for estimates of expected travel).

The Contractor shall complete an informal report documenting for each test point acquired during the task period;
- the extent of laminar flow achieved
- pressure distributions, attachment line location
- mass flow sensor flow rates
- Mach number, angle of attack (alpha), altitude, sideslip angle (beta), valve angles
- technical discussion explaining results from each test point

Metrics:
Timely retrieval of flight data is critical to allow time for analysis prior to the next flight. Minimal acceptable response time for providing summary listings of hot film and microphone sensor findings is 6 working hours after DFRC makes the FDAS available. Minimal acceptable response time for generating key data plots is 4 hours after the time averaged data base is available. Reduced response time for providing this flight-by-flight information will be used to assess the level of performance exceeding the acceptable level. Minimal acceptable content for the informal report shall be as noted

...ve. Documentation of additional measured parameters for each test point will also be used to assess the level of performance exceeding the acceptable level.

Deliverables:
1. Summary listings for each flight of hot film and microphone sensor status.
2. Key data plots showing trends of measured parameters on the suction panel.
3. Informal report documenting performance of the test panel.

Schedule: This task is to be completed by January 31, 1997.

2. The Contractor shall analyze suction system measured data, which includes static pressures, temperatures, suction flow rates, valve angles and turbocompressor RPM to determine:

1) performance of all individual elements of the suction system, including turbocompressor, ducts, valves, sensors and suction compartments.

2) recommended changes to test points for next flights based on performance

3) long-term design solutions for any existing performance problems.

Metrics:
Timely completion of suction system analysis will be important for a subset of the flights to be conducted during this period of performance. The flights which must be analyzed shall be identified by the Task Monitor based on specific objectives and test plans for each flight. For flights identified by the Task Monitor, minimal acceptable response time for performance data and recommended changes is 16 working hours after DFRC makes the FDAS available. Reduced response time will be used to assess level of performance exceeding the acceptable level.

Deliverables:
a. Reports of analysis for each case analyzed (Contractor's format)
b. Presentation of analysis at a performance review meeting at DFRC

Schedule: This subtask is to be completed by January 31, 1997

4. Government Furnished Items:

Office space in B641 will be provided. Accounts on appropriate LaRC, DFRC and ARC (NAS) computers will be provided to access the government F-16XL flight data base.

1. Task Order Number and Title	Number: DF10	Revision: 1	Date: 10-28-96
Title: F-16XL Supersonic Laminar Flow Control Flight Experiment Data Analysis			

5. Other information needed for performance of task.

The Contractor will be required to present the data results (defined in section 3 above) at DFRC. The estimated number of presentations at DFRC will be three for subtask 1 and one for subtask 2. The purpose of the travel will be to review existing flight data, provide a status of results and provide inputs for future testing.

6. Security clearance required for performance of work:

All effort will be unclassified however personnel will be required to complete nondisclosure agreements with industry (BCAG and MDA). The data generated will be protected by the Limited Exclusive Rights to Data (LERD) data protection clause under the High Speed Research Program.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: January 31, 1997

8. NASA Technical Monitor: Michael C. Fischer
M/S: 170 Phone: 804-864-1921

1. Task Order Number:: DA15 Revision: ____ Date of Revision:___
Title: Rapid Euler CFD for High-Performance Aircraft Design

2. Purpose, Objective or Background of Work to be Performed:
To apply and enhance, as necessary, rapid Euler CFD methods for advanced high-performance aircraft concepts in the industry preliminary design environment. The results will be gauged for time, both computer and labor hours, accuracy and ease of use as defined by the skill levels of the users. The ultimate objective is to routinely utilize CFD by industry aircraft preliminary and conceptual design teams. This effort is being sponsored by the Methods for Affordable Design (MAD) within the High Performance Aircraft Office of the Airframe Systems Program Office.

The Lockheed-Martin Tactical Aircraft Systems (LMTAS) SPLITFLOW Euler code will be applied to the LMTAS designed advanced tailless delta wing fighter concept at a subsonic Mach number for conditions encompassing the falling leaf phenomenon (nominally angles of attack from 0 to 30+ degrees at sideslip angles). Accuracy will be judged by the ability to predict 6-component aircraft forces and moments for the stated conditions and the falling leaf phenomenon. Existing experimental data will be used for these comparisons. Complementary analysis will be performed with LMTAS-selected linear theory methods, and comparisons will be made for time, accuracy and ease of use. Selected cases for Navier-Stokes analysis may be jointly selected by the Government and the Contractor for benchmarking purposes. The Contractor will also apply their SPLITFLOW Euler code to several subsonic cases of the Langley Modular Transonic Vortex Interaction (MTVI) model for comparison of time, accuracy and speed with the Langley USM3D Euler code. The flow conditions and the geometry for the latter MTVI computations will be provided by the Government from the Langley developed experimental database.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

1.1 Contractor shall:

a)- Generate the required surface and corresponding flow field grids for all selected geometries.

b)- Perform Euler computations for the baseline (serrated trailing edge) delta wing at an alpha-sweep (i.e., 0, 10, 15, 20, 30 degree and Mach = 0.3, for sideslip angles of 0, and 5 degrees. Furthermore, perform Euler computations, for the same baseline delta wing, at finer angle-of-attack increments (i.e., 0, 5, 10, 15, 20, 22, 24, 26, 28, 30 degree) and Mach = 0.3, for sideslip angles of 10 and 20 degrees.

c)- Perform Euler flow computations for the baseline (serrated trailing edge) delta wing at a beta-sweep (i.e., 2.5, 5, 7.5, 10, 12.5, 15, 17.5, 20 degree) and Mach = 0.3 for alpha = 20 degree.

d)- Perform complementary analysis with LMTAS-selected linear theory method to identify the application range. The conditions are selected to partially complement the matrix defined in above step (b) for an alpha-sweep (to be selected jointly between the Government and the Contractor) and Mach = 0.3 but only for sideslip angles of 0, and 5 degree.

e)- Perform thin-layer Navier-Stokes computations for the baseline delta wing at 5 different angles of attack to be identified, with NASA consultation, from the above step (b) Euler analysis to isolate the aerodynamic effects due to the viscosity.

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f)- Perform Euler computations for a tailless MTVI configuration at an alpha-sweep (i.e., 12, 20, 30, 40) and Mach = 0.4, for sideslip angle 0 degree. Furthermore, perform Euler computations, for the same tailless MTVI configuration, at finer angle-of-attack increments (i.e., 6, 12, 16, 20, 25, 30, 35, 40, 45) and Mach = 0.4, for sideslip angle 2 degree.

1.2 Deliverables:

a)- The Contractor shall conduct an informal mid-term review at approximately three month into the study period. A teleconference will be held at Langley's direction with the participants in the study. Working plots of solution results at the time of report will be provided to NASA by FAX for review.

b)- The Contractor shall conduct a final oral review at NASA Langley consisting of a view-graph presentation summarizing the results at the end of performance period (i.e., June 29, 1998).

c)- The Contractor will provide appropriate metric goals for time, accuracy, and ease of use that satisfy the Contractor's view of routine utilization of CFD in the industry preliminary and conceptual design environment.

d)- The Contractor shall provide a final written report that documents the aerodynamic and computational results by June 29, 1998. The aerodynamic results will include forces and moments (lift, drag, pitching moment, rolling moment, and yawing moment) as well as the available pressure distributions (i.e., for only the MTVI computations). The computational results will include the convergence properties, computer resource requirements, an estimate of problem set-up time, and a discussion of the strength and weaknesses of the SPLITFLOW code for preliminary design applications.

1.3 Performance Evaluation:

a)- The Contractor performance will be evaluated based on a timely (i.e., mid-term and final reviews) delivery of computational results discussed in above various task descriptions which total to about 5 viscous and 40 inviscid Euler solutions along with about 10 linear method solutions.

b)- The Contractor performance will be evaluated based on a timely delivery of the final written report to document the computational results and data analysis consistent with all the attributes defined in above "deliverables" section 1.2 (d).

ART (NAS1-96014) Task Order Page 3

1. Task Order Number:: DA15 Revision: ___ Date of Revision:___ Title: Rapid Euler CFD for High-Performance Aircraft Design

4. Government Furnished Items: None

5. Other information needed for performance of task. The Contractor shall conduct a final oral review at NASA Langley consisting of a view-graph presentation summarizing the results at the end of the performance period (i.e., June 29, 1998).

6. Security clearance required for performance of work: None

7. Period of Performance	
Planned start date: January 27, 1998	Completion date: June 29, 1998

8. NASA Technical Monitor: Farhad Ghaffari M/S: 286 Phone: 804-864-2856

1.Task Order Number and Title: FAA01 **Revision:** 0 Date: 6/11/99
Title: FAA R&D Support

2. Background of Work to be Performed:

The Federal Aviation Administration (FAA) Research and Development organization, AAR, currently maintains two field offices within the NASA Aeronautical facilities, one at NASA Langley Research Center (LaRC), AAR-210, and the other at NASA Ames Research Center. The LaRC R&D Field Office is actively involved in joint R&D activities with NASA in several areas related to the improvement of air safety and terminal area productivity.

Hazardous atmospheric conditions such as Clear Air Turbulence (CAT), Wind Shear, Microbursts and Wake Vortices pose ever-greater danger to both safety and productivity. New and novel technological breakthroughs are needed to deal with these issues. Project SOCRATES is one of the new initiatives in the FAA related to detection and early warning of the above atmospheric hazards. The goal is the deployment of an opto-acoustic technology which will be able to detect the sound emitted by these hazardous phenomena at a sufficient range to permit timely warning.

The contractor shall provide engineering support to the LaRC R&D Field Office in its work related to the above programs. The contractor shall review and document proposed methodologies and experiments; participate in and coordinate research analyses and experiments, and analyze and document results from experiments and analyses.

3. Task Description:

Support shall be provided at the LaRC R&D Field Office in all phases of work. Contractor shall participate in all interactions with LaRC R&D Field Office partners and customers, as needed, and represent LaRC R&D Field Office's work when specifically authorized, including frequent travels to the project sites or meeting places.
The contractor shall provide a regular oral and written status report to the LaRC R&D Field Office management and the Task Monitor on the progress of subtasks and processes to be supported.

3.1 The contractor shall conduct an evaluation of the proposed theory and modeling techniques and experiments and develop implementation plans for deploying new sensor technology and test techniques as needed. The contractor shall participate in and present evaluation results at regular (monthly) SOCRATES planning and review meetings with FAA R&D personnel, FAA Air Traffic Controllers, and industry partners in Boston or other cities as required.

Deliverables:

Oral reports and written documentation of the above activities and meetings.

Minimum Acceptable Performance for activities to be supported:

a) An informal Oral or written report of each significant activity within 15 days of the meeting.

b) A written monthly summary of the significant accomplishments.

c) An executive summary report of all accomplishments every six months.

Exceeds Acceptable Performance:

a) Support activity completed prior to scheduled date for minimum acceptable performance.

b) Support activity completed solely by the contractor.

c) Presentation of the accomplishments in a public meeting or in a formal publication.

3.2 The contractor shall participate in the field tests conducted by the FAA and industry partners at various international airports. The contractor shall conduct and document pre- and post-project activities and analysis processes for each field test to be supported.

Deliverables:

Oral reports and written documentation of the above field-test.

Minimum Acceptable Performance for activities to be supported:

a) An informal Oral or written report of each significant activity within 15 days of the completion of the field test.

b) A written monthly summary of the significant accomplishments.

c) An executive summary report of all accomplishments every six months.

Exceeds Acceptable Performance:

a) Support activity completed prior to scheduled date for minimum acceptable performance.

b) Support activity completed solely by the contractor.

c) Presentation of the accomplishments in a public meeting or in a formal publication.

3.3 The contractor shall travel to FAA headquarters and meet with FAA R&D management as needed. The contractor shall provide technical guidance and training related to advances made in the SOCRATES program. The contractor shall participate in discussions and provide coordination and advocacy for the SOCRATES program.

Deliverables:

Oral reports and written documentation of the above meetings.

Minimum Acceptable Performance for activities to be supported:

a) An informal Oral or written report of each significant activity within 15 days of the meeting.

b) A written monthly summary of the significant accomplishments.

c) An executive summary report of all accomplishments every six months.

Exceeds Acceptable Performance:

a) Support activity completed prior to scheduled date for minimum acceptable performance.

b) Support activity completed solely by the contractor.

c) Presentation of the accomplishments in a public meeting or in a formal publication.

4. Government Furnished Items:
The government shall provide adequate and safe working area, any hardware (computer), software and documentation, needed to accomplish the work, and all necessary funds for any training and travel.

5. Other information needed for performance of task:
Year 2000 Compliance: Any information technology (IT) provided under this task must be Year 2000 compliant. To ensure this result, the contractor shall provide documentation, comprised of the "Contractor Y2K Compliance Verification Form" and its supporting documentation, describing how the IT items demonstrate Year 2000 compliance.

6. Security clearance required for performance of work: NASA AH (after hour access).

7. Period of Performance:

Planned start date: 6/28/99	Expected completion date: 9/30/00

8. NASA Technical Monitor: George C. Greene, FAA R&D Field Office, NASA Langley
M/S: 250 Phone: 757-864-5545

1. Task Order Number:: DS18 Revision: *1* Date of Revision: *10/1/99*

Title: RLV tank design and analysis

Revision 1: Updates status of Subtasks 1, 2, and 6; expands Subtasks 3, 4, and 5; adds new Subtask 8 and renumbers subtasks accordingly; revises Table 1; extends task completion date; makes some clarifications as needed.

2. Purpose, Objective or Background of Work to be Performed:

The objective of this work order is to ***develop and*** update finite element mesh models for reusable launch vehicles' (RLV) conformal and lobed tanks and perform analyses to generate results for design and optimization.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

The contractor shall perform the following modeling and analysis tasks:

1) ***(Completed)*** One conformal LOX tank and one conformal LH2 tank of different design concepts shall be modeled. Meshes of varying fidelity may be required to address global behaviors and local high stress issues. It is expected possibly that three design concepts including a ring-frame-stringer concept, a sandwich concept, and a hybrid concept will be investigated. One coarse mesh model, one fine mesh model, and one global/local model using transition element or interface element to connect local regions to the outside global region shall be generated for each tank concept. Buckling, linear and nonlinear NASTRAN and COMET-AR analyses of the models are required.

2) ***(Completed)*** One multi-lobed LOX tank and one multi-lobed LH2 tank of different design concepts shall be modeled. Meshes of different fidelity may be required to address global behaviors and local high stress issues. It is expected possibly that three design concepts including a ring-frame-stringer concept, a sandwich concept, and a hybrid concept will be investigated. One coarse mesh model, one fine mesh model, and one global/local model using transition element or interface element to connect local regions to the outside global region shall be generated for each tank concept. Buckling, linear and nonlinear NASTRAN and COMET-AR analyses of the models are required.

3) One integrated conformal tank mesh model which contains the conformal LOX and LH2 tanks and the inter-tank structure shall be created ***and updated with new design concepts. Finite element analyses shall be conducted using three load cases including a landing load case, a maximum axial acceleration load case, and a maximum normal launch load case***. Buckling, linear and nonlinear NASTRAN and COMET-AR analyses are required.

4) One integrated multi-lobed tank mesh model which contains the lobed LOX and LH2 tanks

and the inter-tank structure shall be created ***and updated with new design concepts. Finite element analyses shall be conducted using three load cases including a landing load case, a maximum axial acceleration load case, and a maximum normal launch load case***. Buckling, linear and nonlinear NASTRAN and COMET-AR analyses are required.

5) ***New design concepts may include a sandwiched wall design, a ring-frame and skin-stiffener wall design, an isogrid wall design, or a hybrid design. Ring frames shall be modeled as beam elements in the mesh model.***

6) ***(Completed)*** Nonuniform pressure loads, landing gear loads, aerodynamic loads, gravity loads, and temperature distributions need to be applied on each model.

7) Results need to be checked with strength allowables and ***stability or*** deformation constrains. Sectional properties of each substructure shall be adjusted to meet the design requirements.

8) ***Conduct design optimization to minimize the weight of tank structures.***

9) Provide internal loads of subcomponents and subcomponent models for NASA to perform design optimizations ***or local detailed analyses***. Optimization results shall be used in the final tank mesh models.

10) Tanks finite element models shall be reviewed by NASA technical monitor and comments shall be incorporated in the model refinements.

Deliverables:

1) The Contractor shall deliver the following finite element models (marked with x in Table 1) and runstreams created electronically.
2) The Contractor shall deliver the results (such as plots of deformed shape, stresses, and strains) of the finite element analyses.
3) The Contractor shall deliver a contract report documenting the analysis results.
4) The Contractor shall provide electronic subcomponent models and boundary loading conditions for NASA.

Metrics:

Meets- Complete NASTRAN analyses and document results for the conformal and tanks. Provide subcomponent models and internal loads for NASA.

Exceeds- All task elements are completed and all deliverables are met on 10/30/00.

Table 1 Finite element models

	Integrated FEM Models	Subcomponent Models
Conformal Tanks	X	X
Lobed Tanks	X	X

4. Government Furnished Items:

(a) Tanks' ***design concepts*** and loading conditions.

(b) NASTRAN and PATRAN codes access.

(c) Computers access.

5. Other information needed for performance of task.

Year 2000 Compliance: Any information technology (IT) provided under this task must be Year 2000 compliant. To ensure this result, the contractor shall provide documentation describing how the IT items demonstrate Year 2000 compliance.

6. Security clearance required for performance of work:

Unclassified. *Computer system access requires US citizenship or Permanent Resident status.*

7. Period of Performance	
Planned start date: Task, Mar. 20, 1999 ***Revision 1, Nov. 1, 1999***	Completion date: ***Sep. 30, 2000***

8. NASA Technical Monitor: John T. Wang
M/S: 240 Phone: 757-864- 8185

ART (NAS1-96014) Task Order Page 1

1. Task Order Number:: <u>RB01</u> Revision: ____ Date of Revision:	
Title: Microgravity Emissions Laboratory Support	

2. Purpose, Objective or Background of Work to be Performed:

The Microgravity Emissions Lab (MEL) at NASA Glenn Research Center (GRC) is making use of low frequency vibration test apparatus that was previously located at NASA LaRC. As part of the NASA LaRC Microgravity Program Support Office, Lockheed Martin Engineering and Sciences Company (LMES) personnel developed and operated the low frequency vibration test apparatus to measure disturbance characteristics of small fans and pumps used in microgravity science facilities. To efficiently initialize the operation of the low frequency vibration test apparatus at GRC, it is necessary to obtain the consultation of experienced operations personnel.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

3.1 Tasks. The Contractor shall provide technical support and meet with GRC personnel both at NASA LaRC and at NASA GRC. At GRC, the Contractor shall assist in the setup, calibration, and operation of the low frequency vibration test apparatus.

3.2 Deliverable. The Contractor shall submit a letter report of all assistance provided GRC by October 31, 1999.

3.3 Metrics. Submittal of letter report by October 15, 1999 will be considered exceeding the minimum requirements.

4. Government Furnished Items:

none

5. Other information needed for performance of task.

This effort should include travel and per diem to Cleveland, Ohio for one LMES personnel not to exceed one week

6. Security clearance required for performance of work:

none

7. Period of Performance

Planned start date: 9/20/99

Completion date: 10/31/99

8. NASA Technical Monitor: Robert A. Golub
   M/S: 461 Phone: 757-864-5281

1. Task Order Number:: RC01 Revision: 1 Date of Revision: 10/27/99

Title: Aeroelastic Modal Analysis and Testing

Revision 1 adds Task 2 and extends the task completion date.

2. Purpose, Objective or Background of Work to be Performed:

The contractor shall perform tasks in support of the Fast and Accurate Buffet and Limit Cycle Oscillation Prediction program. A major part of this program is verifying Computational Aeroelasticity (CA) computer programs by correlation with analysis. An essential element of this effort is the FEM or finite-element–models for generating vibration modes for input to the CA programs. The objective of this effort is to update and improve existing FEMs for two wings for which the data are available for verification purposes. For the task, the contractor will be expected to provide either informal reports (in contractor-specified formats) or formal contractor reports that summarize the results of each task.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

Task 1: Further development and updating of Finite Element Models for the TDT-DAST Aeroelastic Wing-2 and the AGARD Aeroelastic Standard Configuration-1, wing 445.6

Existing structural finite element models for the TDT-DAST Aeroelastic Wing-2 and the AGARD Aeroelastic Standard Configuration-1, wing 445.6 were written for the computer finite element system EAL. These FEMs shall be converted to the current version of NASTRAN.

Background- The data from tests of the TDT version of DAST ARW-2 wing is of current interest for evaluating Computational Aeroelasticity methods. Although a modal model is available, the original finite element model was written in the for EAL finite element computer system. There is a need to convert the original input data for EAL to the current NASTRAN program for finite element analysis to facilitate further updating of the model. Similarly the FEM model for the AGARD Standard Aeroelastic Configuration I, Wing 445.6 needs to be updated for the current version of NASTRAN.

Deliverables: A report including description of the finite element model analysis and published test results. Electronic files for NASTRAN input, modal output, and job execution for each wing.

Performance Measurement:

1) For minimum acceptable performance:

a) The report must be complete, understandable, and professionally written in a contractor-specified form.

b) The contractor shall provide deliverables in a timely manner.

c) Analytical models must be detailed enough to show critical dynamic behavior and sensitivity to structural boundary conditions. Predicted dynamic and static behavior shall correlate accurately with test results.

2) To exceed minimum performance, the contractor can:

Provide deliverables two or more weeks ahead of schedule.

Schedule: Due October 30, 1999

<u>Task 2:</u> Preliminary assessment and analysis of the Models for Aeroelastic Validation Research Involving Computations (MAVRIC)-I - Business Jet Model FEM in support of limit cycle oscillation (LCO) testing in the TDT.

Existing structural finite element models for the MAVRIC-I model require assessment and possible refinement and correlation with the actual wind-tunnel model undergoing refurbishment. Also, new tip-store concepts require modeling and analytical assessment for impact on dynamic loads and stress. Task 2 requires an assessment of the validity of existing FEMs, and identification of potential model safety issues resulting from proposed new tip stores.

Deliverables: A report summarizing the existing FEM selected for further development along with current vibration and flutter results. A comparison of the FEM with the physical model, design drawings, and existing test data should be included. Finally, a preliminary assessment of potential model safety issues arising from new tip store concepts should also be included.

Performance Measurement:

1) For minimum acceptable performance:

a) The report must be complete, understandable, and professionally written in a contractor-specified form.
b) The contractor shall provide deliverables in a timely manner.
c) Analytical models must be detailed enough to show critical dynamic behavior and sensitivity to structural boundary conditions. Predicted dynamic and static behavior shall correlate accurately with test results.

2) To exceed minimum performance, the contractor can: *Provide deliverables two or more weeks ahead of schedule.* *Schedule: Due December 31, 1999*

4. Government Furnished Items: • 1 Sun SPARC workstations and access to MSC NASTRAN and PATRAN Software. • 1 MacIntosh computer with Microsoft Office software • 1 laser printer

5. Other information needed for performance of task. Year 2000 Compliance: Any information technology (IT) provided under this task must be Year 2000 compliant. To ensure this result, the contractor shall provide documentation, comprised of the "Contractor Y2K Compliance Verification Form" and its supporting documentation, describing how the IT items demonstrate Year 2000 compliance.

6. Security clearance required for performance of work: None.

7. Period of Performance	
Planned start date: 1 July 1999	Completion date: *December 31, 1999*

8. NASA Technical Monitor: Robert M. Bennett .M/S: 340 Phone: 757-864-2274

1. Task Order Number:: RB02 Revision: *1* Date of Revision: *12/7/99*

Title: Experimental Hardware Development and Process Improvement

Revision 1 adds Subtask 2.

2. Purpose, Objective or Background of Work to be Performed

The Models Systems Branch (MSB) develops model systems and technology for a wide variety of experimental hardware research needs used in LaRC aerospace testing facilities and selected flight research experiments off center. These model system structures are constructed using composites and/or metallic aerospace materials. The model system configurations typically involve complex geometry, extensive instrumentation, high dimensional precision and stringent structural loading performance. The MSB team develops a concept design by documenting the specifications and performance requirements for the research hardware. The MSB team consults with the research customer and the fabrication activities throughout the detail design to ensure that the model systems meets the research needs and takes advantage of efficient fabrication techniques. If insufficient specification or performance is not defined, the MSB team executes feasibility studies and/or sensitivity analyses to provide a basis upon which the research requirements can be defined more explicitly. The design may involve new technology that is immature and necessitate risk reduction strategies such as; proof-of-concept development, material testing/characterizations and structural verification tests. The MSB team uses Pro/Engineer computer aided engineering software to develop and document the model system. In addition, The MSB team uses Microsoft Office software tools to develop, document and share the design development with the research requestor and the fabrication activity. The Contractor shall develop detailed designs on a focused subset of models systems, which are force and moment (F&M) metal model systems. An example of such a model system is the Langley Single Stage (to orbit) Vehicle LSSV configuration. In addition, The Contractor may develop F&M model systems to be used in high Reynolds number testing performance or hypersonic testing.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

Task 1:

The Contractor shall perform the following tasks as member of an integrated metal models product cycle team (IMMPCT) funded under the Wind Tunnel Enterprise (WTE).

Develop geometry and lofts defining the model system configuration

Generate input for the IMMPCT planning and process improvement functions that include: work breakdown structure, time estimates, subtask schedule and capturing metrics on the design cycle time

Execute detail design including documentation in compliance with our inhouse ISO 9001 processes LAPG1710.15 and CP-508. They can be found on the LaRC website /lms.

Identify potential process cycle time improvements through a review of collected metrics, schedule achievement, design cycle time and assessment of where process can be improved to short cycle time.

Deliverables: Detail design drawings, CAD geometry definitions and fabrication liaison on force and moment metal models. Development of Cycle time process improvement metrics including; work breakdown structures, time estimates, design schedule to a contracted scheduling planning activity. Design modifications and fabrication liaison in support of the 3% Blended Wing Body model.

Schedule of Deliverables: Work breakdown structures, time estimates and schedule are due 3 weeks after model task definition has been provided. Conceptual design, CAD geometry definition, detail design shall be delivered as defined by the model task schedule. Cycle time process improvement metrics 9/31/00

Metrics for Deliverables:

Minimum performance

Detail design documentation shall be compliant with ISO9001 processes LAPG1710.15 and CP-508 and be delivered within the schedule and time estimate provided by the Contractor for the design activity.

Exceeding minimum performance

Contractor would exceed the minimum performance with suggestions of improvements to models design process that improve (reduce) the cycle time. Development of methods or techniques to existing design process that reduces cycle time of model design/fabrication process. Perform work in a more rapid manner than the original schedule and time estimate (at least one week earlier than specified date of completion).

Task 2:

The Contractor shall develop conceptual designs, detailed designs, structural analyses and coordinate fabrication of the mechanical structure subsystems of a Complex Alternative Control Vehicle Model and accompanying less complex complete model systems. The Government will provide which subsystems of the model or models are required for design, analysis and fabrication coordination at the beginning of the task. Additionally, the Government will provide design specifications including instrumentation, structural, thermal and aero loads and operating environment of specified subsystem or complete model.

Deliverables: Schedules, time estimates, CAD/CAE models, detail drawings and analysis report.

Schedule: Time estimates and schedule are due 3 weeks after model task specification has been provided. Conceptual design, CAD geometry definition, detail design and analysis report shall be delivered as defined by the model task schedule.

Metrics:

Minimum performance
Detail design documentation shall be compliant with ISO9001 processes LAPG1710.15 and CP-508 and be delivered within the schedule and time estimate provided by the Contractor for the design activity.

Exceeding minimum performance
Contractor would exceed the minimum performance with suggestions of improvements to models design process that improve (reduce) the cycle time. Development of methods or techniques to existing design process that reduces cycle time of model design/fabrication process. Perform work in a more rapid manner than the original schedule and time estimate (at least one week earlier than specified date of completion).

4. Government Furnished Items:

Mechanical design software Pro/Engineer

Office productivity software MS/Office 97

Office space

Unix workstation and desktop PC or Windows NT workstation

Office space

Selected training in process improvement on an as needed basis.

5. Other information needed for performance of task.
Year 2000 Compliance: Any information technology (IT) provided under this task must be Year 2000 compliant. To ensure this result, the Contractor shall provide documentation describing how the IT items demonstrate Year 2000 compliance.

6. Security clearance required for performance of work: None

7. Period of Performance

Planned start date: 11/30/99 Completion date: 9/30/00

8. NASA Technical Monitor: Drew J. Hope

M/S: 238 Phone: 757-864-7278

1. Task Order Number: RD02 Revision: __ Date of Revision:
Title: Using Software Engineering Methods and Techniques to Improve V&V in the Simulation Environment

2. Purpose, Objective or Background of Work to be Performed:
The Contractor shall research software engineering techniques, processes, and tools to determine methods that may facilitate effective translation of test data to simulation databases. Additionally, candidate approaches to validate a simulation database with respect to the test database, and with respect to consistency within the simulation aerodynamic database shall be evaluated. This would greatly increase the productivity of aerospace research requiring the use of LaRC software simulators. The results would be applicable to other NASA simulation environments as well as industry.

As LaRC simulation projects have grown in size, complexity, and number, and the available staff has decreased, it has become apparent that there is a need to define common, consistent, and cost-effective software processes that can be used across multiple projects within an organization and which support automated configuration control. Presently, each time improvements are made to a database of aerodynamic coefficients, extensive re-coding is required to implement the new dataset in the simulator, which results in increased workload and time for assessments of configurations to be evaluated. These datasets are generated from wind tunnel tests conducted in various facilities, flight test results, or updated analysis of existing datasets. This proposal will evaluate methodologies for automating the verification and validation (V&V) of simulation models using data directly accessed from the wind tunnel database. This may also provide the foundation for developing tools capable of semi-automatically generating a simulation aerodynamic model directly from a wind tunnel database.

Among the many potential software-engineering practices that could be integrated into the current simulation data management and analysis systems, this proposal will primarily focus on developing a more automated means of performing verification and validation of a simulation model. This will be accomplished by searching for discontinuities in the database and comparing the simulation model with wind tunnel data. An automated or semi-automated method of conducting V&V on existing simulation models would provide significant savings in staff hours.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

The Contractor shall research current software engineering techniques and practices used in the simulation applications and document the lessons learned and efficiency of the software engineering and V&V methods. The Contractor shall evaluate methods by which V&V of a simulation model can be performed more efficiently. The Contractor shall recommend a technique or techniques that provide a more automated method of verification and validation of simulation models. The Contractor shall consider techniques that could be used to develop a software tool that is capable of generating simulation aerodynamic models directly from the wind tunnel database in an automatic or semi-automatic fashion.

Deliverables:

1) Identify and document present processes and methods used in development of simulation aerodynamic models, including methods of V&V. February 29, 2000
2) Report on 'Best Practices' in V&V methods for data conversion from wind tunnel to simulation environment. April 30, 2000
3) Report on recommended approach for implementation of 'Best Practices'. May 31, 2000
4) Demonstration of sim-aero database V&V using X29 models and wind tunnel data. September 30, 2000

Acceptable performance:
1) Deliverables met on schedule.
2) Recommendation of specific software engineering technique(s) that can be expected to result in more efficient, cost-effective methods for V&V of simulation models.
3) Demonstration of V&V software tool.
4) All tools developed shall be compatible with existing NASA LaRC hardware and software as appropriate.

Exceeds acceptable performance:
1) Inputs and outputs easily re-configurable to facilitate compatibility with such products as Matlab, Access, LaSRS++, etc.
2) Development of software tool that automatically searches for discontinuities in the aero model database and makes comparisons with the wind tunnel data.
3) Show progress towards the development of a software engineering method for automatic or semi-automatic generation of aerodynamic models directly from wind tunnel data.

4. Government Furnished Items: Wind tunnel data for TBD configuration Simulation model for TBD configuration Account on government computer for access to Matlab

5. Other information needed for performance of task.

6. Security clearance required for performance of work: No clearance required

7. Period of Performance	
Planned start date: 12/15/99	Completion date: 9/30/00

8. NASA Technical Monitor: N. Campbell M/S: 153 Phone: 757-864- 1131

1. Task Order Number and Title	Number: RD01	Revision: *1*	Date *12/9/99*
Title: AOMI and MSG Experimental Displays			

2. Background: The Crew Vehicle Integration Branch has a continuing responsibility to conduct human (specifically airline pilots) performance studies of Flight Deck Systems Concepts. The purpose of this task is to enhance the Intermediate Design Evaluation and Simulation (IDEAS) Lab located in Building 1168 to support upcoming experiments, in particular MSG and AOMI research.

Revision 1

Added Schedule (7) to extend the deliverable date for Subtask 3 to January 31, 2000. The extension is necessary because it took longer than expected to supply the GFE B757 VAPS code needed to complete the subtask. The expected completion date was also extended to January 31, 2000.

3. Subtask Descriptions: The contractor shall perform the following subtasks:

1. Provide schedule and requirement documentation at start of task.
2. Develop a linear aerodynamic performance model for a B757 using the FLSIM modeling and simulation environment.
3. Integrate the product from Subtask 2 with GFE B757 VAPS flight deck displays and an out-the-window display.

MSG:

4. Develop a configurable generic polar star display where each vertex represents a raw or derived parameter value.
5. Integrate the product from Subtask 4 to the control surfaces (*i.e.*, flaps, elevator, rudder, ailerons, spoilers, EPR). (Note: the user will define the movement of the vertices.)
6. Develop a dotted circle around the polygon from Subtask 5 such that it is tangent to the vertices when all parameters are normal (*i.e.*, when all parameters are normal, the polygon will be regular).
7. Integrate the products from Subtasks 5 and 6 into the IDEAS Lab and its FLSIM developed aircraft models and VAPS developed displays.

AOMI:

8. Develop AOMI experimental configuration of hardware and monitors (Appendix A).
9. Develop Strips display concepts; SC & SCT conditions (Appendix C).
10. Develop Interlacing display concepts; IC & ICT conditions (Appendix C).
11. Develop AOMI control/display panel (Appendix B).
12. Develop experimenter event marker:" a means by which the experimenter can insert a time-stamped string of the format "expt_evt(##)" into simulation data files, where "##" is a sequential index of these events in a file.
13. Integrate the products in Subtasks 8 through 12 into the IDEAS Lab and its FLSIM developed aircraft models and VAPS developed displays. The four display concepts in

subtasks 8 and 10 should be integrated to run separately.

14. Support integration of EEG, HRV, and GSR measurement equipment into IDEAS Lab simulation by providing synchronization signals to external equipment.
15. Provide data collection for two types of files. The first file contains 25 frequency-sampled parameters (both experimentally-defined constants and simulation variables), sampled at 10 Hz and time-stamped. The second file type contains time-stamped events including all touchscreen events, inceptor events, and experimenter event marker events.

16. Update and maintain documentation of all code and update and maintain the operational manual for the Citation X/Citation Jet.
17. Continue using the configuration management software and hardware plan for the IDEAS Lab.
18. Update and maintain documentation of the IDEAS lab software in accordance with the LMS Policy Manual to support ISO 9001 Software Project Management Plan requirements.
19. Maintain the Software Project Management Plan for the IDEAS Lab.
20. Demonstrate Y2K compliance for all software developed under this task. (NASA will ensure that all hardware and operating systems are Y2K compliant.)

Metrics:

a. Delivery of the schedule for task (Exceeds if less than three weeks)
b. Adherence to schedule (Exceeds if less than one month slippage)
c. Operation of B757 simulation from take-off, to flying around a fictitious pattern, and to landing using control inceptors (Exceeds if tunes and uses multiple NAV aids or if able to fly one or more actual routes)
d. MSG configurable polar-star display of n-vertices (maximum n of 12) with its parameter name displayed near its associated vertex
e. Implementation of display configuration for AOMI experiment (Appendix A)
f. Implementation of Strips display concepts (SC & SCT conditions) as per Appendix C.
g. Implementation of Interlaced display concepts (IC & ICT conditions) as per Appendix C.
h. Implementation of AOMI control panel, in manual mode, as per Appendix B.
i. Implementation of experimenter event marker.
j. Demonstrate data collection of frequency-sampled parameters and discrete events.
k. Synchronization of IDEAS lab datafiles with external datafiles recording EEG, HRV, and GSR measurements.

Deliverables:

(1) Models developed
(2) Software developed
(3) Schedule for software completion
(4) Documentation for operation and use of software

Schedule:

(1) Strips display concepts (SC & SCT conditions) – 8 DACA[1]

(2) Interlaced display concepts (IC & ICT conditions) – 11 DACA

(3) AOMI control/display panel in manual mode – 15 DACA

(4) Integration with physiological measurement system – 15 DACA

(5) Experimental event marker – 15 DACA

(6) Data recording demonstration – 23 DACA

(7) Integrated product from Subtask 2 and the GFE B757 VAPS flight deck displays, and the out-the-window display in the IDEAS Lab – January 31, 2000

All other subtasks completed by December 31, 1999.

4. Government Facilities and Equipment Provided:

1. IDEAS Lab (Silicon Graphics Workstations, side stick controllers, peripheral hardware, lab space for facility configuration and operation.)
2. VAPS software tool
3. FLSIM software tool
4. B757 VAPS displays
5. Linear aerodynamic performance model for a B757
6. Definition of parameters for MSG
7. EEG, HRV, GSR measurement equipment and software
8. Definition of parameters to record in frequency-sampled files.
9. Experimenter specified scenarios and user initiated triggers for AOMI

5. Other information needed for performance of task:

6. Security clearance required for performance of work: All work will be unclassified; however, personnel may be required to complete nondisclosure agreements with NASA, industry, or airlines.

7. Period of Performance:	
Planned start date: August 31, 1999	Expected completion date: ***January 31, 2000***

8. NASA Technical Monitor: Anna Trujillo
M/S: 152 Phone: 757-864-8047

[1] DACA, Days after Contract Award.

ART AS1-96014) Task Order Page

1. Task Order Number and Title — Number: — Revision:

   Title:

   Applied Computational Fluid Dynamics (CFD) for Rotorcraft Research in the Subsonic Aerodynamics Branch

2. Purpose, Objective or Background of Work to be Performed:
   As rotor and fuselage designs become more integrated, compact, and complex, close rotor-wake-fuselage interactions and interference are an increasingly important part of the performance characteristics of rotorcraft. This can be attributed to increased disk loading, more compact designs, low level flight requirements, and the increased requirement for directional trim after the loss of the tail rotor which results in larger vertical tail surfaces. These effects are especially important in the design and placement of the anti-torque system and the hortizontal and vertical stabilizers. In addition, the correct prediction of rotor performance, loads, vibration, and noise is dependent on an accurate model of the interactional aerodynamics between the rotor, its wake, and the fuselage. Verification of code predictions must be accomplished through experiment.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

3.1 The contractor shall analyze the helicopter configurations Sikorsky S-92, McDonnell Douglas Apache IEFABS, and the generic research rotor configuration ROBIN using the rotorcraft version of INS3D. The generation of the grid for INS3D is considered part of the analysis. The analysis shall also provide the streamlines, the pressure distribution on the fuselage, and the fuselage separation locations for the configurations. Rotor performance and trim will also be calculated. The contractor shall update the OVERFLOW code with the rotor capability developed for INS3D and compare the OVERFLOW results to an INS3D checkcase.

Deliverable: Streamlines, pressure distributions on the fuselage, and fuselage separation locations in the form of 3D configuration plots and table output of results for each configuration. Results must be delivered electronically as image files and tables. Within 4 weeks following the completion of an activity, a memo documenting the computational activity will be delivered. Code and documentation for OVERFLOW with rotor capability will be delivered; code to be delivered in electronic format. Documentation for OVERFLOW to be in the form of a memo.

Minimum acceptable performance: Calculations, plots, and electronic files delivered for all three configurations by 30 June 1997. OVERFLOW with rotor capability compared with INS3D check case.

Exceeds minimum acceptable performance: Calculations, plots, and electronic files available for Apache IEFABS available within 3 months of receiving final configuration, or S-92 calculations completed by 30 January 1997. OVERFLOW ready for release to industry customers by 30 June 1997.

3.2 The contractor shall determine the technologies which will make the output of INS3D useful for providing input for the acoustic prediction code WOP-WOP. This may include, but is not limited to, incorporation of rotor flapping into INS3D. The theory for inclusion of the identified technologies into INS3D will be developed. New options will be incorporated into the INS3D code. Functionality of new options will be demonstrated using a check case of INS3D.

Deliverable: Memo documenting the options assessed and recommending the best method for incorporation into INS3D. INS3D code upgraded with new technology.

Minimum acceptable performance: Memo by 30 June 1997.
Exceeds minimum acceptable performance: Demonstration of new options in INS3D by 30 June 1997.

1. Task Order Number and Title	Number:	Revision:
Title: Applied Computational Fluid Dynamics (CFD) for Rotorcraft Research in the Subsonic Aerodynamics Branch		

4. Government Furnished Items:

Office space, 3D Graphics Workstation, account on supercomputer, terminal to access supercomputer and codes, safety-of-flight monitoring equipment, software for post-processing output and preparing reports. Computer codes: INS3D, OVERFLOW, Tecplot, WOP-WOP, GRIDGEN, VSAERO.

5. Other information needed for performance of task.

S-92 configuration will be defined by Sikorsky and transmitted in the form of drawings.

Apache IEFABS configuration grid will be furnished by the Government or McDonnell Douglas Helicopter Company in electronic format.

6. Security clearance required for performance of work:

A security clearance is not required to perform this task.

7. Period of Performance	
Planned start date: 7/1/96	Expected completion date: 6/30/97

8. NASA Technical Monitor: Susan A. Gorton
M/S: 286 Phone: 804-864-5059 Susan A. Gorton 6/26/96

1. Task Order Number and Title	Number:	Revision:
Title: Free Flight Rotorcraft Research Vehicle (FFRRV) flight support.		

2. Purpose, Objective or Background of Work to be Performed:

Under this task the contractor shall refine flight hardware and software for flight testing and operations development of small helicopters as research platforms to mature critical technologies necessary for the Free Flight Rotorcraft Research Vehicle (FFRRV) flight test vehicle. This work consists of vehicle modifications and testing, sensor system design and testing, flight dynamics simulation development and validation as well as demonstrations to show the research potential to prospective clients and current customers.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

I. Modify Model Flight Hardware

The contractor shall test and modify the model flight hardware developed at LaRC as required to achieve an operational duration of one hour while carrying fifteen pounds of payload. The hardware shall also be modified in an effort to ensure reliability and data repeatability while flying. The reliability goal is 30 one hour operational flights between which only component inspections and routine maintenance is required. To accomplish this the contractor may be required to focus energy towards drive system integrity, vehicle performance, engine cooling, engine starting, and vibration reduction through accurate balancing.

The contractor shall meet the expectations if the reliability requirements are demonstrated while carrying fifteen pounds of payload by March 1997. By increasing either payload, flight duration or reliability, the contractor can exceed these requirements.

II. Flight Sensor Development

The contractor shall design, coordinate fabrication, and test integrated instrumentation systems capable of being attached to the modified model flight hardware and able to monitor and collect flight dynamics information. This effort may involve engineering development in the areas of electronics, firmware, and navigation software. The testing shall involve both bench and calibrated facilities, such as rate tables, as well as flight testing on the model flight hardware. The resulting hardware must be dynamically responsive, able to capture the helicopter's performance, > 50Hz while still small enough and low enough in energy consumption that the modified flight hardware can carry the equipment.

The contractor shall meet the expectations if the integrated flight sensor hardware is able to achieve a 50Hz throughput by March 1997. Additional bandwidth will be considered as a way the contractor can exceed this expectation. In addition, any weight or volume reductions as compared to the original hardware combining a mSPU and associated power supplies, weighing approximately six pounds, are ways the contractor can exceed this objective.

III. Simulation Development and Validation

The contractor shall utilize the sensor systems developed in item II and the flight hardware in item I and derive a forward model of the vehicle's flight dynamics suitable for flight control development. This computational model shall be validated against actual flight data taken with the intention of characterizing the vehicle's dynamics as well as the installed sensors. This resulting model shall be dynamically accurate to within 10%, as evaluated one parameter at a time. These flights will require operator skills to a tolerance of ± 2 ft in altitude and ± 3 ft horizontal 90% of the time while performing both steady and dynamically aggressive maneuvers.

The contractor shall meet this objectives if they are able to demonstrate this performance by March 1997. They shall exceed the objective if they are able to either fly more accurately or if the simulation model has less than a 10% error.

IV. Demonstrate As Required

The contractor shall support demonstrations of the project to both current supporters as well as prospective clients. This support shall include performing flight tests in a responsive manner, ideally with weeks of notice but possibly only with a few days notice. This support shall also include tailoring the vehicle's hardware and supporting electronics such that the customer's utility is maximized. This tailoring includes items such as vehicle portability enhancements and the design and integration of demonstration payloads. Possible payloads required to be demonstrated include FLIR or day TV. These demonstrations will be both local as well as remote sites requiring travel.

The contractor shall meet this objective if they are able to demonstrate the flight hardware upon notice. To exceed this objective the contractor must be innovative in how they address user desires while still accomplishing the other objectives of this task.

1. Task Order Number and Title	Number:	Revision:
Title: Title: Free Flight Rotorcraft Research Vehicle (FFRRV) flight support		

4. Government Furnished Items:

Shop area, tools, data acquisition equipment, materials and flight area

5. Other information needed for performance of task.
One trip to FBI demonstration, one trip to UAV (Unmanned Aerial Vehicle) conference, one trip to Army demonstration, and one trip to unmanned vehicle equipment convention. Each trip will be about 4 days. Further demonstration travel is anticipated and will be conducted on an as needed basis.

6. Security clearance required for performance of work:

Current work is unclassified. Potential future business may require seceret clearance

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: W. Todd Hodges
.M/S: 289 Phone: 804-864-4238

D4XC4

1. Task Order Number and Title Number: Revision:
   Title: Component Integration Branch Numerical Simulation/Design Method Development Support for Subsonic Transports

2. Purpose, Objective or Background of Work to be Performed:
Numerical simulation of propulsion airframe integration (PAI) characteristics and propulsion induced effects on advanced subsonic transports, such as those currently under study in the Advanced Subsonic Technology (AST) Program, requires modeling of complex configurations which include wing, body, nacelle, pylon, and jet exhaust flow. In many cases, simulation of the inlet flow and fan duct flow are also required. In order to reduce design cycle time, the development of viscous computational design methods is also a high priority in the AST Program. This task will provide the Component Integration Branch (CIB) with numerical simulation /design method development support for subsonic transport applications.

3. Description of the Work to be Performed:

1. The contractor shall conduct Computational Fluid Dynamics (CFD) analysis using existing grids and the OVERFLOW Navier-Stokes code for the Pratt & Whitney advanced pylon concept model which is to be tested experimentally in 1996. The purpose of this effort is to establish the applicability of utilizing CFD for configuration component loads estimation as opposed to currently required loads model tests. A total of 4 cases will be assigned under this subtask. Two concurrent cases may be assigned and run at the same time. The geometry and flow conditions will be specified by the NASA CIB at the time of the case assignment. The contractor shall prepare OVERFLOW input files according to the given flow and configuration conditions, execute the OVERFLOW Navier-Stokes code, obtain a converged solution, and postprocess the solution to obtain pressure and Mach number distributions in the flow field, integrated force and moment coefficients (total and component as specified), and qualitative flow quantities such as identification of flow separation.

Deliverables:

a) Computer files of the original grid, connectivity database, solution file, and diagnostic files for convergence in residue and performance parameters (lift and drag for the configuration and some components)
b) Results of post-processing for items specified in the subtask description in both numerical and graphical form
c) Documentation of run time, convergence history, grid sequencing and multigrid process, and any irregularities noted during the run.

Schedule of Deliverables:

Deliverables a), b), and c) shall be delivered to NASA CIB within two weeks of the initial assignment of each case.

Minimum Acceptabl erformance:

a) Residue convergence of at least 2.5 orders of magnitude from the initial condition.

b) Performance parameter convergence such that the root-mean-square deviation from the mean value is less than one-half of one-percent, and the slope of the mean value shall be zero for at least 200 iterations at the fine grid level.

Exceeds Minimum Acceptable Performance:

a) Converged solution is obtained in less than 10 Cray-C90 cpu hours or equivalent on other computer platforms.

b) Completion of the CFD solution and post-process requirements in less than the required time period.

2. The contractor shall develop a viscous inverse design method by integrating the OVERDISC design cycle algorithm with the PAB3D Navier-Stokes code. The contractor shall modify the OVERDISC algorithm as necessary to work with the PAB3D code, conduct test case computations to verify the proper operation of the new design method, compare results with existing OVERFLOW/OVERDISC inverse design method results on same test case, and document the procedures of using this inverse design method in the form of a Users' Manual.

Deliverables:

a) A complete set of computer codes, shell scripts, and documentation.

b) Solution files and graphical documentation of the pressure distributions and configuration section profiles of the test case configuration for all design cycles.

c) A Users' Manual of the design procedure developed.

Schedule of Deliverables:

Deliverables a), b), and c) shall be delivered by June 30, 1997.

Minimum Acceptable Performance:

The test case result shall indicate equal or better performance than the inverse design results obtained with the OVERFLOW/OVERDISC inverse design procedure.

Exceeds Minimum Acceptable Performance:

a) The test case result indicates at least a 10-percent improvement in performance over that obtained with the OVERFLOW/OVERDISC inverse design procedure.

b) The test case result indicates at least a 20-percent decrease in computer cpu time from that required for the OVERFLOW/OVERDISC inverse design procedure.

3. The contractor shall conduct a CFD code comparison analysis for power effects on an advanced subsonic transport wing/body/pylon/nacelle configuration. Realistic fan and core exhaust flows shall be modelled for the installed turbofan nacelle and a total of 6 code/flow/geometry/turbulence model combinations (cases) shall be analyzed. The contractor shall use existing grids for this configuration and obtain solutions using both the OVERFLOW and the PAB3D codes. Two transonic flow conditions or pylon geometries shall be analyzed with each code. The contractor shall obtain converged solutions at

three grid levels usin_ .ne grid sequencing option for both ,des. At the fine grid level, the multigrid option in the OVERFLOW code shall be used. The contractor shall obtain two sets of converged solutions for each PAB3D flow condition/geometry computational case - one set using the PAB3D two-equation k-e turbulence model option and another set using the PAB3D algebraic Reynolds stress turbulence model option. Sensitivity of the flow solutions to turbulence modeling shall be assessed based on the two sets of PAB3D solutions. For each case computed in this subtask, the contractor shall postprocess the solution to obtain pressure and Mach number distributions in the flow field, integrated force and moment coefficients (total and component as specified), and qualitative flow quantities such as identification of flow separation. Three cases will be defined by NASA/CIB within one month of contract award and the remaining three cases will be defined by NASA/CIB no later than October 1, 1996.

Deliverables:

a) Computer files of the original grids, connectivity databases, solution files, and diagnostic files for convergence in residue and performance parameters (lift and drag for the configuration and some components)

b) Results of post-processing for items specified in the subtask description in both numerical and graphical form

c) Documentation of run time, convergence history, grid sequencing and multigrid process, and any irregularities noted during the run.

Schedule of Deliverables:

Deliverables a), b), and c) for all computational cases shall be delivered to NASA CIB by February 1, 1997.

Minimum Acceptable Performance:

a) Residue convergence of at least 2.5 orders of magnitude from the initial condition.

b) Performance parameter convergence such that the root-mean-square deviation from the mean value is less than one-half of one-percent, and the slope of the mean value shall be zero for at least 200 iterations at the fine grid level.

Exceeds Minimum Acceptable Performance:

a) Converged solution is obtained in less than 30 Cray-C90 cpu hours or equivalent on other computer platforms.

b) Completion of the CFD solution and post-process requirements in less than the required time period.

1. Task Order Number and Title	Number:	Revision:
Title: Component Integration Branch Numerical Simulation/Design Method Development Support for Subsonic Transports		

4. Government Furnished Items:
   - a) Office space
   - b) Computer accounts on SABRE and/or EAGLE computers
   - c) Access to Iris workstation
   - d) Existing subsonic transport configuration grids and grid specifications
   - e) OVERFLOW, OVERDISC, and PAB3D software
   - f) Existing test case results from OVERFLOW/OVERDISC inverse design method

5. Other information needed for performance of task.
   - a) The contractor shall adhere to existing AST Limited Exclusive Rights Data (LERD) agreements, restrictions, and procedures for all existing information and any new information produced by this task. In addition, the contractor shall protect any information marked as "Proprietary" by outside customers.

6. Security clearance required for performance of work:
   All work will be unclassified, however personnel may be required to complete nondisclosure agreements with industry customers and/or the AST Program office.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Steven E. Krist
M/S: 280 Phone: 804-864-3046

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JUN 12 1996
H. P. HANEY

PRINTED: 6/12/96

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ART \S1-96014) Task Order F _ 1

1. Task Order Number and Title	Number:	Revision:
Title: Component Integration Branch Grid Modeling Support		

2. Purpose, Objective or Background of Work to be Performed:
Numerical simulation of propulsion airframe integration (PAI) characteristics and propulsion induced effects often requires modeling of complex configurations which include wing, body, nacelle, diverter, inlet, exhaust nozzle, and supersonic jet exhaust. The complexity of the problem and the high resolution requirements are such that extreme care must be taken in the computational analysis even when the most advanced Navier-Stokes codes are used. Areas of concern include grid size and quality, turbulence modeling, specific methods used for the Navier-Stokes solver, and well posed boundary conditions. This task will provide grid modeling support for specific High-Speed Research (HSR)/PAI problems.

3. Description of the Work to be Performed.

1. The contractor shall modify existing HSR Ref. H or equivalent HSR configuration wing-body grids to include additional grid blocks to resolve details of the jet exhaust flow and its interactions with the airframe. The grid type is structured, with either patched or chimera grid connectivity between blocks. Grid quality is defined by grid expansion ratio, cell skewness limit, viscous grid resolution quantified by the y-plus value of the first grid height, grid cell aspect ratio, and conformity to surface geometry specifications. A total of four sets of grid modifications shall be completed under this subtask.

Deliverables:

a) Grid coordinate files shall be delivered in PLOT3D format, in Cray and SGI standard 64-bit unformatted floating point numbers and integers. I-blanking record in the PLOT3D file is optional, depending on the style of documentation.

b) Documentation of dimension and physical locations of each block, inter-block connectivity relationships, identification of grid generation software and restart files, and notes if there are exceptions or deviations from the original grid specifications shall be delivered.

Schedule of Deliverables:

Deliverables a) and b) shall be delivered to the Component Integration Branch at the NASA Langley Research Center(LaRC) within one (1) month of the initial problem assignment.

Minimum Acceptable Performance:

Finished grid quality metrics (expansions ratio, skewness, y-plus, aspect ratio, and surface conformity) shall not be exceeded by 5 percent.

Exceeds Minimum Acceptable Performance:

a) Grid topology innovations which result in smaller grid size without compromising grid quality, or

b) Exceptional grid quality which results in accelerated convergence in the Navier-Stokes code execution, or

c) Delivery of completed grid files ahead of agreed upon delivery schedule.

2. The contractor shall generate multiblock structured grids for installed axisymmetric nacelles with the HSR Ref-H transonic and supersonic wing-body configurations. The grid topology shall conform to existing Boeing Co. grids constructed for rectangular installed nacelles. These grids will contain approximately 4.7 million grid points in approximately 12 blocks. Grid quality specification will be issued at the time of the assignment. The grid block connectivity will contain both patched and chimera types. The generation of two different grids and up to two revisions for each grid will be included in this subtask.

Deliverables:

a) Grid coordi les shall be delivered in PLOT3D fo in Cray and SGI standard 64-bit unformatted floating point numbers and integers. I-blanking record in the PLOT3D file is optional, depending on the style of documentation.

b) Documentation of dimension and physical locations of each block, inter-block connectivity relationships, identification of grid generation software and restart files, and notes if there are exceptions or deviations from the original grid specifications shall be delivered.

Schedule of Deliverables:

Deliverables a) and b) shall be delivered to the Component Integration Branch at the NASA LaRC within six (6) weeks of the initial problem assignment for each of the two original grids and, if grid revisions are requested, deliverables a) and b) shall be delivered within two (2) weeks of such request.

Minimum Acceptable Performance:

Finished grid quality metrics (expansions ratio, skewness, y-plus, aspect ratio, and surface conformity) shall not be exceeded by 5 percent.

Exceeds Minimum Acceptable Performance:

a) Exceptional grid quality which results in accelerated convergence in the Navier-Stokes code execution, or

b) Delivery of completed grid files ahead of agreed upon delivery schedule, or

c) Exceptional quality in the initially generated grid such that no revision is required.

1. Task Order Number and Title	Number:	Revision:
Title: Component Integration Branch Grid Modeling Support		

4. Government Furnished Items:
   a) Office space
   b) Computer accounts on SABRE and/or EAGLE computers
   c) Access to Iris workstation
   d) Existing HSR Ref-H grids and grid specifications

5. Other information needed for performance of task.
   a) HSR configuration geometry, flow conditions, existing grids, and new grid specifications shall be provided by the Component Integration Branch at LaRC as required.
   b) The contractor shall adhere to existing HSR Limited Exclusive Rights Data (LERD) agreements, restrictions, and procedures for all existing information and any new information produced by this task. In addition, the contractor shall protect any information marked as "Proprietary" by outside customers.

6. Security clearance required for performance of work:
   All work will be unclassified, however personnel may be required to complete nondisclosure agreements with industry customers and/or the HSR Program office

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: S. Paul Pao
   .M/S: 280 Phone: 804-864-3044

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DM-X11

ART Task Order

1. Task Order Number and Title: Number: Revision:
Unstructured Grid Computations About Several High-Lift Technology Concept Configurations

2. **Purpose:**
To compute the steady flow field about the 0.05-scale high-lift Technology Concept Airplane (TCA) and compare to 14x22 wind-tunnel data. The effects of different flap deflections on performance will also be investigated.

3. **Subtask Description:**

1. The contractor shall obtain five existing TCA wing/body/nacelle/empennage surface grids, which model the different leading- and trailing-edge flap schedules (i.e., one grid will model the optimum flap deflection schedule, and the others will be variations about that optimum). Using the surface grids as data bases the contractor shall then generate five unstructured surface and volume grids, each grid shall contain no more than 1.2 million points. All the grids shall be constructed to properly simulate the inviscid flow field for the high-lift configurations. The contractor shall be required to obtain solutions for power on and power off take-off and landing conditions (consistent with the 14x22 wind-tunnel test); therefore, the grids should be appropriately resolved in the regions of the nozzle exhaust.

Deliverable: Five unstructured grids, which will be used to solve the inviscid flow field about the TCA model.

Metric: Each grid will contain no more than 1.2 million points so it can run under 230MW on the C-90 machine at NAS.

Minimum acceptable performance: All the grids specified above completed by Oct. 30, 1996.

Exceeds minimum acceptable performance: Five baseline grids completed by August 1, 1996 or at least two additional grids by Oct. 30, 1996.

Schedule: Subtask 1 shall be completed by Oct. 30, 1996.

2. The contractor shall solve the Euler equations on the five grids mentioned above using a proven unstructured grid code. An assessment of the effects of flap deflection on performance shall be addressed for the flow through nacelles (power-off case) only. The optimum flap deflection configuration will be simulated for the take-off power condition. Several angles of attack shall be run for each case. All computational results (unpowered) will be compared to experimental data when it becomes available in Feb. 1997. Postprocessing of each converged flow solution shall be completed to explain surface and off-surface flow details as well as impact wind-tunnel test run plans. The contractor shall point out areas of deficiency and recommend possible courses of action to improve the agreement.

Deliverable: Documentation of results for the flap deflection effectiveness study, which shall also include 14X22 Foot wind-tunnel comparisons. Documentation of power-on case results.

Metric: The contractor shall obtain 2 to 3-orders of magnitude reduction in the residual as well as converged lift history plots.

Minimum acceptable performance: For each of the five unpowered and one powered take-off configuration, three angles of attack shall be obtained within eight weeks of completion of the wind tunnel tests.

Exceeds minimum acceptable performance: Obtaining solutions for the additional grids generated in task 1 or completing the five unpowered and one powered case by the end of the wind tunnel tests.

Schedule: April 30, 1997

3. The contractor shall simulate power-on/power-off conditions for the full 0.05-scale high-lift TCA configuration in ground to determine the effect of the jet on aerodynamic performance. The contractor shall be required to generate several unstructured grids of the TCA, one for each angle of attack since the wind-tunnel walls will be modeled. Due to the amount of grid generation required for just one case, only the optimum high-lift configuration geometry will be considered. Euler solutions for several angles of attack will be obtained, and the computational forces and moments and surface pressure distributions will be extracted from the results to compare with the 14x22 data when it becomes available.

Deliverables: Three angle of attack solutions (converged) for the unpowered and powered optimum high-lift case.

Metric: Computational grids containing 1.2 million points or less. Converged solutions with 2-3 orders of reduction in residual magnitude.

Minimum acceptable performance: Three angle of attack solutions (converged) for the unpowered and powered case by June 30, 1997.

Exceeds minimum acceptable performance: Three angle of attack solutions (converged) for the powered and unpowered case mentioned above plus an additional configuration (ie., a different flap deflection scenario).

Schedule: June 30, 1997.

4. The contractor shall apply an unstructured grid Navier-Stokes method to solve the subsonic flow field about a full unpowered high-lift TCA configuration and obtain a drag-polar from converged solutions. The viscous grid may be obtained elsewhere or generated by the contractor.

Deliverables: Comparison of computational data with experiment.

Metric: Converged solution with 2-3 orders of reduction in residual magnitude.

Minimum acceptable performance: Results documented for three angles of attack by June 30, 1997.

Exceeds minimum acceptable performance: Documented results for more than one configuration at three angles of attack by June 30,1997.

Schedule: June 30, 1997

4. **Government Facilities and Equipment Provided:**
Office space, 3D graphics workstation, account on supercomputer (NAS), terminal to access supercomputer and codes, software for post-processing output and preparing reports.

5. **Other information needed for performance of task:**
None

6. **Security clearance required for performance of work:**
None

7. **Period of Performance:** July 1, 1996 - June 30, 1997

8. **NASA Technical Monitor:**
Guy Kemmerly M/S: 286 Phone: (804) 864-5070

1. Task Order Number:: DA13 Revision: ____ Date of Revision:_

Title: Rapid Euler Technology Assessment for Innovative Control Effectiveness Using the SPLITFLOW Code..

2. Purpose, Objective or Background of Work to be Performed:

Prepare a Contractor Report based on results from computations performed under Task Order DA12 on Advanced Tailless/Delta Wing Fighter model using the aerodynamic prediction capabilities of the SPLITFLOW code. This study is part of an Euler Technology Assessment for Preliminary Aircraft Design sponsored by NASA Langley Research Center. This task is intended to document previously obtained results on the SPLITFLOW application capabilities in preliminary design environment.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

1.1 Contractor shall modify the informal final report from Task Order DA12 to meet with NASA's requirements for a low number Contractor Report on the application of the SPLITFLOW code to the preliminary design environment. The computational results for fifty cases, 10 viscous and 40 inviscid Euler solutions, will be included. The five viscous solutions for the deflected spoiler configuration that were not available at the completion of DA12 will be included in the fifty cases.

1.2 Deliverables: The contractor shall provide a formal written report of NASA low number Contractor Report quality that documents the aerodynamic and computational results obtained on DA12. The aerodynamic results will include forces and moments (lift, drag, pitching moment, rolling moment, and yawing moment) as well as the available pressure distributions. The computational results will include the convergence properties, computer resource requirements, an estimate of problem set-up time, and a discussion of the strength and weaknesses of the SPLITFLOW code for preliminary design applications. The color CFD flow images in the informal report for DA12 shall be converted to reproduction quality black and white images. The formal written report is required at the end of performance of the task (Oct 15, 1997)

1.3 Performance Evaluation: The contractor performance will be evaluated based on a timely delivery of the formal written report to document the computational results and data analysis of Task Order DA12 consistent with all the attributes defined in above "deliverables" section 1.2 above.

4. Government Furnished Items: none

5. Other information needed for performance of task. none

6. Security clearance required for performance of work: none

7. Period of Performance	
Planned start date: Sept 22, 1997	Completion date: Oct 15, 97

8. NASA Technical Monitor: Farhad Ghaffari .M/S: 499 Phone: 804-864-2856

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1. Task Order Number and Title Number: Revision:

Title: Advanced Computational Implementation

2. Purpose, Objective or Background of Work to be Performed:

Background:
NASA Langley Research Center has been involved in developing advanced and efficient controls or integrated controls-structures design and analysis tools for a number of NASA programs, such as the EOS program and Small Spacecraft Technology Initiative (SSTI). These tools are geared toward reducing the time and cost involved with the design and/or redesign of aerospace systems which typically are represented by large-order models (in the order of thousands). These tools are based on two approaches to design and analysis, the deterministic approach and the nondeterministic approach. The deterministic approach reduces the computational burden by enhancing existing algorithms through sparse computation or other novel approaches, while the nondeterministic approach uses artificial neural nets, fuzzy logic, and stochastic techniques to reduce the need for frequent computations. These advanced design and analysis developments are expected to substantially reduce the overall cost associated with the design of the new generation of spacecraft.

Scope:
The scope of this task involves enhancing the implementability, through optimization of the computational time and memory usage efficiency, of algorithms developed by NASA Langley for control design and analysis of aerospace systems.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

Tasks:

1. Optimize the computational time and memory usage efficiency of Langley-developed deterministic or nondeterministic dynamics and controls analysis algorithms for aerospace systems. The number of Algorithms would not exceed five.
2. Develop simulation and computer programs that implement the above-mentioned improvements for validation purposes.
3. Perform simulations of these algorithms with one Langley-defined test cases to demonstrate the accuracy and efficiency of the optimized algorithms.

PRINTED: 6/12/96

1. Task Order Number and Title | Number: | Revision:

Title: Advanced Computational Implementation

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Deliverables:

1. Optimized deterministic or nondeterministic dynamics and control design and analysis algorithms [2/28/97]. Contractor shall provide in a contractor report:
   a. Detailed documentation of algorithmic changes
   b. Detailed description of trades investigations considered for time and memory management

2. Simulation and computer programs for optimized dynamics and control design and analysis algorithms [6/30/97]. Contractor shall provide:
   a. Source code for the simulation and computer programs in electronic form
   b. Detailed documentation of the simulation and computer programs in the form of a contract report

3. Simulation and trade study results for validation [6/30/97]. Contractor shall provide in a contractor report:
   a. Detailed simulation results for the Langley-defined test cases using the optimized algorithms
   b. Detailed documentation of timing and memory trade study results for the optimized algorithms

4. Contractor shall submit informal monthly technical progress reports

Minimum Acceptable Performance Standards:

1. LaRC furnished, optimized algorithms require at least 10-percent less computational time and memory than the corresponding LaRC-developed algorithms.
2. Simulations and computer programs are error free. Results will be compared with results obtained from an LaRC independent check program.
3. Simulations and computer programs must be able to run on L-aRC-defined platforms: MATLAB, FORTRAN, and C programming environments on UNIX-based SUN workstations running SOLARIS 2.4 or higher OS.
4. Monthly progress reports.
5. Issues and concerns which jeopardize successful completion are communicated within 48 hours of discovery.

ART (NAS1-96014) Task Order Page 3

1. Task Order Number and Title	Number:	Revision:
Title: Advanced Computational Implementation		

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Significantly exceeds minimum acceptable performance:

1. Optimized algorithms require at least 25-percent less computational time and memory than the corresponding LaRC-developed algorithms.

4. Government Furnished Items:
Access to a workstation, FORTRAN and C compilers, MATLAB, publisher software, and LaRC developed algorithms.

5. Other information needed for performance of task.

6. Security clearance required for performance of work:

7. Period of Performance	
Planned start date: 7/1/96	Expected completion date: 6/30/97

8. NASA Technical Monitor: Peiman Maghami
.M/S: 161 Phone: 804-864- 4039

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JUN 19 1996
H. P. HANEY

PRINTED: 6/12/96

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ART(NAS1-96014) Task Order Page 1

1. Task Order Number and Title Number:
Revision:
Title: Wake Vortex Field Data Analysis and Interpretation

2. Purpose, Objective or Background of Work to be Performed:
NASA has initiated the Terminal Area Productivity (TAP) program to improve airport capacity through several means, including systems to permit reduced longitudinal and lateral aircraft separations, air traffic control automation, and low visibility surface operations research. The wake vortex element of the TAP program is being conducted in cooperation with the FAA Integrated Wake-Vortex Program Plan, which supports a NASA/FAA agreement in wake vortex systems research. A critical enabling element in the program is the ability to accurately estimate the aircraft spacing required due to the wake vortex generated by each aircraft. A system to estimate this wake constraint at major airports, in real-time, as a function of changing weather conditions, is being developed by NASA Langley through a combination of analysis, numeric wake vortex simulation, and field observations. These analyses and field studies are extremely data and software intensive. The purpose of this task is to provide for data retrieval from field equipment, archival, quality control, processing, production plotting, and distribution to researchers, and for software development to meet program goals.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

Subtask 1. The contractor shall examine the data and assess the data quality based on the instrumentation/manufacture's specifications for each sensor from the 1995 and 1997 field experiments. Define, develop, document and implement data quality assessment criteria/algorithms. The contractor shall maintain a catalog of weather types (stability, wind, solar flux) for all periods of interest from the perspective of having quality wake vortex measurements or having quality aircraft and ground weather data for atmospheric planetary boundary layer (PBL) modeling. This catalog will include data from the 1994, 1995 and 1997 field experiments.

Other research organizations and personnel require rapid access to specific field data. The contractor will process queries from the NASA research staff and provide list of case numbers and file names for data that matches the query criteria. An example query is to provide a list of all wake cases for neutral atmospheric stability and wind less than 10 knots where all lower atmosphere sensors were providing quality data. Develop a list of data cases with high-confidence meteorological data for further analysis and interpretation. Data events will be segregated by atmospheric stability, wind strength and gradient, aircraft type, and aircraft initial altitude.

ART(NAS1-96014) Task Order Page 2

1. Task Order Number and Title Number: Revision:
   Title: Wake Vortex Field Data Analysis and Interpretation

3. Tasks, Deliverables and or Products, and performance measurements (continued):
The contractor shall provide a catalog of graphs of the 1995 and 1997 field experiments data.
The contractor shall provide a meteorologist for daily data integrity checking during the 1997 field experiment field experiment period. The data are the measurements of any of the meteorological sensors such as Profiler/RASS, SODAR and mini-SODAR.

The contractor shall analyze and interpret data received from the field deployments to assess the capability and limitations of estimating approach corridor weather state from the suite of ground based sensors used.
The contractor shall establish and maintain the meteorological data bases for the 1994, 1995 and 1997 field experiments. Establishing and maintaining the data bases covers retrieving/receiving ,storing as ASCII files and processing of any data designated by NASA. The ASCII files shall become apart of the data bases. The contractor shall maintain the integrity of the data bases.

The contractor shall provide documentation of the data base for the 1995 and 1997 field experiments. The documentation shall contain information on the storage location, filename meaning, and data base structure.

1. Deliverables: Documentation of quality assessment criteria/algorithms containing background information and derivations of each quality assessment criteria/algorithm when applicable. Examples of the effect of each quality assessment criteria/algorithm on the data. Software implementation shall produce ASCII files of quality assessed data
   Acceptable performance: Documented data quality assessment criteria/algorithms and ASCII files of quality assessed data.
   Exceeds acceptable performance: Generation of ASCII files of quality assessed data and documentation within 2 months of receiving the data.

2. Deliverables: A catalog of weather types in hardcopy and in electronic forms. A monthly list of status of queries for the current month and outstanding queries for past months.
   Schedule of Deliverables: Completed by June 30, 1997.
   Acceptable performance: Catalogs in hard and electronic forms.
   Exceeds acceptable performance: The user friendliness of the catalogs

ART(NAS1-96014) Task Order Page 3

1. Task Order Number and Title Number: Revision:
   Title: Wake Vortex Field Data Analysis and Interpretation

3. Tasks, Deliverables and or Products, and performance measurements (continued):

3. Deliverables: A catalog of graphs in hardcopy and in electronic (postscript files) forms.
Schedule of Deliverables: Completed by September 30, 1996.
Acceptable performance: Catalogs in hard and electronic (postscript files) forms.

Exceeds acceptable performance: The user friendliness of the catalogs. The graphs in the catalog are easily found according to sensor type, time of day, atmospheric stability, heavy arrival periods (for example, Fed-Ex push periods), wind conditions (direction, magnitude and gradient), lidar operation times, measurement heights, and data influenced by synoptic (larger than mesoscale scale) events.

4. Deliverables: Daily summaries of data integrity during the field experiment and an overall summary document after the field experiment are necessary deliverables. Provide optimum settings for measurements from the Profiler/RASS, SODAR and mini-SODAR
Schedule of Deliverables: Completed one week after the 1997 field experiment.

Acceptable performance: Availability of a meteorologist during the time period of the field experiment and daily summaries of data integrity.
Exceeds acceptable performance: A detection, flagging and warning of data from a faulty meteorological sensor within 12 hours of time of detection.

5. Deliverables: Documented optimum settings and assessment criteria/algorithms for determining the quality of the data.
Schedule of Deliverables: Completed by Sept. 30, 1996 or two months before the start of the 1997 field experiment.

Acceptable performance: Settings with justification for their designation as optimum.
Exceeding acceptable performance: Optimum settings generate measures with height resolution better than 10 meters (9 meter resolution is better than 10 meter resolution) and/or with height range greater than 3000 meters and 80% or a larger percentage of the maximum number of points (resolution [points per meter] X range [meters] = number of points) are quality data according to the assessment criteria/algorithms per sensor for every instant of time.

1. Task Order Number and Title Number: Revision:
   Title: Wake Vortex Field Data Analysis and Interpretation

3. Tasks, Deliverables and or Products, and performance measurements (continued):

6. Deliverables: NASA Contractor report of the analysis and interpretation of the data received from the field deployments to assess the capability and limitations of estimating approach corridor weather state from the suite of ground based sensors used.
   The report shall:
   a) Quantify the variability of atmospheric variables (i.e., wind statistics, stability) with spatial variations along the approach path, using both ground based and NASA OV-10 aircraft data, and with variations in the time of day.
   b) Quantify the rate of change of these atmospheric variables during sunrise and sunset atmospheric boundary layer (ABL) changes and suggest techniques and algorithms for using real-time weather observations (sodar, profiler, tower) and time of day and solar flux data to estimate and/or predict the change in these atmospheric variables at these times of day.
   c) Estimate the confidence intervals or variances in these atmospheric variables using the 1994/1995 deployments data.
   Schedule of Deliverables: This portion of the task shall be complete by Feb. 28, 1997.
   Acceptable performance: Statistical data analyses are multiple regression and correlation. Predictions of variability of these atmospheric variables during sunrise and sunset atmospheric boundary layer evolution should be on the order of 15 to 30 minutes.
   Exceeding acceptable performance: Sophistication and effectiveness of the analyses will be used to assess the level of performance exceeding the acceptable level.

7. Deliverables: Documentation of the data base for 1995 and 1997 field experiments and a log of files add to data bases and ASCII files of OV-10 data stored in the appropriate data base.
   Schedule of Deliverables: Completed by June 30, 1997.
   Acceptable performance: Logs in electronic forms and ASCII files of OV-10 data stored in the appropriate data base.
   Exceeds acceptable performance: The user friendliness of the logs.

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ART(NAS1-96014) Task Order Page 5

1. Task Order Number and Title   Number: Revision:
   Title: Wake Vortex Field Data Analysis and Interpretation

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Subtask 2. The contractor shall analyze the OV-10 and meteorological data for the case(s) of rising vortices at Wallops. The contractor shall produce ASCII files of pertinent OV-10 and meteorological data. He shall assess and summarize the quality of the OV-10 and meteorological data. A detailed picture of the atmosphere at the time of the occurrence of the rising vortices shall be constructed. Wind shear, wind magnitude and direction, atmospheric stability, turbulence, synoptic effects and any other effect(s) thought important shall be a part of the picture.

Deliverables: NASA contractor report and ASCII files of pertinent data.
Schedule of Deliverables: Completed by Nov. 30, 1996.

Acceptable performance: Assessment and summary of the quality of the OV-10 and meteorological data and ASCII files of pertinent data.
Exceeds acceptable performance: The clarity and details of the picture painted.

4. Government Furnished Items:

Data from 1994, 1995 and 1997 field experiments. Data from OV-10/C-130 Wake decay flights tests. Access to video equipment in building 1168. Access to AVOSS laboratory (Bldg. 1168, Rm 121), equipment and computer accounts.

5. Other information needed for performance of task.

6. Security clearance required for performance of work:

All work will be unclassified.

7. Period of Performance	
Planned start date: 7/1/96	Expected completion date: 6/30/97

8. NASA Technical Monitor: Burnell T. McKissick
   .M/S: 156A   Phone: 804-864- 2037

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1. Task Order Number and Title Number: Revision:

Title: **Controller/Pseudo-Pilot Support for Aircraft/ATC Research**

2. **Background:** The Crew System and Operations Branch (CSOB) and the Crew/Vehicle Integration Branch (CVIB) of Langley Research Center (LaRC) are engaged in number of research programs which involve an aircraft crew, either flying or taxiing a cockpit simulation or conducting a flight test. These activities require interaction with ground elements of the air traffic system as well as other traffic in the experimental airspace. For validity, that research requires the realism of high fidelity simulation hardware as well as the support of personnel who have experience in controlling aircraft traffic.

3. **Subtask Descriptions:**

1. The contractor shall establish and maintain a pool of local individuals qualified to serve as ATC controllers and pseudo-pilot respondents and provide one or more from the pool to support real-time studies as they are scheduled. Members of the pool shall have the blend of background and unique skills, which when applied in LaRC's Mission Oriented Terminal Area Simulation (MOTAS), will create a realistic ATC environment for real-time piloted-cockpit simulation studies. Further these personnel shall posses an understanding of ATC Center, Terminal, and Oceanic operations, be able to apply accepted ATC procedure, and can speak the professional pilot/controller jargon. The requirement of the subtask are detailed as follows;

   a. Recruit and interview potential controller and pseudo-pilot respondents to establish and maintain a pool of qualified individuals. That pool shall consist of active duty military controllers and retired FAA and military controllers who are available on at least a part-time basis and reside within a reasonable driving distance from LaRC. The pool shall be maintained at a level of 3 to 5 in order to have adequate qualified individuals to meet the required experimental support

   a. The contractor shall provide one or more controller/pseudo-pilot respondents for each real-time simulation study requiring that support. As the studies vary, so will the requirements for the controller/pseudo-pilot respondents. For example, some studies will require a generic Air Traffic Control (ATC) service that a series of individuals can fulfill. Other studies may require a deeper involvement which can only be fulfilled by one or two individuals with more available time, such as retired controllers.

   Metric: Minimum acceptable performance shall be based on availability and realism of controller performance. Maximum acceptability number of either check-out or data production simulation runs canceled, because of contractor supplied controller/pseudo-pilot non-availability, shall be no more than 3 % of a study's real-time sessions. In addition 90 % of simulation subject flight crews shall rate the ATC support realism as at least adequate (2) on a post experiment questionnaire with a five point rating scale.

1. Task Order Number and Title	Number:	Revision:
Title: **Controller/Pseudo-Pilot Support for Aircraft/ATC Research**		

3 **Tasks. Deliberables. and or Products. and performance measurements (continued):**

The possible ratings of ATC realism shall be: 0 - seriously deficient, 1- somewhat deficient, 2 - adequate, 3 - more than adequate, 4 - highly realistic. Greater percentage of availability and higher realism ratings will be used to assess the level of performance exceeding the acceptable level.

Deliverable: The availability and support of a contractor supplied controller for specified real-time-piloted simulation studies check-out and all data-gathering production runs

Schedule: Subtask 1 shall be completed by December 31,1996.

The controller display interfaces and communication interfaces available in the LaRC MOTAS facility;.

4. **Government Facilities and Equipment Provided:** The controller display interfaces and communication interfaces available in the LaRC MOTAS facility;.

5. **Other information needed for performance of task:**
The length of time that a controller/pseudo-pilot is required to participate in a particular study may vary form 3 hours to 8 weeks, depending on the research experiment. Personnel will on occasion be required in the evening hours of 17:00 to 24:00 , although the normal expected hours will be between 8:00 to 17:00. The number of experiment per year requiring controller/pseudo-pilot support is expected to be between 3 and 7.

6. **Security clearance required for performance of work:**
All work will be unclassified however personnel will be required to obtain an ADP clearance for access to the MOTAS lab.

7. **Period of Performance:**	
Planned start date: July 1,1996	Expected completion date: June 30, 1997

8. **NASA Technical Monitor:** Leonard Credeur
M/S: 156A Phone: 804-864- 2021

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ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title Number: Revision:

Title: **Human Engineering Methods Research Support**

2. Purpose, Objective or Background of Work to be Performed:

Human Engineering Methods (HEM) research at NASA Langley develops human response measurement technologies to assess the effects of advanced crewstation concepts on the crew's ability to perform flight management tasks effectively. The approach taken includes establishing basic concepts and theories, developing and validating new concepts and innovative techniques through analysis, simulation, and laboratory testing, and demonstrating the most promising concepts in operational environment tests. A primary objective of the Human Engineering Methods research program is to develop methods for evaluating the impact of automation on the functioning of manned systems.

3. Subtask Descriptions:

1. The purpose of this task is to provide technical support for conducting laboratory and simulator studies in which people perform tasks designed to be analogous to tasks that crewmembers perform in flight management and measurements of their behavioral and psychophysiological response are taken. The contractor shall support tasks associated with programming and operating data acquisition and analysis systems to support experiments for developing psychophysiological technologies for assessing effects of new technologies on human performance. The contractor shall perform analyses and studies in support of laboratory and simulator experiments, and technology transfer projects.

The contractor shall support the following elements of this subtask:

1. Support simulator experiment to provide critical test of the performance consequences of hazardous states of awareness. This experiment is intended to determine the effects of hazardous states of awareness, as identified by EEG monitoring, on both perceptual and cognitive processes in a flight simulation. Support will involve the actual operation of the instrumentation and application of the data collection and analysis methods in the conduct and analysis of the experiment.

   Methodology developed during previous contract:

   A Mental Awareness Measure shall be based on the engagement index identified in previous HEM research (see Pope, Bogart and Bartolome reference below).

   Perceptual momentary capability shall be assessed using Ramped Alerting Events (RAEs), sensory stimuli in the visual, auditory, and tactile modalities that are introduced by gradually increasing their intensity until the subject responds. Latency to respond shall be the perceptual performance measure.

1. Task Order Number and Title Number: Revision:

Title: **Human Engineering Methods Research Support**

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Cognitive momentary capability shall be assessed using tasks designed to require choice decision-making in response to RAEs and subsequent memory retrieval, computational and problem-solving challenges. The specific tasks shall be identified in the proposed implementation plan submitted by the Contractor for approval by the Technical Monitor.

These capability tests shall be presented at times determined from the real-time physiological record to represent hazardous states of awareness and immediately prior to and following presentations of the Re-Engagement Event (REE). The REE used shall be a sensory-perceptual event presented at a readily detectable level at times when extreme Hazardous States of Awareness are identified.

A closed pattern flight scenario modeled after that used in the Cognitive Analysis of Descent simulation shall be used. Subjects shall be recruited from the contracted subject pool.

Hypotheses:

A Mental Awareness Measure will predict Measures of Performance immediately following a Re-Engagement Event (REE).
Presentation of a Re-Engagement Event (REE) will result in an increase in awareness such that there will be no significant performance differences between Hazardous State of Awareness (HSA) and Effective State of Awareness (ESA) conditions.
The (performance and engagement index) recovery profiles for a well-rested subject will show short-term improvements (increases) in response to a Re-Engagement Event. These improvements will be diminished or absent in the response of a fatigued subject.

Additional questions:

What is the nature of fluctuations in engagement over extended time periods?
What is the nature of the recovery of engagement from an HSA?

Deliverables:
Implementation, resource allocation and documentation plan
January 1997: Deliver instrumentation systems and operating documentation for conducting performance consequences of hazardous states of awareness experiments
January 1997: Deliver methods (developed, implemented and documented for user) to collect and analyze physiological and behavioral data from performance consequences of hazardous states of awareness experiments
May 1997: Data report of statistical analyses performed on behavioral and psychophysiological data

1. Task Order Number and Title Number: Revision:

Title: **Human Engineering Methods Research Support**

3. Tasks, Deliverables and or Products, and performance measurements (continued):

June 1997: Deliver experiment data analysis results to determine the effects of hazardous states of awareness, as identified by EEG monitoring, on both perceptual and cognitive processes in a flight simulation

June 1997: Deliver performance consequences of hazardous states of awareness experiment data analyses, and results and conclusions draft documentation (i.e., input for a journal article draft) of studies to determine the effects of hazardous states of awareness, as identified by EEG monitoring, on both perceptual and cognitive processes in a flight simulation

1.2 - Support in-house laboratory experiments (with intact signal grounding) to validate biocybernetic system for validating index of operator engagement in automated task environments. (Use experiment description in Pope, Bogart, and Bartolome as a model. Continuing studies at Old Dominion University have replicated and extended these findings (Prinzel, et. al., 1995)). (It was discovered after the publication of the referenced journal article that the experiment had been conducted with a broken signal ground.) Support will involve the actual operation of the instrumentation and application of the data collection and analysis methods in the conduct and analysis of the experiment.

Prinzel, L. J., III, Scerbo, M. W., Freeman, F. G., & Mikulka, P. J. A bio-cybernetic system for adaptive automation. Proceedings of the 39th Annual Meeting of Human Factors and Ergonomics Society, 1995.

Pope, A. T., Bogart, E. H., and Bartolome, D. S. Biocybernetic System Evaluates Indices of Operator Engagement in Automated Task. Biological Psychology, Special Edition: EEG in Basic and Applied Settings, 1995, 40, 187-195.

Deliverables:

Implementation, resource allocation and documentation plan

July 1996: Deliver instrumentation systems and operating documentation for conducting from biocybernetic engagement index validation experiments

July 1996: Deliver methods (developed, implemented and documented for user) to collect and analyze physiological and behavioral data from biocybernetic engagement index validation experiments

December 1996: Data report of statistical analyses performed on behavioral and psychophysiological data

January 1997: Deliver experiment data analysis results to validate biocybernetic system for validating index of operator engagement in automated task environments

1. Task Order Number and Title Number: Revision:

Title: **Human Engineering Methods Research Support**

3. Tasks, Deliverables and or Products, and performance measurements (continued):

February 1997: Deliver biocybernetic engagement index validation experiment data analyses, and results and conclusions draft documentation (i.e., input for a journal article draft) of studies to validate biocybernetic system for validating index of operator engagement in automated task environments

1.3 - Analyze data previously collected in the "Cognitive Analysis of Descent" (CAD) simulator experiment. The purpose of this experiment is to validate a workload profile designed from subjective measures by correlating the subjective measures with physiological measures (Bogart, Bartolome and Burdette, 1996; Latorella, Bogart and Bartolome, 1996).

Deliverables: Implementation, resource allocation and documentation plan
July 1996: Deliver methods (developed, implemented and documented for user) to analyze physiological and behavioral data from CAD experiments
July 1996: Data report of statistical analyses performed on behavioral and psychophysiological data
August 1996: Deliver experiment data analysis results to determine subjective and physiological data correlations in "Cognitive Analysis of Descent" simulator experiment
October 1996: Deliver CAD experiment data analyses, and results and conclusions draft documentation (i.e., input for a journal article draft) of studies of subjective and physiological data correlations in "Cognitive Analysis of Descent" simulator experiment

1.4 - Support " Biocybernetic Studies of Task Engagement" Task Order Contract experiments (NASA Contract NAS1-19858, Task Assignment No.. 82). The contractor will be responsible for the actual operation of the instrumentation and application of the data collection and analysis methods in the conduct of the experiment.

Deliverables: Implementation, resource allocation and documentation plan
July 1996: Deliver instrumentation systems and instructional operating documentation for conducting Biocybernetic Studies of Task Engagement experiments
July 1996: Deliver methods (developed, implemented and documented for user) to collect and analyze physiological and behavioral data from Biocybernetic Studies of Task Engagement experiments

1. Task Order Number and Title Number: Revision:

Title: **Human Engineering Methods Research Support**

3. Tasks, Deliverables and or Products, and performance measurements (continued):

1.5 - Support "Incongruity, Incongruity Resolution, and Mental States: The Measure and Modification of Situational Awareness and Control" Cooperative Agreement experiments. The experiment is essentially a replication of the study published in Pope and Bogart, 1993 to increase confidence in the 1993 results by expanding the study population size. Support will involve providing instructional operating documentation for the program participant to collect and analyze physiological and behavioral data from experiments designed by the program participant. The program participant will be responsible for the actual operation of the instrumentation and application of the data collection and analysis methods in the conduct of the experiment.

Pope, A. T., and Bogart, E. H. Identification of Hazardous Awareness States in Monitoring Environments. SAE Technical Paper No. 921136, SAE 1992 Transactions: Journal of Aerospace, Section 1 - Volume 101, 1993, pp. 449-457.

Deliverables: Implementation, resource allocation and documentation plan
July 1996: Deliver instrumentation systems and instructional operating documentation for conducting Cooperative Agreement experiments
July 1996: Deliver methods (developed, implemented and documented for user) to collect and analyze physiological and behavioral data from Cooperative Agreement experiments

1. 6 - Support analysis of "Cognitive Analysis of Pilotage" (CAP) simulator experiment. The purpose of this experiment is to explore the possibility that the auditory event-related potential (ERP) can gauge the readiness state of a pilot prior to an emergency situation. Amplitude differences within the ERP waveform are to be compared across experimental conditions (Bartolome, Bogart, and Burdette, 1996). Support will involve the actual application of the analysis methods in the analysis of the previously conducted "Cognitive Analysis of Pilotage" experiment.

Deliverables:
Implementation, resource allocation and documentation plan
July 1996: Deliver methods (developed, implemented and documented for user) to analyze physiological and behavioral data from CAP experiments
July 1996: Data report of statistical analyses performed on behavioral and psychophysiological data
August 1996: Deliver experiment data analysis results to determine subjective and physiological data correlations in "Cognitive Analysis of Pilotage" simulator experiment

1. Task Order Number and Title   Number: Revision:

Title: **Human Engineering Methods Research Support**

3. Tasks, Deliverables and or Products, and performance measurements (continued):

October 1996: Deliver CAP experiment data analyses, and results and conclusions draft documentation (i.e., input for a journal article draft) of studies of subjective and physiological data correlations in "Cognitive Analysis of Pilotage" simulator experiment

1.7 - Support MOA to transfer the indicated NASA-developed products (see note 1 below). Support will involve providing instructional operating documentation for the program participant to implement the NASA-developed technology. The program participant will be responsible for the actual operation of the instrumentation and application of the data collection and analysis methods in the conduct of the research and development program.

Note 1:

a. Attention and engagement assessment technology (LAR Patent Case No. LAR 15367-1, "Method for Visually Integrating Multiple Data Acquisition Technologies for Real Time and Retrospective Analysis") for use in a research program in the evaluation of flight or maintenance crew alertness status at the McDonnell Douglas Corporation. Deliverables 2 and 3 due in March 1997

b. Biocybernetic technology (LAR Patent Case No. LAR 15367-1, "Method for Visually Integrating Multiple Data Acquisition Technologies for Real Time and Retrospective Analysis") for use in a research program in computer-based instructional systems at the Saybrook Institute Graduate School and Research Center (SAA# 268). - Deliverables 2 and 3 due in November 1996

c. CREW technology (Crew Response Evaluation Window) (LAR Patent Case No. LAR 15367-1, "Method for Visually Integrating Multiple Data Acquisition Technologies for Real Time and Retrospective Analysis") – an interactive experimenter analysis capability for integrated display of flight deck scene, pilot lookpoint, engagement index and stress measures - for use in a research program in driving safety using driving simulators at the University of Virginia Health Sciences Center (SAA# 221). Deliverables 2 and 3 due in July 1996

d. CREW technology (Crew Response Evaluation Window) (LAR Patent Case No. LAR 15367-1, "Method for Visually Integrating Multiple Data Acquisition Technologies for Real Time and Retrospective Analysis") for use in a cooperative research/development project with Deaton Ashcraft Group, Inc. to develop a commercial product that can assist individuals with severe disabilities to communicate (SAA# 281). Deliverables 2 and 3 due in March 1997

1. Task Order Number and Title Number: Revision:

Title: **Human Engineering Methods Research Support**

3. Tasks, Deliverables and or Products, and performance measurements (continued):

e. EAST (Expanded Attention Span Training) technology (U. S. Patent No. 5,377,100) for use in a cooperative development project with J&J Engineering, Inc. to develop a commercial product to add to a line of biofeedback training systems. Deliverables 2 and 3 due in August 1996

f. CREW technology (LAR Patent Case No. LAR 15367-1, "Method for Visually Integrating Multiple Data Acquisition Technologies for Real Time and Retrospective Analysis") for use in a cooperative research/development project with Media Solutions, Inc. to develop a commercial product to assess television audience response (SAA# 284). Deliverables 2 and 3 due in November 1996

g. Attention and engagement assessment technology (LAR Patent Case No. LAR 15367-1, "Method for Visually Integrating Multiple Data Acquisition Technologies for Real Time and Retrospective Analysis") for use in a research program in the evaluation of impairment/incapacitation countermeasures with Exxon Biomedical Sciences. Deliverables due in July 1996

h. Biocybernetic technology (LAR Patent Case No. LAR 15367-1, "Method for Visually Integrating Multiple Data Acquisition Technologies for Real Time and Retrospective Analysis"), also known as CREW (Crew Response Evaluation Window), for use in a research and development program in computer-based instructional systems with Consulting Associates, Inc. (CAI).

i. CREW technology (LAR Patent Case No. LAR 15367-1, "Method for Visually Integrating Multiple Data Acquisition Technologies for Real Time and Retrospective Analysis") to Stanford Medical School for the purpose of developing and evaluating a clinical psychophysiological assessment and training technology to assist patients with chronic stress related disease. Deliverables 2 and 3 due in March 1997

<u>Deliverables</u>:

1. Implementation, resource allocation and documentation plan
2. Deliver instrumentation systems and instructional operating documentation for conducting a research program in the evaluation of flight or maintenance crew alertness status
3. Deliver methods (developed, implemented and documented for user) to collect and analyze physiological and behavioral data from a research program in the evaluation of flight or maintenance crew alertness status

1. Task Order Number and Title Number: Revision:

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3. Tasks, Deliverables and or Products, and performance measurements (continued):

1.8 - Support indicated experiments (see Note 2:) The contractor will provide instructional documentation in the use of the deliverables for the indicated program participant to collect and analyze physiological and behavioral data from experiments designed by the program participant. The program participant will be responsible for the actual operation of the instrumentation and application of the data collection and analysis methods in the conduct of the experiment.

Note 2: Experiments

a. "Evoked Brain Potential Methods for Advanced Flight Deck Evaluations" (National Research Council Research Associate Program). Program participant is National Research Council Research Associate. Deliverables 2 and 3 due July 1996

b. "An Evaluation of Candidate Auditory Warning Signals to be Presented in the Cockpit" (NASA Graduate Student Researcher Program - Virginia Tech). Program participant is NASA Graduate Student Researcher - Virginia Tech. Deliverables 2 and 3 due July 1996

c. "Operator Attention Strategies for Flexible Information Management" (NASA Graduate Student Researcher Program - Catholic University). Program participant is NASA Graduate Student Researcher - Catholic University. Deliverable 2 and 3 due January 1997.

d. "Biocybernetic Correlates of Operator Engagement", (NASA Graduate Student Researcher Program - Old Dominion University). Program participant is NASA Graduate Student Researcher - Old Dominion University. Deliverables 2 and 3 due July 1996

e. "An Analysis of Psychophysiological Parameters Related to Arousal/Engagement in a Computer Simulated Flight Management Environment", (NASA Graduate Student Researcher Program - Old Dominion University). Program participant is NASA Graduate Student Researcher - Old Dominion University. Deliverables 2 and 3 due July 1996

f. "Fixation Discrimination in Human Attentional Lapses", (Air Force Institute of Technology (AFIT) graduate student project). Program participant is Air Force Institute of Technology (AFIT) graduate student. Deliverables 2 and 3 due July 1996

1. Task Order Number and Title Number: Revision:

Title: **Human Engineering Methods Research Support**

3. Tasks, Deliverables and or Products, and performance measurements (continued):

g. NASA Langley Aerospace Research Summer Scholars (LARSS) Program. Program participant are NASA Langley Aerospace Research Summer Scholars. Deliverables 2 and 3 due July 1996

Deliverables:
1. Implementation, resource allocation and documentation plan
2. Deliver instrumentation systems and operating documentation for conducting an experiment in the participant program.
3. Deliver methods (developed, implemented and documented for user) to collect and analyze physiological and behavioral data from an experiment in the participant program.

1.9 - Support human engineering methods and neuroscience workshop and exposition. Support will involve providing to the Technical Monitor the means to make technical demonstrations of HEM experiment setups and measurement capability at human engineering methods and neuroscience workshop and exposition.

Deliverables:
Implementation, resource allocation and documentation plan
June 1997: Deliver instrumentation systems and operating documentation for conducting human engineering methods and neuroscience workshop and exposition
June 1997: Deliver methods (developed, implemented and documented for user) to make technical demonstrations of HEM experiment setups and measurement capability at human engineering methods and neuroscience workshop and exposition

Metrics for the elements of Subtask 1: Plan for reliability and validity assessment of products shall be submitted by the Contractor for approval by the Technical Monitor.

Minimum acceptable performance for the elements of Subtask 1:
For instrumentation deliverables - Demonstration to Technical Monitor of reliable functioning of and validity of results from products using benchmark tests proposed by Contractor and approved by Technical Monitor, and, when conducting exposition demonstration, Time Between Failure of 90% of the exposition demonstration. Failure is defined as loss of data or delay of greater than 15 minutes in the demonstration's progress due to factors within the Contractor's control.

1. Task Order Number and Title Number: Revision:

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3. Tasks, Deliverables and or Products, and performance measurements (continued):

For methods deliverables - Demonstration to Technical Monitor of reliable functioning of and validity of results from products using benchmark tests proposed by Contractor and approved by Technical Monitor, and, when conducting exposition demonstration, Time Between Failure of 90% of the exposition demonstration. Failure is defined as loss of data or delay of greater than 15 minutes in the demonstration's progress due to factors within the Contractor's control. Presentation and briefing of products to technical monitor.

For analysis results, graphics and documentation deliverables - Presentation and briefing of products to technical monitor.

Positive answers to the following questions:
Were the methodologies and experiments performed as planned?
Were results obtained as planned?
Are the results scientifically valid?
Are conclusions drawn from results valid?
Are conclusions open to other interpretations?
Do conclusions leave important questions unanswered?
Did the effort make efficient use of schedule and personnel resources?
Was the effort completed on time?

For program participant studies - instructional documentation in the use of the deliverables.

Significantly exceeds minimum acceptable performance for the elements of Subtask 1:
For instrumentation deliverables - When conducting exposition demonstrations, Time Between Failure of 100% of the sessions in the experiment.

For methods deliverables - When conducting exposition demonstrations, Time Between Failure of 100% of the sessions in the experiment.

For documentation and presentation deliverables - Video and/or other dynamic forms of presentation and documentation
Delivery of products prior to scheduled delivery
Technical demonstrations of experiment setups and measurement capabilities to NASA management and visiting researchers
For program participant studies - instruction in the use of the deliverables
Suggestions that would save time and/or money to the government

1. Task Order Number and Title   Number: Revision:

Title: **Human Engineering Methods Research Support**

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Subtask 2. Establish and maintain a pool of test subjects for human response testing and provide groups of test subjects for human response testing. Such will involve the solicitation, screening, calibration, selection, remuneration and delivery of test subjects to the experiment sites as scheduled. The requirements for this subtask are detailed as follows:

1. Interview and recruit potential subjects and maintain a pool of subjects for participation in experiments in which people perform tasks designed to be analogous to tasks that crewmembers perform in flight management and measurements of their behavioral and psychophysiological response are taken. The pool of prospective test subjects shall be established and maintained in such a way as to meet the following requirements:

a. Potential subjects may be required by the experiment plan to take sensory, perceptual and/or cognitive screening tests (administered by the Contractor). The completed test records shall be used by the Contractor to determine the suitability of each candidate for participation in the experiments.

b. Subjects shall be over 18 years of age. Subjects shall be catalogued by the Contractor according to name, age, sex, geographic location, and occupation. This information becomes the property of the US Government.

2. Deliver up to 4 subjects per day to the NASA Langley Research Center test site on two weeks prior notice. An average of 12 subjects per month will be required, although the requirements during some months may be greater or less than the average of 12 per month. No more than 60 subjects per month will be required. All transportation shall be coordinated and provided by the Contractor. The times for delivery to and pickup from the test site shall be met by the Contractor with an allowable tolerance of +20 minutes. Of the total number of subjects delivered per month, about half may be required to be previously unused in other experiments conducted at LaRC, depending on the nature of the particular experiment. Some subjects may be required for two days at a time and/or for subsequent testing during the year. The normal testing period will be between 8:00 a.m. and 5:00 p.m. The normal test site will be Building 1268A at the NASA Langley Research Center. Subjects generally will participate in experiments for periods up to four hours on any given day.

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Title: **Human Engineering Methods Research Support**

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Metric: Maximum acceptable number of test subject no-shows is 5% over the period of performance of the task. Maximum acceptable tardiness in subject delivery and/or pickup time is 20 minutes. Accurate records screening tests and documentation is required. Lesser numbers of no shows and more timely delivery and pick up of subjects will be used to assess the level of performance exceeding the acceptable level.

Deliverable: Test subjects delivered to test site on specified dates and times; screening test records, and documentation of classification of subjects.

Schedule: Subtask 2 shall be completed by June 30,1997.

4. **Government Facilities and Equipment Provided:**

The facilities of the Human Engineering Methods laboratory (Room 1139, Building 1268A & Room 118, Building 1168), described below, and the Flight Simulators (Building 1268A) will be provided for the performance of this task.

Behavioral response and psychophysiological response measurement systems have been developed to assess mental loading, stress, task engagement, and situation cognizance. Measurement capabilities include topographic brainmapping (EEG and evoked responses), monitoring of pulse, heart and muscle electrical activity (EKG and EMG), skin temperature and conductance, respiration, and tracking of eye lookpoint (oculometry) and overt behavior (video analysis). A real-time multi-attribute task (MAT) battery has been developed to recreate flight management task conditions in the laboratory setting for initial testing of advanced human response measurement concepts. Mobile physiological monitoring and behavioral response capture stations are located at cockpit simulator sites to refine these measurement concepts for flight management research.

Currently, simulator studies at NASA Langley employ a recently developed tool called CREW (for Crew Response Evaluation Window) (LAR Patent Case No. LAR 15367-1, :Method for Visually Integrating Multiple Data Acquisition Technologies for Real Time and Retrospective Analysis"). In CREW, several human response monitoring technologies are brought together in a display window using virtual instrument programming. The individual response technologies include video, eye tracking, physiological stress monitoring, and brainwave signal processing. CREW permits the experimenter or evaluator to select and simultaneously view several, previously scattered, sources of physiological and behavioral response information in a single,

1. Task Order Number and Title	Number:	Revision:
Title: **Human Engineering Methods Research Support**		

4. Government Furnished Resources continued:

integrated display window. CREW is designed to be used both on-line in piloted experiments to monitor and supervise the progress of experiments in real-time and off-line to enable detailed analysis of videotape recordings of the CREW display.

NASA LaRC possesses technology which relates to psychophysiological measurement of humans, specifically for the purposes of human factors evaluations of system designs. Biocybernetic systems employing these measurements can be used for evaluating manned system designs for compatibility with human capabilities.

NASA LaRC has developed a biocybernetic technology using a psychophysiological measure, the electroencephalogram (EEG), for assessing pilot sustained attention, engagement and awareness in a laboratory flight simulation environment.

A spin-off of this research is a prototype game called EAST intended to demonstrate the concept of improving attention skill by rewarding specific brain signal (EEG) patterns with success at playing an action video game. The overall goal of training is improved performance on academic tasks requiring sustained attention and concentration. The concept has been determined to have applicability to children with ADD. NASA has been awarded patent no. 5,377,100 for the invention, entitled "Method of Encouraging Attention by Correlating Video Game Difficulty with Attention Level."

1. Task Order Number and Title Number: Revision:

Title: **Human Engineering Methods Research Support**

5. Other information needed for performance of task.

The Contractor will secure NASA LaRC Institutional Review Board (IRB) approval for the conduct of studies employing human subjects. IRB approval may consist of expedited review as allowed by the IRB.

Reports applicable to this task include:

Pope, A. T., Bogart, E. H., and Bartolome, D. S. Biocybernetic System Evaluates Indices of Operator Engagement in Automated Task. Biological Psychology, Special Edition: EEG in Basic and Applied Settings, 1995, 40, 187-195.

Pope, A. T., and Bogart, E. H. Identification of Hazardous Awareness States in Monitoring Environments. SAE Technical Paper No. 921136, SAE 1992 Transactions: Journal of Aerospace, Section 1 - Volume 101, 1993, pp. 449-457.

Prinzel, L. J., III, Scerbo, M. W., Freeman, F. G., & Mikulka, P. J. A bio-cybernetic system for adaptive automation. Proceedings of the 39th Annual Meeting of Human Factors and Ergonomics Society, 1995, in press.

LAR Patent Case No. LAR 15367-1, "Method for Visually Integrating Multiple Data Acquisition Technologies for Real Time and Retrospective Analysis"

U. S. Patent No. 5,377,100 to NASA for an invention by Ed Bogart and Alan Pope entitled "Method of Encouraging Attention by Correlating Video Game Difficulty with Attention Level"

Statement of Work, NASA Contract NAS1-19858, Task Assignment No.. 82

NASA Graduate Student Researcher Program - Virginia Tech Research Proposal
NASA Graduate Student Researcher Program - Catholic University Research Proposal
NASA Graduate Student Researcher Program - Old Dominion University Research Proposals (2)
National Research Council Research Associate Research Proposal
Air Force Institute of Technology (AFIT) graduate student Research Proposal

Space Act Agreements #: 221, 268, 281, 284,

Bartolome, D. S., Bogart, E. H., and Burdette, D. W. Investigating Operator Alertness Using ERPs, Poster Session at Human Factors and Ergonomics Society Annual Meeting, September 2-6, 1996.

1. Task Order Number and Title	Number:	Revision:
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5. Other information needed for performance of task continued.

Bogart, E. H., Bartolome, D. S., and Burdette, D. W. Validating Experimental Scenario Workload Levels Using Physiological Measures, Poster Session at Human Factors and Ergonomics Society Annual Meeting, September 2-6, 1996.

Latorella, K. A., Bogart, E. H., and Bartolome, D. S., Subjective and Physiological Measures of FPM Workload: Findings from Scenario Design, First International Conference on Engineering Psychology and Cognitive Ergonomics, 1996.

The subtasks can be conducted concurrently.

6. Security clearance required for performance of work:
All work will be unclassified however personnel may be required to complete nondisclosure agreements with industry or airlines.

7. Period of Performance	
Planned start date: July 1,1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Alan T. Pope
.M/S: 152 Phone: 804-864- 6642

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ART (NASA-96014)Task Order Page 1

1. Task Order Number and Title Number: Revision:

Title: **Flight Deck Design and Integration Programming Support and Research Workstation Development**

2. **Background:** The Crew Vehicle Integration Branch and the Crew Systems Operations Branch have a continuing responsibility to conduct human (specifically airline pilots) performance studies of Flight Deck Systems Concepts under the HSR Design and Integration program, and the Base R&T. The purpose of this task is to provide technical support for realizing these concepts as computer prototypes and developing a workstation that will allow testing of these prototypes.

3. **Subtask Descriptions:** The contractor shall perform the following subtasks:

1. Provide programming support for the development of computer prototypes of flight deck design and integration concepts. The delivery platform will vary with research project. The primary platform will be a Silicon Graphics workstation, however projects may require the platform to be a PC, Macintosh, or a Web page.

The projects anticipated for this performance period are

Management of Non-Normal Situations project involves developing a software prototype for providing information to the flight crew in times of non-normal activities. The information provided is in the form of destination alternates, systems management options, and task and procedure options. Programming of systems displays, navigation displays, and primary flight displays as well as the underlying functionality that provides the information will be required. Approximate start date September 1996

Crew-Autoflight Interaction project involves developing mode control panel displays and integrating those displays into the simulation workstation described below. It also involves developing the primary flight display and the mode annunciators. Approximate start date, July 1996.

Deliverable:
Schedule for code development and completion.
Formal demonstration of the prototype
Code and documentation prototype.
Actual costing information on a per experiment basis.

Metric:
Delivery of the schedule one week from start date
Adherence to schedule - slippage not more than a month
Resolution of technical issues - issues are identified and resolved without causing delay in schedule
The number of revisions of code after the initial delivery (three or less).
Amount of time to port code to LaRC simulation facilities if required (Minimum performance is one person/week or less).

Schedule: Subtask 1 shall be completed by June 30,1997.

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Title: **Flight Deck Design and Integration Programming Support and Research Workstation Development**		

2. Develop and maintain a prototyping workstation capability for use in prototype evaluation and pre-simulation checkout. The course specification for this capability is

a) The workstation will have the following display elements:

Primary Flight Display
Navigation Display
FMS Display
Mode Control Panel
2 Systems Displays
Out the Window Display

b) The workstation will have the following control elements:

Side Stick controller
Throttle
FMS Display
Mode Control Panel
4 Touch Panels on Displays (Systems, PFD, and ND)

c) The workstation shall be capable of running stand-alone or in concert with LaRC simulation facilities (Including use of LaRC aero models in the workstation.)

d) Displays shall be directly portable to the LaRC Part Task Simulator. The contractor shall assist in defining the displays for the Part Task Simulator as part of this task.

e) The workstation shall be flexible to allow for reconfiguration.

Deliverable:
Schedule for workstation development and completion.
Formal demonstration of the prototype workstation capability
Code that will run on a Silicon Graphics workstations and documentation for prototype workstation capability.
Hardware configured for usability of developed workstation code

Metric:
Delivery of the schedule one week from start date
Adherence to schedule - slippage not more than a month
Resolution of technical issues - issues are identified and resolved without causing delay in schedule
The number of revisions of code after the initial delivery (three or less).
Amount of time to port code to LaRC simulation facilities if required (Minimum performance is one person/week or less).
Reconfigurability (Minimum performance is ability to reconfigure from a B757 Flight Deck configuration to a General Aviation Flight Deck configuration is one day or less.)

Schedule: Subtask 2 shall be completed by February 30, 1997

1. Task Order Number and Title	Number:	Revision:
Title: **Flight Deck Design and Integration Programming Support and Research Workstation Development**		

4. **Government Facilities and Equipment Provided:** Silicon Graphics Workstations, Side Stick Controllers, Thrust Levers, Peripheral hardware, Lab Space for Facility configuration and operation.

5. **Other information needed for performance of task:**

6. **Security clearance required for performance of work:**
All work will be unclassified however personnel may be required to complete nondisclosure agreements with industry or airlines.

7. Period of Performance:	
Planned start date: July 1,1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Paul C. Schutte
.M/S: 152 Phone: 804-864-2019

DCX06 FDCD-58

ART(NAS1-96014) Task Order Page 1

1. Task Order Number and Title Number: Revision:

Title: **XVS Simulation and Flight Test Graphics Programming**

2. Purpose, Objective or Background of Work to be Performed:

The contractor shall provide the specialized real-time graphics programming support for the Building 1298 part-task simulation and flight research needs of the Crew/Vehicle Integration Branch. This support will including initial production/application of specialized graphical models/techniques using the Silicon Graphics Incorporated (SGI) platforms associated with the Visual Imaging Simulator for Transport Aircraft Systems (VISTAS), and VISTAS III (now under development). The new software must be integrated into existing software written in C++ object code and utilizing the Open Graphics Library (OGL) routines. Some of the software will also be modified to operate in the flight environment of either the Aircraft Terminal Operation and Planning Systems (ATOPS) aircraft or the CALSPAN Total In-Flight Simulator (TIFS) aircraft.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

1. The contractor shall develop real-time sensor imagery simulation. The sensor simulation will be capable of displaying simulated images of visible, passive millimeter wave, and infra-red sensors. The frequency range of the simulated passive millimeter wave sensor will be 94 Ghz and the simulated infra-red sensors shall include mid-wave (2-5 microns) and long-wave (8-12 microns) frequencies. The deliverable will be two databases and software object code to render the databases at a frame rate of better than 20 hertz. The first database will include the following airports: Langley Air Force Base, Patrick Henry Field, Wallops Field, and Salisbury Airport. To support the High Speed Research (HSR) flight tests with the CALSPAN TIFS aircraft a second database will be developed that depicts the Buffalo, NY airport area. The airports should accurately represent the runway and taxiway visual cueing environments of these airports.

   Deliverable: The deliverable will be two databases and a software object code to render the databases on the SGI computers. Weekly demonstrations of progress.

 PRINTED: 6/12/96

1. Task Order Number and Title	Number:	Revision:
Title: **XVS Simulation and Flight Test Graphics Programming**		

Description of Work - continued

Metrics: Acceptable performance is for the database and rendering software to be completed by September 20, 1996. The software will render the databases at a frame rate of better than 20 hertz. Exceeds performance is for the software to be completed prior to the above date and to operate at better than 30 hertz.

2. The contractor shall implement the latest High-Speed Civil Transport (HSCT) Reference-H aerodynamic model, mathematical models of aircraft aerodynamics, landing gear model, system / subsystems, and graphical displays, and their associated pilot interfaces to operate on the CVIB part-task simulation facilities and interact with the graphic displays. The model update should be completed by September 20, 1996. The model will be updated to the latest version of the Reference-H model and any changes to the landing gear model within 6 weeks of their release by the High Speed Research (HSR) program.

   Deliverables: Real-time software that will depict the latest version of the Reference-H aerodynamic model. Weekly demonstrations of progress.

   Metrics: Acceptable performance is for the software update is to be completed by September 20, 1996. The software must be able to run on one SGI ONYX 100 MHz Central Processing Unit (CPU) at an update rate of 20 hertz. Exceeds performance is for the software to be ready prior to the above data and to operate at greater than 30 hertz.

3. The contractor shall integrate other software developed under this task to have a fully functional simulation of aircraft models, aircraft controls, outside visual scene, and aircraft displays. These integrations and modifications will implement display configuration changes and landing scenarios that will be used in a symbology workshop developing symbology that will be used on NASA's B-737 aircraft in subsequent flight tests. The software must operate at an update rate of greater than 20 hertz and will be ready for use before September 20, 1996. The software will integrate with

1. Task Order Number and Title Number: Revision:
Title: **XVS Simulation and Flight Test Graphics Programming**

Description of Work - continued

existing SGI experiment control and display rendering software to conduct appropriate simulation experiments. The contractor shall operate the software and monitor it's functioning during any experiments, workshops, and demonstrations. There should be 2 experiments, 1 workshop, and as many as 3 demonstrations by September 30, 1996. The contractor shall operate the SGI computers during the workshops and monitor their performance in order to insure that they function as programmed.

Deliverable: Functional integration of software and hardware in building 1298 part-task simulators. Weekly demonstrations of progress.

Metrics: Acceptable performance is for the software to operate at an update rate of 20 hertz and will be ready for use by September 20, 1996. Exceeds performance is for the software to operate at an update rate of 30 hertz and ready for use before September 20, 1996.

4. The contractor shall upgrade to OGL graphics software that draw the 747-400 aircraft instruments, the Primary Flight Display (PFD) and the Navigation Display (ND). This software package will operate at update rate of greater than 20 hertz. The software package will be configurable so that it will operate with either of the three CVIB workstations (VISTAS, VISTAS III, or the collimated).

Deliverables: Linkable objects that represent the 747-400 upgraded aircraft instrument software. Weekly demonstrations of progress.

Metrics: Acceptable performance is for the 747 aircraft instrumentation software to be available by September 20, 1996 and operate at 20 hertz. Exceeds performance is for the software to operate at 30 hertz and be ready before the above date.

4. Government Furnished Items:

The following GFE equipment will be furnished to the contractor:

(1) Office space

(2) Access to 3 Onyx Reality SGI Computers with associated hardware and software

(3) Access to 4 SGI PI computers

5. Other information needed for performance of task.

The contractor will be subject to and required to sign the HSR LERD document because of access to sensitive data and models associated with the HSR program.

6. Security clearance required for performance of work:

The contractor will be handling LERD data and software.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: September 30, 1997

8. NASA Technical Monitor: Randall L. Harris, Sr.
M/S: 152 Phone: 804-864-6641

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JUN 19 1996
H. P. HANEY

PRINTED: 6/12/96

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ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title   Number: Revision:

Title: **Flight Deck Design and Integration Pilot Support**

2. **Background:** The Crew Vehicle Integration Branch and the Crew Systems Operations Branch have a continuing responsibility to conduct human (specifically airline pilots) performance studies of Flight Deck Systems Concepts under the HSR Design and Integration program, the Terminal Area Productivity program and the Base R&T. The purpose of this task is to provide technical support for conducting laboratory studies regarding these concepts.

3. **Subtask Descriptions;** The contractor shall perform the following subtasks:

1. Provide pilots with experience in airline operations to act as confederates in simulation experiments. The confederates will generally act as first officer in the simulation. The contractor will be notified when an experiment is being designed that will require confederate pilots. The contractor should assign a pilot to that experiment to become familiar with the requirements and to provide experiment design reviews from an airline pilot perspective. Written reviews of the experiment will be required. Pilots should be available for on-site and telephone discussions of the experiment.

   The contractor shall provide information regarding the cost of the task on a per experiment basis.
   The experiments for this performance period are
   - High Altitude Emergency Decompression Scenario
   - Predictive Information for Expediting Warnings experiment
   - Crew-Autoflight Interaction experiment
   - Terminal Area Productivity concept experiment
   - Performance Effects of Awareness Characterized by Hazardous and Effective States

   Metric: Minimum amount of airline experience is 20 years with a major air carrier (such as United, American, Delta, USAir) Years of experience in excess of 20 and pilot's understanding of experimental design will be used to assess the level of performance exceeding the acceptable level.

   Deliverable: Pilot participation as a confederate in the experiments. Experiment reviews in written form. Actual costing information on a per experiment basis.

   Schedule: Subtask 1 shall be completed by June 30,1997.

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1. Task Order Number and Title Number: Revision:
Title: **Flight Deck Design and Integration Pilot Support**

Description of Work continued

2. Establish and maintain a pool of test subjects for advanced flight deck studies, ranging from interviews and surveys to computer workstation studies and experiments, to studies in flight simulators and research aircraft. Such will involve the solicitation, screening, selection, and engaging of subjects. The requirements for this subtask are detailed as follows:
   1. Recruit potential subjects and maintain a pool of subjects for participation in flight deck experiments. The pool of prospective test subjects shall be established and maintained in such a way as to meet the following requirements:
      a. Potential test subjects shall be required to complete a background history questionnaire provided by NASA and administered by the Contractor. The completed questionnaires shall be forwarded by the Contractor to an authorized NASA official who will determine the suitability of each candidate for participation in the experiments. This requirement may be waived by NASA for certain test subjects.
      b. Subjects shall be over 18 years of age. Subjects shall be cataloged by the Contractor according to name, age, sex, geographic location, years of piloting experience, training, simulator experience, and time in aircraft type information. This information becomes the property of the US Government.
   2. Subjects for studies shall be provided in a timely manner after receipt of the task assignment. Deliver up to 5 subjects per day to the NASA Langley Research Center test site on two weeks prior notice. An average of 8 subjects per month will be required, although the requirements during some months may be greater or less than the average of 8 per month. No more than 40 subjects per month will be required. All transportation, lodging, meals, incidental costs and fees shall be coordinated and provided by the Contractor. The times for delivery to and pickup from the test site shall be met by the Contractor with an allowable tolerance of +20 minutes. Of the total number of subjects delivered per month, about three quarters may be required to be previously unused in other experiments conducted at LaRC, depending on the nature of the particular experiment. Some subjects may be required for two days at a time and/or for subsequent testing during the year. The normal testing period will be between 8:00 a.m. and 5:00 p.m. The normal test site will be either Building 1268 or Building 1168 at the NASA Langley Research Center. Subjects generally will participate in experiments for periods up to eight hours on any given day.

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1. Task Order Number and Title	Number:	Revision:
Title: **Flight Deck Design and Integration Pilot Support**		

Description of Work continued

3. The contractor shall provide information regarding the cost of the task on a per experiment basis.

The experiments for this performance period are

High Altitude Emergency Decompression Scenario
Predictive Information for Expediting Warnings experiment
Crew-Autoflight Interaction experiment
Terminal Area Productivity concept experiment
Performance Effects of Awareness Characterized by Hazardous and Effective States

Metric: Maximum acceptable number of test subject no-shows is 5% over the period of performance of the task. Maximum acceptable tardiness in subject delivery and/or pickup time is 20 minutes. Lesser numbers of no shows and more timely delivery and pick up of subjects will be used to assess the level of performance exceeding the acceptable level.

Deliverable: Test subjects delivered to test site on specified dates and times; documentation of classification of subjects.

Schedule: Subtask 2 shall be completed by June 30,1997.

4. **Government Facilities and Equipment Provided:** Flight Deck simulation and workstation facilities.

5. **Other information needed for performance of task:**

6. **Security clearance required for performance of work:**
All work will be unclassified however personnel may be required to complete nondisclosure agreements with industry or airlines.

7. Period of Performance:	
Planned start date: July 1,1996	Expected completion date: June 30, 1997

8. **NASA Technical Monitor:** Paul C. Schutte
.M/S: 152 Phone: 804-864-2019

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H. P. HANEY

PRINTED: 6/12/96

1. Task Order Number and Title Number: Revision:

Title: **Development and Implementation of B757 Guidance and Control Laws**

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Notes:

1. The following B757 G&C laws and engagement logic are available in a proprietary Boeing 757 simulation data package provided by NASA.
- Pitch inner loop control law
- Roll inner loop control law
- Pitch outer loop modes: Altitude hold, vertical speed hold, vertical navigation (VNAV), go-around, glideslope capture, glideslope track, flare, and angle-of-attack limiting
- Roll outer loop modes: Heading hold, lateral navigation (LNAV), localizer capture, localizer track, decrab, and rollout
- Autothrottles modes of calibrated airspeed hold, Mach hold, Engine Pressure Ratio (EPR) hold, and vertical speed hold and associated engagement logic
- Automatic stabilizer trim

2. In a prior contract, the following G&C laws were initially implemented but not checked out using high-level programming and rapid prototyping software tools called Xmath, SystemBuild, and C Autocode generator (Integrated Systems, Inc. software tools version 5.0 licensed to LaRC) –Pitch inner loop, roll inner loop, pitch outer loop modes, and roll outer loop modes.

3. The following research flight control modes will be designed and provided by NASA:
- Basic pitch manual, flight path angle (FPA) hold, and pitch-axis Velocity Control Wheel Steering (VCWS)
- Basic roll manual, track angle (TRK) hold, and roll-axis VCWS

DELIVERABLES

The Contractor shall deliver a final technical report that describes the implementation of the B757 G&C laws, the mode control logic, and the non-linear B757 aircraft simulation. The report shall include time history plots that show a performance match with the time history plots provide by NASA which will demonstrate the proper operation of the B757 non-linear aircraft simulation, B757 the G&C laws coupled to the aircraft simulaiton, and the mode control logic.

The Contractor shall deliver initial and final implementation documentation, and initial and final C source code for the B757 non-linear aircraft simulation, B757 G&C laws, and the mode control logic in the form of ASCII files. The initial C source code will be delivered after initial implementation of G&C laws prior to verification testing of the G&C laws in the non-linear aircraft simulation. The final C source code will delivered after verification testing of the G&C laws.

1. Task Order Number and Title Number: Revision:

Title: **Development and Implementation of B757 Guidance and Control Laws**

3. Tasks, Deliverables and or Products, and performance measurements (continued):
The schedule for delivery of the documentation and C source code is

Oct 11, 1996 Deliver initial stabilizer trim and autothrottle specifications and C source code file generated from the C Autocode generator software tool. The specifications shall be in the form of SystemBuild block diagrams and an associated text description. An Xmath/SystemBuild data file of the block diagrams compatible with the NASA LaRC Sun Sparc10 workstations shall also be included.

Dec 15, 1996 Deliver a source code ASCII file for the implemented B757 non-linear aircraft simulation in the form as connected to SystemBuild software tool that is compatible with the NASA LaRC Sun Sparc10 workstations. Also, deliver documentation that describes how to operate the aircraft simulation and its coupling to the B757 G&C laws and mode logic. **

Apr 30, 1997 Deliver a Xmath/SystemBuild data file of the implemented B757 G&C laws and mode control logic that have been validated in the B757 non-linear simulation. The file must be compatible with version 5.0 of the Xmath and SystemBuild software tools licensed to operate on Sun Sparc10 workstations at NASA LaRC. Also, deliver verified C code generated from the C Autocode generator software tool (in the form of ASCII files) for the B757 G&C laws and mode logic and associated documentation of code for interface with real time simulation. **

June 30, 1997 Deliver final documentation describing the batch non-linear simulation tests to verify proper operation of the implemented G&C laws and mode logic including time histories plots. **

The Contractor shall prepare and deliver quarterly progress reports on the above work.

Note: ** These deliver dates are dependent upon the time when the B757 batch non-linear aircraft simulation is completed by NASA (currently scheduled for mid-June '96) and that time is dependent upon timely receipt of B757 simulation information from Boeing.

PERFORMANCE STANDARDS

The performance of the Contractor will be based on the level of satisfactory accomplishment of the tasks and the timeliness of meeting the dates for deliverable items. Delivery dates missed due to any delay in the government provided information will not affect the performance rating. The performance of the Contractor will be rated on the basis as described below:

Exceeds acceptable performance All tasks are satisfactorily completed ahead of schedule and on budget.

1. Task Order Number and Title	Number:	Revision:

Title: **Development and Implementation of B757 Guidance and Control Laws**

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Acceptable performance — All tasks are satisfactorily completed on schedule and on budget.

Acceptable performance of the tasks will be determined by comparing the Contractor-generated time-history plots (obtained from the performance of the implemented G&C laws coupled to the B757 simuation) against the time-history plots of G&C law performance from the Government-provided Boeing proprietary B757 simulation data package. For acceptable performance, the Contractor-generated plots should match the Government-provided time-history plots to less than 5% in both magnitude and frequency response.

4. Government Furnished Items:

1. Batch non-linear B757 simulation coded in C^{++} for integration with the implemented G&C laws and mode logic and, subsequently, for verification of proper operation of them.

2. Documentation of B757 G&C laws and engagement logic response from proprietary Boeing simulation data package.

3. Time-history plots of coupled B757 G&C law response from proprietary Boeing simulation data package.

4. Access to Sun Sparc10 workstation computers containing the licensed Xmath/SystemBuild and C Autocode generator software tools (version 5.0) for implementation of G&C laws and logic.

5. Process time on Sun workstation computers to implement G&C laws and logic and generate C code.

6. Definition of basic pitch manual, basic roll manual, FPA, TRK, pitch VCWS, and roll VCWS G&C laws and engagement logic.

7. Definition of mode control panel engagement logic.

8. Documentation, Xmath/SystemBuild data files, and C source code files for the initial implementation of the B757 pitch and roll inner loops, and pitch and roll outer loop modes developed under a prior contract.

1. Task Order Number and Title	Number:	Revision:
Title: **Development and Implementation of B757 Guidance and Control Laws**		

5. Other information needed for performance of task.
examples: List essential travel required for successful performance of task, number of trips, duration, destination and the need for the travel.
List any applicable documents and where or how they can be obtained.
List any safety, environmental, legal, data rights, etc. issues

6. Security clearance required for performance of work:
List all security issues, if the task description is to be classified special handling of the task will be required by the COTR before issued to the contractor.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997.

8. NASA Technical Monitor: Richard M. Hueschen
.M/S: 489 Phone: 804-864-4036

PRINTED: 6/12/96

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FCCD-15 Friedman F-14

1. Task Order Number and Title Number: Revision:
Title: Spin and Tumbling Research

2. Purpose, Objective or Background of Work to be Performed: Spin and tumbling research is conducted in the NASA Langley 20-foot Vertical Spin Tunnel using the unique vertical airflow capability of the facility. The research encompasses high performance military aircraft, experimental aircraft, and general aviation aircraft. The experimental results are used to predict full scale airplane characteristics. A typical spin tunnel test program is described in NASA TN - 85660. 2 to 3 such tests may be conducted during the contract period.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

1. Model Preparation

a) For an existing model: Contractor shall ensure that model is configured to perform required experiment. Specify any necessary repairs and/or modifications and confirm completion. Ballast model to the required test conditions.

b) For a new model: Contractor shall determine model scale and specialized design features needed for test including break-away parts, location of R/C components, and number of spare parts. Confirm satisfactory completion of model. Calculate scaling parameters and ballast model to test conditions.

Deliverables: Dynamically scaled radio-controlled test model, copies of all scaling and ballasting calculations

Metrics: All controls operable, mass characteristics +/- 3%, ready one week prior to test

2. Reynolds Number Effects

Contractor shall conduct computational and experimental studies to quantify and assess the effects of Reynolds Number on high angle of attack flight dynamics. Contractor shall develop techniques for correcting for these effects.

Deliverables: Research report including description of studies, data, analysis, and significant results

Metrics: Coverage of appropriate tunnel Reynolds Number range, correction techniques adjust at least 80% of discrepancy at angles of attack above 60 degrees (Tunnel Reynolds Number range 200,000 to 500,000 and corresponding flight range)

3. Test Operations

Contractor shall configure the 20-foot Vertical Spin Tunnel including data acquisition systems to conduct required tests. Contractor shall conduct tests to obtain appropriate data, including visual, video, and computer-generated time histories.

b) Method and code documented by memo and inline comments

Acceptable performance:

a) Results from developed method shall be comparable or better than results obtained by estimated technique developed by Harry Heyson (See NASA TN D-6476 by Harry Heyson)

Exceeds acceptable performance:

a) acquisition time increases no more than 1% per data point

3. The contractor shall maintain the data acquisition system, which consists of the data acquisition code "PRESSURE" and "FORCIL", file server (12 gigabits of storage, 1 gigabit is designated for storage of current test data), and data acquisition computer and graphic workstation for 12 Ft. tunnel and '30x60 Ft tunnel'. Shall install software upgrades on a non-interference basis. Shall modify code to calculate test specific data. (Usually consist of 2 to 3 additional inputs and 4 to 5 additional calculations.) Shall maintain test data base with backups and data archival on a non-interference basis.

Deliverables:

a) Code modifications to meet specific needs
b) Code modifications documented in form of memo and inline comments
c) Weekly backups and data archival to maintain 20 megabytes of available disk space
d) Log of system upgrades, code modifications, and backups
e) Software upgrades installed

Acceptable performance:

a) Code is operational for scheduled tunnel entries
b) Accuracy and timeliness of implementing software updates
c) Overall performance level of acquisition system. Timely and efficient response to system problems

Exceeds acceptable performance:

Recommend system upgrades to better meet test requirements that result in time and/or cost savings to the government

1. Task Order Number and Title   Number: Revision:
Title: Spin and Tumbling Research

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Deliverables: Complete set of test data sufficient to analyze the spin and tumbling characteristics of the configuration, including one chart per loading condition, one table for each configuration variable, one time history per spin mode (including recovery), parachute test results

Metrics: minimum 3 runs per spin block, each flight control assessed, minimum 3 cg positions, minimum 4 major store loadings assessed, chute sizes above and below recommended

4. Reporting

Contractor shall prepare a Summary Test Briefing including Vu-Graph charts and selected video clips describing and summarizing the test program.

Deliverables: Charts and video tape
Metrics: Test description, major results, significant conclusions comprehensive video tape

Contractor shall prepare a final report presenting all results with supporting analysis and conclusions determined.

Deliverables: NASA Contractor Report (CR)
Metrics: Complete test description, all significant results, text and supporting illustrations; 90 days after test

4. Government Furnished Items:

Shop area, swing rig, 20 foot Vertical Spin Tunnel, access to data acquisition equipment, test model, configuration drawings, mass characteristics, model shop support, photo service, computers

5. Other information needed for performance of task.

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FDCD-16 ONFA-

1. Task Order Number and Title Number: Revision:
   Title: Vehicle Dynamics Branch Test Support

2. Background of Work to be Performed:
The contractor shall provide system trouble shooting, data acquisition code modifications and documentation for the static and dynamic test systems. During the year, the branch will conduct approximately 12 static tests, each of 4 weeks duration, in the 12 Ft tunnel. The static test system consists of a data acquisition computer and test signals (balance, tunnel Q, model attitude, and test specific signals). The dynamic test schedule usually consists of 2 test entries per year. Each entry is of an approximate 5 week duration in which 4 - 5 models shall be tested. Tunnel entries shall be in 14x22 Ft. tunnel. The dynamic test system consists of the forced oscillation rig, data acquisition computer and forced oscillation rig outputs (balance, sine/cos potentiometers, oscillation amplitude and frequency signals). The rig is oscillated at a set frequency and data is acquired over a selected number of oscillations to provide a data point.

3. Subtask Description:

1. The contractor shall setup for the forced oscillation test in a checkout area, connecting the oscillation rig outputs to the acquisition computer and verifying the system is operational prior to the scheduled tunnel entry. The forced oscillation system is operational when:
   1) In-phase and out-of-phase forcing signals are 180 degrees (+\- 0.1 degree) out-of-phase
   2) Magnitude of the forcing signal is oscillating between +/- 10 volts (-/+ 0.2 volts)
   3) Difference between in-phase and out-of-phase wind off zero and a data point taken with no wind falls within x counts

   Deliverables: Setup documented in form of a memo one week prior to tunnel entry

   Metrics: Forced oscillation system operational and verified two weeks prior to a scheduled entry

2. The contractor shall develop and implement a method of applying wall corrections, high alpha corrections and blockage corrections to the static and forced oscillation test technique. It is preferable to apply the corrections to the data in the data acquisition code, if the acquisition time per point is not increased more than 2%. If this is unobtainable, corrections shall be applied as a post processing task.

   Deliverables:
   a) Verified code to apply wall and blockage corrections to data obtained from static and forced oscillation tests

ART(NASA1-96014) Task Order Page 2

1. Task Order Number and Title	Number:	Revision:
Title: Vehicle Dynamics Branch Test Support		

4. Government Furnished Items:

Checkout area, access to forced oscillation rig, computer codes "FOSCIL" and "PRESSURE", and data acquisition computer system, and terminal to access data acquisition computer

5. Other information needed for performance of task.

6. Security clearance required for performance of work:

Security clearance, secret level, may be required for some tests. (possibly 1 to 2 test)

7. Period of Performance	
Planned start date: 7/1/96	Expected completion date: 6/30/97

8. NASA Technical Monitor: Norma Campbell
.M/S: 355 Phone: 804-864- 1131

ART (NASA1-96014) Task Order Page 3

Note: the following information <u>will not</u> be provided to the contractor but is required to allow the COTR to determine a preliminary cost estimate. This page will be replaced with negotiated final funding information and limitations at time of task initiation.

1. Task Order Number and Title — Number: — Revision:

   Title:

   Vehicle Dynamic Branch Test Support

10. Government's Estimated Cost Limitation:

    Task 1 Cost: $ 15K

    Task 2 Cost: $ 50K

    Task 3 Cost: $ 55K

    Total Cost: $ 120K

    Provide the best estimate of the cost by task.

11. Other Direct Cost Estimates:

12. Funding information:

    List Job Orders and RTR information and Purchase Request number if available.

DCX13

Morelli

1. Task Order Number and Title Number: Revision:
Title: Parameter Identification (PID) for F18 HARV and F15 ACTIVE Aircraft

2. BACKGROUND/OBJECTIVE: System Identification is the science of determining a mathematical model of a physical system (plant) on the basis of measured inputs and measured outputs of that system. The F-18 HARV and F-15 ACTIVE are modified high performance aircraft that are designed for research at high angles of attack. Both are fully instrumented for flight research. The HARV features thrust vectoring and nose strakes. The ACTIVE features nozzled thrust vectoring and a close-coupled canard. In order to carry out the research objectives of programs attached to these aircraft, it is necessary to have a flight validated mathematical model of the aerodynamic properties (stability and control derivatives) of each of these vehicles. System identification or parameter identification (PID) is the methodology/technology used to ascertain such mathematical models from flight testing of these aircraft

3. Description of Work to be Performed:
There are two main objectives of this task: 1. to develop and deliver to the government a set of stability and control derivatives for the F-15 ACTIVE aircraft, including an assemblage of results from LARC and ARC wind tunnel test since 1980 (approximately 6 reports) and the development of flight test results as detailed below. Flight test results will require the definition of flight test maneuvers, oversight of flights involving those maneuvers including pre- and post- flight briefs with pilots, and analysis of resulting flight test data to extract stability and control derivatives at NASA selected flight conditions throughout the aircraft's flight envelope. 2. to complete documentation of F-18 HARV flight test results as they relate to System Identification flights and deliver presentation on results at Final High Angle of Attack Technology Conference at LaRC on September 17-19, 1996.

1. Deliverables for the F15ACTIVE as follows:
   a. Definition of PID maneuvers for flight cards by November 1, 1996.
      I. This shall include the determination of the number of flight maneuvers required and number of flights (typically 10 - 15 flights)
   b. Brief and debrief of pilots on each mission and results for flight tests either electronically or in person at DFRC between the start of this task and March 1, 1997
   c. ID analysis of data developed as a result of flights flown in accordance with 1. a & b above including the identification of all linear longitudinal and lateral stability and control derivatives and nonlinear derivatives (approx. 30 derivatives) as identified as non-zero by May 1, 1997.
   d. A Contractor Report containing 1a,b,&c above and a comparison of 1.c with available wind tunnel results by June 30, 1997.

2. Deliverables for the F18HARV as follows:
   a. PID Analysis of F18 HARV PID/System Identification flights conducted between April 1, 1996 and May 30, 1996 by August 30, 1996 (Approximately 3 flights of 50 minutes each)
   b. A Contractor Report on analysis in 2.a above by September 15, 1996.
   c. Presentation of report in 2.b above at NASA High Angle of Attack Technology Conference September 17-19, 1996 at LaRC.

ART (NAS1-96014) Task Order Page 2

1. Task Order Number and Title   Number: Revision:

   Title: Title: 1. TITLE: Parameter Identification (PID) for F18 HARV and F15 ACTIVE Aircraft

3. Description of the Work to be Performed Continued

   Metrics: Above deliverables define minimum acceptable performance.

   Significantly exceed minimum acceptable performance: Identification of future PID research issues shall be accorded an additional 15 performance points and recommendations on methods to resolve such issues shall receive an additional 15 points.

4. Government Furnished Items: 4. Government Furnished Items:
   a. High fidelity 6 degree of freedom simulation model of F15ACTIVE and access to same on government computer.
   b. MacIntosh Centris or equivalent workstation and MATLAB software with System Identification Toolbox.
   c. Office Space for 4.b and LaRC Network connection.

5. Other information needed for performance of task.
   a. Travel: Two trips to Dryden Flight Research Center of one week duration each to complete 3.1.b above.

6. Security clearance required for performance of work:
   a. Contractor must be cleared for ITAR (International Trade and Arms Regulations) data access.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30 1997

8. NASA Technical Monitor: James G. Batterson

   M/S: 489   Phone: 804-864- 4059

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Ref: (1) HSR Planning and Control Document for the period Jan. 1, 1996 to Dec. 31, 1996 for 41.1.2 Guidance and Control and 4.3.5 Flight Controls.

(2) Dornfeld, G.M., Lanier, J.K., Phillips, B.A., Kuta, J.F., Milligan, K.H., Stephens, A.T., "High Speed Civil Transport Reference H - Cycle 2A Simulation Data Base", NASA Contract NAS1-20220, Task 7, WBS 4.3.5.2.. March, 1995

(3) Dornfeld, G.M., Lanier, J.K., Milligan, K.H., Parker, J.M., Phillips, B.A., Stephens, A.T., "High Speed Civil Transport Reference H - Cycle 2B Simulation Data Base", NASA Contract NAS1-20220, Task 7, WBS 4.3.5.2., July, 1995

(4) Sotack, R. A., Chowdry, R.S., Buttrill, C.S., "MATLAB/Simulink Implementation of the Ref. H Cycle 1 Simulation", NASA TM.

(5) Buttrill, C. Final Review of Guidance & Flight Control Technology Development in HSR for the PCD1 planning period, February 21-22, NASA LaRC.

(6) Adams, W.M. Jr. and Hoadley S.T.: "ISAC: A Tool for Aeroservoelastic Modeling and Analysis." NASA TM-109031, December 1993.

(7) Jackson, E. Bruce: "Manual for a Workstation-based Generic Flight Simulation Program (LaRCsim) Version 1.4." NASA TM-110164, May 1995.

3. Description of Work to be Performed:

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Subtask 1 Simulation Development and Model Integration

Background

A major element of the HSR Phase II program in Flight Controls will be the development of integrated models to support multidisciplinary dynamic analysis and controls development. These integrated models will support primary flight control development, aeroservoelastic analysis and active control studies, flight/propulsion interaction studies, flying qualities assessment in all flight phases, and stability and control power assessments. This simulation task is primarily one of integration. The major component subsystem models will be defined outside of this task.

Objective

Using databases and subsystem models provided by industry and the LaRC Simulation Systems Branch (SSB), develop and refine an integrated HSCT simulation in MATLAB/Simulink language. The databases and subsystem models will be of a size and

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complexity similar to the Cycle 1 (8/94), Cycle 2A (3/95), and Cycle 2B (7/95) simulation models delivered by Boeing under Task 7 of NAS1-20220. See references (2) and (3). The MATLAB/Simulink simulation shall be constructed to make use of SSB provided software with minimal modification. The simulation will support controls design and analysis and configuration assessment. These batch simulations will require extensive capabilities for trim and linear model extraction. Minimum capabilities for trim/optimization include but are not restricted to: level flight, trim to variable gamma for fixed thrust, climbing/descending turns to selected g, trim to minimum fuel flow using excess controls, trim to fixed alpha. The simulation shall produce MATLAB compatible linear model files and be capable of simulating mixed continuous/discrete dynamic systems.

Perform interface tasks with the Simulation Systems Branch (SSB), as required, in validating simulation software developed and adapted under this task with the real-time simulation developed by SSB.

Implement subsystem models, such as turbulence, actuator, and aeroservoelastic models as defined by the government and in the subtask, "Aeroservoelastic Modeling and Analysis."

Deliverables:

a) MATLAB/Simulink implementation of Ref. H QSAE Cycle 3. The deliverable shall be (a) collection of m-files, scripts, data-sets and code required to execute trim cases, static checks, and dynamic checks. 8/96

b) MATLAB/Simulink implementation of Ref. H QSAE Cycle 3 packaged to permit secure file transfer to industry and NASA sites as determined by the government. These will include, but not be limited to, LeRC, ARC, Douglas in Long Beach, and Lockheed in Georgia. 9/96

d) Script files and software to automatically generate trim, stability, and control power analyses along HSR baseline mission profile using MATLAB/Simulink simulation. 10/96

d) Initial documentation that describes the MATLAB/Simulink implementation of Ref. H QSAE Cycle 3. The document should serve as a user's guide. This will be a high number CDCR. 12/96

e) Final documentation of QSAE Cycle 3, dynamic aeroelastic model, control laws as implimented for 11/96 piloted assessment. 6/97

f) Top level design specifications for Graphical User Interface (GUI) being developed by the government using Matlab development tools. Verification of utility of GUI implimentations. 6/97

Metrics:

a) Timeliness of deliverables a & b, which are critical to the HSR GFC program as defined in Ref (1).

b) Quality of the match of the static checks. Number of trim shots successfully matched (to within 0.1 % of Euler angles, control deflections, flight path and velocity vector angles and pilot station accelerations, and to within 0.5% of all other quantities)

c) Quality of the match of the dynamic checks. Number of dynamic checks successfully matched (to within 0.1% per second of Euler angles, control deflections, flight path and velocity vector angles and pilot station accelerations, and within 0.5% per second on other quantities).

d) Errors found in the Cycle 3 delivery from Boeing and communicated in a timely clear manner to industry partners are indicators of excellent performance.

e) Timeliness of deliverables d & e.

f) Quality of innovation, technical execution, and documentation, as determined by the customer.

Government Furnished Items:

a)	Undocumented MATLAB/Simulink implementation of Ref. H QSAE Cycle 2B with a preliminary implimentation of dynamic aeroelastics.	5/15/96
b)	Data files and documentation required impliment Ref. H Cycle 3 quasi-static-elastic aero math model and cycle 3 propulsion model. These data files and documentation will be generated under Task 36 of NAS1-20220.	6/16/96.
c)	Control wiring diagrams and flow specification in Simulink for Ref H Cycle 3 long/lat/dir control laws. These data files and documentation will be generated under Task 36 of NAS1-20220.	8/20/96

<u>Subtask 2 Aeroservoelastic Modeling and Analysis</u>

Background

Industry has and will continue to deliver rigid-body airframe models with quasi-static-elastic (QSE) adjustments. This subtask will develop and apply methods to augment QSE simulation models by providing the information required so that the first N_{sy} symmetric and N_{as} anti-symmetric modes can be added to the rigid DOF in both batch and real-time

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simulation. The number of modes to be included will be affected by the computational power of the real-time Convex computers, the motion-base bandwidth, and the authority of longitudinal SAS systems required for rigid-body dynamics. Preliminary estimates suggest that modes with in-vacuo frequencies under 10 Hz might be included in a mixed rigid/elastic simulation. An approach towards insuring that as elastic modes are added/deleted from the list of those actively simulated, the net QSE effects remain unchanged, has been developed. Verification is required that the simulation satisfies this property . The ASE models shall include gust and control modes, effect of modes on sensor outputs, and hinge moment estimates.

It is anticipated that the Integration of Structure, Aerodynamics, and Controls (ISAC) system of programs (Ref. 6), tempered with steady-state constraints from simulation QSE aero data, will provide inputs necessary for inclusion of elastic equations of motion into the batch and real time simulations as well as a valuable capability for rapid linear aeroservoelastic analysis of candidate HSCT concepts. Flutter predictions as well as ride quality and other gust response characteristics are among the early analyses which will be enhanced by this effort. This modeling work will also support studies to determine the benefits and feasibility of structural mode control (SMC) on the full-scale airplane.

Objective

Develop elastic and aeroelastic models for Reference H and alternate configurations of the High-Speed Civil Transport that are required to do the following: (1) include elastic dynamics in integrated full-envelope real-time and batch simulation models implemented at LaRC and (2) support aeroservoelastic, structural mode control (SMC), and primary flight controls dynamic analysis. A key element of this support will be to provide linear models at approximately 40 specified points in the flight envelope. The exact mass case, Mach, and altitude of desired linear analysis points will be detemined as the subtask progresses.

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Deliverables:

a) Initial draft of document that describes the cycle 1 MATLAB/Simulink implementation of dynamic aeroelastic modes. The document should serve as a user's guide. Shall be suitable for a draft high number CDCR. 7/96

b) Data files with modal displacement data at critical nodes enabling smooth interpolation for slope and deflection inputs into unsteady aero codes for the Ref. H airplane. 7/96

c) Modifications to the ISAC code according to specifications/theory provided by the government that will correct linear ISAC aerodynamics based upon nonlinear rigid and QSE database data. 8/96

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d) A,B,C,D linear models to support methodology development for optimal sensor placement for structural mode control, ride quality analysis, and load control. ongoing

e) Aeroservoelastic subsystem model with extended Mach range suitable for inclusion in the MATLAB simulation for the Ref. H airplane. Current model includes only one Mach point. Will include data files with generalized mass, stiffness, aerodynamic forces, and modal sensor coefficientsts (including mode displacement load coefficients) required to develop integrated rigid/elastic simulation models. 8/96

f) Methods and code for calculating the MilSpec integral-based and the ISO ride discomfort indices incorporated into the gust response analysis capabilities of ISAC. 9/96

g) Modification to ISAC that upgrades the loads computation to a summation of forces approach for more rapid convergence with number of elastic degrees-of-freedom retained. 11/96

h) Preliminary documentation of subroutine structure of ISAC to include outline and selected modules to support code modification as required by HSR. 12/96

i) Draft of updated document that describes the MATLAB/Simulink implementation of dynamic aeroelastic modes. 6/97

Metrics for Deliverables:

a) Timeliness of deliverables a & e. Excellent performance would be in the month specified. Good performance would no later than the following month.

b) Quality of innovation, technical execution, and documentation, as determined by the customer.

Subtask 3 Uncertainty Modeling Tool Development

Background

Analytical formulations of complex nonlinear aircraft mathematical models are required for advanced multivariable robust control analysis and design methods to be systematically applied to an HSCT. The huge size and tabulated nature of Ref. H baseline simulation models prohibit this analysis. Tractable models, preferably analytic, are needed to support the application of emerging robust control methodologies. This subtask represents a follow-on of work documented in "HSR Aerodynamic Database Modeling using Multivariate Orthogonal Functions" (part of Ref 5).

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Objective:

Develop and apply methods for parameterization of the Ref. H HSCT aerodynamic data base with analytical multivariate polynomial expressions. Apply these methods to the Ref. H. simulation model as updated under the subtask, "Simulation Development and Model Integration." Develop a MATLAB interface to the selected parameterization method. Using parametric models based on Ref. H Cycle 2B and Cycle 3, determine the accuracy of parametric models developed over the flight envelope and develop additional uncertainty descriptions to account for discrepancies.

Deliverables:

a) A parameterization of the Ref. H HSCT 2B lateral/directional data base with analytical expressions. Computer code to mechanize this parameterization. 8/96

b) An assessment of the discrepancies of the parameterized model over the flight envelope relative to the tabularized data, and characterization of additional uncertainty descriptions required to account for these discrepancies. 9/96

c) An informal report describing the above parameterized models and their development. Shall include validation of model by comparison with tabular data simulation, and characterization of additional uncertainty models to account for discrepancies in the model. 10/96

d) A parameterization of the Ref. H HSCT 3 longitudinal/lateral/directional data base with analytical expressions. Computer code to mechanize this parameterization. 4/96

e) An assessment of the discrepancies of the parameterized model over the flight envelope relative to the tabularized data, and characterization of additional uncertainty descriptions required to account for these discrepancies. 5/97

f) An informal report describing the above parameterized models and their development. Shall include validation of model by comparison with tabular data simulation, and characterization of additional uncertainty models to account for discrepancies in the model. 6/97

Metrics for Deliverables:

a) Number of parameterized models generated, and RMS of the discrepancies between the parameterized models and the tabularized data over the flight envelope.

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b) Time history plots comparing nonlinear simulations of the vehicle using the parameterized models to corresponding vehicle simulations using the tabularized data.

c) Characterization and assessment of additional uncertainty descriptions required to account for discrepancies in the parametric models over the flight envelope.

d) Quality of innovation, technical execution, and documentation, as determined by the customer.

e) Timeliness in meeting the deliverables schedule.

Subtask 4 Stability and Control, Flying Qualities Assessment, & Noise Procedures

Objective:

Provide engineering support for flying qualities assessment of the HSR baseline configuration. Provide stability and control power assessments of the HSR baseline in all flight phases. Provide assessments and recommendations on community noise impacts and noise abatement strategies. Maintain proficiency and working knowledge of applicable FAR regulations. Provide recommendations on flying qualities requirements over the HSCT flight envelope. Support piloted evaluations of HSCT concepts as right seat engineer/test conductor. Complete documents that describe previous work in this technical area (deliverable i & j) and which are approximately 80% complete already.

Deliverables:

a) Memo recommending flying qualities criteria for flight above Mach 1.6 for the purposes of guiding unstart tolerance performance of the HSCT mixed compression inlet. Should recommend minimum necessary "carefree" maneuvering envelope for the pilot in supersonic climb, pushover, cruise, and top-of-descent. 7/96

b) Updated and refined noise prediction data package for use in both takeoff and landing phases of flight for use with the Ref H Cycle 3 simulation model. 9/96

c) Flight cards and simulation test plan for Reference-H noise abatement takeoff and landing procedures, recovery from the limit flight envelope, and control function failures. 10/96

d) Memos of record describing initial S&C analyses of HSR baseline airplane concept. 10/96

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e) Input to a joint HSR report documenting the HSR Flight Controls piloted evaluation study to be conducted in Nov/Dec 1996 at LaRC. Input shall take the form of a standalone CR. Shall include proposed risk abatement strategies. 2/97

f) Refined evaluation of Reference-H airport/community noise characteristics. Examination of the pilotability and associated merits of nonstandard 3-dimensional takeoff and landing procedures. 2/97

g) Identify applications of thrust vectoring to improve the viability of HSCT aircraft. Deliverable would be a short memo delivered at the conclusion of the 1996 Ref.-H assessment. 4/97

h) Summary memo-of-record with final S&C analyses of HSR baseline airplane concept (Cycle 3). 6/97

i) CDCR on Piloted Simulation Comparison of Standard and Advanced Takeoff Noise Abatement Procedures for a Representative High-Speed Civil Transport report. Draft ready for technical review. 6/97

j) CDCR data report of Ref.-H test in LaRC 30x60 tunnel. Draft ready for technical review. 6/97

Metrics for Deliverables:

a) Timeliness and completeness of deliverables b), c), e), and f) as they tie into a Level 3 HSR Flight Controls milestone described in Ref. (1).

b) Quality of innovation, technical execution, and documentation, as determined by the customer.

Subtask 5 Support for GFC's secure Web site

Background

Timely dissemination of HSR Flight Deck information is of extreme importance to the HSR Flight Deck community. A World Wide Web (WWW) server has been established to provide secure, encrypted access to Flight Deck-related information, including technical reports, draft documents, simulation data bases, and administrative information. The majority of this information originates in document formats that are not useful for on-line access via Web clients, however, and current translation algorithms are incomplete at best. This subtask would integrate and support the WWW sites already in place for (a) Guidance & Flight Controls (GFC) , (b) External Visibility (XVS), and (c) Design & Integration (D&I)

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Objective

This task provides support for maintaining the Flight Deck (GFC, XVS, D&I) documents collection on an existing limited-access Web server. "Maintaining" is understood to mean: (1) adding documents to the server, and (2) organizing the total document set in a logical-tree using hyperlinks.

In addition to maintaining the Web document collection, the task requires aperiodic modification to the Web server access list. This is accomplished with a Netscape Navigator client program. On an infrequent basis, the task will involve shutdown and restart of the Web server software; this is accomplished via a Telnet connection to the host. Automatic translation programs shall be investigated and implemented a to maximum extent possible.

In addition, the HSR program office has selected ADAPT, a software system developed at LaRC, as the HSR standard for secure email and file transmission. ADAPT is compatible with Netscape. It is anticipated that use of the ADAPT system, which is still in beta test, will be more difficult than Netscape.

Documents that are to be placed on the GFC Web server include: (a) monthly reports by Flight Controls (4.3.5) and Guidance & Control (4.1.2), (b) weekly telecon minutes, (c) memos-of-record, (d) formal documents and contract deliverables under NAS1-20220, Tasks 30 and 36, and NAS1-20219, Task 9. A rough-order-of-magnitude estimate for a "typical" month is about 30 documents of various lengths for a total of 300 pages.

Documents that are to be placed on the XVS & D&I Web server sites include: (a) monthly reports, (b) weekly telecon minutes, (c) memos-of-record, (d) formal documents and contract deliverables. A rough-order-of-magnitude estimate for a "typical" month is about 40 documents of various lengths for a total of 400 pages.

Deliverables:

a) Rapid translation of documents to either Hypertext Mark-up Language (HTML) or Portable Document Format (PDF) from a variety of source documents (including text, Microsoft Word 6.0, LaTeX, and PostScript files), generally within 24-72 hours of receipt. Accuracy is important; HTML version must be proofread and compared to original source document.

b) Document hierarchy on GFC + Flight Deck Web server together with up-to-date hypertext-based collection of GFC documentation on GFC Web server.

c) Sufficient explanatory HTML pages to provide navigation capability throughout the GFC and Flight Deck Web structure.

d) Backup set of source and HTML documentation on Macintosh-compatible removable media. Backups to be performed at regular intervals.

e) Interface with the HSR ADAPT system. All valid HSR ADAPT users shall have access to the GFC and Flight Deck Web server.

f) Up-to-date access list to GFC and Flight Deck Web server.

g) Any translation tools and scripts procured or developed in support of this task.

Metrics for Deliverables:

a) A record of the total number of documents placed on the server along with their size. A record of the time required to provide translation of documents. Excellent performance would be for all documents less than 10 pages to be available within 24 hours of receipt and larger documents within 72 hours.

Subtask 6 Support for piloted simulations

Background

A major component of the HSR effort for this period are piloted evaluations of candidate HSCT designs performed in ground- and flight-based simulation facilities, such as the Langley Visual/Motion Simulator (VMS) and the USAF Total In-Flight Simulator (TIFS). Several activities in support of these simulations are to be provided under this subtask, including transcription of pilot comments (for the Langley VMS study) and preparation of the simulation model for the TIFS study.

Objective

This task provides support for the two simulation studies outlined above.

The first task is to provide transcription of recorded pilot verbal comments obtained during the Fall 1996 Reference H Piloted Assessment to be conducted on the Langley VMS simulator. This shall require use of transcribing tape players to convert verbal pilot comments into computer text files. These files shall be organized by task ID (several pilots will comment on each task), with one text file for each task ID containing the comments of several pilots. To ensure confidentiality, names of the pilots shall be eradicated from the transcription; the pilots shall be referred to as "Pilot A", "Pilot B", etc. where the designation of "A" and "B", etc. shall be defined by the Government. In addition, someone knowledgeable about aircraft flight dynamics and flight test techniques shall review the transcriptions for accuracy. A separate file shall be generated for each separate task, containing the collected pilot comments from all pilots for that task. Each pilot's individual comment block shall be preceeded by the pilot designation, date, and run numbers associated with that evaluation.

The second task supports the planned Spring 1997 Inceptor Downselect study to be performed onboard the TIFS aircraft. This specialized NC-131H aircraft is used to perform in-flight simulations of various other aircraft, including the Reference H HSCT design. It uses the LaRCsim implementation of Ref.-H to generate pilot station accelerations that match the simulated aircraft response to pilot inputs. To prepare for this study, this subtask is to install the Cycle 3 Ref.-H model, as delivered by the Simulation Systems Branch (described in subtask 1) into the LaRCsim shell structure on a Government computer and to verify proper implementation by comparison with industry-provided check case data. This task requires knowledge of the IRIX 5.x operating system, FORTRAN and ANSI C programming languages, as well as the use of several IRIX utilities, including rcs, make, and a debugging tool (either dbx or gdb). LaRCsim is described in reference (7).

Deliverables:

a) A complete set of pilot comment transcripts in ASCII text file format as described above. Due two weeks after the delivery of the final pilot comment recording.

b) A comparison of trim shots, showing LaRCsim trim results compared to industry-provided trim results, for all appropriate Cycle 3 trim cases.

c) Co-plots of time histories comparing LaRCsim dynamics with industry-provided dynamic check cases for Cycle 3.

Metrics for Deliverables:

a) Turn-around time between delivery of pilot comment recordings and the receipt of transcript files, measured in hours; less then 336 hours is satisfactory.

b) Number of lines of code installed into LaRCsim

c) Number of trim shots successfully matched (to within 0.1 % of Euler angles, control deflections, flight path and velocity vector angles and pilot station accelerations, and to within 0.5% of all other quantities)

d) Number of dynamic checks successfully matched (to within 0.1% per second of Euler angles, control deflections, flight path and velocity vector angles and pilot station accelerations, and within 0.5% per second on other quantities).

Government Furnished Items (Subtask 6):

c) Loan of transcribing cassette and microcassette players.

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d) Access to SGI Onyx computer with IRIX 5.x and LaRCsim source code installed.

4. Government Furnished Items (All subtasks):

a) Access to Macintosh Centris (or better) desktop computers with LaRC standard software suite (MS Office, Quickmail, Network access)

b) Access to Sun Sparc 10 and UltraSparc class Unix workstations with Matlab/Simulink licenses.

5. Other information needed for performance of task.
examples: List essential travel required for successful performance of task, number of trips, duration, destination and the need for the travel. List any applicable documents and where or how they can be obtained. List any safety, environmental, legal, data rights, etc. issues

6. Security clearance required for performance of work:
List all security issues, if the task description is to be classified special handling of the task will be required by the COTR before issued to the contractor.

All individuals working on this task must have received an HSR data sensitivity briefing by the HSR data security officer (currently Joe Mathis), must have read the HSR data Sensitivity handbook, and signed the HSR loyalty oath. The HSR program is NOT classified. The data in HSR is often proprietary or LERD.

7. Period of Performance.

Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Carey Buttrill
M/S: 489 Phone: 804-864-4016

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2. Purpose, Objective or Background of Work to be Performed:

The Airborne Information for Lateral Spacing Team is conducting a series of studies to develop and prove a concept for conducting closely spaced parallel runway approaches in low visibility conditions. The contractor shall provide data management, data reduction, data base configuration and management, analysis of software performance, and development of necessary software to support the planned studies. During the year the team will conduct approximately four studies on fixed based simulators and in flight on the NASA TSRV Airplane.

The following studies shall be supported under this subtask:

1. The TSRV-PR Simulation Study already in progress which will require continued data management and data reduction support.

2. The TSRV-PR2 Simulation Study which will require data management and data reduction support as well as analysis and development of software and algorithms intended for use in conjunction with operating the study.

3. A TSRV simulation test of the finalized concept for close parallel operations which will be duplicated in the inflight demostration planned for FY99. This will require the contractor to analysis the alerting agorithms planned for use in the simulation and develop specification for the data collection, data base management and data reduction.

4. The flight testing of a modified localizer guidance capability based on differential GPS. This will require the contractor to analysis the alerting agorithms planned for use in the tests, develop specifications for the data collection, manage data base, and data reduction.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

Subtask Description

1. Develop specifications for the data acquisition based on the data collection process used in earlier related experiments with any modifications for the new situation included. The specification shall include as a minimum, the position, velocities, heading, bank, pitch, angular velocities and all axes control inputs of the two aircraft involved in the test scenarios. The specifications shall also include continuous and discrete control mode changes such as inputs to the control mode panel, the control display unit (CDU), mike switch closures of the pilot, copilot, and the ATC controller operating at the MOTAS station. It shall also address

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3. Tasks, Deliverables and or Products, and performance measurements (continued):

oculometer eye tracking data. The specifications shall include requirements for accuracy/resolution and frequency of the data recording. The specifications shall identify the data storage media, data format and units for all variables to be recorded.
Deliverables:
a) Set of data reduction specifications
b) Briefing on the specifications and written description a minimum of 30 days prior to the scheduled start of the experiment.

2. Conduct the data reduction- The contractor shall complete statistical data reduction of the data acquired during the tests. A portion of this process shall be conducted during the period that the test is in progress to provide a "quick-look" capability. The quick-look capability shall include a table of the main measures of the experiment broken down by sessions. The final data reduction process shall be completed within 60 days after the test measurements have been completed. The data reduction will include determining means and standard deviations of all significant measures as shall be determined from the experiment design which NASA representative will make available upon specifying the experiment at least 60 days prior to the scheduled beginning of the testing. Final statistical data reduction shall include appropriate statistical significance tests for the experiment design, including t-tests, F-tests, and analysis of variances. A spread sheet such as Microsoft EXCEL or other off-the-shelf statistical packages may be used. The spread-sheet analysis is estimated to require analysis of 500 data runs (approximated average) for each of the four planned tests. Each data run will have approximately 0.5 megabytes of data associated with it in the analysis.

Deliverables:
a) "quick-look" capability
b) Where possible, the quick-look data for each session shall be mad available not more than 24 hours after the session has been completed. Data will be in a mass storage file format
c) Time history plots of the dynamic behavior of the aircraft and related state information after each session. Data will be in a mass storage file format.

3. The Contractor shall develop, maintain, and update data bases necessary to support the simulation operations. These data bases include aircraft to operate as traffic in the test and their performance characteristics, scenarios presenting the profile of parallel traffic to be used in the simulation. The data bases will include statistical traffic mixes based on traffic data from 7 major airports (the data base for each airport is approximately 0.5 megabytes in size), airline fleet mixes based on data from the FAA and airline companies (the fleet mix data base is approximately 0.5 megabytes).

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3. Tasks, Deliverables and or Products, and performance measurements (continued):

4. The Contractor shall develop, maintain, and update a data base of the data collected during each of the four tests. This shall include the data collected from the realtime simulation tests and flight tests. It shall also include output for the oculometer and of all other measurements taken in support of these tests. The data sets for each experiment will contain approximately 500 data runs (approximated average) with approximately 50 variables recorded in each experiment at a frequency of 10 samples per second. Data runs will normally be of 10 minutes average duration.

5. Develop prototypes to demonstrate the dynamic behavior of the displays on desktop host computers such as a PC or graphics computer. The Contractor will complete two prototype simulations to support the experiments planned. The prototype required for the new display formats planned will build on the existing software and are anticipated to require the similar level of effort as past development. The prototypes will include new lateral path deviation algorithms and intruder alerting algorithms that will be supplied by the Government. The prototype demonstrations will include algorithms to drive the simulated flight director command bars during escape maneuvering. The performance of the flight director command bars in the prototype will be specified by the Government. The prototype will also include guidance schemes similar to and compatible with TCAS schemes to assist pilots during escape maneuvers in the parallel runway environment. It is estimated that this development will require 10000 lines of code in the C language for operations require on IBM compatibles using Microsoft C and 2000 lines of code in the VAPS language (Silicon Graphics based Virtual Application Prototyping System).

6. Fine tune the scenarios required for operation of the test runs. This will be a procedure of modifying the data recorded during special flights (flight templates) made for the scenario development to comply with the specifics of the experiment requirements. The flight template files are approximately 2 megabytes each. Approximately twenty-eight templates will be modified for each test to be initiate and approximately 450 encounter scenarios will be generated using government supplied FORTRAN software previously developed for this process adapted by the Contractor meet experiment specifications.

7. Conduct analysis of the alerting algorithms planned for use in the simulation tests. The Contractor shall develop software and complete independent analysis of the alerting algorithm to be used in the planned experiments. The algorithms shall be provided by NASA at least 60 days prior the start of the experiment. The analysis will be delivered not later than 30 day prior to scheduled start of the experiment or 30 days after written descriptions of the algorithms are provided to the Contractor. The software will consist of simplified dynamic models of the aircraft in the encounter scenarios. It shall incorporate the alerting algorithms

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3. Tasks, Deliverables and or Products, and performance measurements (continued):

and shall exercise the alerting algorithms through a wide range of dynamic encounter environments to ascertain that the alerting algorithms are functioning as required for the parallel runway process. The analysis will identify encounter conditions where the algorithms are either generating false alarms or missing alerts. An estimated 2000 lines of FORTRAN code is require for the software development. The analysis should incorporate a scheme for randomly varying the parameters of the two airplanes involved in the scenarios over a specified band as typically done in a Monte Carlo analysis. The Monte Carlo analysis capability purchased earlier by the Government and available from the NASA representative may form the basis for this analysis. The Contractor shall deliver the results of the analysis to NASA in an informal briefing and shall deliver a 2 to 5 page written analysis along with appropriate charts, graphs and figures.

General Deliverables:

1. The software developed in support of the subtasks shall be delivered to the Government along with written reports describing any software. These reports will be 2 to 5 pages in length and shall include a description of the intended function of the software and any equations or formulas incorportated in the algorithms, the required input data and formats, the output formats and report descriptions, and any additional information necessary to make the software available to potential users. A flowchart of the software shall be included.

2. Written and oral reports of the results of analysis which will typically include a one or two page description of the reported data along with an oral briefing to the NASA representative.

3. Written descriptions of data bases developed in support of the studies. These will include the content of the data base, and storage and access information. The contractor shall also provide oral descriptions to the NASA representative and other NASA contractors working on the studies.

4. A brief description of each task and product will be prepared by the contractor prior to the task being started. The contractor shall provide an estimate of the completion date and resources required to complete the task, to be included in this description.

Metrics: The contractor shall complete 85 percent of all tasks on schedule and within the resources defined in paragraph 4 above, with good quality within scope of these specifications. Exceeding the minimum performance will require that the contractor completes 95 percent of all tasks on schedule, within the specifications and within the resouces defined. On 75 percent of the all task, the contract shall require only an overview level description of the task needed and will determine the methods and products to the satisfaction of the NASA representative.

ART (NAS1-96014) Task Order Page 5

1. Task Order Number and Title	Number:	Revision:
Title: Airborne Information for Lateral Spacing Test Support		

4. Government Furnished Items:

Data acquisition computers and desk top computers to the host the software packages necessary to complete the required tasks. Descriptions of the alerting algorithms planned for the experiments. Descriptions of the experiment design for each planned test.

5. Other information needed for performance of task.

6. Security clearance required for performance of work:

None of the tasks to be performed require handling of classified material or documents. ADP clearance for realtime computer control area will be necessary.

7. Period of Performance	
Planned start date: 7/1/96	Expected completion date: 6/30/97

8. NASA Technical Monitor: Marvin Waller
MS 156A Phone: 804-864- 2025

ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title — Number: DC18 — Revision:

   Title: Review of HAV-2 weapons models for operation on another piloted simulation program in the Langley DMS.

2. Purpose, Objective or Background of Work to be Performed:

   As part of a previous contract, a weapon system model was developed and implemented in the HAV-2 piloted simulation. This weapon system provided a more realistic environment with which to evaluate impacts of improved airplane technology in today's flight environment. The weapon system model was used successfully in the previous task. No NASA civil service staff was involved in the model development and implementation. This model needs to be made available for other simulation studies currently being conducted at NASA.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

The purpose of this task is to enable re-implementation of the weapons system models on another NASA simulation. Specifically, the models should be reviewed, and recommendations should be made for effective implementation on other simulation studies. Copies of available documentation for the weapon systems models used in the HAV-2 and other information required for understanding and use of the models shall be supplied.

Deliverables:
1. Recommendations on incorporating weapon systems models in a NASA simulation.
2. Copies of available documentation on the weapon system models.
3. Dissemination of information to NASA researcher to enable him to effectively use and modify the models.

Performance Metrics:
1. Completion of initial part of task (deliverable #1) to enable use of the models by 3/10/97.
2. Completion of task on time.

4. Government Furnished Items:

5. Other information needed for performance of task.

6. Security clearance required for performance of work: SECRET

7. Period of Performance

Planned start date: 2/10/97	Expected completion date: 4/11/97

8. NASA Technical Monitor: J. M. Brandon
   M/S: 153 Phone: 804-864-1142

PRINTED: 2/6/97

ART (\S1-96014) Task Order Paƒ 1

1. Task Order Number and Title Number: Revision:
   Title: Documentation of HARV Piloted Simulation Results for Control Law Design and a One Versus Two Air Combat Study

2. Purpose, Objective or Background of Work to be Performed:
   a) Under a previous contract, a new piloted simulation technique was developed in an effort to predict pilot induced oscillations (PIO) prior to flight. This technique was successfully applied to the F-18 High Alpha Research Vehicle (HARV) to evaluate modifications to the control laws to reduce PIO tendencies. This work shall be presented at a conference in September 1996.
   b) High-angle-of-attack control system design guidelines for fighter airplanes were developed as part of the NASA High Alpha Technology Program (HATP). These guidelines were applied to several control law designs for the F-18 HARV and preliminary flight validation was completed. Results of these tests shall be presented at a conference in September 1996.
   c) A series of airplanes with various agility levels were evaluated in a piloted simulation study of one vs. one and one vs. two air combat using high off boresite missiles and guns. Results from this study shall be presented at a conference in September 1996.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

The purpose of this task is to provide documentation in the form of a technical papers of a) the piloted simulation technique to reproduce pilot induced oscillations and b) flight validation results of control law design guidelines from the F-18 HARV.

Deliverables:
1. Contractor report on piloted simulation technique 8/13/96
2. Presentation of paper at High Alpha Technology Conference, NASA Langley 9/17-19/96
3. Contractor report on control law design guidelines. 8/13/96
4. Presentation of paper at High Alpha Conference, NASA Langley 9/17-19/96
5. Contractor report on high off boresite missiles and guns study 8/13/96
6. Presentation of paper at High Alpha Conference, NASA Langley 9/17-19/96

4. Government Furnished Items:
   Access to Sparc computer, Differential Maneuvering Simulator, and HARV flight data.

5. Other information needed for performance of task.

6. Security clearance required for performance of work: Secret

PRINTED: 4/3/96

1. Task Order Number and Title	Number:	Revision:
Title: Documentation of HARV Piloted Simulation Results for Control Law Design and a One Versus Two Air Combat Study		

7. Period of Performance	
Planned start date: 7/1/96	Expected completion date: 9/30/96

8. NASA Technical Monitor:	D.J. Dunham
.M/S: 355	Phone: 804-864- 5061

DCX 16

1. Task Order Number and Title Number: Revision:

Title: **Dynamics and Control Branch High Performance Aircraft Controls Support**

2. Background and Purpose of Work to be Performed:

The Dynamics and Control Branch conducts research in the area of dynamics and control of high performance aircraft. Specifically, flight control laws have been and will be designed for flight test on the High Alpha Research Vehicle (HARV) and the Advanced Control Technology for Integrated Vehicles (ACTIVE) aircraft. The purpose of this task is to provide simulation, analysis, data retrieval and processing, and computer programming support for this research.

3. Subtasks Description:

The Contractor shall perform the following subtasks:

1. MODELING, SIMULATION, AND CONTROLS

Maintain, upgrade, modify, and verify the batch simulations of the F/A-18 HARV aircraft on the Sun UNIX computers for use in the development of advanced control laws for the HARV; implement modifications to existing control laws and implement new control laws in the batch simulations; supply Differential Maneuvering Simulator (DMS) programmers with modifications and checkcases for the HARV simulation on the DMS; implement modifications to the HARV Sparc simulation as made available by Dryden Flight Research Center (DFRC) controls and simulation personnel and provide DFRC with modifications to the HARV control law code; provide control law validation checkcases from the HARV Sparc simulation to DFRC; analyze differences between checkcase time histories produced on the HARV Sparc simulation and checkcase time histories produced on the DFRC Sparc, HIL, and Iron Bird simulations; compare flight test data with simulation data and perform analysis of the differences; and prepare reports to document the analysis of simulation and flight test data. Scope: It is anticipated that new HARV control laws will be limited to not more than three modifications to existing control laws. These modifications should result in not more than ten checkcases per modification.

Develop from Government-furnished aerodynamic databases and simulation modules an ACSL/FORTRAN batch simulation of the F-15 ACTIVE aircraft with linear-model-generating capability to be hosted on the Sun UNIX computers for use in the development of advanced control laws for the ACTIVE aircraft; develop a real-time version of the ACTIVE simulation and implement it on the DCB Advanced Controls Evaluation Simulator (ACES) facility; modify the ACTIVE simulation to incorporate aerodynamic model revisions resulting from wind tunnel tests and from in-flight parameter identification tests of the ACTIVE configuration; modify the ACTIVE simulation to implement a Government-furnished detailed engine model suitable for use in integrated flight/propulsion controls design; implement modifications to the ACTIVE simulation as made available by DFRC; implement advanced control laws in the ACTIVE simulation; develop batch and real-time simulations of the tailless aircraft by modifying the ACTIVE simulations to incorporate aerodynamic models of the tailless configuration

PRINTED: 4/3/96

1. Task Order Number and Title Number: Revision:

Title: **Dynamics and Control Branch High Performance Aircraft Controls Support**

3. Subtasks Description (continued):

resulting from analysis and wind tunnel tests; supply DMS programmers with modifications and checkcases for the ACTIVE simulation on the DMS; conduct training sessions for DCB personnel in the architecture, content, capabilities, and operation of the ACTIVE simulation; and prepare detailed documentation describing the ACTIVE and tailless batch simulations. Scope: The ACSL/FORTRAN batch simulation of the F-15 ACTIVE aircraft will be developed from the ACTIVE simulation provided by DFRC and currently hosted on the ACES facility. It is anticipated that new ACTIVE control laws will be limited to one longitudinal control law and one lateral/directional control law.

Deliverables:

1) Upgraded batch simulations of the F/A-18 HARV aircraft hosted on the DCB Sun UNIX computers.
2) Computer files of checkcases produced with the HARV batch simulation.
3) ACSL/FORTRAN batch simulation of the F-15 ACTIVE aircraft with linear-model-generating capability hosted on the DCB Sun UNIX computers.
4) Real-time simulation of the F-15 ACTIVE aircraft hosted on the DCB ACES facility.
5) ACSL/FORTRAN batch simulation of the Tailless F-15 ACTIVE aircraft with linear-model-generating capability hosted on the Sun UNIX computers.
6) Real-time simulation of the Tailless F-15 ACTIVE aircraft hosted on the DCB ACES facility.
7) Computer files of checkcases produced with the ACTIVE batch simulation.
8) Reports documenting the analysis of simulation and flight data.
9) Reports documenting in detail the ACTIVE simulations.

Metrics:

a) Where practical, validation of the simulations will be accomplished by comparison of checkcase time histories from the ACTIVE simulations with time histories produced on the DFRC or other appropriate simulations. Engineering judgment and experience will be used to assess the adequacy of the time history comparisons. User friendliness and flexibility will be a consideration in assessing the overall quality of the simulations and in assessing the level of performance exceeding the acceptable level.
b) Draft reports documenting the ACTIVE simulations shall be submitted within three months after completion of simulation implementation and checkout (minimum acceptable performance).

1. Task Order Number and Title	Number:	Revision:
Title: **Dynamics and Control Branch High Performance Aircraft Controls Support**		

3. Subtasks Description (continued):

c) Draft reports documenting analysis activities shall be submitted within two months after completion of the analysis (minimum acceptable performance).

Schedule:

a) The initial ACTIVE batch simulation shall be operational no later than September 1, 1996.
b) Simulations will be updated/upgraded as changes and model revisions are provided by the Government.

2. PROGRAMMING

Develop ACSL/FORTRAN code and Marlab M-files to implement Kalman Filter algorithms and other state/parameter estimators and atmospheric turbulence models from block diagrams and flow charts provided by the Government; implement this code in HARV or ACTIVE batch simulations.

Deliverables:

1) ACSL/FORTRAN computer code implementing state estimators and turbulence models in HARV or ACTIVE batch simulations.
2) Parameter and state estimation and turbulence data produced by batch simulation for analysis and evaluation
3) Matlab m-files of government provided block diagrams and flow charts to analyze flight and simulation data.
4) Detailed documentation describing computer programs
5) Contractor report on analysis and results.

Metrics:

a) Production of verified, operational, documented ACSL/FORTRAN code at a average rate of 50 lines of code per day nominally will be considered minimum acceptable performance. Engineering judgment and experience will be used to adjust the minimum acceptable production rate based on code complexity. Higher production rates together with code modularity, flexibility, and user friendliness will be used to assess performance exceeding the acceptable level.

3. FLIGHT DATA RETRIEVAL/PROCESSING

Retrieve electronic files of HARV and ACTIVE flight data from DFRC flight data storage using the Getfdas and Getdata software for use by the HARV and ACTIVE Control Law Design Teams in analyzing and evaluating advanced control laws - parameters and flight times to be specified by the Technical Monitor; process retrieved flight data to convert units and calculate new parameters using Getdata; develop modifications to Getdata to

PRINTED: 4/3/96

ART(NASA1-96014) Task Order Page 5

1. Task Order Number and Title	Number:	Revision:
Title: **Dynamics and Control Branch High Performance Aircraft Controls Support**		

4. Government Furnished Items:
   a) Access to DCB Sun computer complex and ACES facility.
   b) Changes to the HARV and ACTIVE simulations in the form of specifications, computer code, or models.
   c) Access to flight data on the DFRC GetFdas system.
   d) MacIntosh Centris or equivalent desktop computer with software to include
      (i) Microsoft Office
      (ii) KaleidaGraph
      (iii) Matlab
      (iv) Mac-X

5. Other information needed for performance of task.
   Some travel may be required to attend program reviews and to obtain modeling and simulation data. It is anticipated that such travel will not exceed the following:

   a) Trip to Dryden Flight Research Center, Edwards, CA, - 4 days (2 duty days, 2 travel days).
   b) Trip to Lewis Research Center, Cleveland, OH - 1 1/2 days.
   c) Trip to St. Louis, MO - 1 1/2 days.

6. Security clearance required for performance of work:
   Work will be unclassified. Some data and models may be ITAR Restricted requiring U.S. citizenship.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: W. Thomas Bundick
   M/S: 489 Phone: 804-864-4062

D-XL-1

ART (NAS1-96014) Task Order

1. Task Order Number and Title	Number:	Revision:
Title: **Aircraft Noise Subjective Research Support**		

2. **Background:** The Structural Acoustics Branch has a continuing responsibility to conduct human response studies of aircraft interior and community noise under the Advanced Subsonic Technology Noise Reduction Program. The purpose of this task is to provide technical support for conducting laboratory and in-home studies in which people are exposed to and make judgments on noise stimuli representative of noises heard in aircraft interiors and in communities exposed to aircraft flyover noise.

3. **Subtask Descriptions:** The contractor shall perform the following subtasks:

1. Develop a library of in-flight recordings of aircraft interior noise for 25 to 30 different current general aviation, commuter, business , and commercial transport aircraft in the binaural /sound quality format. The contractor shall make recordings of the aircraft interior sounds during ferry flights of new aircraft and aircraft returning from maintenance or repair, during flights specially arranged with manufacturers, and during some regularly scheduled commercial flights. During a typical flight, recordings will be made at one location each, during takeoff and landing and at 3 to 5 locations during cruise. Ferry flights will typically originate in Seattle, WA; Long Beach, CA; Wichita, KS; Atlanta, GA; or Savannah, GA. Specific aircraft types and recording locations in the aircraft will specified by the government. Scheduling of flights will be through agreement of the government and manufacturers or operators.

   Metric: Since notification of available flights may range from several days to several hours, ability to respond quickly to travel requirements is necessary. Minimum acceptable percentage of successful response to recording opportunities where at least 24 hour notification is given is 80%. Minimum acceptable dynamic range of the recordings is no less than the maximum dynamic range of the recording system - 10 dB. Greater percentage of successful response to recording opportunities and improved dynamic range of the recordings will be used to assess the level of performance exceeding the acceptable level.

   Deliverable: Aircraft interior noise recordings in DAT format.

   Schedule: Subtask 1 shall be completed by December 31,1996.

Subtask Descriptions: Continued

2. Prepare noise stimuli for use in three tests of passenger response to aircraft interior noise using the recordings obtained in subtask 1. The purpose of the first test is to compare responses using binaural headphone and free-field stimuli presentation methods; the second is to provide an assessment of the sound quality in the interiors of current aircraft; the third is to determine the preferred broadband spectra of interior noise due to turbulent boundary layers. The number of noise stimuli required per test will typically be 150 to 200. Stimuli preparation shall be accomplished using SDRC IDEAS Sound Quality software on a SGI workstation and/or on WAVE Sound Editor software on a PC. Specific noise characteristics of the stimulifor each test will be provided by the government at least 6 weeks prior to start of the test.

   Metric: Minimum acceptable signal to noise ratio for the stimuli is no less than the maximum obtainable by the editing and playback systems-10dB. No audible extraneous noises are acceptable. Improved signal-to-noise level of the stimuli will be used to assess the level of performance exceeding the acceptable level.

   Deliverable: Interior noise test stimuli in optical CD format and in the data base of the sound editing hardware/software.

   Schedule: Subtask 2 shall be completed by January 31, 1997

3. Develop software for Macintosh Newton palm-top computers for obtaining subjective responses in the tests specified in subtask 2 and for interfacing the palm-top computers to the data acquisition workstation. The responses shall be related to the degree of acceptability and comfort or other attributes of individual aircraft interior noise stimuli and shall be entered by the subjects on graphical scales.

   Metric: Ability to record appropriate response measures is required. User friendly qualities of the system for the test subjects and test conductor, and flexibility for use in future subjective response tests will be used to assess the level of performance exceeding the acceptable level.

   Deliverable: Software for subjective data acquisition/interface system in Newton machine language installed on six Newton palm-top computers and on the data acquisition workstation.

   Schedule: Subtask 3 shall be completed by September 30,1996.

4. Provide instruction of test subjects, collection of subjective response data, and measurement of physical characteristics of the noise stimuli for sound quality analyses for the three subjective tests specified in subtask 2. It is anticipated that each of the tests specified in subtask 2 will require 30 to 50 test subjects, tested in groups of four to six subjects each, with one or two groups tested per day.

Subtask Descriptions: Subtask 4 continued

   Metric: Adherence to safety requirements for human response testing (LMI

7100.8 and protocol for Aircraft Interior Noise Facility Testing) is required. Maximum acceptable loss of test subject response information due to procedural errors or errors in collection of subjective or measurement data is 5%. Loss of subject response information less than 5% will be considered to assess the level of performance exceeding the acceptable level.

Deliverable: Tabulated subjective responses in hardcopy and in SPSS, Excel spreadsheet and/or FileMaker Pro database files.

Schedule: Subtask 4 shall be completed by June 30, 1997.

5. Analyze subjective and acoustic data from the first two tests specified in subtask 2 and provide statistical information relating passenger response to the physical characteristics of the noise stimuli.

   Metric: Minimum acceptable statistical data analyses are: Analysis of Variance, multiple regression and correlation. More sophisticated analyses specifically for sound quality factors will be used to assess the level of performance exceeding the acceptable level.

   Deliverable: Data report of statistical analyses performed on subjective and acoustic data.

   Schedule: Subtask 5 shall be completed by June 30,1997.

6. Establish and maintain a pool of test subjects for human response testing and provide groups of test subjects for human response testing. Such will involve the solicitation, screening, calibration, selection, remuneration and delivery of test subjects to the experiment sites as scheduled. The requirements for this subtask are detailed as follows:
   1. Interview and recruit potential subjects and maintain a pool of subjects for participation in experiments in which people rate the acceptability or annoyance of noises. The pool of prospective test subjects shall be established and maintained in such a way as to meet the following requirements:

      a. Potential test subjects shall be required to complete a medical questionnaire provided by NASA and administered by the Contractor. The completed questionnaires shall be forwarded by the Contractor to an authorized NASA medical officer who will determine the suitability of each candidate for participation in the experiments. This requirement may be waived by NASA for certain test subjects.

      b. Subjects shall be over 18 years of age. Subjects shall be cataloged by the Contractor according to name, age, sex, geographic location, and occupation. This information becomes the property of the US Government.

      c. Potential subjects must submit to pre- and post-test audiograms (administered by the Contractor) performed under supervision of a State Certified audiologist in a soundproof test room with calibrated equipment according to standard procedures. Those with hearing loss (in either ear) greater than 40 dB (ISO Standards, 1964) over the frequency range of 500 Hz to 6,000 Hz will not be permitted to participate in the experiments. Occasionally subjects with a hearing loss no greater than 20 dB may be required. The pre-audiogram shall be performed within two weeks of the experiment, preferably on the same day in which the subject participates, and the post-audiogram should be immediately following the experiment. Audiometric records shall be maintained by the Contractor and made available to NASA on request. Any test subject who is found to have an excess of 5 dB threshold shift between pre- and post-audiograms shall be rechecked to ensure a return to pretest hearing levels. This requirement for pre- and post-test audiograms may be waived by NASA for certain test subjects.

2. Deliver up to 12 subjects per day to the NASA Langley Research Center test site on two weeks prior notice. An average of 12 subjects per month will be required, although the requirements during some months may be greater or less than the average of 12 per month. No more than 60 subjects per month will be required. All transportation shall be coordinated and provided by the Contractor. The times for delivery to and pickup from the test site shall be met by the Contractor with an allowable tolerance of +20 minutes. Of the total number of subjects delivered per month, about half may be required to be previously unused in other experiments conducted at LaRC, depending on the nature of the particular experiment. Some subjects may be required for two days at a time and/or for subsequent testing during the year. The normal testing period will be between 8:00 a.m. and 5:00 p.m. The normal test site will be Building 1208 at the NASA Langley Research Center. Subjects generally will participate in experiments for periods up to four hours on any given day.

Metric: Maximum acceptable number of test subject no-shows is 5% over the period of performance of the task. Maximum acceptable tardiness in subject delivery and/or pickup time is 20 minutes. Accurate records of audiometric tests and documentation is required. Lesser numbers of no shows and more timely delivery and pick up of subjects will be used to assess the level of performance exceeding the acceptable level.

Subtask Descriptions: Subtask 6 continued

Deliverable: Test subjects delivered to test site on specified dates and times; audiograms, audiometric records, and documentation of classification of subjects.

Schedule: Subtask 6 shall be completed by June 30, 1997.

7. Recruit, provide and remunerate 35 test subjects, each for a period of 8 weeks, for an in-home test to study the relationships between number and noise level of aircraft overflights to daily annoyance response. Test subject/home selection shall be limited to households with no children less than eight years old, test subject generally at home during day and evening, test subject planning no extended periods away from home

overflights to daily annoyance response. Test subject/home selection shall be limited to households with no children less than eight years old, test subject generally at home during day and evening, test subject planning no extended periods away from home during test period, and home not in area customarily exposed to aircraft noise. The general requirements for test subjects specified in items 6.1.a, 6.1.b and 6.1.c above shall apply.

Metric: Maximum acceptable number of subject drop-outs is 3. Lesser numbers of drop-outs will be used to assess the level of performance exceeding the acceptable level.

Deliverable: Test subject/home site agreements in place one week prior to test site start date.

Schedule: Subtask 7 shall be completed by June 30,1997.

4. **Government Facilities and Equipment Provided:** Aircraft interior simulation facility, binaural recording/play back equipment, sound quality software for noise stimuli analysis, digital spectral and temporal sound editing software and equipment for stimuli preparation/modification, Macintosh and Newton computers for subjective data acquisition software development, PC and high level graphics workstation for data acquisition and stimuli preparation, audiometric booth and audiometer.

5. **Other information needed for performance of task:**
Most of the subtasks can be conducted concurrently, however subtask 4 cannot begin until subtask 3 is completed. Subtask 5 cannot begin until the first test of subtask 4 is completed. Significant ammounts of travel are required for subtask 1. It is estimated that the equivalent of 10 roundtrips to Seattle, WA or Los Angeles, CA. with one night hotel and one and one-half days per diem will be required for each trip.

6. **Security clearance required for performance of work:**
All work will be unclassified however personnel may be required to complete nondisclosure agreements with industry or airlines.

7. **Period of Performance:**	
Planned start date: July 1,1996	Expected completion date: June 30, 1997

8. **NASA Technical Monitor:** Kevin P. Shepherd	
.M/S: 463	Phone: 804-864- 3583

PRINTED: 6/6/96

ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title	Number:	Revision:
Title: F-18 Forebody Strake Simulation		

2. **Background:** The purpose of this task is to improve the capability to assess the flowfields over highly maneuverable aircraft at high angles of attack. These flows are dominated by massively separated vortical flowfields whose behavior is difficult to predict by analytical means. NASA has developed a High Alpha Technology Program (HATP) to exploit the high alpha flight regime in order to increase vehicle performance and safety; program elements include the development of advanced computational solvers, improved ground-based to flight correlation methods, and control concepts. The thrust of this task is the application of solvers based on a hybrid scheme incorporating block-structured grids and unstructured grids to a control concept which has been built and is being flight tested on the High Alpha Research Vehicle at NASA Dryden. The purpose of the hybrid approach is to allow the highly vortical flows to be predicted through solution to the Euler equations for complex geometries using unstructured grids and to supplement where necessary the calculations with viscous solutions using structured grids. The unstructured-grid approach is applicable to very general geometries but is less efficient in computer speed and memory per grid point than structured-grid solvers. Communication between the two computational grid systems is passed through a planar cross-section attached to the slender forebody of the vehicle.

3. **Subtask Descriptions:**

1. The contractor shall develop and apply a hybrid structured/unstructured-grid method for the analysis of the Articulated Nose Strake for Enhanced Roll Effectiveness (ANSER) being flight-tested on the NASA High Alpha Research Vehicle. The contractor shall obtain patched-grid viscous solutions for the isolated forebody and integrate the forebody solution into a hybrid structured-unstructured grid approach to account for configuration effects. In addition, the contractor shall compare the solutions and control effectiveness with flight-test and ground-based experiments over a range of angles of attack and strake deflection angles and provide an estimate through grid refinement of the truncation error level of the calculation.

   Metric: A minimum level of performance is computational results for three strake deflections at three angles of attack. The figure of merit for the methodology will be composed of the three elements of the hybrid solution procedure (surface modeling and grid generation time, computational time, and memory allocation) to attain a converged solution. A minimum level of performance is that the hybrid procedure be at least as efficient as current structured-grid methods which require two months to grid a complex configuration, 30 microseconds per grid point per iteration, and 50 words of memory per grid point. Superior performance can be accomplished through demonstration that the hybrid approach is more efficient than existing approaches based on structured-grid or unstructured-grid approaches.

   Deliverable: Document the findings and the computational procedures used to obtain them in a formal technical report to be presented at the closeout conference of the HATP in September 1996.

ART (NAS1-96014) Task Order

1. Task Order Number and Title Title: **F-18 Forebody Strake Simulation**	Number:	Revision:

4. Government Furnished Items: Engineering workstation for code development and solution visualization, flight data for validation, surface model for ANSER

5. Other information needed for performance of task. None

6. Security clearance required for performance of work: None

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: Oct. 15, 1996

8. NASA Technical Monitor: Dr. James L. Thomas
.M/S: 128 Phone: 804-864-2163

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H. P. HANEY

PRINTED: 6/5/96

1. Task Order Number and Title — Number: — Revision:

Title: Ducted Fan Noise Prediction Using 3-D Navier-Stokes Simulation Methods

2. **Background:** Accurate prediction of ducted fan noise is an important element of the NASA Advanced Subsonic Technology (AST) Noise Reduction program. Current methods rely extensively on field measurement techniques. As computers continue to become more powerful, Euler and Navier-Stokes computer codes for ducted-fan noise prediction have become increasingly affordable. Since linear theory cannot accurately predict flow fields in the non-linear regions near the rotor and stator, a combination of non-linear and linear theory seems to be a natural way
to approach this problem: Navier-Stokes in the region near the rotor and stator blades to predict the complex non-linear fluid dynamics there, and linear theory to predict how the perturbations propagate to the far field.

3. **Subtask Descriptions:**

1. The contractor shall provide thin-layer Navier-Stokes calculations based on overset-grid systems of the unsteady near-field loads on the Langley 12" Advanced Ducted Propulsion (ADP) ducted fan engine. The contractor shall provide the overset-grid geometries and compare global aerodynamic properties with other computations and experiment. The contractor shall determine the grid size and time step necessary both to (a) generate, and (b) propagate upstream at least one rotor chordlength forward of the rotor leading edge the 1 and 2 blade passage frequency (BPF) tones. In addition, the contractor shall predict far-field noise based upon a NASA-provided far-field acoustic wave propagation code with inputs from the near-field unsteady flowfield, compare the far-field noise levels to experimental data, and identify reasons for disagreement (if any) between the results.

   Metric: Successful completion of the computations within the required period of performance. Superior performance criteria for exceeding the minimum level is based upon the relative efficiency of the method in comparison to existing patched-grid computational methods as judged by the computational time required to obtain a given level of solution accuracy.

   Deliverable: The deliverable is a final formal report documenting the results.

   Schedule: This subtask shall be completed by January 30, 1997.

2. The contractor shall add higher-order temporal and spatial discretization capability to the code described in subtask 1 in order to reduce the number of grid points duct acoustic modes.

   Metric: Demonstrated reproducibility of the lower order results in subtask 1 for a single which compares within .5% accuracy at a cost of 1/4 the number of grid points.

Deliverable: Informal report documenting the algorithm modifications and the results obtained.

Schedule: This subtask shall be completed by June 30, 1997.

ART (NAS1-96014) Task Order

1. Task Order Number and Title Number: Revision:
Title: **Ducted Fan Noise Prediction Using 3-D Navier-Stokes Simulation Methods**

4. Government Furnished Items: Engineering workstations for code development and solution visualization, acoustic far-field prediction code, computer time.

5. Other information needed for performance of task. None

6. Security clearance required for performance of work: None

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Dr. James L. Thomas
M/S: 128 Phone: 804-864-2163

ART Task Order

1. Task Order Number and Title	Number:	Revision:
Title: **Aeroacoustics Computational Support**		

2. **Background**: The Aeroacoustics Branch has a continuing responsibility to develop and use computer codes which predict nearfield and farfield noise from all classes of aircraft and their components. Much of this work is driven by requirements of the High Speed Research and Advanced Subsonic Technology Programs, as well as base research in jet noise and rotorcraft noise.

3. **Subtask Descriptions:** The contractor shall perform the following subtasks:

1. Debug and validate a moving surface Kirchhoff postprocessor for use with Eversman's ducted fan noise radiation code. The contractor shall predict farfield noise from ducted fans using these codes and compare results with measured data and with predictions from the Boundary Integral Equation Method (BIEM) code. Data sets to be used include farfield noise measured from the NASA 12" ducted fan model and from the Boeing 18" ducted fan (rotor-alone). The contractor shall debug theKirchhoff post processor as required to complete this study. To facilitate these calculations, the contractor shall write and verify software to interface the unsteady aerodynamics code CFL3D with acoustic codes at Langley.

   Deliverables : An informal activity report. The debugged and validated postprocessor based on Kirchhoff formula for moving surfaces for Eversman's code. Predicted farfield acoustic data for rotor-stator interaction and comparison with BIEM code. Interface software between aerodynamic and acoustic codes.

   Schedule: Complete subtask by June 30,1997.

   Metrics: Minimum acceptable performance would be demonstrated if the delivered code generated a null field (to machine accuracy) inside the Kirchhoff surface. User-friendliness and exceptional efficiency of the code will be evidence of a level of performance exceeding the acceptable level.

2. Calculate and map flow field parameters (pressure, velocity, and temperature) of candidate engine fan/core stream mixers when mated to a lobed mixer ejector nozzle operating in the take-off and cruise modes. The contractor shall also develop computer codes to predict ejector flowfield of lobed mixer/ejector nozzle operating in the suppressed mode.

   Deliverables: Computer codes developed in this subtask and an informal report detailing results of numerical simulations of required flowpaths, including electronic files and graphic representations.

   Schedule of Deliverables: Informal report of results for the fan/core stream mixer calculations by October 31, 1996. Software codes for the mixer/ejector flowfield by June 30, 1997.

Metrics for Deliverables: Codes must successfully simulate mixing flow field and results must be plotted in formats which facilitate comparisons of alternative designs.

3. Make the following modifications to CAMRAD.Mod1, the comprehensive rotorcraft performance code:

   a. include ability to model tiltrotor configurations (including fuselage, wing, tail and nacelle aerodynamics)
   b. include ability to model multiple rotors, ie 2 in either side by side (tiltrotor) or main and tail rotor configuration
   c. develop and implement improved tip vortex modeling
   d. install new University of Maryland free wake model (MFW) in CAMRAD.Mod1. This model includes additional free wake vortex trailers.
   e. install Langley's vortex wake roll-up model in CAMRAD.Mod1(MFW)
   f. correct the Beddoes indicial aerodynamic model in CAMRAD.Mod1. Validate with the Bo015 Hart data.
   g. validate all modifications and fully document the entire CAMRAD.Mod1-HIRES in a formal NASA publications.

   Deliverables: The complete CAMRAD.Mod1 code with specified modifications listed above along with informal documentation of the software modifications and their validation. Formal NASA report documentation of the entire CAMRAD.Mod1-HIRES code.

   Schedule of Deliverables: Complete task by June 30, 1997.

   Metrics for Deliverables: Minimum acceptable performance would be demonstrated if the delivered, validated codes include listed modifications and corrections. User-friendliness and exceptional efficiency of the code will be evidence of a level of performance exceeding the acceptable level.

4. Make the following modifications to the Tiltrotor Aeroacoustic Code (TRAC) and its subordinate codes:
   a. modify and validate the full potential code FPX and the vortex embedding model for the wake to properly model tiltrotor configurations.
   b. implement and validate blade motion modeling in FPRBVI code. The contractor shall make necessary changes to enable accurate modeling of tiltorotors including grid generation modifications, blade motion modeling, and modified boundary conditions. The contractor shall validate the new code by comparing with both model and flight data for the XV15, JVX, UH60, and Bo105. This data will be provided by NASA.
   c. create grids for the following rotors: XV15, JVX, Bo105, Uh60, OLS, V22 and TRAM and develop and validate CAMRAD.Mod1 decks for each rotor, fuselage, wing, nacelle configuration.

d. develop methods / procedures to run CAMRAD.Mod1, FPRBVI, FPX, WOPWOP and ROTONET in a unified manner. The contractor shall also develop and validate the free-flight mode for the LaRC ROTONET/BVI system and TRAC.

f. address inquiries from NASA and external users (industry, government, acedemia) concerning the preparation of inputs for the TRAC codes and the interpretation of their results.

h. extract the rotor broadband module from ROTONET and create a stand-alone version, RBN/SA, which will also interface with TRAC.

j. test and incorporate developed prediction codes which include FPXBVI, ROTTILT, CAMRAD.Mod1-PMARC, TIN2.

k. develop plotting and animation codes to visualize ground contours of calculated noise metrics from the LARC prediction codes.

l. use TRAC (CAMRAD.Mod1-HIRES, FPRBVI, FPXBVI, WOPWOP, TIN2, RNM, RBN, ROTTILT) codes to synthesize appropriate noise predictions for comparison with data from the 1994 BO-105 test at the DNW tunnel, the XV-15 flight (helicopter mode and prop mode), V-22, TRAM, Uh60 (flight and model data), JVX isolated and semi-span model, and the 500E flight test.

Deliverables: Upgraded codes (CAMRAD.Mod1-HIRES, FPRBVI, FPXBVI, WOPWOP, TIN2, RNM, RBN, ROTTILT) along with informal documentation of their validation and comparison with data.

Schedule of Deliverables: Complete the task by June 30, 1997.

Metrics for Deliverables: Minimum acceptable performance would be demonstrated with a delivered set of operable TRAC codes which include the listed modifications. User-friendliness and exceptional efficiency of the code will be evidence of a level of performance exceeding the acceptable level.

ART Task Order

1. Task Order Number and Title	Number:	Revision:
Title: Aeroacoustics Computational Support		

4. Government Furnished Items:
- DEC model VR219 monitor
- Disk drive subsystem box
- DEC Alphastation
- Apple Macintosh computer and Silicon Graphics Iris Computer
- Access to a NASA Cray computer
- IBM model 6091 19" monitor
- IBM RS/6000 model 320 computer
- disk drive subsystem box with 800MB, 1 GB SCSI hard disks
- Tripplite model BC1250LAN power supply
- Apple PowerMac model 6100/60 computer
- Apple SCC-G28J-A monitor
- Apple Select 300 laser printer
- Farfield noise data from 12" ADP demonstrator
- Farfield nosie data from Boeing 18" fan rig
- Validated version of Eversman's ducted fan noise radiation code
- Unvalidated version of Kirchhoff postprocessor for Eversman code
- PAB-3D Navier-Stokes solver that contains several appropriate turbulence models suitable for initial evaluations
- GRIDGEN program for development of appropriate surface and volume grids
- Geometries of mixers either through IGES or neutral PATRAN files
- JVX model proprotor data: performance, wake, acoustic and performance
- Uh60 windtunnel and flight data: aerodynamics and acoustic
- Bo105 windtunnel data: aerodynamics, wake, dynamics and acoustic
- V22 flight data: aerodynamics, performance and acoustic
- XV15 windtunnel and flight data: aerodynamics, performance and acoustic
- OLS windtunnel data: aerodynamics, dynamics and acoustic
- 500E flight data: aerodynamics, performance and acoustic

5. Other information needed for performance of task.
All solid model geometry provided are industry limited exclusive rights data and all numerical simulations performed are protected under the NASA HSR. Those performing work under this work element must be US citizens or permanent resident aliens.

6. Security clearance required for performance of work: None.

7. Period of Performance: One year	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Joe W. Posey
.M/S: 461 Phone: 804-864-7686

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ART Task Order

1. Task Order Number and Title — Number: — Revision:

Title: Aeroacoustic Test Support

2. Purpose, Objective or Background of Work to be Performed: The Aeroacoustics Branch has as a mission the reduction of flight vehicle noise and the development of research and design tools for noise prediction. The purpose of this task is to support aeroacoustic research and technology development related to experimental testing. This support includes assembly, calibration, and utilization of instrumentation and test models; data acquisition and analysis; experimental testing of rotors, jets, ducted fans and other sound-producing devices in wind tunnels, facilities, anechoic chambers, and outdoors (including, in flight).

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements): The contractor shall perform the following subtasks:

1. Perform on-site data reduction and analysis of acoustic, weather, and aircraft state and position data acquired during a terminal area operations acoustic flight test of multiple aircraft, hereafter referred to as the NRTC flight test. This test is currently planned to be conducted at Crows Landing, CA (south of Modesto), nominally in the September 1996 timeframe, and is scheduled to last four weeks. The test duration could be impacted by external influences such as weather and aircraft mechanical problems. The contractor shall process data received from multiple sources, including NASA digital data recording systems and digital recordings from FAA, Sikorsky Aircraft, and McDonnell Douglas Helicopter Systems. A typical data flight condition lasts approximately three minutes, although that can vary from 90 seconds to six minutes depending on airspeed and descent rate. Data from up to 56 microphone locations will be acquired for each flight condition, with up to 36 of those microphones recorded using the NASA systems. The maximum number of flight hours in one day should not exceed four. The contractor shall also pack data processing equipment prior to shipment by NASA, perform pretest setup and post-test teardown of that equipment, and packup the equipment prior to departing the test site.

   Metric: Computation of Sound Exposure Level (SEL) ground contours for each flight condition, using only the NASA ground board microphones (up to a maximum of 36), to be computed overnight, and be available in graphic format to all parties within 24 hours of receipt of the data tapes. Minimum acceptable percentage of data runs processed in this timeframe is 80 percent of all "good" runs, where a good run is defined as one in which no anomalies occurred during any part of the recording process. SEL contours including data from all ground board microphones shall be computed during the test period, provided digital data transfer from other organizations can be achieved. Greater percentage of processed data runs, as well as additional noise metrics made available in this timeframe, will be used to assess the level of performance exceeding the acceptable level.

   Deliverable: SEL contours in both graphic and digital formats, both raw and processed data archived on both optical disk and tape media.

Schedule: Subtask 1 shall be completed within one week of the cessation of flight testing.

2. Perform post-test data processing and analysis of acoustic, weather, and aircraft state and position data acquired during multiple acoustic flight tests of various aircraft. The contractor shall process data that was not processed during on-site analysis, as well as perform additional analyses that optimize statistical confidence and identify signal-noise ratio (SNR) for all microphone locations. Specific flight test data to be analyzed are as follows:

   a. Growth Rotor Blade test (80 runs + ambients, with 18 microphone channels/run digitized at 25 kHz, run times range from 1 to 4 minutes).

   b. XV-15 Terminal Area Operations acoustics flight test (175 runs + ambients, with 20-30 microphone channels/run digitized at 20 kHz, run times range from 1 to 5 minutes).

   c. NRTC test described in subtask 1.

   Metric: Computation of Sound Exposure Level (SEL) ground contours, areas inside a minimum of three different SEL levels, and selected narrowband spectra for each flight condition. Minimum acceptable percentage of data runs processed in this manner is 95 percent of all "good" runs, where a good run is defined as one in which no anomalies occurred during any part of the recording process. For the remainder of runs, identification and documentation of the reasons why these cases cannot be processed shall be provided. Greater percentage of processed data runs, as well as additional noise metrics computed, will be used to assess the level of performance exceeding the acceptable level.

   Deliverable: SEL contours and narrowband spectra in both graphic and digital formats, tabulated and digital files of areas of specified SEL levels, post-processed data archived on both optical disk and tape media.

   Schedule: Subtask 2 shall be completed by June 30, 1997.

3. Develop all necessary virtual instruments, using LabVIEW, to operate a new remote digital data acquisition system that is under development by NASA for use in acoustic flight testing. This system will eventually grow from the initial two-channel prototype to a 30-microphone system, where each channel is controlled by an RF link. The contractor shall develop virtual instruments that allow operators to control data acquisition parameters such as sample rate, gain, and anti-aliasing filter setting of both individual channels and groups of channels..

   Metric: Ability to control acoustic data acquisition is required. Minimum number of controls include selection of sample rate, control of gain on each channel, and monitoring of each system. The system shall provide operators with the capability to both operate and monitor any channel to verify proper functioning of each individual channel. System operation functions shall include acquisition start and stop, as well as selection of calibration and test data acquisition Additional features will be used to assess the level of performance exceeding the acceptable level.

Deliverable: LabVIEW virtual instruments to control data acquisition on electronic media (either disk or tape). Data acquisition system user's manual.

Schedule: Subtask 3 shall be completed by June 30, 1997.

4. Modify the Acoustics Division Data Reduction and Analysis System (ADDRAS) to condense it from 30 to 12 channels, retaining all functionality of the system. ADDRAS is used to process data from analog FM tape, currently resides in six instrumentation racks, and can digitize up to 30 channels simultaneouslyThe contractor shall demonstrate the functionality of the 12-channel system by reprocessing data from three FM tapes (to be provided by NASA) that were previously analyzed on the original ADDRAS system. The contractor shall also compare the reprocessed with the original data (to be provided by NASA) to assess system functionality.

   Metric: Reduction in spatial area for ADDRAS from six to four racks of instrumentation. Reprocessed data matching that processed with original system to within 1 dB. Closer agreement (less than 1 dB) will be used to assess the level of performance exceeding the acceptable level.

   Deliverable: Modified 12-channel ADDRAS system. Schematic layout of modified system, showing locations of all instrumentation and routing of cables. Documentation of comparison of reprocessed data with original data in contractor-selected format.

   Schedule: Subtask 4 shall be completed by December 31, 1996.

5. Develop and implement an electronic access system for rotorcraft acoustic data bases which will provide secure, easy-to-use electronic access to acoustic data bases by U.S. industry partners via network connections, and allow users to examine the test matrix, identify specific runs of interest, and select to either examine these data visually, or download the selected data to their local computer. The contractor shall implement the XV-15 data base described in subtask 2b above into this system. The contractor shall also provide instruction and assistance to the four main U.S. helicopter companies--Bell, Boeing, Sikorsky, and McDonnell Douglas.

   Metric: Ability to easily access and examine data by specific external users, while access is denied to all other users. On-line help for users shall also be available. Available software and network systems shall be used, and software shall be freely available if at all possible. As a minimum, no external users shall have to purchase any software Industry feedback shall be used to adapt system for improved use.

   Deliverables: User's manual for the remote access systemwhich can consist of a combination of existing documentation and original writing. XV-15 data incorporated into the system.

   Schedule: Subtask 5 shall be completed by June 30, 1997 combination of existing documentation and original writing. XV-15 data incorporated into the system.

Schedule: Subtask 5 shall be completed by June 30, 1997.

6. Perform on-site data reduction and analysis of acoustic, weather, and aircraft state and position data acquired during an acoustic flight test of the V-22 tiltrotor aircraft. This test is currently tentatively planned to be conducted at a test site near Waxahachie, TX, nominally in the Spring 1997 timeframe, and is scheduled to last two weeks. The test duration could be impacted by external influences such as weather and aircraft mechanical problems. The contractor shall process data received from NASA digital data recording systems. A typical data flight condition lasts approximately three minutes, although that can vary from 90 seconds to six minutes depending on airspeed and descent rate. Data from up to 36 microphone locations will be acquired for each flight condition. The maximum number of flight hours in one day should not exceed three. The contractor shall also pack data processing equipment prior to shipment by NASA, perform pretest setup and post-test teardown of that equipment, and packup the equipment prior to departing the test site.

   Metric: Computation of Sound Exposure Level (SEL) ground contours for each flight condition should be computed overnight, to be available in graphic format to all parties within 24 hours of receipt of the data tapes. Minimum acceptable percentage of data runs processed in this timeframe is 80 percent of all "good" runs, where a good run is defined as one in which no anomalies occurred during any part of the recording process. Greater percentage of processed data runs, as well as additional noise metrics made available in this timeframe, will be used to assess the level of performance exceeding the acceptable level.

   Deliverable: SEL contours in both graphic and digital formats, both raw and processed data archived on both optical disk and 8-mm tape.

   Schedule: Subtask 6 shall be completed within one week of the cessation of flight testing.

7. Perform post-test data reduction and analysis of data acquired during a flight test of an F-15 aircraft at NASA Dryden in Fall 1996. The contractor shall convert raw data resulting from the F-15 acoustics flight test (ground static, code validation and climb-to-cruise noise measurements) into an easily accessible database containing engineering units data. The raw data consists of sets of time correlated measurements from aircraft tracking, atmospheric conditions during the test (weather), on-board aircraft and engines dynamic state parameters, and far-field microphone measurements. The shall also construct and archive a database in the same to that developed and published for the F-18 and F-16XL acoustics flight test (NASA CDTM-pending and which contains ensemble averaged acoustics data. The database shall consist of time-match engineering data for each of the component data sets for each valid flyover. The flight test will result in about 50 sets of data to be reduced and correlated. A master copy of the database shall be archived on optical storage media.

   Metric: Computation of Sound Exposure Level (SEL) ground contours, areas media.

Metric: Computation of Sound Exposure Level (SEL) ground contours, areas inside a minimum of three different SEL levels, and selected narrowband spectra for each flight condition. Minimum acceptable percentage of data runs processed in this timeframe is 95 percent of all "good" runs, where a good run is defined as one in which no anomalies occurred during any part of the recording process. For the remainder of runs, identification and documentation of the reasons why these cases cannot be processed shall be provided. Greater percentage of processed data runs, as well as additional noise metrics computed, will be used to assess the level of performance exceeding the acceptable level.

Deliverable: SEL contours and narrowband spectra in both graphic and digital formats, tabulated and digital files of areas of specified SEL levels. Post-processed data archived on both optical disk and tape media.

Schedule: Subtask 7 shall be completed by June 30, 1997.

8. Develop all necessary virtual instruments (using LabVIEW) and software (using FORTRAN and/or C programming languages) to operate an off-the-shelf digital data acquisition and reduction system that has been purchased by NASA for use in wind tunnel and laboratory experiments. This system will primarily be used to acquire acoustic data, although data from pressure transducers, strain gages, and other dynamic sensors may occasionally be used. This system will primarily be operated with up to 32 channels of acoustic sensors, although the system can be configured to increase the number of sensors on blocks of channels by reducing the sample rate of the channels. The contractor shall create virtual instruments that allows users to control data acquisition parameters such as sample rate, including the capability to select either internal or external sample clocks and triggering, gain, anti-aliasing filter setting, AC or DC coupling, and number of samples/recording duration.

Metric: Ability to control acoustic data acquisition and reduction is required. Minimum number of controls include selection of internal -vs.- external trigger and sample clock, control of gain on each channel, both individually or in groups, FFT block size, and number of data blocks in an ensemble average. The system shall permit control of both individual channels and groups of channels by user selection and shall provide the capability to couple with external systems. Data processing shall include capability to compute ensemble averaged time histories and narrowband spectra on all channels, and integration of spectra to compute noise metrics. Graphic display of all processed data shall be provided. Additional features will be used to assess the level of performance exceeding the acceptable level.

Deliverable: LabVIEW virtual instruments and additional source code to control data acquisition on electronic media (either disk or tape). Data acquisition system user's manual.

Schedule: Subtask 8 shall be completed by January 31, 1997.

9. Perform on-site data acquisition, reduction and preliminary analysis of acoustic, wind

Schedule: Subtask 8 shall be completed by January 31, 1997.

9. Perform on-site data acquisition, reduction and preliminary analysis of acoustic, wind tunnel state, and rotor model performance data during an acoustic test of industry-developed low noise tiltrotor concepts. This test is currently planned to be conducted at the 14- by 22-Foot Subsonic Tunnel at NASA Langley, nominally in the Spring 1997 timeframe, and is scheduled to last 10 weeks running two shifts per day. It is possible that this could become a 3-shift operation. The data acquisition system will be controlled by the software developed under subtask 8, and nominally 16 microphones will be used in the test. The 16 microphones mount on a traversing wing, and control of the traversing system must be tightly coupled with the acoustic, wind tunnel, and rotor performance data acquisition. A nominal value of traverse positions for a given tunnel and rotor operating condition is 17, with acquisition of all microphones required at each traverse position. The contractor shall perform the following activities:

a) Pretest setup of equipment, post-test teardown and packup.
b) Acquire daily pre- and post-calibrations of all microphones, and incorporate those calibrations into engineering unit conversions of all acoustic data acquired.
c) Acquire test data, per the requirements of the NASA-provided test plan

d) Process data as it is acquired in near real-time. The data processing must meet the requirements of the NASA-provided test plan. Processing of data, in the form of both ensemble-averaged time histories and narrowband spectra, from a particular traverse position shall begin as soon as data is acquired, while the test continues with additional acquisition. The data processing system shall provide graphic access to the processed as soon as it has been processed.
e) Compute integrated values from each microphone position, and produce a contour of these integrated values upon completion of acquisition and processing at a full sweep of traverse positions.
f) Backup all data on both tape and optical disk media at the completion of each day's testing.

Metric: Data acquisition time for a complete set of traverse positions should average no more than 40 seconds per traverse position. Computation of average time histories and narrowband spectra for all microphone measurement locations for a data run shall be completed within three minutes of completion of data acquisition at the last traverse position of a set. Computation of integrated metric contours (such as integration of the narrowband spectra from the 5th to 40th rotor harmonics, known as BVISPL) for each test condition should be completed and plotted within two minutes of completion of data processing for the run. Minimum acceptable percentage of data runs processed in this timeframe is 95 percent of all "good" runs, where a good run is defined as one in which no anomalies occurred during any part of the recording process. Greater percentage of processed data runs, improved speed performance, additional data acquisition features (such as a traverse automatic restart in case of anomalies during data acquisition), and additional noise metrics made available in this timeframe, all will be used to assess the level of performance exceeding the acceptable level.

traverse automatic restart in case of anomalies during data acquisition), and additional noise metrics made available in this timeframe, all will be used to assess the level of performance exceeding the acceptable level.

Deliverable: Ensemble-averaged time histories, narrowband spectra, and integrated metric contours in both graphic and digital formats. Both raw and processed data stored on both optical disk and tape media.

Schedule: Subtask 9 shall be completed within one week of the cessation of testing.

10. Perform post-test data processing and analysis of acoustic, wind tunnel state, and rotor model performance data from an acoustic test of three tiltrotor configurations (two different isolated rotor models and one semi-span configuration that used one of the two rotor sets used in the isolated rotor testing; hereafter known as the JVX test). The contractor shall analyze the data to provide a detailed comparison of the two isolated rotor models, including both rotor aerodynamic performance and acoustics, for all matching test conditions. The contractor shall also perform statistical analysis of the trends produced by these comparisons. Additionally, the contractor shall perform a similar comparison using data from the semi-span configuration with data from the corresponding isolated rotor model. Approximately 60-65 test conditions were measured for each of the three configurations.

    Metric: Maximum noise levels, area inside multiple noise contours, and rotor trim conditions are to be compared for each matching test condition for both pairs of comparisons. Minimum acceptable percentage of data runs compared in this manner is 90 percent of the total number of matching test conditions. Greater percentage of processed data runs, additional noise metrics compared, and additional performance parameters compared, will be used to assess the level of performance exceeding the acceptable level.

    Deliverable: Formal contractor report documenting the analysis of trends for both sets of comparisons. Digital copies in ASCII format on diskette or tape of all trend data files used to develop the analysis.

    Schedule: Subtask 10 shall be completed by June 30, 1997.

11. Develop an integrated controls program using Intec Controls Paragon software for operation of the Jet Noise Laboratory's Dual Stream Propulsion Model with all subsystem tasks involving the use of air, propane, hydrogen, nitrogen and water. The contractor shall also develop software capable of operating the Jet Noise Laboratory's 3-axis traverse systems and software to acquire microphone and conventional aero data on a SUN UNIX platform. In addition, the contractor shall develop methods for data archiving and retrieval of digitized time records for post-processing.

    Metric: Ability to operate dual stream propulsion model and subsystem elements and ability of software to satisfy NASA LaRC Systems Criteria is required. Functionality of 3-axis traverse systems is also required. Speed and accuracy of data acquisition, archival, and retrieval software to manage acoustic and aero data for test programs in the NASA AST and HSR programs will be used to assess performance exceeding the acceptable level

Deliverable: Software for control of and for acquiring, archiving and retrieving data from the Jet Noise Laboratory's systems.

Schedule: Operational software for traverse and propulsion model systems by September 30, 1996. Remaining tasks by June 30, 1997.

12. Prepare NASA-provided ADP demonstrator model for test in Anechoic Noise Research Facility as follows: a.) Examine the model, support carts, and model-related instrumentation; repair and refurbish as necessary. b.) Check to ensure that all required equipment and instrumentation are available, including vacuum pump, pressure supply, microphone hoop array, and microphone traverse, that the equipment are working within specifications, and that calibrations are current. c.) Prepare model fan for test, including installation of vacuum and pressure lines to model, and installation of required model health monitoring transducers. d.) Complete test equipment preparation, including installation of in-duct microphone array, installation of far-field microphone array. e.) Assist in installation and check out of the data acquisition system and of the control system computer.

    Metric: Minimum acceptable performance is that test is ready to begin on schedule with no delays due to overlooked hardware or instrumentation problems. Identification and resolution of potential problems will be used to assess the level of performance exceeding the acceptable level.

    Deliverable: Model and auxiliary systems ready for testing on schedule.

    Schedule: Subtask 12 will be completed by July 19, 1996

13. Operate the ADP demonstrator and require data for the Active Boundary Layer Control test. The test will be performed in the Anechoic Noise Facility, B-1218A in the 4th quarter FY '96. The contractor shall maintain the operability of the model and the model support equipment throughout the test period, and monitor the model's health in accordance with the model operation procedures. The contractor shall also perform daily calibration of microphones and pressure equipment; perform model changes throughout the test as required by test plan; and collect and archive data including model operating conditions, far-field acoustic data, in-duct acoustic data, and control parameters. Data will be gathered and archived on a government-furnished DEC Alpha computer, using two NEFF data acquisition front ends, one for the near field acoustic data and one for the in-duct acoustic data. In addition the contractor shall develop software for data acquisition.

    Metric: The contractor is responsible for operation of the model, the model support equipment, and the data acquisition hardware and software. Minimum acceptable performance is that no delays in the test schedule are caused by improperly prepared model, model support, or acoustic data acquisition hardware. Timely identification and resolution of test-delaying problems will be used to assess the level of performance exceeding the acceptable level.

Deliverable: Model and auxiliary systems to conduct the test. Report defining software developed for data acquisition submitted before completion of test.

Schedule: Subtask 13 shall be completed by September 16, 1996

14. Reduce acoustic data from the Active Boundary Layer Control test and provide plots to identify azimuthal directivity patterns of Blade Passage Frequency and twice Blade Passage Frequency tones with comparison of control off to control on. The contractor shall also develop data reduction routines to reduce acoustic data to identify directivity patterns of broadband noise with comparison of control off to control on. Additionally, the contractor shall develop data reduction routines to reduce data to identify the circumferential and radial distribution of tone noise in the duct. Data reduction will be performed on a government-furnished DEC Alpha computer.

    Metric: The minimum acceptable performance is completed analysis of the data identified in the subtask description by the completion date. The ability to generate additional plots in formats other than that described abouve for greater physical understanding will be used to assess the level of performance exceeding the acceptable level.

    Deliverable: Report including data reduction routines used in the analysis and all specified plots in hard copy. Data files to be submitted on 3-1/2" floppy disk.

    Schedule: Subtask 14 shall be completed by September 27, 1996

15. Prepare ADP demonstrator model and instrumentation for entry in NASA 14- by 22-foot wind tunnel. The contractor shall: a.) Install blade passage sensors, fan exit guide vane set with porous vanes, and a microphone array mounted on a traversions system. b.) Write and verify computer programs to control microphone traverse and to do storage and post processing of data collected during the test. c.) Ensure that the model and model support equipment are in good working order, and provide for transportation of equipment from the Anechoic Noise Research Facility to the 14- by 22-foot wind tunnel. d.) Install the government-furnished NEFF data acquisition systems for the microphone traverse and for the directional microphone array, the government-furnished DEC Alpha computer, and the government-furnished traverse control hardware in the facility. e.) Confirm operation of the software to control the traverse, to control and coordinate the NEFF data acquisition systems, and to store data. f.) Ensure proper installation of the tunnel acoustic treatment, the microphone traverse, the fan model and model support equipment, and the directional array.

    Metric: Minimum acceptable performance is that test is ready to begin on schedule with no delays due to avoidable hardware problems. Identification and timely resolution of potential test start delaying problems will be used to assess the level of performance exceeding the acceptable level.

Deliverable: Model and auxiliary systems ready for testing on schedule.

Schedule: Subtask 15 shall be completed by June 30, 1997

16. Support the Porous Stator Vane test as follows: a.) Run and maintain the model and the model support equipment throughout the test period, and monitor the model's health in accordance with the model operation procedures. b.) Perform daily calibration of microphones. c.) Perform model changes through the test as required by test plan. d.) Collect and archive data including model operating conditions, far-field acoustic data, wind tunnel parameters, and data from any instrumentation developed especially for this test. e.) Ensure orderly cataloging and storage of acoustic treatment. f.) Arrange for transportation to return the model and its support equipment to the Anechoic Noise Research Facility.

    Metric: Completion of the test matrix within the allotted test window is the only option available in that schedule slippage is not permitted. The contractor cannot be held responsible for completion of the test matrix, because the contractor has no control over facility problems. However, the minimum acceptable performance by the contractor is that no delays in the test schedule are caused by avoidable problems concerning the model, model support, or acoustic data acquisition hardware. Timely identification and resolution of test-delaying problems will be used to assess the level of performance exceeding the acceptable level.

    Deliverable: Model, model support, and acoustic data acquisition equipment that are operating within specifications throughout the test. An informal report identifying the location of all equipment after test has been dismantled.

    Schedule: Subtask 16 shall be completed by June 30, 1997

4. Government Furnished Items: High level workstations and accompanying software for processing and analyzing flight test data, data acquisition and reduction system for wind tunnel work, ADDRAS system for analog tape processing, printers and other peripherals for use during both testing and data analysis, storage media (Subtasks 1-10). All control industrial I/O, including Paragon TNT software, instrumentation for data acquisition, and computer mainframes including optical disc drives for data archiving (Subtask 11). The Anechoic Noise Research Facility, the 14- by 22-foot VSTOL subsonic wind tunnel, the 12" ADP demonstrator fan model with hardware for the two tests, lubrication cart, slipring coolant distribution cart, PC fan speed control computer, NEFF 495 data acquisition systems, DEC Alpha computers for data acquisition, reduction, and analysis software development (Subtasks 12-16).

5. Other information needed for performance of task.

Most tasks can be accomplished independently. However, subtask 1 must be completed before subtask 2c can begin. Subtask 8 must be completed before subtask 9 can begin. Subtasks 12 through 16 are to be performed in sequence. It should be recognized that facility schedule changes may cause changes in test start dates.

6. Security clearance required for performance of work:

Some of the data handled under tasks 2a and 6 are classified SECRET. Appropriate clearance and knowledge of proper handling of such data are requied. Additionally, data associated with tasks 2b, 5, 9, and 10 are considered Limited and Exclusive Rights Data (LERD) under the Advanced Subsonic Technology program. LERD data cannot be published openly, and dissemination is restricted to program participants. Some of the data handled under tasks 1 and 2c may be considered company proprietary, and should be handled appropriately. In addition, all data acquired in Subtask 7 is protected under LERD by NASA's HSR and SAT program, which require U.S. citizenship or permanent resident alien status for access.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: J. S. Preisser
.M/S: 461 Phone: 804-864-3618

DFx07

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ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title Number: Revision:

   Title: HSR Structural Acoustics Research Support

2. Background:

   The Structural Acoustics Branch has a continuing responsibility to conduct interior noise studies under the High Speed Research Program. The purpose of this task is to provide technical support for development of loads models, an interior noise prediction model, and passive and active control techniques for interior noise.

3. Description:

   The contractor shall modify a zero pressure gradient fully coupled panel-turbulent boundary layer interaction model to account for the presence of adverse and favorable pressure gradients. This model consists of a modified version of CFL3D, a NASA developed computational fluid dynamics code, that accounts for the coupling between the boundary layer and a flexible surface. The method is based on the unsteady Reynolds-averaged Navier Stokes equations with the introduction of coherent turbulence structures at the inflow. The contractor shall use the modified code to assess the importance of pressure gradients in supersonic viscous flow on structural response and noise transmission.

   Metric:

   Acceptable performance is demonstrated by the ability to successfully compute the effect of both adverse and favorable pressure gradients. Performance exceeding the acceptable level is demonstrated by incorporation of the pressure gradient results into a semi-empirical supersonic turbulent boundary layer pressure fluctuation model developed by Boeing.

   Deliverables:

   1. Informal final report documenting the model and results.
   2. Computer code for evaluating the effects of pressure gradients.
   3. Brief monthly progress reports.

   Schedule:

   1. This task shall be completed by October 31, 1996.
   2. Monthly progress reports shall be submitted electronically to the NASA technical monitor by the second Tuesday of each month.

PRINTED: 6/5/96

ART (NAS1-96014) Task Order Page 2

1. Task Order Number and Title Title: HSR Structural Acoustics Research Support	Number:	Revision:

4. Government Facilities and Equipment Provided:

   Remote access and CRUs on LaRC CRAY computer, remote access to Structural Acoustics Branch DEC Alpha workstation, X-windows terminal.

5. Other information needed for performance of task:

   Boeing document no. D6-81571 Rev. A, "An In-Flight Supersonic Turbulent Boundary Layer Surface Pressure Fluctuation Model," March 1995 (available from NASA technical monitor).

   Modified version of CFL3D code.

6. Security clearance required for performance of work:

   All personnel will be required to conform with the guidelines set forth in the current version of the "High-Speed Research Technology Transfer Control Handbook," available from the HSR Program Office. All personnel will be required to sign the HSR Non-Disclosure Agreement provided in the Technology Transfer Control Handbook. Portions of the work may be designated as Limited Exclusive Rights Data (LERD) by the HSR Structural Acoustics Integrated Technology Development (ITD) team and distribution of that work will be restricted as indicated in the Technology Transfer Control Handbook.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: October 31, 1996

8. NASA Technical Monitor: Stephen A. Rizzi
   M/S: 463 Phone: 804-864-3599

(iii) DF. 11

ART Task Order

1. Task Order Number and Title Number: Revision:
   Title: Compressible and Non-Equilibrium Turbulence Research Support

2. Background: The purpose of this task is to provide a database for model development of compressible turbulent transport equations, to provide a methodology for using parallel processors in direct numerical simulation (DNS) of turbulent flows, and to develop models and methodologies for the prediction of non-equilibrium turbulent flows.

3. Subtask Descriptions:

1. The contractor shall develop a capability to numerically solve transport and conservation equations for statistically unsteady flows based on higher-order turbulent closure models and, within the same numerical framework, provide the capability of performing large eddy simulation (LES) computations. The contractor shall provide these capabilities through extensions to the NASA-supplied code ISSAC which increases the spatial accuracy to fourth order and the temporal accuracy to second order. The code ISSAC has been used extensively to test and validate second-moment-closure turbulence models.

   Metric: The minimum level of performance is an operational and debugged numerical code capable of solving turbulent flows (stationary or statistically unsteady) with higher-order turbulent closures as well as subgrid scale models. Performance exceeding the minimum is a code that allows time-accurate simulations to be performed with less than 25% additional cost over the existing ISAAC solver on a per grid point per time step basis.

   Deliverable: An operational numerical solver applicable to a variety of complex turbulent flows. An informal report describing the computational method.

   Schedule: Subtask 1 shall be complete by December 1, 1996.

2. The contractor shall determine a benchmark problem to assess the relationship between unsteady RANS solutions and LES solutions and determine the accuracy and feasibility of providing solutions from the two distinct though complimentary approaches. The contractor shall compute the flow using these two approaches with the code in subtask 1, assess the truncation error in the simulation and ensure they are smaller than the modeling differences and less than 3%, and compare to the experimental data.

   Metric: The minimum level of performance is the identification of a suitable unsteady flow problem which has sufficient experimental data available to assess the ability of each type of solution methodology in predicting the flow and unsteady RANS and LES computations for this problem with an estimate of the level of truncation error.

   Deliverable: A formal report describing the set of benchmark data and showing the comparative performance of unsteady RANS solutions and LES solutions.

   Schedule: Subtask 2 shall be completed by June 1, 1997.

3. The contractor shall improve and maintain the ISAAC code to the state-of-the-art level in turbulent closure capability, implement steady and unsteady turbulent closure models as described in subtask 1, and apply the code to six turbulent flow test cases in order to facilitate the distribution of the technology to outside users for use in large-scale computations.

Metric: The minimum level of performance is a modular code suitable for use by other government agencies and industry and which computes the six test cases with a level of truncation error less than 1%. Performance exceeding the minimum will be attained by successfully demonstrating the code for ten test cases, including at least two unsteady flow test cases.

Deliverable: A state-of-the-art and modular computer code capable of predicting complex turbulent flows using higher-order closure models. A manual and guide for users which contains validation test cases for the turbulence models.

Schedule: Subtask 3 shall be completed by June 30, 1997.

4. The contractor shall perform stability analyses of compressible, cold wall boundary layer flows, determine the forcing frequency and location of the most unstable mode in such flows, and ascertain what parameter range is available for practical DNS of such flow. In addition, the contractor shall develop a procedure for performing such calculations on the SP2 parallel processor at LaRC, and develop database management and post-processing procedures for statistical diagnostics. The contractor shall perform the computations with a code developed by M.M. Rai (NASA Ames), which is a high order accurate, upwind-biased, finite-difference technique used in conjunction with an iterative-implicit time-advanced scheme.

   Metric: The minimum level of performance is a well-posed compressible cold-wall boundary layer flow simulation with inflow conditions determined from stability analysis which is suitable for running on the SP2 and includes a procedure for storing restart files and datafiles for statistical analysis of the results. Performance exceeding the minimum will be judged on the extent to which the Reynolds number capability on the SP2 exceeds that available on a C90 single processor capability

   Deliverable: An operational DNS code on the SP2.

   Schedule: Subtask 4 shall be completed by October 1, 1996.

4. Government Furnished Items: Engineering workstations for code development and solution visualization, computer time..

5. Other information needed for performance of task. None

6. Security clearance required for performance of work: None

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30,1997

8. NASA Technical Monitor: Dr. James L. Thomas	
.M/S: 128	Phone: 804-864-2163

DFX19

ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title Number: Revision:

Title: **Comparison of Boundary Layer Correlation Models for Structural Response**

2. **Background:**

The Structural Acoustics Branch has agency responsibility for aircraft interior noise control for both subsonic and supersonic aircraft. Boundary layer generated interior noise is an important part of the overall interior noise in high speed subsonic and supersonic aircraft. In order to assess the structural design parameters and noise control treatments, an accurate representation of the boundary layer pressure loading as it relates to panel response is necessary. Present multi-point correlation models provide a computationally efficient manner to apply these necessary boundary layer loads without the computational expense of a fully coupled fluid-structure problem. However, some questions have arisen with respect to the correct model to be used as well as to how much detail must be included. The purpose of this task is to define the effect of different loading models on panel response.

3. **Task Description**

The contractor shall provide an assessment of the structural response of an aircraft panel to excitations provided by three different two point correlation models. These models are the Corcus model, the Efimsov model and the two point correlation model derived from LES modeling effort by Singer (CR198276). The contractor shall predict the cross-spectral panel response for the uncoupled solution for a pressure loading represented by each of the three above models exciting a finite element model of a typical aircraft panel.

Metric: The minimum acceptable level of performance is the demonstration, with sufficient statistical confidence that the results of the study are a realistic representation of the true expected value, of the response for all positions (modes) of the panel for a frequency range of 2000 Hz or greater. The data is expected to take the form of modal coupling coefficients or wavenumber response data. Performance exceeding the acceptable level will be judged on accuracy of the results, completeness of important loading and coupling parameters, ease of interpretation and timeliness of the product.

Deliverable: A report relating each loading model to each of the important panel model consisting of either design curves or tables relating the structural modal response to differences in the loading models.

Schedule: The task shall be completed by September 30, 1996

4. Government Furnished Items:

Access to Sun and SGI workstations, Mainframe and C-90 computers and software as required.

5. Other information needed for performance of task. None

6. Security clearance required for performance of work: None

PRINTED: 6/17/96

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: September 30, 1996

8. NASA Technical Monitor: Dr. Craig L. Streett
.M/S: 170 Phone: 804-864-2230

DFX17

ART Task Order

1. Task Order Number and Title Number: Revision:

Title: Aircraft Noise Prediction Program (ANOPP) Development, Maintenance, and Support

2. Purpose, Objective or Background of Work to be Performed:

The ANOPP code has the capability to predict source noise for supersonic and subsonic fixed-wing jet aircraft. It can fly these sources in steady fly-over, take-off and approach (landing) configurations accounting for noise propagation corrections. It computes and plots several acoustic metrics for aircraft noise certification and community noise impact studies. For this contract effort, the ANOPP program as defined in TM-83199 is restricted to conventional take-off and landing (CTOL) Turbofan powered aircraft. This includes the programs recently acquired but not necessarily incorporated or documented that have been developed under the High-Speed Research (HSR) and Advanced Subsonic Technology (AST) programs, i.e., ANOPP level L03/02/11. No effort to support the rotorcraft or propeller source noise prediction capabilities of ANOPP is herein required.

The objective of this task is to implement new prediction capabilities for the ANOPP system, provide maintenance services for code updates, debugging, and corrections, and provide prediction code support to NASA and Government approved ANOPP customers. The government will track progress of the contractor utilizing monthly technical progress reports, monthly financial reports and comprehensive semi-annual and annual technical oral reviews.

3. Description of the Work to be Performed

The contractor shall perform the following subtasks:

1. The contractor shall maintain a master copy of the ANOPP code on a GFE DEC ALPHA computer system. After each new system update generation as required in this subtask,the contractor shall deliver an archive copy of the code to the Government. Code changes shall be implemented and tracked using the GFE computer systems detailed in section 4. The contractor shall maintain a capability to generate executable versions of the code which run on DEC VAX, IBM, HP, SUN, Apollo, Silicon Graphics, and IRIS computer systems.

   Metric: The contractor is expected as a minimum to provide easily readable archived copies of the master codes. The codes as specified under subtask 2 shall be incorporated into each respective archived copy of the code.

   If the code can be easily accessed with only minor problems for execution and the technical documentation is completed for the included codes for each archived code copy, then these criteria will be used accordingly to assess a level of performance exceeding the acceptable level.

   Deliverables and schedule:
   Updated archived ANOPP code copy on 8mm tape on December 13, 1996, and on June 30, 1997.

2. The contractor shall implement into ANOPP, prediction codes or module updates being

developed by the Government or its contractors under HSR and AST programs. Following are code modules (or updates) currently under development for predicting source noises:

(1) small engine jet mixing, core and turbine noise (new code),
(2) fan noise prediction from large turbofan engines (updated code),
(3) fan noise from large turbofan engines with treated inlets (new code),
(4) fan noise for the YJ-101 engine (new code),
(5) fan noise from XF-120 engine (log added and spectral calculated) (new code),
(6) jet noise from single circular, supersonic jets (new code), and
(7) jet noise from 2-dimensional mixer-ejector nozzles (new code).

The contractor shall also generate technical documentation for these modules consistent with NASA TM-83199.

Metric: The contractor is expected to deliver completed codes (executable versions) with technical documentation concerning input, output and results of execution of each of the codes. The codes shall be demonstrated to reproduce the government furnished results using the data that was used for code development and/or validation.

In addition to the generation of the code module technical documentation, the generation of documentation to introduce persons to the operation of code and other written information or ideas and concepts which result in making the utilization of the code easier or faster executing will all be used to assess a level of performance exceeding the acceptable level.

Deliverables and schedules:

ANOPP Source module code with documentation as follows:

Source module	Due date
(1) small engine jet mixing, core and turbine noise	3/31/97
(2) fan noise prediction from large turbofan engines	10/31/96
(3) fan noise from large turbofan engines w/ treated inlets	1/31/96
(4) fan noise for the YJ-101 engine	9/30/96
(5) fan noise from XF-120 engine	12/30/96
(6) jet noise from single circular, supersonic jets	6/30/97
(7) jet noise from 2-dimensional mixer-ejector nozzles	9/30/96

3. The contractor shall keep an updated executable copy of the code available on the GFE DEC ALPHA for Government acquisition and use and shall add each new module, from subtask 2, when they are completed. The contractor shall keep a database (Microsoft Works Database) consisting of prediction code customers, addresses, code versions, etc. (current database will be furnished as a starting point) and issue new copies of the code only to those U.S. companies and government agencies that are approved by the NASA. The contractor shall debug and correct code errors as reported to them by NASA or approved industry customers. If the contractor determines that a reported error or correction requires a major effort, he shall contact the COTR for guidance before committing resources to implement an update to the code. The contractor shall distribute updated or corrected copies of the ANOPP code to those customers who are approved by the Government and who want to be updated. The contractor will not be held responsible to actively support old ANOPP versions if the versions are more than four levels behind the current update level.

Metric: The government will track progress of the contractor utilizing the monthly technical progr... reports and monthly financial reports. ... is required that a response to 80% of the customers will occur within three weeks of notification of a code problem.

The contractor can exceed the acceptable level of performance by demonstrating a sustained level of code problem resolution for greater than 80% of customer in less than the allowable three week period.

Deliverables and schedules:

1. Updated customer database each month
2. Code update activity summary reports each month
3. Updated and corrected code copies to customers as appropriate.

4. The contractor shall provide NASA and its approved customers support as follows:

1. The contractor shall use ANOPP or other government-furnished codes such as the FAA's Integrated Noise Model, the AirForce's NoiseMap, or the NASA-LaRC Flight Operations code/programs to generate predicted community noise footprints and certification levels for candidate HSR and AST aircraft scenarios as defined in writing by the COTR. Two scenarios will be provided per month.

2. The contractor shall provide data reduction services for the F-15 Acoustics Flight test. The contractor shall convert the raw data resulting from the F-15 acoustics flight test (ground static, code validation and climb-to-cruise noise measurements into an easily accessible database containing engineering units data and ensemble averaged acoustic data. The raw data consists of sets of time correlated measurements from aircraft tracking, atmospheric conditions during the test (weather), on-board aircraft and engines dynamic state parameters, and far-field microphone measurements. The contractor shall construct the database to be similar to that developed and published for the F-18 and F-16XL acoustics flight test (NASA CDTM - pending) and consist of time-match engineering data for each of the component data sets for each valid flyover. The flight test as currently envisioned will result in about 50 sets of data to be reduced and correlated. A master copy of the database shall be archived on optical storage media.

3. The contractor shall provide assistance to customers in code installation, operation and preparing input for and interpreting output from the ANOPP code.

4. Requests from customers for on-site or at LaRC training shall be reported to NASA. Decisions for providing training will be based on the available workforce resources at the time of the request.

Metric: Computation of A-weighted Sound Levels, Sound Exposure Levels (SEL), Day/Night Average Sound Levels (DNL), Noise Exposure Forecasts (NEF), , Perceived Noise Levels (PNL), Tone Corrected Perceived Noise Levels (PNLT), and Effective Perceived Noise Levels (EPNL) shall be in accordance with the established noise metrics standards (NASA CR 3406) or Federal Air Regulations, Part 36. Results of ground level contours for the above metrics is expected within three weeks of the written request.

For the F-15 flight test, the computation of SEL ground contours, areas inside a minimum of three different SEL levels, and selected narrowband spectra for each flight condition are required. Minimum acceptable percentage of data runs processed in this time frame is 95% of all "good" runs, where a good run is defined as one in which no anomalies occurred during any part of the recording process. For the remainder of the runs, identification and documentation of reasons why these cases cannot be processed shall be provided. Greater percentage of processed data runs, as well as additional noise metrics computed, will be used to assess the level of performance exceeding the acceptable level.

Deliverables and schedule:

1. Reports of predictions for the HSR and AST subject cases, provided within three weeks of the respective requests.

2. Informal report and an engineering unit database and acoustic results from the F-15 acoustics flight test 6/30/97

3. Customer support activity summary reports each month.

4. Government Furnished Items:

The Government shall furnish two DEC Alpha 3000, one DECstation 5000/200 and one MicroVAX 3300 computer systems to be used to maintain the master ANOPP code copy, for implementation of new prediction code capability, to perform acoustic system studies, and to debug and/or correct code errors.

The Government shall furnish five PowerMacintosh computer systems to be used for database development, preparation of materials in Microsoft Word format resulting from code studies, and to communicate monthly reports and other deliverables to the Government.

The Government shall furnish one IBM PC AT and one IBM PC Model 50 to support execution of the FAA INM and AirForce NOISEMAP programs.

The Government shall furnish an approved list of ANOPP customers. This list shall serve as an example of the customer database that is to be maintained by the contractor and to serve as the basis for determining customer support requirements.

The Government shall furnish the databases and/or prediction code information along with documentation necessary to implement the new prediction code capabilities listed in subtask 2.

The Government shall furnish on the schedule shown below the databases and/or computer codes along with documentation to provide the basis for the prediction code generation specified in subtask 2:

Source module	database/code/ documentation availability date
(1) small engine jet mixing, core and turbine noise	1/31/97
(2) fan noise prediction from large turbofan engines	7/1/96
(3) fan noise from large turbofan engines w/ treated inlets	11/1/96
(4) Fan noise for the YJ-101 engine	7/1/96
(5) fan noise from XF-120 engine	10/30/96
(6) jet noise from single circular, supersonic jets	9/30/96

(7) jet noise from 2-dimensional mixer-ejector nozzles	7/19/96

5. Other information needed for performance of task. The ANOPP computer code, its databases and documentation are to be considered as U.S. Government controlled property. The contractor shall not distribute or disclose any of the material/information/data associated with this code without the expressed consent of the Government.

6. Security clearance required for performance of work: None

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: R. A. Golub
.M/S: 461 Phone: 804-864-5281

DF 14

(14)

ART/SAERS Task Order Page 1

1. **Task Order** Number: Revision:

Title: **Tail Buffet Research Support**

2. Background and Description.

The NASA High Alpha Program identified vortex/fin interactions as the primary cause of tail buffet on twin-tailed fighters. Previous design methods involved limited experimental and empirical design tools. A cooperative effort was established between NASA Langley and McDonnell Douglas Aerospace (MDA) to develop new design methods based on neural network technology. This task will support this development by performing data analysis and documentation of an experiment to provide neural network training data and expand the learning space.

3. Task Description.

Provide post-test analysis and documentation of the vortex/fin interaction experiment.

Background: The experimental data was obtained during a 6-month period in the NASA Langley Basic Aerodynamics Research Tunnel (BART). The data consists of:

1. Force and moment data for wing alone and wing/tail combinations
2. 3-components velocity data obtained with a laser velocimeter
3. Buffet pressures on the vertical tails

The contractor shall provide post-test analysis of the data that will include: all bias corrections to the Lv data, analyis of vortex strength (vorticity & circulation), vortex core position, correlated velocities with buffet pressures on the tail, scaling of the buffet pressures consistent with the AGARD criteria for buffet response, calculation of power spectra, phase, and correlations. The contractor shallcorrect all force and moment data for blockage and interference using the wall pressure signature technique.

Deliverables and Schedule:

1. Document the results of the analysis of the test data in a final report (9/96).
2. Provide the raw and corrected data to NASA and MDA in a mutually agreed upon format (9/96).
3. Document all software developed in the performance of this task (9/96).

Metrics for Deliverables:

Minimum level of success: deliverables on schedule.
High level of success: all deliverables before 9/96.

PRINTED: 6/12/96

ART Task Order Page 2

1. Task Order Title: **Tail Buffet Research Support**	Number: Revision:

4. Security clearance required for performance of work:
Personnel working on this task may not release any of the work performed under this Task to any party except those designated by the Task Technical Monitor

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: September 31, 1996

8. NASA Technical Monitor: W. L. Sellers III
.M/S: 170 Phone: 804-864- 2224

ART Task Order

1. **Task Order.** Number: Revision:

Title: **Laminar Flow Control Project Support**

2. **Objective of Work to be Performed.**

The objective of this task is to support the laminar flow control (LFC) subelement of the Advanced Subsonic Technology (AST) program through post-test support of a wind-tunnel experiment and subsonic design tool testing.

3. **Subtask Descriptions.** The contractor shall perform the following subtasks:

1. Provide post-test support of a LFC swept wing wind-tunnel experiment.

   Background: A recently completed experiment used leading-edge suction for laminar flow control on a swept-wing model to control the growth of crossflow-vortex boundary-layer instabilities. One solid and three porous leading-edge panels with different suction-hole diameters and spacing were tested on the base model.

   The contractor shall (1) develop hardware to make micro-porsity measurements, (2) make micro-porosity measurements on the porous leading-edge panels (which is required because the laser-drilling process was inconsistent in the size, shape, and spacing for the holes), (3) develop and incorporate an accurate boundary-layer profile data fitting scheme/code, which will be able to read from the PRISM database, perform the fit, and perform spanwise spectral analysis, (4) use a technique to more clearly resolve the IR images which have unclear transition fronts caused by changes in surface temperature during acquisition, and (5) document surface roughness on solid and porous leading-edge panels.

   Deliverables and Schedules:
   1. Documentation of micro-porosity measurements in the analysis notebook (6/97).
   2. Boundary-layer profile data fitting software (9/96).
   3. Documentation of the process and the results of process on IR images in analysis notebook. (6/97)
   4. Documentation of the surface roughness measurements from leading-edge panels into analysis notebook (12/96).
   5. Informal monthly progress reports.
   6. Two-page technical highlight of significant accomplishments to date (twice a year upon request with figures as appropriate).

   Metrics for Deliverables:
   Minimum level of success: all deliverables on schedule.
   High level of success: all deliverables before 12/96.

2. Use interacting boundary layer theory to parameterize the effect of waviness on the evolution of crossflow disturbances.

Deliverables and Schedules:

1. Informal report documenting effect of waviness on crossflow disturbances (10/96).
2. Two-page technical highlight of significant accomplishments to date (10/96).

Metrics for Deliverables:

Minimum level of success: deliverables on schedule

High level of success: deliverables by 9/96.

4. Government Furnished Items:

1. NAS Cray Computer hours (approximately 30 C-90 hrs)
3. Micro-porosity measurement equipment
4. Access to surface roughness measurements
5. Wind-tunnel analysis notebook.

5. Other information needed for performance of task.
No travel is required for this Task.

6. Security clearance required for performance of work:
Personnel working this Task must sign a form indicating that the work performed under this Task will not be released to any party except those designated by the Task Technical Monitor.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Ronald D. Joslin
.M/S: 170 Phone: 804-864-2234

ART Task Order

Note: the following information will not be provided to the contractor but is required to allow the COTR to determine a preliminary cost estimate. This page will be replaced with negotiated final funding information and limitations at time of task initiation.

1. Task Order. Number: Revision:

Title: **Laminar Flow Control Project Support**

10. Government's Estimated Cost Limitation:

Task 1 Cost: $ 60,000.

Task 2 Cost: $ 30,000.

Total Cost: $ 90,000.

Provide the best estimate of the cost by task.

11. Other Direct Cost Estimates:

12. Funding information:

PR DFL.1193

Task 1:	R20891	538-05-15-04	25,000.
Task 2:	R20822	505-59-10-37	30,000.
	R19823	538-05-15-01	35,000.
			90,000.

ART Task Order Page 1

1. Task Order Number and Title	Number:	Revision:
Title: Airframe Noise Tasks 1		

2. **Background:** NASA LaRC began an in-house effort to determine the fundamental noise sources of a subsonic high-lift system in 1994 by performing detailed flow physics experiments and computations. This effort is in support of the AST Noise Reduction Program's goal to achieve 4db noise reduction on an advanced high-lift system based on fundamental flow physics of the noise source. The tasks below describe experimental and computational work necessary to accomplish this goal.

3. **Subtask Descriptions:**

The purpose of the following tasks 1,2 and 3 are to calculate the Reynolds Averaged Navier-Stokes (RANS) solution for the unsteady flowfield associated with the flap side edge and slat of a subsonic high-lift system.

1. The contractor shall compute the steady flowfield over the NACA 63-215 wing (unswept) and compare with experimental data obtained in the ARC 7x10, Langley Quiet Flow Facility (QFF) and Low Turbulence Pressure Tunnel (LTPT) experiments. The contractor shall obtain a converged solution on several grids of increasing resolution and make detailed comparisons with available experimental data. The contractor shall also quantify the near field sound source intensity of the flap and slat from turbulence statistics of the solution.

   Metric: A 3 order of magnitude residual reduction is required in the RANS solution of the 7x10 flap-edge flowfield in 10 C-90 hours utilizing 4 million grid points. The use of less C-90 hours to obtain the same residual reduction for a 6 million point grid case will be used to assess performance in excess of its acceptable level.

   Deliverable: An informal final report which documents the detailed flow physics for the landing configuration obtained from the calculation as well as comparisons with experiment.

   Schedule: Subtask 1 shall be complete by June 30, 1997.

2. The contractor shall determine the mean flowfield about a flap+slat model of the trapezoidal wing scheduled for testing in the 14x22 in the spring of 1997. The contractor shall compare with the detailed flap-edge and slat flowfield solution for both the swept and and unswept model.

   Metric: Minimum standard of performance is 3 orders of magnitude reduction in the solution residual within 50 C-90 hours for a 6 million grid point case which computes the flowfield surrounding the trapezoidal wing at landing conditions. The use of less C-90 hours to obtain the same residual reduction for a 6 million point grid case will be used to assess performance in excess of its acceptable level.

   Deliverable: An informal final report which documents the effect of sweep on the flap and slat mean flow.

   Schedule: Subtask 2 shall be completed by June 30, 1997.

3. The contractor shall convert the time-accurate multi-grid version of TLNS3D to a parallel code and use the parallel version to compute the unsteady flowfield over the trapezoidal wing which will be tested by NASA LaRC in the 14x22. The existing steady-state parallel code shall be used as a baseline.

PRINTED: 7/3/96

Metric: A grid-converged solution is required on each of the subit...tions for the unsteady solutions with comparisons of unsteady quantities within 10% of experimental measurements, or explain any discrepancy. Producing unsteady flowfield quantities with sufficient accuracy for use in acoustic propagation codes will be used to assess performance in excess of its acceptable level.

Deliverable: A computer code which calculates time-accurate solutions for complex configurations with 6 million grid points on a distributed memory computer.

Schedule: Subtask 3 shall be completed by June 30, 1997.

4. Develop and validate a large eddy simulation (LES) noise prediction method for a 3-D cavity based on a dynamic sub-grid-scale model. To validate the model, the contractor shall perform calculations for a 3-D cavity and compare results with Georgia Tech Research Institute experimental data, to be supplied by NASA, at Reynolds numbers greater than or equal to 50,000.

   Metric: The minimum acceptable performance is LES calculations for the 3-D cavity with numerical truncation errors less than 5% for Re < 50,000. Performance which exceeds the minimum would be the extent to which the calculation can be applied at Reynolds number greater than 50,000 with numerical truncation errors less than 5%.

   Deliverable: Validated 3-D cavity noise prediction code.

   Schedule: This task shall be completed by October 1, 1996.

4. Government Furnished Items:

Quiet Flow Facility, flap edge models, 14x22, LTPT, workstations, computer time, Reynolds Averaged Navier-Stokes solutions, noise reduction concepts of flap side-edge, experimental data for CFD validation.

5. Other information needed for performance of task.

It is estimated that trips may be required to present results to an Airframe Noise Working Group meeting on the West Coast.

6. Security clearance required for performance of work:

All work will be unclassified however, personnel may be required to complete nondisclosure agreements with industries or airlines.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30 , 1997

8. NASA Technical Monitor: Dr. Michele G. Macaraeg
.M/S: 128 Phone: 804-864-2295

ARTS Task Order

1. Task Order Number and Title **Number:** **Revision:**

Title:

Surface and Volume Grid Generation for Aerothermodynamic Analysis

2. Purpose, Objective or Background of Work to be Performed:

The NASA Langley Research Center Aerothermodynamic Branch (AB) provides experimental and computational data and analysis to define the aerothermodynamic performance of Space Transportation Systems (STS) and Planetary Entry (PE) vehicles across the speed range.

The general purpose of this task is to provide the structured surface and volume grids for STS and PE vehicles for use in a variety of existing computational codes including LAURA, DPLUR and TLNS3D. These codes provide engineering through "benchmark" analyses of Space Transportation Systems and planetary entry vehicles.

The expected outcome of this task is structured grids for X-33 Program Phase II, X-34, X-35, Hyper-X and PE vehicle computational analysis.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

The contractor shall provide structured surface and volume grids for the X-33 Program Phase II, X-34, X-35, Hyper-X and PE vehicles consistent with the input requirements of AB flow analysis software; such grids shall be constructed with software that is compatible with that used by AB members. Flow codes currently used in the AB are LAURA, DPLUR, and TLNS3D. Structured grid generation within the AB is based on the ICEM, 3DMAGGS and 3DGRAPE/AL software.

Computational analysis for the Phase I X-33 Program required the generation of approximately 60 structured surface and volume grids of which one-third were for a complete configuration, one-third were partial grid constructions for control surface parametric studies and one-third were of a general nature. The grid generation requirements for the X-33 Phase II analysis are expected to be of similar magnitude. Requirements for other vehicles (X-34, X-35, Hyper-X and PE vehicles) are expected to be 20 grids.

Typically, surface definition is supplied in the form of a database grid by the government, it's contractors or industry. For surface defined by the AB, the contractor shall maintain a surface definition capability that is based on the ICEM software.

The contractor shall, as part of the grid generation process, insure that surface databases are consistent with the grid generation software being used in AB and that the structure of the databases will not degrade the quality of dependent volume grids.

Deliverables: The contractor shall deliver, in a single or multi block PLOT3D format, surface and volume grids to support aerothermodynamic analysis for the X-33 Phase II Program and the X-34, X-35, Hyper-X, and Planetary Mission Programs.

Metrics: Complete configuration volume grids shall be delivered in 2 weeks and partial volume grid constructions for parametric studies shall be delivered in 1 week after the contractor has access to the vehicle surface database.

DGx 02

ARTS Task Order

1. Task Order Number and Title **Number:** **Revision:**

Title:
Surface and Volume Grid Generation for Aerothermodynamic Analysis

3. Tasks, Deliverables and or Products, and performance measurements (continued):
The above metrics describe a minimum acceptable performance. To exceed minimum performance the contractor can, for example:

1) identify and implement procedures that produce a measurable decrease in the manpower and/or computer resources required to generate a grid,

2) create and implement software that produces a measurable decrease in the manpower and/or computer resources required to generate a grid.

4. Government Furnished Items:
The government will provide Silicon Graphics (SGI) hardware for grid generation work. In addition, the government will provide time on Cray mainframes on an as needed basis. The government will provide the ICEM software for surface definition and the construction of surface databases, the GRIDGEN software for surface grid generation and the 3DMAGGS and 3DGRAPE/AL software for the elliptic grid smoothing.

5. Other Information needed for performance of task.
The contractor should be aware that the AB does analysis for industry proprietary programs. All information concerning such programs must be handled with confidentiality and all deliverables, as defined in the above section 3, are the sole property of the customer.

6. Security clearance required for performance of work:
A secret level of security clearance is required for this task.

7. Period of Performance	
Planned start date: 7/1/96	Expected completion date: 6/30/97

8. NASA Technical Monitor:
K. James Weilmuenster
M/S: 408A
Phone: 804-864-4363

1. **Task Order Number:**	**Revision:**
Title: Hypersonic Airbreathing Propulsion Systems Analysis and Testing	

2. Scope and Objective of Work:

The Hypersonic Airbreathing Propulsion Branch (HAPB) of the Gas Dynamics Division (GDD) at NASA Langley Research Center performs research on the design, testing, and engineering data analysis of airbreathing engine flow paths for propulsion of trans-atmospheric hypersonic vehicles. These propulsion systems are intended to operate in the supersonic/hypersonic flight regime with combustor flows transitioning form subsonic to supersonic; hence they are referred to dual-mode scramjets. Critically important elements of this research include the testing of scramjet engine configurations and components in HAPB scramjet test facilities, the collection of appropriate data, and the evaluation of the scramjet component performance through engineering analysis of the data. In addition, the development of appropriate methods and processes to understand and interpret the experimental test data, to predict the ramjet/scramjet performance, and to extrapolate experimental data to flight performance is an important requirement.

The objectives of this task are:

1. The analysis of HAPB experimental scramjet data to obtain performance assessments of various engine flow path configurations.

2.- The building of and improvement to CFD codes describing the flow physics of a hypersonic vehicle and the propulsive flow path.

3. The application of computational codes to predict and analyze facility operation, scramjet performance, and engine flow path integration with a hypersonic vehicle.

The successful performance of this Task requires knowledge and experience in a variety of disciplines, including supersonic fluid dynamics, thermodynamics and combustion chemistry of gases, experimental techniques and scramjet test facility operation, computational fluid dynamic codes and their implementation on computer systems, and technical and mechanical operation of experimental apparatus in combustion laboratories.

The metrics for each Task describe the minimal acceptable performance. Actions by the contractor to exceed minimal performance are identified in the Task descriptions.

DGX04

1. Task Order Number: **Revision:**
continued

Title: Hypersonic Airbreathing Propulsion Systems Analysis and Testing

3. Work to be Performed:

3.1 . Analysis and Interpretation of Scramjet Data.

The contractor shall perform work to catalogue, analyze, and interpret experimental data from scramjet engine and component tests that have been and will continue to be acquired in HAPB ground test facilities. These facilities include the Arc-Heated Scramjet Test facility (AHSTF), the Combustion-Heated Scramjet Test Facility (CHSTF), the Direct-Connect Supersonic Combustion Test Facility (DCSCTF), the Eight-Foot High-Temperature Tunnel (8-Ft HTT). The contractor also may recommend test plans for scramjet engines in these facilities. In particular, the contractor shall:

1.- Maintain and modify as required, the LOOK computer code to provide data plots from any scramjet test program in the HAPB test facilities–AHSTF, CHSTF, DCSCTF, 8-Ft HTT– or from the Direct Connect Module (DCM) tests at GASL, Inc. In general, one major modification to the LOOK code is required per facility per year.

2.- Catalogue the data and maintain the database, including spreadsheets, data plots, pre-and post-run analyses, and notes for the Advanced Reusable Propulsion Technology (ARPT) engine. Post-run analysis includes immediate data screening to identify any improperly functioning instrumentation. The ARPT tests will require an expected 100 tests over a 6 month period.

3.- Provide full analysis of the data from the completed Concept Demonstration Engine (CDE), and the ARPT tests, including comparisons with existing data analyses for other engines. The expected outcomes of this Task are the timely and accurate calculation of the appropriate engineering parameters which quantify the scramjet flow path performance (such as inlet capture, kinetic energy efficiency, mixing and combustion efficiencies, and net force) and test facility operating conditions, and graphical presentation of the test results in a format suitable for assessment of the engine operation and performance.

Deliverables:

1.- The LOOK code modified appropriately for the scramjet engine model and test facility of each test program.

2.- Reports to NASA test engineer of any improperly functioning intrumentation (identified during post-run analysis) prior to next scheduled run.

3.- Cataloging of test data into engineering units and parameters with documented retrieval and access procedures for the ARPT engine test series.

4.- Post-test processing of data from the ARPT tests to obtain standard test performance parameters and graphical output to aid in test sequence development.

5.- Correlation of the ARPT scramjet performance parameters in a form suitable for comparison with other existing engine test results.

6.- Written reports of the data analyses for the CDE and ARPT tests, documenting the data analysis methods, engine performance, and details of the test facility operation.

Metrics: *(Describe minimal acceptable performance (MAP))*

1.- Availability of the modified LOOK code to HAPB staff one week before test series start.

2.- Cataloged test data accessible to HAPB staff without assistance.

3.- Post-test data processing within one day of access to the data set for each test.

4.- Test series reports (Deliverable 6) for the CDE delivered by August 30, 1996, and for ARPT within four (4) months of test completion.

To exceed MAP, the contractor can, for example: (1) develop and recommend engine test programs, including fuel injection, data sources, test sequences, and pre-test predictions, for tests of the Hyper-X vehicle in the 8-Ft HTT, the DFX model in the AHSTF, and the ARPT engine in either the CHSTF, DCSCTF, or the DCM; (2) suggest data analyses plans and additional measurements which enable a better assessment of engine performance; (3) create and implement improvements to the computer codes and data storage.

3.2 Performance of Hypersonic Propulsion Systems:

3.2.1 The contractor shall derive and use a common basis to compare the performance of the hydrogen-fueled subscale ramjet/scramjet engines and engine components tested to date in HAPB test facilities. In particular, data from tests of the following engine models shall be included:

In the HAPB Arc-Heated STF: 3-strut, Parametric, A, A1, A2, A2+, C, SX20, and SXPE;

In the HAPB Combustion -Heated STF: 3-strut, Parametric, Step-strut, A2, B1, C, and GBL

In the LaRC 8Ft HTT: CDE

Each data set includes measurements of facility operation, fuel supply and schedule, and model pressures, temperatures, and force balance readings at regular intervals during the facility operation. The contractor shall assemble and catalogue a definitive data set for each engine or component test series, including facility operation conditions, and establish an analysis methodology for the comparison of the performance of the configurations and test facilities. Scramjet performance is indicated by engineering quantities such as inlet mass capture, inlet kinetic energy efficiency, fuel mixing and combustion efficiencies, net thrust, and fuel specific impulse. The expected outcome of this Task is a definitive comparison of the operation and performance of the various scramjet engines through the establishment of a database, over the flight regime simulated by the test facilities, which includes the effect of ground test facility operation, engine model scale, and fuel injection configuration, and from which a performance ranking of the engine configurations can be made.

Deliverables:

1.- Technical report (NASA Contractor's) which documents the results of the NASA Parametric engine tests in the AHSTF and CHSTF to study effects of facility flow distortion and test gas composition.

2.- Documentation of the assembled and cataloged database for each engine test, which describes the data selection process.

3.- Written documentation describing the analysis methodology developed for the performance comparisons and the justification of the procedure.

4.- Technical report (NASA Contractor's) which documents the analysis and performance comparison results, and which includes a "goodness" ranking of the various emgine configurations.

5.- Quarterly reports on the status of the Task.

Metrics: *(Describe minimal acceptable performance (MAP))*

1.- Completion of report (#1) on NASA Parametric engine for review by October 1, 1996, with final delivery by December 31, 1996.

2.- Delivery of technical report (#4) on the method and comparative results by June 1, 1997.

3.- Database includes at least three (3) definitive data sets for each model test series.

To exceed MAP, the contractor can, for example, provide further analysis (analytical or numerical) to relate scramjet performance in the vitiated flows to that in real air (flight).

3.2 Performance of Hypersonic Propulsion Systems:

3.2.2 The contractor shall develop and improve analytical methods, procedures, and tools for the computation of the propulsive performance of hydrogen and hydrocarbon fueled ramjet and scramjet flow paths, for use in pre-test predictive, post-test data interpretation, and the rational extrapolation from ground test data to flight. The Contractor shall justify the method/procedure using data from HAPB engine component tests and apply the method to the Hyper-X vehicle engine flow path. The expected outcomes of this Task are the improvement of scramjet engine cycle analysis methods for assessing performance, and an analytical computational tool for scramjet flow path prediction.

Deliverables:

1.- A scramjet cycle analysis method which accounts for and includes losses and flow distortion due to viscosity, heat addition, and shocks.

2.- Formal documentation of the scramjet engine cycle procedure for hydrogen and hydrocarbon fueled engines.

3.- Results from the application of the cycle method to the Hyper-X vehicle engine flow path.

4.- Transfer of the analytical tools usage capability to other users.

Metrics: *(Describe minimal acceptable performance (MAP))*

1.- Demonstrated results and ease of application superior to standard cycle analysis methods.

2.- Delivery of documentation on June 1, 1997.

3.- Availability of Hyper-X vehicle engine flow path analyses to aid in test-plan definition.

4.- Availability of the distortion-based cycle analysis procedure for hydrocarbon fueled engines by January 31, 1997.

To exceed MAP, the contractor can, for example, compare the cycle new method with other cycle analysis methods and document the differences--advantages, disadvantages. Apply the new methodology to compare engine configurations at several conditions over the speed range.

3.3. Computational Fluid Dynamics of Hypersonic Propulsion Systems and Facilities

3.3.1 The contractor shall apply existing Computational Fluid Dynamics (CFD) codes to analyze the flow field physics of the propulsive flow path of the hypersonic vehicle configuration of the Hyper-X program, from which the performance of the fully integrated (tip-to-tail) vehicle can be quantified. In performing these analyses, the contractor shall make modifications or enhancements to the CFD codes as necessary to obtain the performance parameters of interest or adapt the code to a particular flow path configuration. The expected outcomes of this subtask are the establishment of methods for defining integrated performance and the scaling of experimental flow path data to flight conditions.

Deliverables:

1.-Establishment and documentation of a database containing the current capabilities of ground tests and CFD to predict flight performance.

2.- An assessment of the critical differences in performance observed between small, middle, and full scale hypersonic airbreathing vehicle configurations.

3.- Documentation and implementation of new or improved methods or procedures for extrapolating vehicle flight performance from subscale ground test data.

Metrics: *(Describe minimal acceptable performance (MAP))*

1.- Establishment of current capabilities by September 30, 1996.

2.- Results of scaling assessment documented by December 31, 1996.

3.- Flight scaling methods documented by June 1, 1997.

To exceed MAP, the contractor can, for example, (1) provide suggestions on vehicle testing to aid in the planning; or (2) implement code and analysis improvements.

1. Task Order Number: *continued*	**Revision:**
Title: Hypersonic Airbreathing Propulsion Systems Analysis and Testing	

3.3. Computational Fluid Dynamics of Hypersonic Propulsion Systems and Facilities:

3.3.2 The contractor shall develop, improve, and apply CFD codes for analyzing the flow physics of hypersonic airbreathing propulsive flow paths and hypervelocity shock-expansion and reflected shock tunnels (SET & RST). The expected outcomes of this subtask are the continued development of the CFD code LARCK to include state-of-the-art turbulence and turbulence-chemistry models, codes for the prediction and flow physics analysis of pulse facility operation and scramjet components, and the application of these codes to specific problems.

Deliverables:

1.-The LARCK code with improved turbulence and chemistry models.

2.- Analysis of the Hyper-X scramjet propulsive flow path with the LARCK code at Mach 7 and 10 flight conditions.

3.- Complete and documented LARCK code analysis of the ramp fuel injectors in the CDE tests.

4.- Development of a computer code and its application to the detailed analysis and prediction of unsteady and combusting flows in the NASA HYPULSE facility in both SET and RST operation mode.

5.- Development and documented application of an analytically based code, which is executable on a workstation (or PC), describing the flow in a pulse facility.

Metrics: *(Describe minimal acceptable performance (MAP))*

1.- LARCK code improvements by September 30, 1996.

2.- Completion of the Hyper-X flow path studies at Mach 7 by January 31, and Mach 10 by June 30, 1997.

3.- Documented analysis of the CDE ramp data by December 31, 1996.

4.- Analysis of pulse facility flow processes and operation by October 31, 1996

To exceed MAP, the contractor can, for example, provide (1) analyses of the HYPULSE operation for detonation drive mode of operation; (2) support for the analytical modeling of the HAPB PISTL shock tube.

1. Task Order Number: *continued*	**Revision:**
Title: Hypersonic Airbreathing Propulsion Systems Analysis and Testing	

3.4 Fundamental Combustion Studies Laboratory Operation

The contractor shall provide the technical services and operational support for the operation of and data collection in the HAPB Fundamental Combustion Studies Laboratories, which includes the High-Speed Combustion Lab, the Nonintrusive Diagnostics Lab, and the CARS/PDV Lab in Building 1221C. The expected outcome of this Task is orderly and safe operation of combustion apparatus to meet the research needs of combustion and measurement systems studies in HAPB.

Deliverables:

1.- Configure and modify existing data acquisition systems to support laser-based diagnostic development and testing in all labs.

2.- The fabrication or modification of small mechanical, electrical, or electronic components for use in the combustion and diagnostic labs.

3.- Assembly, modification, and operation of gaseous flow apparatus to supply the combustion lab burners.

Metrics: *(Describe minimal acceptable performance (MAP))*

1.- Operation of the laboratories and fluid systems in a safe and efficient manner in compliance with NASA Safety Regulations.

2.- Timely and efficient operation of the various labs to meet test schedules.

1. Task Order Number: *continued*	Revision:
Title: **Hypersonic Airbreathing Propulsion Systems Analysis and Testing**	

4. Government Furnished Items:

The Government shall make available to the Contractor the following equipment and items:

1.- Data acquired in scramjet engine and component tests and the operating conditions of NASA facilities.

2.- Access to the HAPB Fundamental Combustion Laboratories in Bldg. 1221C.

3.- Access to and accounts on NASA and LaRC computer systems, including the HAPB distributed UNIX network (hyp00, hyp01), LaRC SNS system (Sabre, Borg, etc.), the NAS system at Ames RC (vonNeuman), and the NASA ACSF system at Ames RC (Eagle), and secure computing environments at LaRC (Thunderbolt) and in HAPB (Secure1).

4.- Design details and the propulsive flow path lines of the NASA Hyper-X and ARPT configurations as needed.

5.- Access to NASA pulse facilities and operational attributes.

5. Other information needed for performance of task.

Task 3.1 : One 3-day trip to a Technical Conference

Task 3.2 : One 3-day trip to St. Louis, MO to participate in meetings about Hyper-X.
One 4-day trip to Technical Conference.

Task 3.3 : One 4-day trip to Technical Conference on west coast.

Task 3.4 : none

6. Security clearance required for performance of work:

Certain work done under this Task Order will expose the contractor to classified or sensitive material which falls under ITAR control. Therefore, the contractor shall be a US citizen and possess a security clearance level to SECRET.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor:

R. Wayne Guy

M/S: 168 Phone: 804-864-6272

e-mail: r.w.guy@larc Fax: 4-6243

ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title Number: Revision:
   Title: Model Closed-Loop Aircraft Flight Conrol Computer Operation

2. Purpose, Objective or Background of Work to be Performed:
   Modeling and analysis of the unfaulted EUT is conducted to establish a reference for correct operation for the real-time distributed control function monitor. Models include the control law calculations, input/output selection process, and redundancy management strategy. Modeling and analysis of EUT failure modes that occur during testing is performed and used to assess the effects on closed-loop system safety, performance, and reliability. In addition, characterizing failure modes of the EUT can lead to design strategies for fault containment, accommodation, and recovery as well as improved fault tolerance of the basic design.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

1. The contractor shall provide state-space models of the B737 Autoland control laws as implemented in the AlliedSignal Flight Control Computer.

Deliverable: State-space models of the B737 Autoland control laws as implemented in the AlliedSignal Flight Control Computer.

Schedule: Models shall be delivered by 10/96.

Metrics: (Satisfactory Effort) All models shall produce outputs that are within 10% of the measured control commands obtained from the AlliedSignal Flight Control Computer.
(Exceeds) All models shall produce outputs that are within 5% of the measured control commands obtained from the AlliedSignal Flight Control Computer.

2. The contractor shall provide state-space models of the B757 control laws as implemented in the IOG B757 simulation code.

Deliverable: State-space models of the B757 control laws as implemented in the IOG B757 simulation code.

Schedule: Models shall be delivered by 1/97.

Metrics: (Satisfactory Effort) All models shall produce outputs that are within 10% of the control commands obtained from the IOG B757 simulation code.
(Exceeds) All models shall produce outputs that are within 5% of the control commands obtained from the IOG B757 simulation code.

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1. Task Order Number and Title	Number:	Revision:
Title: Model Closed-Loop Aircraft Flight Conrol Computer Operation		

3. Tasks, Deliverables and or Products, and performance measurements (continued):

3. The contractor shall provide state-space models of the B757 control laws as implemented in the Fly-By-Light (FBL) subsystem control computer.

<u>Deliverable</u>: State-space models of the B757 control laws as implemented in the IOG B757 simulation code.

<u>Schedule</u>: Models shall be delivered by 1/97.

<u>Metrics</u>: (Satisfactory Effort) All models shall produce outputs that are within 10% of the measured control commands obtained from the FBL subsystem control computer.
(Exceeds) All models shall produce outputs that are within 5% of the measured control commands obtained from the FBL subsystem control computer.

4. The contractor shall provide by 7/97 state-space models of the control law calculations measured from the Fly-By-Light (FBL) subsystem control computer during upset testing.

<u>Deliverable</u>: State-space models of the B757 control law calculations measured from the Fly-By-Light (FBL) subsystem control computer during upset testing.

<u>Schedule</u>: Models shall be delivered by 7/97.

<u>Metrics</u>: (Satisfactory Effort) All models shall produce outputs that are within 10% of the measured control commands obtained from the FBL subsystem control computer during testing.
(Exceeds) All models shall produce outputs that are within 5% of the measured control commands obtained from the FBL subsystem control computer during testing.

4. Government Furnished Items:

Desk-Top Workstations and software will be made available to the contractor to enable fulfillment of contract objectives. These items will remain the property of NASA LaRC and will be used solely for the purposes outlined in this task order. All work shall be performed in NASA Langley Building 1220 on a non-interference basis.

5. Other information needed for performance of task.

Text books, technical reports, and papers will be made available to the contractor to enable fulfillment of contract objectives. These items will remain the property of NASA LaRC and will be used solely for the purposes outlined in this task order.

6. Security clearance required for performance of work:
Security clearance is not required.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Celeste M. Belcastro	
M/S: 130	Phone: 804-864-6182

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ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title Title: Compound Semiconductor Growth in Space	Number:	Revision:

2. Purpose, Objective or Background of Work to be Performed:

The Microgravity Science Team within the Sensors Research Branch, FETD, recently completed a compound semiconductor growth experiment on the Space Shuttle and is preparing for an additional shuttle experiment in late 1997.

During the 12-month period of July 1996 to June 1997, this team must complete analysis of its present sample, learn from the past experiment, design the new experiment, perform additional calibration of and testing in the flight prototype furnace, and prepare for flight operations in the Payload Operations Control Center (POCC) at the Marshall Space Flight Center.

PRINTED: 6/6/96

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

1. Sample Analysis

The contractor shall provide material analysis of both the flight sample and Earth-based test growths. These analyses shall include x-ray diffraction, x-ray and gamma- ray absorption and tomography views, electron microprobe analysis, grain boundary delineation via chemical etching, and optical microscopy.

Deliverables: Photographs of Laue x-ray plots, film of radiographic data, plots of composition vs. position of microprobe data, photographs of etched samples, and photomicrographs of the sample. All deliverables due by June 30, 1997.

Minimum acceptable performance:
One set of the deliverables for the flight sample.

Exceeds minimum acceptable performance:
Sufficient data to determine effects of microgravity on the growth of these crystals, coupled with recommendations for further analysis.

2. Sample Preparation and Furnace Analysis

The contractor shall prepare samples for both Earth-based tests and the subsequent flight test. This preparation shall include material synthesis, ampoule preparation, vacuum system work for both ampoules and materials, and packaging. The contractor shall also maintain, calibrate and operate the Earth based furnaces and perform tests in the flight furnace.

Deliverables: Packaged samples for both Earth-based tests and the flight experiment. Calibration curves for the furnaces involved in the experiments. All deliverables due by June 30, 1997.

Minimum acceptable performance:
Three Earth-based samples and one flight sample with accompanying furnace calibration curves.

Exceeds minimum acceptable performance:
Six Earth-based samples and three flight samples with accompanying furnace calibration curves.

4. Government Furnished Items:

Computer equipment, hardware, software and equipment associated with the Microgravity function will be made available to the contractor to enable fulfillment of contract objectives. These items will remain the property of NASA LaRC and will be used solely for the purposes outlined in this task order. All work shall be performed in NASA Langley Buildings 1202 and 1299 on a non-interference basis.

5. Other information needed for performance of task.

Three 1-week trips to MSFC.

Three 1-week trips to KSC.

6. Security clearance required for performance of work:

None.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Archibald L. Fripp
.M/S: 473 Phone: 804-864- 1503

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ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title	Number:	Revision:
Title: Low Visibility Landing and Surface Operations Flight Test Support		

2. Purpose, Objective or Background of Work to be Performed:
This research is conducted under the Terminal Area Productivity (TAP) Low Visibility Landing and Surface Operations (LVLASO) program whose objective is to safely achieve clear weather airport capacity in instrument weather conditions. As part of this program, a series of flight tests will occur which demonstrate an integration of surface automation technologies. The tests include an integration of ground based and airborne systems. This task order focuses on the airborne systems which include real-time display software and interfaces between flight hardware.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

1. The contractor shall develop a software architecture to support the integration of conceptual prototypes of flight deck displays for the LVLASO flight test project.

The contractor shall integrate, into this architecture, software modules being developed including:
(1) A 3-D audio system
(2) A Roll-Out-Turn-Off guidance system
(3) A taxi navigation and situation awareness system

The contractor shall test and validate the above in the Transport Systems Research Vehicle (TSRV) simulator, Research System Integration Laboratory (RSIL), and 757 aircraft.

The contractor shall document all delivered software products.

<u>Deliverables</u>: Validated software system prior to scheduled Atlanta flight demonstration currently planned for 5/97. Documentation 7/97. Slips in the flight schedule due to unforeseen circumstances will also slip this delivery schedule accordingly.

<u>Metrics</u>:
Minimum acceptable:
- All deliverables submitted by due date.
- System performs all required functions.

Exceeds minimum performance:
- Expedited delivery of deliverables.
- Enhanced functionality
- Enhanced system performance
- System independence with respect to airport and platform.

2. The contractor shall develop and implement the required interfaces to the LVLASO flight test computers. These interfaces include communicating with the digital datalinks onboard the aircraft, the flight deck displays, the 3-D audio components, the pilot input device, and the flight management system. Inter-computer communication must also be supported.

The contractor shall also develop data storage routines to execute on the flight computers during testing.

The contractor shall test and validate the above in the TSRV simulator, RSIL, and 757 aircraft.

The contractor shall document all delivered software products as well as the I/O architecture.

Deliverables: Validated I/O system prior to scheduled Atlanta flight demonstration currently planned for 5/97. Documentation 7/97. Slips in the flight schedule due to unforeseen circumstances will also slip this delivery schedule accordingly.

Metrics:
Minimum acceptable:
- All deliverables submitted by due date.
- System performs all required functions.

Exceeds minimum performance:
- Expedited deliverables schedule.
- Enhanced functionality
- Enhanced system performance

3. The contractor shall create Head-Up Display (HUD) graphics software to implement ROTO guidance displays (as specified by NASA engineers) which will serve both ROTO simulation studies and the Atlanta flight demonstration.

Deliverables: Validated graphics software for both actual and simulated ROTO HUDs prior to scheduled Atlanta flight demonstration currently planned for 5/97. Slips in the flight schedule due to unforeseen circumstances will also slip this delivery schedule accordingly.

Metrics:
Minimum acceptable:
- All deliverables submitted by due date
- Code readability acceptable.
- Software performance acceptable.

Exceeds minimum performance:
- Expedited deliverables schedule
- Enhanced software performance
- Enhanced functionality

4. The contractor shall integrate HUD approach guidance (as specified by NASA engineers) into the LVLASO flight test software architecture. The contractor will be supplied with stand-alone Flight Dynamics HUD software for a Silicon Graphics Incorporated (SGI) computer.

The contractor shall test and validate the above in the TSRV simulator, RSIL, and 757 aircraft.

The contractor shall document all delivered software products.

Deliverables: Validated software for both actual and simulated ROTO HUDs prior to scheduled Atlanta flight demonstration currently planned for 5/97. Documentation 7/97. Slips in the flight schedule due to unforeseen circumstances will also slip this delivery schedule accordingly.

Metrics:
Minimum acceptable:
- All deliverables submitted by due date
- Code readability acceptable
- Software performance acceptable

Exceeds minimum performance:
- Expedited deliverables schedule
- Enhanced software performance
- Enhanced functionality

4. Government Furnished Items:

Computer equipment, hardware, software, and equipment associated with the SIB computer laboratory, TSRV simulator, RSIL, and 757 aircraft and desk-top workstations will be made available to the contractor to enable fulfillment of contract objectives. These items will remain the property of NASA LaRC and will be used solely for the purposes outlined in this task order. All work is to be performed in NASA Langley building 1220, the above laboratories, and the 757 aircraft on a non-interference basis.

5. Other information needed for performance of task.

Manual, schematics, technical reports, and papers will be made available to the contractor to enable fulfillment of contract objectives. These items will remain the property of NASA LaRC and will be used solely for the purposes outlined in this task.
Essential travel is required for tasks 1 and 2 above to support flight testing at the Hartsfield Atlanta International Airport. Minimum of three one-week trips required. More trips may be necessary but for shorter durations.

6. Security clearance required for performance of work:

Security clearance is not required.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor:	Steven D. Young	Denise R. Jones
M/S: 152D	Phone: 804-864-1709	804-864-2006

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ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title | Number: | Revision:

Title: Implement Monitor for Aircraft Flight Control Computer Functional Anomaly Detection

2. Purpose, Objective or Background of Work to be Performed:

Research conducted under the Flight Crucial Systems program and the Advanced Subsonic Technology Fly-By-Light/Power-By-Wire (FBL/PBW) program requires an analytical and experimental environment to conduct fault tolerance assessments of critical flight computers in the context of system functionality. This research will lead directly to processes for certification compliance demonstrations of complex integrated critical systems to requirements for operation in electromagnetic environments (EME), such as lightning and High Intensity Radiated Fields, and to requirements for fault containment that would ensure continued safe flight and landing of commercial aircraft. Fundamental to this research is the ability to monitor the Equipment Under Test (EUT) in real-time for anomalies in sub-system functions such as control law calculations, redundancy management, and input/output rate and range checks. This enables degradation in performance and/or reliability to be detected in real time during the tests.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

1. The contractor shall implement mathematical algorithms in C code for detecting functional anomalies in the throttle and elevator control law calculations that correspond to values generated by Sperry FORTRAN code of the Linear 737 Autoland Simulation for AIRLABS.

Deliverable: Implementation in C code of mathematical algorithms for detecting functional anomalies in the B737 Autoland throttle and elevator control law calculations.

Schedule: Implementation shall be completed by 9/96.

Metrics: (Satisfactory Effort) Calculated probabilities of false alarm and missed detection for the C code implementation shall be within 10% of the corresponding values generated in MATLAB code.

(Exceeds) Calculated probabilities of false alarm and missed detection for the C code implementation shall be within 5% of the corresponding values generated in MATLAB code.

2. The contractor shall implement real-time C code algorithms for detecting functional anomalies in the B737 Autoland control law calculations of the AlliedSignal Flight Control Computer.

Deliverables: Real-time C code implementation of algorithms for detecting functional anomalies in the B737 Autoland control law calculations of the AlliedSignal Flight Control Computer.

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H. P. HANEY

3. Tasks, Deliverables and or Products, and performance measurements (continued):

2. (continued)

Schedule: Implementation shall be completed by 11/96.

Metrics: (Satisfactory Effort) Calculation time for each data frame shall be 50 ms for compatibility with the AlliedSignal Flight Control Computer.
(Exceeds) Calculation time for each data frame shall be less than 50 ms for compatibility with the AlliedSignal Flight Control Computer.

3. The contractor shall implement real-time C code algorithms for detecting functional anomalies in the control law calculations of the B757 FBL subsystem control computer.

Deliverables: Real-time C code implementation of algorithms for detecting functional anomalies in the control law calculations of the B757 FBL subsystem control computer.

Schedule: Implementation shall be completed by 12/96

Metrics: (Satisfactory Effort) Calculation time for each data frame shall equal the control cycle data frame of the FBL subsystem control computer.
(Exceeds) Calculation time for each data frame shall be less than the control cycle data frame of the FBL subsystem control computer.

4. The contractor shall perform tests of the real-time C code algorithms for detecting functional anomalies in the control law calculations of the B757 FBL subsystem control computer to empirically determine probabilities of false alarm and missed detection.

Deliverables: Results of tests to determine probabilities of false alarm and missed detection of the real-time C code algorithms for detecting functional anomalies in the control law calculations of the B757 FBL subsystem control computer.

Schedule: Results to be delivered by 2/97.

4. (continued)

Metrics: (Satisfactory Effort) Empirically determined probabilities of false alarm and missed detection are within 10% of calculated values.
(Exceeds) Empirically determined probabilities of false alarm and missed detection are within 5% of calculated values.

5. The contractor shall implement by 7/97 mathematical algorithms in real-time C code for detecting functional anomalies in the control law calculations of the Honeywell Recoverable Flight Control Computer.

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Deliverables: Real-time C code implementation of algorithms for detecting functional anomalies in the control law calculations of the Honeywell Recoverable Flight Control Computer.

Schedule: Implementation shall be completed by 7/97.

Metrics: (Satisfactory Effort) Calculation time for each data frame shall equal the control cycle data frame of the Honeywell Recoverable Flight Control Computer.
(Exceeds) Calculation time for each data frame shall be less than the control cycle data frame of the Honeywell Recoverable Flight Control Computer.

4. Government Furnished Items:

Computer equipment, hardware, software, and equipment associated with the Closed-Loop Test Laboratory and a Desk-Top Workstation will be made available to the contractor to enable fulfillment of contract objectives. These items will remain the property of NASA LaRC and will be used solely for the purposes outlined in this task order. All work is to be performed in NASA Langley Building 1220 on a non-interference basis.

5. Other information needed for performance of task.
Manuals, schematics, technical reports, and papers will be made available to the contractor to enable fulfillment of contract objectives. These items will remain the property of NASA LaRC and will be used solely for the purposes outlined in this task order.

6. Security clearance required for performance of work:

Security clearance is not required. However, contractor will be subject to the limited data rights and proprietary information restrictions of the High-Speed Research contract relative to Task item 5.

(HSR Contract COTR: Mike Lewis, 47655)

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Celeste M. Belcastro
M/S: 130 Phone: 804-864-6182

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ART (NAS1-96014) Task Order Page 1

1. **Task Order Number and Title** **Number:** **Revision:**

   Title: High Speed Research Air-to-Air Multi-target Tracking Radar Assessment and Flight Evaluation.

2. **Purpose, Objective or Background of Work to be Performed:**
   The Sensors Research Branch has the responsibility for the development, assessment, and flight evaluation of X-Band Air-to-Air Multi-target Tracking (AAMT) Radar sensor in support of the High Speed Research eXternal Vision Systems (HSR-XVS). The purpose of this task is to provide technical and software support for the computer simulation assessment and flight evaluation of AAMT radar. The contractor shall provide software modifications to existing analysis, visualization, and simulation tools; perform test case computer simulation runs for the assessment of AAMT radar performance; and download, process, and archive AAMT radar flight data. The contractor shall also develop the flight test plans for the flight evaluation of AAMT radar during the HSR flight experiment scheduled between Dec 1996 and April 1997. Approximately 10 separate flight test experiments will be conducted during this time period.

3. **Description of the Work to be Performed**
   1. The contractor shall maintain the operation of the Integrated Electromagnetic Sensor Simulation (IESS) software which is implemented as a Ptolemy application. This software, which is presently under development and modification, is in its Alpha stage. The Beta version is to be completed by Oct 1, 1996, and Version 1 by June 1997. The contractors work includes incorporating software modifications to the existing implementation, and maintaining proper file organization and configuration control. The contractor shall track IESS changes by developers and incorporate/merge changes into a locally maintained version. Hyper Text Markup Language (HTML) shall be used for software and user manual documentation, and updated as needed to reflect the changing IESS configuration environment.

      Deliverable: Brief memos documenting the IESS configuration changes.
      Schedule: End of each month.
      Metric: Timely and accurate reports on the IESS configuration. Proper and accurate operation of IESS.
      Meets: The contractor provides efficient control and operation of the locally maintained IESS configuration, accurately reports on the IESS configuration, and identifies problems that may arise in its operation.
      Exceeds: Provides timely helpful consulting support to users of the IESS software. Reports software deficiencies, makes recommendations for solutions, and provides methods for improving the operation of the IESS environment.

PRINTED: 6/6/96

3. **Tasks, Deliverables and or Products, and performance measurements (continued):**

2. The contractor shall conduct case study simulation runs of AAMT radar utilizing the IESS/ Ptolemy environment. The contractor shall connect the various stars(modules)of Ptolemy to simulate the specified AAMT configuration and specify the operating parameters in the simulation. Specifications and requirements of AAMT configuration designs to be simulated will be provided by the HSR RF-Sensor Team principle investigator. The contractor shall generate visualization displays which illustrate the results obtained from each case run.

Deliverable:	Case run results documented in form of tables, plots and brief description of results.
Schedule:	Initial case runs Sept 30, 1996; Follow-on cases Dec 31, 1996 and April 30, 1997. Preliminary interim results prior to these delivery dates.
Metric:	Timely delivery of case study results and documentation.
Meets:	Provides results of case study simulations on time with suitable tables, plots, and descriptive information to clearly illustrate test results.
Exceeds:	Performs additional analysis and case studies runs to help provide greater insight into optimum AAMT design. Incorporates case study results into Informix database.

3. The contractor shall develop flight test plan documentation for the AAMT radar to be flown on the NASA 737 between DEC 1996 and April 1997. The contractor shall interface with the HSR flight test director and attend scheduled flight planning meetings to coordinate the AAMT experiment requirements. The contractor shall obtain inputs from the HSR RF-Sensor Team principle investigator for the flights, defining test scenarios, time lines, multiple A/C flight paths, radar configuration control, etc. The contractor shall be required to coordinate the operation of the radar with the test conductor, and to log notes during the flight experiments.

Deliverable:	Flight test plan documentation.
Schedule:	Draft Document for review, Oct 1996. Final Document, Nov., 1996.
Metric:	Timely and accurate delivery of test plan, and accurate coordination of flight planning and testing.
Meets:	Delivers clearly organized, well documented test plan on time. Provides accurate and timely coordination of flight plan activities.
Exceeds:	Develops detailed multi-aircraft flight scenario designs and descriptions, including plots showing radar line of sight range and Az/El angle variation during target aircraft approaches.

3. Tasks, Deliverables and or Products, and performance measurements (continued):

4. The contractor shall provide software modifications and system integration for the collection, downloading, and processing of flight experimental radar data. The contractor shall download radar data, stored during experiment flights on high capacity hard drives, to 8 mm DOS tapes. The tapes shall than be copied to high capacity UNIX work station hard drives. From the hard drives the contractor shall then archive the data to 8 mm TAR tapes. All data files shall also be copied to CD-ROMs. Multiple CD-ROM copies of all data files shall be made for data distribution. Each days flight experiments can produce about 5-10 Gigabytes of raw radar data. Each data file contains about 200 to 900 Mbytes of data. The contractor shall catalog information on all data run files, and incorporate the information into an Informix database. The database shall include flight log entries, processing status, radar parameters such as operating mode, antenna scan type, data run scenario, etc., and other pertinent information.

Deliverable: Downloaded flight radar data to archived tapes and CD-ROMs. Tables and brief catalog report of the processed data files.
Schedule: Tapes, CD-ROMs, and catalog report 4 weeks after each flight test.
Metric: Timely and accurate delivery of processed data and catalog reports.
Meets: Completes, within 4 weeks after each flight, the data downloading, cataloging, archiving on tapes and CD-ROMs, and incorporates catalog information into Informix database.
Exceeds: Completes required data downloading and documentation within 2 weeks after each flight.

4. Government Furnished Items:

Sun SparkStation containing the IESS/Ptolemy software. 737 Aircraft with AAMT radar installed. Sun SparkStation and PC computers, software, Informix database, and tape drives for downloading, processing, and cataloging the AAMT radar flight data files.

5. Other information needed for performance of task.

A/C flights will originate from LaRC so travel is not usually necessary. However, 2 one day trips to Wallops Island may be needed.

6. Security clearance required for performance of work:

All work will be unclassified however personnel will be required to attest to the HSR LERD agreement.

7. Period of Performance

Planned start date: July 1,1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Emedio M. Bracalente
.M/S: 473 Phone: 804-864-1810

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ART (NAS1-96014) Task Order

1. Task Order Number and Title Number: Revision:

Title: Formal Verification of Avionics Partitioning

2. Purpose, Objective or Background of Work to be Performed:

There is a major move in the commercial aviation industry to move away from federated computer architectures to integrated architectures where multiple applications reside on a single Avionics Computer Resource (ACR). The airlines believe that the ACR concept will lead to a significant cost savings. However, the ACR concept also introduces an unprecedented level of complexity in the operating systems of these embedded computer systems and will require a significant change in the certification process used by the FAA.

NASA Langley and the FAA are currently working together to apply formal methods to the design and verification of an Avionics Computer Resource (ACR). It is essential that rigorous mathematically-verified approaches (i.e., formal methods) to partitioning be developed that can guarantee that partitioning between different applications is maintained despite a sharing of resources. These formal methods will provide the foundation for a credible basis of validation and certification.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

The contractor shall investigate the problem of establishing partitioning and noninterference in Avionics Computing Resource (ACR)architectures. The contractor shall create a mathematically-based (formal) model for assuring logical noninterference of separate applications running on an ACR where explicit resource sharing among applications is necessary or desirable.

The contractor shall develop access rules and protocols that are sufficient to ensure logical noninterference even when resourcesharing is conducted in an interleaved fashion. General classes of rules or protocols shall be identified for common avionics applications and a formalized notion of interference-free sharing shall be derived. The contractor shall prove that all invented models methods are guaranteed to provide safe sharing of resources.

A demonstration of the contractor-developed theories and methods shall be constructed for typical cases and be compatible with the Prototype Verification System (PVS) formal specification language and tools, the formal specification language used in the Assessment Technology Branch. The work shall be complementary to other partitioning methods envisioned under the industry-wide ACR movement.

The contractor shall produce a final report detailing the methods developed and demonstrations undertaken. The contractor shall also deliver all formal models, specifications, and proofs constructed during the investigation.

Deliverables

1. Formal models of partitioning specified in a PVS-compatible Language.
2. Formal specifications of designs used in the demonstrations and the transcripts of the formal proofs of the designs.
3. A final report documenting the formal models and the demonstrations. Draft due June 1, 1997. Final due June 30, 1997.

Metric

Minimum performance: Development of a formal model with a single demonstration example. The models and proofs pass all of the PVS proof-chain analysis tests.

The final report is well-written and complete.

Exceeds Minimum: The models are fully definitional with no axioms. The model is demonstrated on two or more typical designs. The models and proofs pass all of the PVS proof-chain analysis tests.

The final report is exceptually well-written, complete, and useful to both formal methods experts and design engineers.

4. Government Furnished Items:

SPARCstation 20

5. Other information needed for performance of task.

Travel Requirements

1. Four trips to Washington, DC to attend RTCA SC-182 meetings.
2. Two domestic trips to attend technical conferences.
3. Two domestic trips to attend technical interchange meetings with industry teams and research partners.

Applicable Documents:

PVS Specification Language: available at

http://www.csl.sri.com/trlist.html

6. Security clearance required for performance of work:

None

7. Period of Performance

Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Ricky W. Butler
.M/S: 130 Phone: 804-864- 6198

1. Task Order Number and Title	Number:	Revision:
Title: Electromagnetics Research		

2.Purpose, Objective or Background of Work to be Performed:
The Contractor shall perform hardware modifications, software maintenance and enhancements, data reduction, computational model development and analysis for the High Intensity Radiation Laboratory (HIRL). The contractor shall configure and integrate existing resources to accommodate the diverse requirements of various experiments conducted in the HIRL. The contractor shall develop a data base in which to store data pertinent to these activities. Reports and presentations shall be generated periodically.

3. DESCRIPTION OF WORK TO BE PERFORMED

3.1. Contractor shall develop a Radio Frequency (RF) Switch Matrix to route signals to various equipment in the HIRL. The RF Switch Matrix shall be built according to government-furnished design with government-furnished hardware components. Software shall be developed to control the Switch Matrix and communicate with existing RF equipment in the HIRL. The software shall monitor and provide status information on the functional state of the switch matrix. The switch matrix shall be integrated with existing equipment in the HIRL.

Deliverables: RF Switch Matrix, RF Switch Matrix Software by April 1, 1997.

Minimum Performance Standards: RF Switch Matrix integrated into HIRL with manual and computer control.

Exceed Performance Standards: RF Switch Matrix software control integrated with additional control software.

3.2. Contractor shall make modifications to the Gigahertz Transverse Electromagnetic (GTEM) cell based on government-supplied performance data. This task includes installation of mechanical and electrical components in the GTEM as well as structural modifications. All components and resources shall be furnished by the government. Contractor shall develop instrument control and data acquisition software for GTEM performance analysis.

Deliverables: GTEM Hardware Modifications, Data Acquisition Software by June 1, 1997.

Minimum Performance Standards: Modifications and data acquisition software completed in accordance with test schedule requirements (available from the Technical Monitor) to facilitate performance analysis.

1. Task Order Number and Title	Number:	Revision:
Title: Electromagnetics Research		

Exceed Performance Standards: Recommend and implement cost effective GTEM hardware and software modifications.

3.3. Contractor shall design and fabricate display panel for government-furnished RF amplifiers. Amplifiers shall be installed into existing HIRL amplifier room and integrated with existing RF equipment. Software shall be developed to control the RF amplifiers and communicate and monitor and provide status information on the functional state of the RF amplifiers.

Deliverables: RF Power Amplifier Interface and Control Software by September 1, 1996.

Minimum Performance Standards: RF Amplifiers integrated into HIRL with manual and computer control.

Exceed Performance Standards: RF Amplifier control software integrated with additional instrument control software.

3.4. The Contractor shall design and develop mechanical, electrical, and electronic interfaces and components for experimental Devices Under Test (DUTs) in the HIRL. This shall facilitate instrument control, data acquisition, and DUT monitoring while in the High Intensity Radiated Fields (HIRF) environment.

The Contractor shall design and implement instrument control and data acquisition software for the conduct of HIRL experiments. The experiments shall be compliant with electromagnetic immunity test procedures specified in RTCA/DO-160D, SAE-AE4R, and emerging related EMI/EMC standards. The software shall include user interface and visualization methods, data acquisition codes, experiment automation codes, enhancement to existing codes, code maintenance, software data analysis methods, and cross platform porting.

Deliverables: Mechanical, Electrical, and Electronic interface to HIRL experiments, Data Acquisition and Instrument Control Software.

Minimum Performance Standards: Experiment interface software and hardware functional at inception of any scheduled HIRL tests. Test schedule to be provided by Technical Monitor 2 weeks before test inception.

Exceed Performance Standards: Recommend and implement time saving modifications to test procedures.

1. Task Order Number and Title	Number:	Revision:
Title: Electromagnetics Research		

3.5. The Contractor shall design and implement an in-house data base to contain HIRL experiment data, calibration data, hardware configurations, and software configurations used during the conduct of electromagnetic testing. The data base must be developed using the popular Microsoft Access tool so as to ensure compatibility, reliability, and easy transfer of information to the user community.

Deliverables: Laboratory Data base

Minimum Performance Standards: Design of data bases.

Exceed Performance Standards: Implementation of data bases.

3.6. The Contractor shall generate quarterly written status and progress reports and one annual oral presentation including visual aids. Technical information and data pertaining to the HIRL is to be disseminated at least quarterly via the World Wide Web (WWW). The Contractor shall also construct, devise, or create two laboratory displays for aforementioned tasks. Displays shall include laboratory, experiment, and software models and displays.

Deliverables: DASC conference paper, two laboratory displays, WWW presence.

Minimum Performance Standards: Quarterly reports of progress. Quarterly web page documents.

Exceed Performance Standards: Technical papers written to be presented at conferences as appropriate. On-line documentations.

3.7. The Contractor shall develop Computer-Aided Design (CAD) models of aircraft and other test articles for use with computational electromagnetic software. The CAD models shall be in the appropriate format to be used with NASA-provided Finite Difference Time Domain (FDTD), Finite Element Methods (FEM), and Method of Moments (MOM) analysis software.

Deliverables: Data Analysis, Data Comparisons, and Modeling Software, Solid Models, Cubic Cell Models, Tetrahedral Cell Models, Triangular Mesh Models

1. Task Order Number and Title	Number:	Revision:
Title: Electromagnetics Research		

Minimum Performance Standards: 757 CAD models to be modified within 2 weeks of request.

Exceed Performance Standards: Preliminary results for Computational Electromagnetic Modeling (CEM) based on created models.

3.8. The Contractor shall develop the necessary software interface to integrate NASA-supplied CEM software. The interface shall combine code for geometry modeling, meshing, analysis software, and post processing software into a cohesive interface to facilitate the CEM process. The Contractor shall develop the capability to display post processed data. The Contractor shall develop documentation for the user interface.

Deliverables: User Interface and documentation

Minimum Performance Standards: Port software to common platform.

Exceed Performance Standards: Propose methodology for implementation of a common graphical platform to be used with a variety of CEM software.

PRINTED: 6/6/96

1. Task Order Number and Title	Number:	Revision:
Title: Electromagnetics Research		

4. Government Furnished Items:

Government shall provide equipment, software, materials, facilities and office space, government data.

5. Other information needed for performance of task.

Contractor-determined travel as required for successful performance of task, including DASC Conference, October 27-31, 1996.

6. Security clearance required for performance of work:

All work is expected to be unclassified, however personnel may be required to complete nondisclosure agreement with laboratory customers.

7. Period of Performance	
Planned start date: 1 July 1996	Expected completion date: 30 June 1997

8. NASA Technical Monitor: Reuben A. Williams
M/S:130 Phone: 804-864-6212

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From: Ivan Clark (5/12/96)
To: R.W.Bales@larc.nasa.gov, a.l.fripp@larc.nasa.gov

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1. Title: Chemical Vapor Deposition Facility

2. Background of work to be performed:
The Chemical Vapor Deposition Facility for Reactor Characterization (CVDF) performs flow field measurements and analysis in support of the NASA Microgravity Sciences program and to foster the technology transfer of instrumentation techniques developed for NASA aerospace applications to the semiconductor and coatings industries.

The contractor shall provide operation, system troubleshooting, facility configuration, test specimen installation and maintenance, and data analysis for the CVDF.

Deliverables: Quarterly report of funds expended for each subtask by labor, travel, and material purchases.

To exceed minimum performance, the contractor can:
a) suggest alternative approaches that result in time and/or cost savings;
) improve specified procedures and/or tools to increase productivity, accuracy, or reduce costs;
c) propose alternative technologies that will benefit the government in achieving the goals or the tasks included herein; or
d) achieve specified deliverables for additional elements of the test matrices.

3. Subtask description:
3.1. Laser velocimetry of horizontal rectangular test vessel (UVA-1):
a) configure CVDF for LV analysis of horizontal rectangular test vessel (UVA 1);
b) configure and maintain UVA 1 test vessel for CVDF LV analysis of flow field;
c) measure UVA 1 flow field over a specified test matrix of susceptor temperature, test gas, and total gas flow rate;
d) analyze flow field and correlate with CFD model and measurements of UVA 1 made by PIV and IR imaging.

Deliverables shall be the flow field data and its correlation to CFD model of this geometry and to PIV and IR imaging measurements of this vessel. Deliverables shall be in both electronic and graphic formats.

linimum acceptable performance: LV flow field measurement of vertical longitudinal central plane with 650C susceptor temperature, 8 lpm flow rate, and each of hydrogen and nitrogen test gas by xx/1996.

2. Laser velocimetry of CFD-RC test vessel:
) configure CVDF for LV analysis of CFD RC test vessel;
b) configure and maintain CFD RC test vessel for CVDF LV analysis of flow field;
c) measure CFD RC flow field over a specified test matrix of susceptor temperature, test gas, and total gas flow rate;
d) analyze flow field and correlate with CFD model and measurements of CFD RC test vessel made by PIV and IR imaging.

Deliverables shall be the flow field data and its correlation to CFD model of this geometry and to PIV and IR imaging measurements of this vessel. Deliverables shall be in both electronic and graphic formats.

Minimum acceptable performance: LV flow field measurement of one measurement plane with a single susceptor temperature, single flow rate, and one test gas by xx/1996.

3.3 Flow visualization of RPI test vessel:
a) configure CVDF for flow visualization analysis of RPI test vessel;
b) configure and maintain RPI test vessel for CVDF flow visualization of flow field;
) record flow visualization of RPI test vessel flow field over a specified test matrix of temperature field and orientation;
d) analyze flow visualization and correlate with CFD model and measurements of RPI test vessel made by IR imaging.

Deliverables shall be the flow visualization data and its correlation to CFD model of this vessel and to IR imaging measurements of this vessel. Deliverables shall be in both electronic and graphic formats.

Minimum acceptable performance: flow field visualization of one measurement plane with a single temperature field and one test vessel orientation by xx/1997.

3.4 PIV of test vessels:
a) configure CVDF for PIV analysis of test vessel;
b) coordinate installation of PIV data acquisition system in CVDF;
c) configure and maintain test vessel for PIV measurement of flow field in CVDF over a specified test matrix of susceptor temperature, test gas, and ɔtal gas flow rate;
d) correlate PIV measurements with CFD model and measurements of test vessel

made by LV and IR imaging.

Deliverables shall be documentation of vessel conditions used for PIV measurements and correlation of PIV results with test conditions, with LV and IR imaging measurements of test vessel, and with CFD model of vessel. Deliverables shall be in both electronic and graphic formats.

Minimum acceptable performance: CVDF and test specimen systems required for PIV operational for duration of PIV test for one test vessel.

3.5 IR imaging of test vessels:
a) configure CVDF for IR imaging analysis of test vessel;
b) coordinate installation of IR imaging data acquisition system in CVDF;
c) configure and maintain test vessel for IR imaging of thermal field in CVDF over a specified test matrix of temperature and flow fields;
d) correlate IR imaging measurements with CFD model and measurements of test vessel made by LV and PIV.

Deliverables shall be documentation of vessel conditions used for IR imaging and correlation of IR imaging results test conditions and, for UVA 1 or CFD RC test vessels, with LV and PIV measurements of test vessel. Deliverables shall be in both electronic and graphic formats.

Minimum acceptable performance: CVDF and test specimen systems required for IR imaging operational for duration of IR imaging test for one test vessel.

4. Government furnished items:
Solvent reservoirs, solvents, cleaning agents, test equipment, microbalances, data acquisition and control systems, data analysis systems, lasers, optical scanning systems, and other related supplies or instruments will be made available to the contractor from existing laboratory resources to enable fulfillment of contract objectives. These items will remain the property of NASA LaRC and will be used solely for the purposes outlined in this task order. All work is performed in NASA LaRC Buildings 1202 and 1299 on a non interference basis.

5. Other information needed for performance of task:
travel estimated at one man-trip equivalent to 3 day meeting in Huntsville, AL

6. Security clearance required for performance of work:
After-hours access to facility is required. Some test specimens to be examined in CVDF shall be of a proprietary nature. Information pertaining to

and/or derived from such specimens shall be handled so as to maintain the proprietary status.

7. Period of performance:
7/1/96-6/30/97

8. NASA TM:
Ivan Clark
M/S 473
804-864-1500

9. ????????

10. Government's estimated cost limitation: [redacted]

11. Other direct cost estimates: ??

12. Funding information: tbd

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1. Task Order Number:: DI15 Revision: ____ Date of Revision:_
Title: Low Visibility Landing and Surface Operations Flight Crew Subject Pool Recruitment

2. Purpose, Objective or Background of Work to be Performed:
Research is being conducted under the Terminal Area Productivity (TAP) Low Visibility Landing and Surface Operations (LVLASO) program to improve the safety and capacity on the airport surface. As part of this program, a series of simulations and flight tests will occur which demonstrate an integration of surface automation technologies. The tests include an integration of ground based and airborne systems. This task order focuses on obtaining flight crew personnel to support this work.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

1. The contractor shall provide flight crew personnel to serve as test subjects for a flight experiment (TAP Level I Milestone) to be conducted at the Hartsfield Atlanta International Airport and associated training to be conducted at NASA Langley Research Center. Subjects may be asked to take part in inteviews, surveys, flight simulation training, and experimental aircraft training and studies. The contractor will be expected to solicit, screen, select, and engage subjects. Subjects shall be provided in a timely manner. All transportation, lodging, meals, incidental costs, and fees shall be coordinated and provided by the contractor.

Pilot requirements:

1 - Must be rated as a 757 captain and must be current
2 - Four subjects, preferrably one pilot each from America West Airlines, United Airlines, DELTA Airlines, and American Airlines.
3 - The technical monitor will approve the use of each subject.
4 - Technical monitor requires at least 1 week notice prior to subject arrival.
5 - A list of preferred subjects will be provided by the technical monitor to Ms. Johns. These subjects have already volunteered to take part in this study through a working relationship with the subject airlines.

LaRC training: Two qualified pilots the week of July 14 for two consecutive days and two qualified pilots the week of July 21 for two consecutive days, for a total of four subjects. Subjects will meet the technical monitor or her representative at B1220 Room 227 no later than 9:00 on the first day of training. An overnight stay is required. Subjects will be able to leave no later than 5:30 PM on the second day. Subjects may be able to leave earlier depending on how fast the training is completed.

Specific dates will be determined by the technical monitor no later than 14 days prior to the schedule crew workdays.

Atlanta testing: The same four subjects used for training at LaRC will be used for testing at Atlanta. Each subject will be needed for two consecutive days. The planned work shift is approximately 5 PM - 2 AM. The scheduled dates are as follows:

Pilot 1 - 8/19-20/97
Pilot 2 - 8/20-21/97
Pilot 3 - 8/21-22/97
Pilot 4 - 8/22-23/97

These dates could change based on schedule slippage.

Subjects will meet the technical monitor or her representation at the Renaissance Hotel lobby no later than 3 PM on the first testing day. Subjects may take the Renaissance Hotel shuttle from the airport terminal to the hotel. Subjects will be able to leave no later than 6 AM on the second day of testing. Subjects may be able to leave earlier depending on how fast the training is completed.

Deliverables:
Four qualified pilots to participate in training at LaRC as described above.
The same four qualified pilots to participate in flight testing at the Hartsfield Atlanta International Airport as described above.

Schedule of Deliverables: See above description.

Metrics for Deliverables: Ability to provide qualified subject pilots to LaRC and the Harstfield Atlanta International Aiport within an allowable tolerance of one hour for the durations and times listed above

4. Government Furnished Items:

Simulation facility and 757 aircraft will be made available to the contractor to enable fulfillment of contract objectives.

5. Other information needed for performance of task.
Travel requirements for the subject pilots are discussed in Section 1.

6. Security clearance required for performance of work:

Security clearance is not required.

7. Period of Performance

Planned start date: 7/1/97	Expected completion date: 9/30/97

8. NASA Technical Monitor: Denise R. Jones
M/S: 152D Phone: 804-864-2006

DMX01

A

ARTS Task Order

1.0 Task Order Number:

Title: Fracture Testing and Analysis of Aircraft Materials and Cracked Stiffened-Panel Configurations

2.0 Purpose, objective, background:

3.0 Description of Task

(A) The Contractor shall conduct fracture tests on standard laboratory specimens made of aluminum and aluminum-lithium alloys under laboratory air and room temperature conditions to determine load-against-crack extension and load-against-displacement per ASTM E561 (Ref. 1), and critical crack-tip-opening angles (CTOA) during stable tearing. CTOA shall be measured with a high-resolution camera and video system (see Ref. 2). All materials will be supplied and specimens will be machined by the Government. Guide plates (supplied by the Government) shall be used in all M(T) and C(T) tests and all tests shall be conducted under stroke control.

Aluminum alloy 2324-T39 shall be tested in four thicknesses (B = 0.5, 0.7 and 0.9 inches) using three different size (W = 2, 4 and 6 inches) compact tension C(T) specimens. A total of 18 C(T) specimens shall be tested. The Government will machined all C(T) specimens from the broken halves of previously tested middle-crack tension M(T) specimens.

Aluminum alloy 2219-T87 shall be tested in two thicknesses, B = 0.05 and 0.08 inches, using 12-inch wide M(T) specimens (2 specimens per thickness). Four 6-inch C(T) specimens of each thickness shall be machined from the broken halves of the M(T) specimens (two LT and two TL) and tested.

Aluminum-lithium alloy 1441 shall be tested in one thickness (B = 0.05 inch) using two, 6-inch wide M(T) specimens in the TL orientation. Four 4-inch C(T) specimens shall be machined from the broken halves of the M(T) specimens (two LT and two TL) and tested.

Aluminum-lithium alloy 2096-T8 shall be tested in one thickness (B = 0.09 inch) using two, 24-inch wide M(T) specimens.

Deliverables (for part A):
Load-against-crack extension data, load-against-displacement data, CTOA against crack extension data on each specimen, brief written summary of each test (noting any testing anomalies), brief informal written monthly report, and a formal written contractor report at the end of project A.

(B) The Contractor shall conduct fracture tests on unstiffened and stiffened panels made of aluminum alloys under laboratory air and room temperature conditions to determine load-against-crack extension and critical crack-tip-opening angles CTOA (see Ref. 2) during stable tearing for a single lead crack and a lead crack in the presence of multiple-site damage (MSD) cracking. The unstiffened and stiffened panels will be designed, machined, manufactured, and supplied by the Government.

Two 48-inch wide 2024-T3 (B = 0.09 inch, special Langley stock) unstiffened panels shall be tested with a single crack (2c/W = 0.33) to develop a guide plate system for wide panels to prevent buckling.

Five 36- or 48-inch wide (TBD by the Government), unstiffened panels made of 2024-T3 (B = 0.063 inch) shall be tested with guide plates. The Contractor shall develop written procedures to precrack the MSD cracks at 1-inch spacings (three different MSD sizes specified by the Government) and then introduce a large lead crack (8-inches) before testing. Guide plates shall be used for the unstiffened panel tests and all tests shall be conducted under stroke control.

Five 36- or 48-inch wide (TBD), stiffened panels made of 2024-T3 sheet with 7075-T6 riveted stiffeners shall be tested with the same cracking patterns that were used in the unstiffened panel tests. Load-against-crack extension shall be recorded for the lead crack behavior and the CTOA shall be measured on the lead crack and on several select MSD cracks. Strain fields and plastic-zone sizes, between various MSD cracks, will be measured by the Government. Guide plates shall "not" be used for the stiffened panel tests and all tests shall be conducted under stroke control.

Deliverables (for part B):
Load-against-crack extension (lead crack) data and CTOA against crack extension data on each specimen, movie and/or video tapes of the failure of the panels with MSD cracking, brief written summary of each test (noting any testing anomalies), brief informal written monthly report, and a formal written contractor report at the end of project B.

(C) The Contractor shall conduct elastic-plastic, finite-element, fracture simulations of all M(T) and C(T) specimens using the CTOA fracture criterion and ZIP2D and/or ZIP3D finite-element codes for all materials tested. The Government will conduct the elastic-plastic, finite-element, fracture simulations using the CTOA fracture criterion and ZIP2D and/or STAGS on the cracked stiffened panels.

Deliverables (for part C):
Brief written report on each material, with charts comparing load-against-crack extension and load-against-displacement showing test data and numerical calculations for each M(T) and C(T) specimen size, brief written summary of each analysis (noting any numerical analysis problems), brief informal written monthly report, and a formal written contractor report at the end of project C.

Performance Standards (parts A, B, and C):
Content of plan, schedule, cost, adherence to test procedures, test data reports and final written Contractor reports meets NASA publication standards.

(D) The Contractor shall develop a common windows graphical-user-interface (GUI) to conduct fatigue crack growth analyses with the FASTRAN (see Ref. 1) code on both a PC and workstation. The Contractor shall use wx-Windows (free commercial software) or equivalent software to develop the GUI. The same GUI and codes must execute on PC's and workstations with minor modifications. The GUI should have capabilities to run two different FORTRAN computer codes (DKEFF and FASTRAN), to read input data files (material data and crack configuration data), create and modify input datafiles, select and display the 16 crack configuration options, input a user defined crack configuration, select and display material crack-growth databases, display and print stress-intensity-factor-against-crack-length plots, display and print stress-intensity-factor-against-crack-growth-rate plots, display and select various aircraft spectra (currently existing in code), input new flight-load spectra datafiles (using the three options currently in the code), and display and print analysis results (crack length against cycles or flights, crack-growth rate against crack length, and crack-opening stresses against crack length). Contractor shall develop a user guide for the GUI. The contractor shall develop and implement a plan to beta-test the code.

Deliverables (for part D):
Brief informal written monthly reports, a common windows graphical-user-interface for PC's and workstations, user guide for GUI.

User-friendly, graphical-user-interface (GUI) for the FASTRAN life prediction code for the PC and workstation windows environment, and a detailed report describing the functions of the GUI.

Plan for beta-testing code.

User's Guide for the GUI FASTRAN Version 4.0 code.

Performance standards(for part D):
Content of plan, schedule, cost, adherence to WX-Windows software, and final written Contractor reports meet NASA publication standards.

4.0 GFE:
The Government will supply the testing machines, photographic equipment, and other equipment (strain gages, displacement gages, etc.) needed to conduct all of the fracture tests. The Government will supply the finite-element computer codes, computer workstation(s) and/or super-computer to conduct the finite-element analyses. The Government will supply the wx-Windows software and manuals.

5.0 Other Information:

Background information references:

1. ASTM Standard Practice for R-Curve Determination, E561-94.
2. Dawicke, D.S. and Sutton, M.A., "Crack Tip Opening Angle Measurements and Crack Tunneling under Stable Tearing in Thin Sheet 2024-T3 Aluminum Alloy", NASA CR-191523, Sept. 1993.
3. Newman, J. C., Jr., "FASTRAN-II - A Fatigue Crack Growth Structural Analysis Program," NASA TM 104159, Feb. 1992 (Revised Copy)

6.0 Security clearance required:

None

7.0 Period of Performance:

Planned start date:	7/1/96
Planned completion date:	6/30/97

8.0 NASA Technical Monitor:

Dr. James Newman, Jr.
M/S 188E
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Dmx1

ART/SAERS Task Order Page 1

1. Task Order Number and Title Number: Revision:
   Title: Composite Development and Databasing

2. Purpose, Objective or Background of Work to be Performed:

Support the HSR Program of Matrix Resin Development by developing composite processing procedures and databasing results.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

Description of Task:
The Contractor shall optimize processing cycles for novel or modified polymeric materials. The Government will submit approximately twelve requests for optimization. The Contractor shall be responsible for carrying these materials forward into the actual composite fabrication process where they shall provide the processing cycles to NASA personnel. The Government will fabricate composites using the contractor-supplied processing cycles. The contractor shall evaluate the thermomechanical properties of the resulting composite specimens. For each polymer system, the development of the processing cycles shall be completed and an informal written report submitted within four weeks of submittal of the request. The evaluation and documentation of results by computer shall be done within two weeks of the completion of the analysis. In approximately 20% of the systems an iteration of the procedures will be required to affect optimization, in which the same guidelines as above will be followed. Specific activities that shall be performed in the processing cycle development will be the measurement of the rheological properties of the polymer system as a function of temperature at various stress rates. Prototype composite panels shall be fabricated and assessed via ultrasonic C-scanning, and after mechanical testing by NASA personnel the process shall be iterated or scaled up for spectrum mechanical testing by NASA. The resulting data shall be analyzed, tabulated, graphed, charted, etc. for evaluation by the NASA-Industry HSR Team.

Deliverables:
The Contractor shall submit informal written reports each month that discuss the schedule and prioritization of the planned experimental program.
The Contractor shall prepare monthly informal reports detailing progress on each system and shall provide the reports to the HSR team leader and task monitor. The report shall include description of the processing development and interpretation of results.
Within two weeks of the completion of the evaluation of a system, the results of the processing development, the processing of the composites, and their mechanical performance shall be formatted for reporting to the HSR Program. Extensive databasing of the results and preparation of graphical reports will also take place within two weeks of the completion of the analyses.

ART/SAERS Task Order Page 2

1. Task Order Number and Title — Number: — Revision:
   Title: Composite Development and Databasing

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Performance Standards
Written reports for analysis requests:
- Efficiency (time to complete, with complexity and competing requests accounted for)
- Quality of report (figures and photographs of publication quality)
- Equipment operating ability

Overall:
- Adherence to schedule
- Cost

4. Government Furnished Items:

Equipment in the Composites and Polymers Laboratory (Building 1293), including rheometer, plastometer, dielectrometer, ultrasonic system, DTA and DSC systems, computer systems, specimen preparation equipment and supplies.

5. Other information needed for performance of task.

The Contractor shall have expertise in the operation of DSC, Rheometer, Parallel-Plate Plastometer, SEM & Image Analyzer, Ultrasonic Analyzer, and shall have advanced knowledge of rheological testing.

The Contractor shall have knowledge and skills in computer use with proficiency in databasing, word processing, desktop publishing, graphics and presentation software.

6. Security clearance required for performance of work:

None

7. Period of Performance

Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Roberto J. Cano
   M/S: 226 Phone: 804-864-3951

PRINTED: 6/12/96

DMX03

ARTS Task Order

1.0 Task Order Number:

Title: Evaluation of the Long Term Durability of Polymer Composites

2.0 Purpose, objective, background:

As a part of the High Speed Research (HSR) program, the LaRC has been tasked to evaluate the long term durability of polymeric matrix composites (PMCs) after exposure to thermal/mechanical fatigue (TMF) environments expected on future high speed civil transport airframes. Exposure of some PMCs to tensile-load TMF environments is already underway in Government-owned testing machines at LaRC. Portions of the material being exposed will be removed from test at various time intervals and cut into smaller specimens for residual mechanical property testing. The specific objective of the work is to determine the variation (if any) of mechanical properties of the materials as a function of exposure time. Maximum exposure times in the test program are expected to be at least 60,000 hours.

3.0 Description of Task

(A) The Contractor shall maintain a log book documenting specimen exposure status, performance of the twenty Government-owned testing machines used for the long-term tests, and downtime required for calibrations, modifications, and repairs. The Contractor shall specify and direct the implementation of calibrations/repairs/modifications to the machines to assure maintenance of required testing capability.

Deliverables

1. Monthly informal status reports on specimen exposures and testing machine performance. Status reporting will include explanations of any load/temperature anomalies or any other deviations from the test plan.
2. Quarterly documentation of calibrations/repairs/modifications of the testing machines.

(B) The Contractor shall plan and conduct mechanical property tests of PMC materials that are currently undergoing exposure to tensile-load TMF environments. Planning shall include specification of specimen/fixture designs and specimen/fixture fabrication plans. The mechanical properties to be determined shall include unnotched tensile and compressive strengths and Young's moduli, and open-hole tensile and compressive strengths. Mechanical properties shall be determined for IM7/5260 and IM7/K3B materials after 0 and 5000 hours of exposure. All testing must conform to applicable ASTM and SACMA standards.

Deliverables
1. Monthly informal status report on planning and testing activities.
2. Documentation of the test plans for the mechanical testing including specimen/ fixture designs and fabrication plans, instrumentation requirements, and data to be recorded. Delivery of documentation required before start of testing.
3. Documentation of the test data and data analysis. Delivery required by June 30, 1977.

(C) The Contractor shall plan new long-term durability tests that include compressive loading. As a part of this effort, the Contractor shall use Government-furnished specimens to determine the capability of Government-furnished fixtures to prevent buckling in the compressively loaded specimens at room and 350F temperatures.

Deliverables
1. Monthly informal status report on planning and testing activities.
2. A test plan for the long-term compressive-loading tests that includes descriptions of the specimens to be exposed, the testing procedures, data to be recorded during test, and the mechanical property testing to be conducted after exposure. Delivery required by Sept. 1, 1996.
3. Documentation of the results of the evaluation of the Government-owned anti-buckling fixture. Delivery required by August 1, 1996.

4.0 GFE:

1. PMC test specimens for the testing programs.
2. Twenty servohydraulic testing machines equipped with elevated temperature test chambers for the long-term testing. (Machines located in B.1205 at LaRC.)
3. All additional testing apparatus, equipment, and hardware needed to conduct the testing programs. (Test equipment located in B.1205 at LaRC.)

5.0 Other Information:

6.0 Security clearance required:

None

7.0 Period of Performance:

Planned start date:	7/1/96
Planned completion date:	6/30/97

8.0 NASA Technical Monitor:

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M/S 188E

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DMX04

ART Task Order Page 1

1. Task Order Number and Title Number: Revision:
Title: Evaluate Fracture Characteristics Of A Stitched/RFI Wing Skin

2. Purpose, Objective or Background of Work to be Performed:

NASA is designing and building a full scale composite wing box for structural evaluation by a ground test. The wing is configured for a commercial transport aircraft. The design will address the requirements of the FAR Part 25 Airworthiness Standards, including adequate strength for discrete source damage. Some form of fracture mechanics must be developed and verified to design a stitched/RFI wing skin with adequate strength for discrete source damage. This task will contribute to that development and verification.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

(A) The Contractor shall design and test center-crack and compact specimens to determine fracture toughness. Specimens of three thicknesses shall be tested to verify the range over which linear elastic fracture mechanics (LEFM) are valid. For the thinnest specimens, only center-crack specimens may be tested; and, for the thickest specimens, only compact specimens may be tested. For intermediate thicknesses, both center-crack and compact specimens shall be tested. Crack-face displacements shall be monitored and radiographs made to determine whether or not significant crack extension occurs, indicating that LEFM is not valid. For the thinnest specimens, LEFM may not be valid and R-Curves shall then be generated using the crack-face displacement results. Twenty specimens per thickness shall be tested, including several crack lengths and duplicate specimens.

Deliverables (for part A):
monthly informal status reports giving progress and results as available
Final NASA Contractor Report upon completion.

Performance standards (for part A):
schedule
cost
final report quality (meets NASA publication standards)

(B) The Contractor shall design, fabricate, and test ten special compact specimens to develop and verify a criterion for crack turning at a stitched flange. The special compact specimens shall have a stitched flange or doubler ahead of the crack tip. The position of the crack tip shall be monitored with increasing load using crack-face displacements and radiographs. Specimens of several thicknesses shall be tested.

Deliverables (for part B):
informal status reports giving progress and results as available
Final NASA Contractor Report upon completion.

ART/SAERS Task Order Page 2

1. Task Order Number and Title	Number:	Revision:
Title: Evaluate Fracture Characteristics Of A Stitched/RFI Wing Skin		

3. (continued)

Performance standards (for part A):
schedule
cost
final report quality (meets NASA publication standards)

4. Government Furnished Items:

A) Stitched/RFI composite specimens.

B) 20-, 50-, and 100-kip closed loop hydraulic testing machines.

C) Specimen grips and ancillary hardware.

D) Instrumentation and data acquisition system.

5. Other information needed for performance of task.
None.

6. Security clearance required for performance of work:
None.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: Sept. 30, 1996

8. NASA Technical Monitor: Clarence C. Poe, Jr.
.M/S: 188E Phone: 804-864-3467

DMY 6

ART/SAERS Task Order

1. Task Order Number and Title

Title: "Thermographic and Ultrasonic NDE for HSR

2.Purpose. Objective, or Background of Work to be Performed:

3. Description of Work to be Performed:

A. The contractor shall perform the following routine and advanced measurements and analyses on a written work request basis using specified methodologies and with NASA developed acquisition equipment and analysis software, in both the NDE laboratory and in in-situ settings:

- actively stimulated temperature histories for large field image scans and for fixed point and line scans
- temperature flux rate data reduction
- material thermal property data reduction
- ultrasonic image scans and multi-point measurements
- ultrasonic velocity, amplitude, and attenuation reduction.

The contractor shall prepare samples and develop specialized holders, stands, lamp enclosures and electrical modifications necessary for setup and performance of measurements.

Deliverables (part A):

- The contractor shall provide archived raw and processed data for up to 40 tests per month with less than one week turn around.
- The contractor shall provide brief reports for each test request and detailed bi-annual reports.

Performance Standards (part A):

- adherence to schedule
- completeness of reports (including include archived raw and processed data, verification of system configurations and methodologies, difficulties encountered, and quality of data).

B. The contractor shall deliver data acquisition and analysis software on a request basis using the LabView software development system to incorporate new pulser/receiver and digitizer boards into the existing laboratory computers, and to interface with the phased array testbed system.

Deliverables (part B):

-The contractor shall deliver data acquisition and analysis software modules incorporated into a graphical user interface

-The contractor shall provide documented source code and manuals.

- The contractor shall provide brief monthly and detailed bi-annual progress reports.

Performance Standards (part B):

-The contractor shall provide a user friendly graghical interface.

-software modules must meet performance specifications detailed in the written work request.

-adherence to schedule

C. The contractor shall maintain a monthly laboratory equipment maintenance log detailing condition of equipment, calibration state, and necessary repairs.

Deliverables (part C):

-The contractor shall provide log book for inspection.

-The contractor shall provide reports of neccessary repairs and calibrations.

Performance Standards (part C):

- log book maintained in up-to-data status.
- reporting of repairs and calibrations

4. Government Furnished Items:

The government shall provide access to computer workstations and printers for documentation, shall provide parts, materials, and components for specimen mounting and preparation, and shall provide acess to the NESB thermography and ultrasonic laboratories and machine shop. The government shall provide LabView development software and manuals for program development.

5. Other information needed for performance of task.

6. Security clearance required for performance of task.

The task is unclassified, however, it is subject to Limited Exclusive Rights Data (LERD) restrictions.

7. Period of Performance

Planned start data: July 1, 1996 Expectedcompletion date: June 30, 1997

DMXO

ARTS Task Order

1.0 Task Order Number:

Title: Measurement of Surface Accuracy of Mirrors

2.0 Purpose, objective, background:

Light-weight, dimensionally-stable mirrors are being developed as competing concepts for service on orbiting spacecraft. These mirrors will significantly reduce the total vehicle launch weights and system inertias, and they represent a significant advancement in the state-of-the-art of materials for optical devices. A core requisite for the mirrors are their surface accuracies, and thus measurements of the surface accuracy is an important part of the selection process.

3.0 Description of Task

The Contractor shall operate and maintain an existing Government-owned Wyko interferometer system, including its associated data acquisition/analysis system. All equipment is located in Room 109 of Building 1148.

- The Contractor shall prepare and deliver a detailed set of instructions for the procedures adopted in the course of operating and maintaining the interferometer system. This is to ensure standardization and repeatability of the measurements made with the system.

- The Contractor shall use the interferometer system to measure the surface accuracy of light-weight, dimensionally-stable mirrors. The competing materials concepts that are being developed and which need to be measured are the following: graphite/polycyanate ester composite, carbon-carbon composite, silicon carbide/silicon carbide foam, silicon carbide/silicon carbide composite, and polyimide/ceramic microcomposite. The mirrors will all be 10 inches or less in diameter. The mirrors may be flats, sphericals, or parabolics. The target mission optical requirements for the mirrors are that they must reflect light in the far infrared region, particularly at 69 microns and 85 microns. The desired surface accuracy is to within 3 microns. The Contractor shall make surface accuracy measurements in vacuum at room temperature and over the temperature range of -250 F to +250 F. The Contractor shall measure the distortion as a function of temperature for each mirror provided and shall document the findings. The Government shall provide no more than eight (8) mirrors for such measurements.

Deliverables and Delivery Dates:

1.- A detailed set of instructions for the procedures adopted in the course of operating and maintaining the interferometer system, by December 31, 1996.

2.- Surface accuracy data for all mirrors submitted by the Government, including computer data files and hard copies of tables and figures produced by the measurement equipment, by June 30, 1997.

Performance Standards:

- The detailed set of instructions developed by the Contractor shall be understandable to new engineers, with reasonable effort.

- Repeatability of the surface accuracy measurements.

- Completeness and clarity of records supplied with the surface accuracy measurements.

- Adherence to schedule.

- Adherence to cost.

4.0 GFE:

The Government shall provide all equipment, software, materials, documents, and facilities at the NASA LaRC.

5.0 Other Information:

6.0 Security clearance required:

None

7.0 Period of Performance:

Planned start date:	7/1/96
Planned completion date:	6/30/97

8.0 NASA Technical Monitor:

Sheila Thibeault
M/S 188B
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DMX17

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1. Task Order Number and Title Number: Revision:
Title: Evaluation NDE Techniques for Inspection of Aluminum Aircraft Fuselages

2. Background
Research under the NASA Airframe Structural Integrity Program have focused on the development of NDE technologies for the inspection of commercial aircraft technologies. The purpose of this task is to further develop the instrumentation developed under this program and access improvements in the performance of the instrumentation.

3. Description of Work

a. The contractor shall plan and conduct a series of field tests of Smart Ultrasonic System for Aircraft NDE (SUSAN),. The contractor shall conduct no fewer than four field tests, approximately one per calendar quarter. The contractor shall also arrange for field tests by third parties, such as airline maintenance facilities, airframe OEM plants, certified aircraft inspectors, and instrumentation manufacturers. As many as four SUSAN units may be loaned to third parties at any time. The contractor shall arrange field tests by no fewer than three parties having large transport aircraft (B747, B737, B727, DC-9, DC-10), and shall arrange field tests by no fewer than two parties having smaller aircraft (commuters, general aviation). Because all field tests will depend upon the availability and scheduling requirements of outside hosts and participants, it is understood that some flexibility must be allowed the contractor in scheduling these activities. Prior to each scheduled field test, the contractor shall submit to NASA a testing plan. Based on the results of each field test, the contractor shall identify and develop suggested bug fixes and improvements in the SUSAN hardware and software, and submit them along with the test results. Each field test typically involves on average three days of field work, plus travel time. Each field test will require some degree of effort toward bug fixes and improvements in mechanical, electrical, and software elements of the system.

Deliverables:
The contractor shall conduct no fewer than four field tests, and shall arrange no fewer than five third-party field tests of the SUSAN. Two to four weeks prior to each scheduled field test, the contractor shall submit to NASA a testing plan. Two to four weeks after completion of each field test, the contractor shall submit a report of the test results and a plan for suggested bug fixes and improvements in the SUSAN hardware and software.

Performance Standards:
Minimum of 4 field tests
Minimum of 4 third-party field
adherence to schedule
Reports will meet NASA publication standards.

b. The contractor will develop improved methodologies for corrosion detection and quantification in multi-layer thin metallic structures with an eddy current multi-frequency isolated field probe. This will involve the development of algorithms for data acquisition and processing, and system hardware. The contractor will design and fabricate alternate probe geometries for enhance the performance of the system. The contractor will test the system on specimens supplied by NASA and shall report the results as they become available. The contractor will develop the methodologies for multi-frequency isolated field test for corrosion detection and quantification in multi-layer thin metallic structures. The contract will perform up to three field test of the enhanced performance system to access the improvement of the system. Two to four weeks prior to each scheduled field test, the contractor shall submit to NASA a testing plan. Two to four weeks after completion of each field test, the contractor shall submit a report of the test results.

Deliverables:
The contractor shall deliver a prototype test system for corrosion detection in multi-layer thin metallic structures utilizing an eddy current multi-frequency isolated field probe. Detailed report on field test results on corrosion detection in multi-layer thin metallic structures. The contractor will deliver the improved algorithms for corrosion detection and quantification. The contractor will deliver improved probes and their designs.

Performance Standards:
Quanitifaction of corrosion in two layers to within 5%
Reports will meet NASA publication standards

c. The contractor will further develop the eddy current self-nulling rotating probe system for detection of cracks under rivets in thin metallic structures to enhance its data acquisition rate and reduce operator fatigue. This will involve the development of algorithms for data acquisition and processing and system hardware. The contractor will design and fabricate alternate probe geometries to enhance the performance of the system. The contractor will test the system on specimens supplied by NASA and shall report the results as they become available. The contractor will perform up to three field test of the enhanced performance system to access the improvement of the system and develop probability of detection curves from the field test. Two to four weeks prior to each scheduled field test, the contractor shall submit to NASA a testing plan. Two to four weeks after completion of each field test, the contractor shall submit a report of the test results.

Deliverables:
The contractor shall deliver an improved prototype self-nulling rotating probe system for detection of cracks under rivets thin metallic structures. The contractor will deliver detailed reports on field test results with probability of detection curves. The contractor will deliver the improved algorithms for crack detection. The contractor will deliver improved probes and their designs.

Performance Standards:
Detection of crack 25 mils from shank of rivet
Reports will meet NASA publication standards

d. The contractor will develop the eddy current self-nulling probe methodologies which minimize the effects of lift-off error in the hand-held self-nulling probe for crack detection. This will involve the development of algorithms for data acquisition and processing and system hardware. The contractor will design and fabricate alternate probe geometries for reduced sensitivity to lift-off while maintaining the performance of the system for detection of cracks system. The contractor will test the system on specimens supplied by NASA and shall report the results as they become available. The contract will perform up to three field test of the enhanced performance system to access the improvement of the system and develop probability of detection curves from the field test. Two to four weeks prior to each scheduled field test, the contractor shall submit to NASA a testing plan. Two to four weeks after completion of each field test, the contractor shall submit a report of the test results.

Deliverables:
The contractor shall deliver a improved prototype self-nulling probe for detection of cracks thin metallic structures which has reduced sensitivity to lift-off error. The contractor will deliver detailed reports on field test results with probability of detection curves. The contractor will deliver the improved algorithms for crack detection with reduce sensitivity to lift-off. The contractor will deliver improved probes and their designs.

Performance Standards:
Reduction in sensitivity of prototype to lift-off error by a factor of 5
Reports will meet NASA publication standards
Reduction in number of false calls by 5

e. The contractor shall provide computer simulations of advanced thermographic techniques. The contractor will perform simulations of different thermographic inspection protocols as prescribed by the government. The simulations will be both 2 dimensional and 3 dimensional representations of experimental configurations. The contractor will provide methodologies for verification of the simulations and verify the simulations based on experimental data supplied by the government. From simulations, the contractor will suggest optimal experimental protocol for different experimental configurations. Contractor will also use simulations to estimate limits of the techniques for detection of flaws in structures. The contractor shall perform the analysis of at least one configuration a week.

Deliverables:
The contractor will deliver detailed reports on the results of the simulations. The contractor will deliver software for analysis of simulations and documentation on the analysis software. The reports will detail expected capabilities of different thermographic technique, suggestion for optimization of techniques, probability of detection curves for different techniques.

Performance Standards:
Reports will meets NASA publication standards

4. Government Furnished Equipment

The government will provide six complete SUSAN systems, comprising portable computer, data acquisition cards (with spares), printer, manual scanner, motorized scanner, and array probes. The government will provide access to personal computers and printers for purpose of document preparation. The government will provide parts, materials and components for approved mechanical or electrical modifications. The government will establish appropriate memoranda of agreement with third party participants to enable full collaborative efforts. The government will supply software for performing the thermographic simulations and a workstation for running the simulations.

5. Travel will be required for testing of instrumentation at facilities such as the FAA Validation Center.

6. No security clearance is required for the task.

7. Period of Performance:
Plan start date: 7/1/96 Expected completion date: 6/30/97

8. NASA Technical Monitor: William P. Winfree
MS 231 Phone: 804-864-4963

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ARTS Task Order

1.0 Task Order Number:

Title: Characterization of MIDAS High Temperature Superconductive Materials

2.0 Purpose, objective, background:

The Materials In Devices As Superconductors (MIDAS) spaceflight experiment will evaluate the electrical properties of high temperature superconductors during a 90 day space mission. The experiment will be launched on STS-79 (8/96), integrated onto Mir, operate for 90 days, and return via STS-81 (12/96). Twenty four superconductive specimens will be flown and tested. The flight data from these specimens will be retrieved and analyzed, and post-flight ground testing will be performed.

3.0 Description of Task

- The contractor shall document the results of measurement verification testing performed pre-flight on the MIDAS data acquisition system. The contractor shall provide statistical analyses of data required to demonstrate the instrument capabilities and shall write a comprehensive report of the test results. The report shall be given a project-specific ID number and placed in the project archives.

- The contractor shall analyze flight data from the superconductive specimens using MIDAS data reduction software and determine the extent of degradation of the specimens due to the space mission.

- The contractor shall analyze data from post-flight electrical characterization of flight specimens, including measurement of critical transition temperature and critical current density. The contractor shall generate plots and identify critical parameters.

- The contractor shall provide post-flight materials characterization of flight specimens, including profilometer measurements of cross-sectional area, SEM/EDAX, and visual inspection/optical microscopy.

Deliverables:

1. - Document detailing the results of the MIDAS Measurement Verification Plan. (8/31/96)

2. - Detailed report documenting the results of the flight data analysis, including plots of the superconductive properties as a function of time in space. (3/31/97)

3. - Electronic data files, hard copies of characterization plots, and an informal report detailing the post-flight electrical and materials characterization of the MIDAS flight specimens. (6/30/97)

Performance Criteria:
- Adherence to schedule
- Comprehensiveness and clarity of reports
- Completeness and clarity of data supplied
- Adherence to cost

4.0 GFE:

Access to the Microelectronics Fabrication Facility, B1238A, Structures and Materials Lab, B1148, and the Light Alloy Lab, B1205. Access to the GSE measurement system and MIDAS data reduction software.

5.0 Other Information:

6.0 Security clearance required:

None

7.0 Period of Performance:

Planned start date:	7/1/96
Planned completion date:	6/30/97

8.0 NASA Technical Monitor:

Stephanie Wise
M/S 188B
Phone: (804) 864-8068
Fax: (804) 864-7730

ARTS Task Order

1.0 Task Order Number:

Title: RAINBOW High Displacement Piezoelectric Actuators

2.0 Purpose, objective, background:

Reduced And Internally Biased Oxide Wafers (RAINBOW) high displacement actuators exhibit extremely high displacements under moderate loads. The process used to produce RAINBOWs involves the high temperature chemical reduction of conventional piezoelectric ceramics, resulting in a monolithic structure containing both piezoelectric and non-piezoelectric layers. These actuators are being developed for use in scanning systems for control of optic positioning for future remote sensing instruments.

3.0 Description of Task

- The contractor shall provide a detailed set of instructions for measuring the displacement properties of RAINBOW actuators, including use of both a fiber optic displacement sensor and a linear variable displacement transducer (LVDT).

- The contractor shall produce and test RAINBOW actuators (~ 100 parts) from PZT-5A and PZT-5H compositions. The contractor shall optimally reduce the piezoelectric and electrode and pole the RAINBOWs. Selected specimens from each production batch shall be characterized including measurement of displacement and ferroelectric hysteresis properties. The contractor shall assemble the RAINBOW actuators into stacks using interdigitated electrodes and measure the properties of the assembled stacks, including displacement under static loads of 100g to 500g.

- The contractor shall use the tape casting process to produce thin, flat piezoelectric ceramics from PZT-4. The contractor shall optimize the process to produce dense ceramic parts, with thicknesses of 0.010" to 0.020". This work shall include optimization of the poling procedure for PZT-4 at elevated temperatures.

- The contractor shall optimize the RAINBOW process to achieve maximum displacement using PZT-4. The contractor shall use both vendor-supplied and tape cast parts to determine the effects of the initial material on the RAINBOW properties.

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Deliverables:
1. - Procedure for measuring displacement in RAINBOWs (10/31/96)

2. - Stacked RAINBOW assemblies for prototype testing (12/31/96)

3. - Data on the tape cast PZT-4 parts (1/31/96)

4. - Data on the properties of RAINBOWs produced from PZT-4, including hard copies of figures and characterization plots (6/30/97)

Performance Criteria:
- Adherence to schedule
- Comprehensiveness and clarity of test procedure
- Comprehensiveness and clarity of test data
- Repeatability of results on tape cast specimens
- Adherence to cost

4.0 GFE:

Access to breadboard test facilities in the Flight Electronics Lab, B1202, the Structures and Materials Lab, B1148, and the Light Alloy Lab, B1205.

5.0 Other Information:

6.0 Security clearance required:

None

7.0 Period of Performance:

Planned start date: 7/1/96
Planned completion date: 6/30/97

8.0 NASA Technical Monitor:

Stephanie Wise
M/S 188B
Phone: (804) 864-8068
Fax: (804) 864-7730

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ARTS Task Order

1.0 TASK ORDER NUMBER:

Title: Testing and Analysis of Metallic Materials for High Speed Aircraft

2.0 TASK OBJECTIVES

Research programs are on-going to develop structurally efficient metallic materials systems for application to airframe structures for supersonic aircraft. The objectives of this task are to determine the mechanical behavior of selected titanium alloys, aluminum alloys and titanium-polymer matrix composite hybrid laminate materials; analyze the microstructure of the materials in various conditions; and correlate the properties with microstructure and processing.

3.0 TASK DESCRIPTION

3.1 Titanium and Aluminum Alloy Sheet

The contractor shall determine the effects of processing, including heat treatment, thermal exposures, and joining and forming operations on the mechanical properties and microstructure of selected titanium and aluminum alloys.

3.1.1 Mechanical Property Testing

The Contractor shall conduct mechanical tests and data analysis to determine mechanical behavior. The Government will submit approximately 100 written test requests to the contractor. A test request will typically consist of 3-20 tests. Specific tests and quantities are detailed below:

The contractor shall conduct ~150 tensile tests to measure tensile yield and ultimate strength, modulus and ductility of the selected alloys. The contractor shall conduct ~ 50 fracture toughness tests using J-integral analysis of R-curves generated from compact tension, extended compact tension, center crack tension and other appropriate test specimens. The contractor shall conduct ~50 S/N fatigue tests on smooth and notched specimens. About 5% of all tests shall be run at -65°F and about 20% of the tests shall be run at temperatures from 150°F to 350°F. All others shall be run at room temperature.

The contractor shall prepare all samples for testing, including measuring specimen dimensions, removing surface flaws that may affect test results, labeling specimens appropriately for record keeping, and applying necessary instrumentation. The contractor shall operate government furnished test machines and ancillary apparatus necessary to collect and reduce the test data. The equipment to be operated includes tensile and fatigue universal testing machines with cryogenic and high temperature chambers, and data acquisition/analysis hardware and software. The contractor shall utilize instrumentation for controlling and measuring load, strain, deflection, fatigue cycles, temperature, gripping pressure, and other parameters necessary to conduct the tests and collect and store data. All tests shall be conducted according to the relevant ASTM standard for the particular tests.

3.1.2 <u>Metallurgical Analysis</u>
The contractor shall prepare metallurgical specimens and perform routine and advanced laboratory analyses on metallic materials. Approximately 75 written analysis requests will be submitted to the contractor. Specific analyses are detailed below:

The contractor shall perform metallurgical analyses on the aluminum and titanium based alloys to determine microstructure features including fracture surface morphology, grain size and structure, phase identification, distribution, and volume fraction, texture, and chemistry. The contractor shall prepare specimens for metallurgical analysis by cutting, grinding, mounting, polishing, and etching. The contractor shall operate optical microscopes, scanning electron microscopes, transmission electron microscopes, electron microprobes, x-ray diffraction apparatus, and scanning Auger spectroscopy systems to generate the required microstructural information.

<u>Deliverables</u>:
- Electronic data files for each specimen within 3 working days of completing testing of each set of specimens. (typically 3- 20 specimens per set)
- Tested specimens with fracture surfaces intact and preserved within 3 working days of test completion.
- Informal written and oral reports for each set of test specimens documenting the test procedures and noting the occurrence of any test anomalies within 3 working days after test completion.
- Written and oral summary of microstructural interpretation of specimens analyzed within 5 working days after completion of analysis.
- Data packages, including photographs, charts, and data plots supporting the microstructural interpretation, submitted at the same time as the written summary of analyses.
- The contractor shall submit informal written reports each month that discuss the schedule and prioritization of analysis requests to be conducted

Performance standards:

- adherence to ASTM or other relevant standards
- adherence to schedule
- cost
- quality of photographs and charts (ie, publication-quality)

3.2 Ti-PMC Hybrid Laminates

The contractor shall develop and execute a plan to determine the effects of thermal exposures (isothermal and cyclic) on the mechanical properties and microstructure of titanium-polymer matrix composite hybrid laminate materials (Ti-PMC) of various compositions and lay-ups (up to 5 material variants).

3.2.1 Mechanical Property Testing

Mechanical properties to be measured before and after exposure include tensile strength, modulus, strain to failure and S/N fatigue. The contractor shall conduct ~50 tensile tests of laminates with smooth specimens. The contractor shall conduct ~60 SN fatigue tests on open-hole specimens. For the fatigue tests, surface foil crack initiation, crack growth rates and fatigue life shall be determined. About 10% of the tests shall be run at -65°F and about 10% shall be run at 350°F. All others shall be run at room temperature.

3.2.2 Thermal Exposures

The contractor shall conduct ~30 thermal cycling exposures of Ti-PMC laminates in an air environment in the temperature range from -65°F to 350°F for up to 3000 cycles. One cycle shall typically be 12-15 minutes. Exposures shall include both unloaded and loaded specimens. The Government will provide the load-temperature-time profile for the cycles.

The contractor shall conduct ~20 isothermal exposures of Ti-PMC laminate speimens, in air at 350_F for times up to 5000 hours. The contractor shall be responsible inserting the specimens in appropriate furnaces, cataloging and tracking the specimens throughout the exposures, and removing the specimens from the furnaces at the appropriate times.

3.2.3 Microstructural Analysis

The contractor shall perform microstructural analyses on the laminates before and after thermal exposures and testing to determine the effects of exposure on the structure and properties of the materials. Features to identify and analyze include fracture morphology, delaminations, disbonds, foil cracking, matrix cracking, fiber failures, and fiber pull out.

Deliverables:

- Plan for evaluation of Ti-PMC hybrid laminates (7/30/96)
- Informal written monthly report of progress
- Formal final report for Ti-PMC hybrid laminates (section 3.2)
- Tested specimens with associated electronic test data files

Performance Standards:

- adherence to ASTM or other relevant standards
- adherence to schedule
- cost
- quality of final report (meets NASA publication standards)

4.0 GOVERNMENT FURNISHED EQUIPMENT

Mechanical testing and metallurgical analysis equipment in the Light Alloy Laboratory in Building 1205. The government will furnish all materials and specimens, in the appropriate condition, to be tested and analyzed.

5.0 OTHER INFORMATION

The contractor shall conform to all government, LaRC, and other standard safety practices in all work areas at all times. Data generated in this task shall not be released to the public without permission of the LaRC Technical Monitor.

6.0 SECURITY

This task write-up is unclassified and no classified work will be done under this task. The contractor will not require access to classified information.

7.0 PERIOD OF PERFORMANCE

Planned task start date: July 1, 1996. Expected completion date: June 30, 1997

8.0 NASA TECHNICAL MONITOR

William D. Brewer
Mail Stop: 188A
Phone: (804) 864-3136
Fax: (804) 864-7893

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ART/SAERS Task Order Page 1

1. Task Order Number and Title Number: Revision:

Title: Testing and Analysis of Light Weight Metallics for Launch Vehicle Structures

2. Purpose, Objective or Background of Work to be Performed:

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

Description of Task

1. The contractor shall design biaxial specimens for testing plates and extrusions with and without stiffeners and with and without flaws. The contractor shall specify flaw shape and size. The contractor shall be responsible for machining and strain gaging of up to 12 specimens with up to 60 gages each. The government shall test the specimens at ambient and -320°F and provide the contractor with the raw test data and the broken specimens. The contractor shall be present to witness the tests as needed. The contractor shall analyze the data and conduct fractographic examinations to correlate properties with fracture behavior. Metallurgical analysis shall be conducted on all material product forms tested.

Deliverables:

- Plan and schedule for conducting biaxial tests (by 7/17/96)
- return tested specimens
- analyzed data files
- photomicrographs
- informal written monthly reports
- formal final report (by 12/31/96)

2. The contractor shall develop a test plan to evaluate the fatigue behavior of government supplied aluminum-lithium plate and weldments. The test plan shall establish fatigue crack growth rates (FCGR) at ambient temperature, 200°F, and -300°F for parent plate, for weldments produced by two welding techniques, and for repair welds of each technique. The test matrix shall not exceed 112 specimens. The contractor shall be responsible for machining specimens using the compact tension (CT) specimen configuration as shown in Figure 1 of ASTM E647-93. The specimen thickness and location and other relevant parameters shall be specified at the time of test. The government shall conduct the FCGR tests and will provide the contractor with the raw test data and the broken specimens. The contractor shall be present to witness the tests as needed. The contractor shall analyze the data and conduct fractographic examinations to correlate properties with fracture behavior. The contractor shall perform metallurgical analysis on each welded panel, including through thickness optical micrographs, hardness and chemistry profiles.

Deliverables:

- Plan and schedule for fatigue crack growth rate testing (by 7/17/96)
- returned tested specimens
- analyzed data files provided in electronic format
- photomicrographs
- informal written monthly progress reports including data for that month
- formal final report detailing test procedures and including all data from the fatigue crack growth rate tests, chemistry and hardness profiles. (by 6/30/96)

3. The contractor shall develop and execute an analysis plan to evaluate the mechanical properties and metallurgical structure associated with government supplied near net shape formed aluminum-lithium products. The plans shall include texture analysis, including orientation distribution functions (ODF) and microtexture (up to 30 analyses) to examine the textural evolution of aluminum-lithium 2195 processed to integrally stiffened barrel sections by roll ring forging and to examine the variation in texture throughout the integral stiffener elements in near net extrusions. The contractor shall document the microstructures associated with the regions of texture analysis. The contractor shall develop a test plan to evaluate the effect of aging practice on fracture behavior at ambient temperature and -300°F of near net shape 1460 and 2195 extrusions. The government will supply appropriately aged product. The contractor will be responsible for machining up to 36 tensile and 36 compact tension or surface flaw specimens. The government shall conduct the tensile and fracture tests and will provide the contractor with the raw test data and the broken specimens. The contractor shall be present to witness the tests as needed and shall analyze the data and conduct fractographic examinations to correlate properties with fracture behavior.. data and conduct fractographic examinations to correlate properties with fracture behavior and conduct fractographic examinations to correlate properties with fracture behavior.

Deliverables:

- Plan and schedule for texture analysis (by 7/17/96)
- plan and schedule for tensile and fracture testing (by 7/24/96)
- returned tested specimens
- analyzed data files provided in electronic format
- photomicrographs
- ODF plots
- informal written monthly progress reports including data for that month
- formal final report detailing test procedures and including all data from tensile and fracture tests. (by 12/31/96)

Performance Standards (elements 1,2, and 3):
Adherence to schedule, deliverables, adherence to special testing requirements, adherence to ASTM standards where specified, cost, compliance of formal report to NASA publication standards

ART/SAERS Task Order Page 2

1. Task Order Number and Title Title:	Number:	Revision:

4. Government Furnished Items:

Structures and Materials Lab, Fatigue and Fracture Lab, Light Alloy Lab, material to be tested, test technical support, raw data

5. Other information needed for performance of task.

Data generated shall not be reported in open literature without the approval of the task manager.

6. Security clearance required for performance of work:

7. Period of Performance	
Planned start date:	Expected completion date:
July 1, 1996	June 30, 1997

8. NASA Technical Monitor: John A. Wagner
M/S: 188A Phone: 804-864-3132

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ARTS Task Order

1.0 Task Order Number:

Title: Testing and Analysis of Advanced Metallic Materials

2.0 Purpose, objective, background:

The purpose of this task is to conduct, on a written work request basis, mechanical tests, metallurgical analyses, and metallic surface preparation with the objective of correlating properties, microstructure, and processing for advanced metallic materials for aerospace applications.

In addition, the comprehensive optimization and characterization of rapid superplastic forming techniques for advanced aluminum alloys will be included in this task. The objectives of this portion of the task are to develop rapid forming cycles for selected candidate materials, analyze the microstructure of the materials in a variety of conditions, and correlate the mechanical properties, microstructure, and part quality associated with rapid processing.

3.0 Description of Task

3.1 metallurgical analysis

The contractor shall prepare metallurgical specimens and perform routine and advanced laboratory analyses on metallic materials. Approximately 100 written analysis requests will be submitted to the contractor. Specific analyses and quantities are detailed below:

The Contractor shall prepare metallurgical specimens and perform routine and advanced laboratory analyses on metallic materials. The Contractor shall section, mount, polish, and chemically etch specimens for optical and scanning electron microscope (SEM) analysis (~600). The Contractor shall slice and dimple foils from metallic specimens for transmission electron microscope (TEM) analysis (~100). The Contractor shall utilize a variety of optical microscopes in conjunction with SEM with energy and wavelength dispersive spectrometry (EDS and WDS) systems and a microtexture analysis system to analyze the chemistry, morphology, and orientation of individual grains and/or particles and of the bulk microstructure (~500). The Contractor shall utilize TEM to assess the fine-scale morphology, chemistry, and phase content of specimens (~100). The Contractor shall conduct bulk quantitative compositional analysis using methods such as atomic absorption, inductively coupled plasma analysis, and other wet-chemistry techniques (~250). These bulk chemical analyses shall include measurement of interstitial oxygen, nitrogen, carbon, and hydrogen concentrations in titanium alloys (~50). The Contractor shall utilize x-ray diffraction to analyze bulk phase content, texture, and residual stresses (~100). The Contractor shall conduct material analyses using differential scanning calorimetry (DSC) and differential thermal analysis (DTA) to identify phase precipitation and solutionizing events (~200). The Contractor shall conduct failure analyses on test coupons and structural components to determine the origin of and reasons for failure (~100). The Contractor shall conduct hardness and microhardness tests (~100).

Deliverables (for 3.1):

- The contractor shall submit informal written reports each month that discuss the schedule and prioritization of analysis requests to be conducted.

- The contractor shall submit an informal written final report listing the analysis requests submitted and the analyses conducted.

- For each analysis request, the contractor shall submit a brief informal written statement of types of analyses to be conducted and estimated time for completion to the requester and the task monitor within 3 working days after receipt of analysis request.

- For each analysis request, the contractor shall submit an informal written and oral report of results to the requester within 3 working days after completion of the analysis. The report shall include description of analyses and interpretation of results. The report shall include any photographs of microstructures, chemical compositions, x-ray and electron diffraction patterns, pole figures, crystallographic orientation distributions, etc, that are necessary to characterize the microstructure.

Performance Standards (for 3.1):
written reports for analysis requests:
efficiency (time to complete, with complexity and competing requests accounted for)
quality of report (figures and photographs publication quality)

overall:
schedule
cost

3.2 mechanical testing

The Contractor shall conduct mechanical tests and data analysis to determine the mechanical behavior of metallic materials. The Government will submit approximately 100 written test requests to the contractor. A test request will typically consist of 3-20 tests. Specific tests and quantities are detailed below:

The Contractor shall operate two hydraulic tensile/compression/fatigue machines with cryogenic and elevated temperature chambers to conduct tests. The Contractor shall conduct tensile and compression tests to measure strength, modulus, and elongation (~300). The Contractor shall conduct fracture toughness tests using J-integral analysis of R-curves generated from compact tension specimens, center-crack tension specimens, and other appropriate specimen configurations (~100). The Contractor shall conduct fatigue crack growth tests using compact tension specimens, center crack tension specimens, and other appropriate test specimen configurations (~50). The Contractor shall conduct S-N fatigue tests on notched and un-notched test specimens (up to 100). The Contractor shall subject loaded and unloaded corrosion specimens in salt solutions (up to 100). The tests listed above shall be conducted at temperatures ranging from -450°F (liquid helium temperature) to 1800°F, with the majority of tests being conducted at room temperature. The Government will supply the specimens machined from aluminum- and titanium-based alloys and composites, although other materials may be included on a limited basis. Product forms will be foils, sheets, plates, rods, forgings, and extrusions.

Deliverables (for 3.2):

- The contractor shall submit informal written reports each month that discuss the schedule and prioritization of test requests to be conducted.

- The contractor shall submit an informal written final report listing the test requests submitted and the tests conducted.

- For each test request, the contractor shall submit a brief informal written statement of equipment, instrumentation, and test standards to be used and estimated time for completion to the requester and the task monitor within 3 working days after receipt of analysis request.

- For each test request, the contractor shall submit an informal written and oral report of results of the tests within 3 working days after completion of the tests. The report shall include description of test procedures, calibrations, specimen dimensions, test anomalies, and electronic data files for each test.

Performance Standards (for 3.2):

written reports for test requests:
efficiency (time to complete, with complexity and competing requests accounted for.
quality of report (figures and photographs publication quality)

overall:
schedule
cost

3.3 surface preparation

The Contractor shall conduct surface preparation of aluminum, copper, nickel, stainless steel, superalloys, and titanium alloys. The Government will submit approximately 100 written work requests to the Contractor. A work request will typically consist of 1- 10 metal specimens. Specific work assignments and quantities are detailed below:

Work assignments shall include chemical precleaning, chemical etching, chemical milling, electroplating, and anodizing of aluminum, copper, nickel, stainless steel, superalloys, and titanium alloys. Product forms will be foils, sheets, and plates limited in size to 10" x 10". The Contractor shall be responsible for ordering chemical supplies; maintaining chemical cleaning baths; monitoring, neutralizing, and disposing of hazardous materials.

Deliverables (for 3.3):

- The Contractor shall submit informal monthly written reports that discuss the schedule and prioritization of work requests to be conducted.

- The Contractor shall submit an informal monthly written report listing the work requests submitted and the work completed.

- For each work request, the Contractor shall submit an informal written and/or oral report of the test results within 3 working days after completion of the work. The report shall include description of the surface preparation procedures, test results, and test anomalies.

Performance Standards (for 3.3):

written reports for test requests:
efficiency (time to complete, with complexity and competing requests accounted for.

overall:
schedule
cost

3.4 superplastic forming:

The Contractor shall formulate and execute a plan to evaluate the rapid SPF properties of emerging superplastic aluminum alloy(s) selected by the Government (up to 2). The superplastic properties of the aluminum alloy(s) shall be evaluated using uniaxial tensile testing, constant biaxial stress cone forming, and biaxial shallow pan forming apparati. The Contractor shall determine forming parameters as a function of forming temperature, flow stress, and strain rate. The contractor shall measure the effects of SPF processing on the tensile and fatigue properties of the alloy(s). The Contractor shall perform metallurgical analyses on aluminum SPF'ed parts to determine the microstructural features including grain size, texture, phase identification, distribution, and volume fraction, void formation, and chemistry. The microstructural features associated with rapid forming shall be correlated with the SPF mechanical properties. The Contractor shall assess the effects of rapid forming on the quality of the formed parts by measuring cavitation levels and part thickness uniformity as a function of forming strain and strain rate.

Deliverables (for 3.4):

- The Contractor shall provide a test plan and schedule for conducting rapid SPF evaluation of aluminum aerospace alloy(s).

- The Contractor shall submit informal monthly written and oral reports that discuss the schedule and test results. These reports shall include data plots, photomicrographs, microstructural interpretation of specimens, and analyses. In addition, a updated schedule and prioritization of tests to be completed shall be included in the report.

- A formal written final report.

Performance standards (for 3.4):
adherence to schedule
cost
final report (meets NASA publication standards)
content of plan

4.0 GFE:

Metallurgical analysis equipment in the Light Alloy Laboratory (Building 1205), including two SEM's, TEM, two x-ray diffraction systems, hardness and microhardness test machines, DTA and DSC systems, ICP system, surface analysis system, and specimen preparation equipment and supplies

Mechanical test equipment in the Light Alloy Laboratory (Building 1205), including cryogenic and elevated temperature chambers, test machines, strain and displacement measurement instrumentation, and System 4000 and Fracture Testing Associates data acquisition systems.

Surface preparation equipment located in Metals Cleaning Laboratory (Building 1229A) including deionized water supply, chemical cleaning and rinse tanks, anodizing equipment, electroplating equipment and supplies, acids, bases, precleaners, neutralizing chemicals, supplies, and related safety equipment.

Uniaxial tensile testing, constant biaxial stress cone forming, and biaxial shallow pan forming apparati in Building 1148.

5.0 Other Information:

The Contractor shall conform to all Government, NASA LaRc, and other standard safety practices in all work areas at all time.

Data generated in this task shall not be released to the public without prior written approval from the LaRC Technical Monitor.

6.0 Security clearance required:

None

7.0 Period of Performance:

Planned start date:	7/1/96
Planned completion date:	6/30/97

8.0 NASA Technical Monitor:

Dick M. Royster
M/S 188A
Phone: (804) 864-3135
Fax: (804) 864-7893

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ART/SAERS Task Order Page 1

1. Task Order Number and Title Number: Revision:
   Title: Polymer Synthesis & Characterization

2. Purpose, Objective or Background of Work to be Performed:

Support in the synthesis and physical characterization of HSR candidate matrix resins and adhesives is required.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

Description of Task:
In order to meet the requirements for the development of high performance polymers with specified properties to satisfy the requirements of the HSR program, the Contractor shall synthesize and characterize novel monomers and polymers. The Government will submit approximately six synthesis/characterization requests for monomers and approximately twelve synthesis/characterization requests for polymers. Each request has to be completed and an informal written report submitted within one month after submittal of the request. For each monomer and polymer, the Contractor shall analyze the ability to undergo chemical curing; evaluate the stability in solution and in melted form; evaluate the thermooxidative stability in environments such as those which the HSR aircraft will experience; and expose and assess how these polymers respond to aircraft fluids, such as jet fuels, deicers, hydraulic fluids and paint strippers. This activity shall include the preparation of needed monomers, their purification and characterization by techniques, such as Differential Scanning Calorimetry, Infrared Spectroscopy, Gel Permeation Chromatography, and Thermal Analysis.

The contractor shall scale-up polymers in order to prepare composites and adhesives from these new materials. The Government will submit approximately three requests for scale-up. These scaled-up systems shall be fully characterized as previously described. Each scale-up request has to be completed and an informal written report submitted within two months after submittal of the request for a scale-up activity. The Government will conduct mechanical tests on the scaled-up composites and adhesives at ambient temperature and 350°F.

Deliverables:
All synthesized materials will be Government property and shall be used exclusively in the HSR Program.
The Contractor shall submit informal written reports each month that discuss the schedule and prioritization of synthetic and analytical requests to be conducted.
The Contractor shall submit an informal written report listing the analysis requests submitted and the analyses conducted.
For each characterization request, the Contractor shall submit a brief informal written statement of types of analyses to be conducted and estimated time for completion to the requester and task monitor within 3 working days after receipt of characterization request.
In the case of scale-up activities, approximately one pound of each material shall be delivered for processing within one month of the synthetic request.
When individual synthesis and/or characterization projects are completed, the Contractor shall submit a formal written report to the requester and task monitor within one month. The report

shall include description of the synthetic activity, analyses and interpretation of results. All formatting and computer databasing for integration into HSR standard reporting form shall be done.

ART/SAERS Task Order Page 2

1. Task Order Number and Title Title: Polymer Synthesis & Characterization	Number:	Revision:

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Performance Standards

Written reports for analysis requests:

- Efficiency (time to complete, with complexity and competing requests accounted for)
- Quality of report (figures and photographs of publication quality)
- Equipment operating ability

Overall:

- Adherence to schedule
- Cost

4. Government Furnished Items:

Equipment in the Composites and Polymers Laboratory (Building 1293), including chromatographs, spectrophotometers, thermal analyzers, DTA and DSC systems, chemical reaction equipment, computer systems, specimen preparation equipment, all chemicals and supplies.

5. Other information needed for performance of task.

The Contractor shall have expertise in the operation of Gel Permeation Chromatograph, Light Scattering Photometer, Differential Viscometer, Osmometer and other chemical analysis instruments, and shall have advanced knowledge of solution chemistry techniques.

The Contractor shall have expertise in the operation of Differential Scanning Calorimeter, Infrared Spectrometer, UV-VIS Spectrophotometer, and shall have advanced knowledge of organic synthesis and chemical analysis techniques.

6. Security clearance required for performance of work:

None

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: James F. Dezern
M/S: 226 Phone: 804-864-4263

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ARTS Task Order

1.0 Task Order Number:

Title: Fatigue and Fracture Testing and Analysis

2.0 Purpose, objective, background:

The objective of this task is to perform specialized fatigue and fracture tests, conduct fractographic characterization of metallic materials and maintain the MEMB fractographic analysis laboratory.

3.0 Description of Task

1. The contractor shall perform detailed destructive examinations on aircraft structure. These examinations will include detailed metallographic and scanning electron microscope (SEM) fractographic analysis. Approximately four Government furnished aircraft fuselage panels (3 ft by 6 ft) will be sectioned and examined in detail for evidence of fatigue cracking and corrosion. This will involve the careful dismantling of the structure and preparation of fractographic specimens. Approximately 1000 specimens will be prepared and examined for evidence of corrosion and cracking using optical microscopy. More detailed SEM examinations will be performed on those specimens containing fatigue cracks (approximately 500 specimens). Detailed records will document the location and morphology of each damaged region. A contractor report shall be issued upon the completion of work on each panel.

2. The contractor shall perform specialized fatigue tests to characterize the short crack behavior in as received and corroded aluminum alloys supplied by the Government. Upon completion of each test, detailed fractographic examinations will be performed to document marker band location on the fracture surface. Approximately 150 fatigue tests shall be conducted on specimens supplied by the Government. Detailed fractography of the 150 specimens shall be performed and fractographic records shall be maintained to document the crack length and load cycle behavior of each fatigue crack.

3. The contractor shall maintain the fractographic laboratory and coordinate all activities associated with the MEMB fractographic facility. The contractor shall maintain a monthly laboratory equipment maintenance log. Duties will include familiarizing and certifying up to five researcher who wish to perform SEM studies.

Deliverables:

Informal written and oral reports of each analysis shall presented after the completion of each analysis. A formal report will be written upon the completion of each work assignment (each panel examination and fatigue test series). A laboratory maintenance log shall be kept by the contractor.

Performance Standards:
The contractor shall perform the minimum quantity of analysis (1650 fracture specimens) and fatigue tests (150 tests) within a twelve month period. Formal reports and monthly maintenance log shall be issued per the assignment outlined above. Final reports quality shall meet NASA publication standards. Metrics shall include schedule and cost.

4.0 GFE:

The contractor shall use existing fatigue testing equipment, optical microscopes, SEM equipment, and associated supplies located in the Mechanics of Materials Fatigue and Fracture Laboratory in Building 1205.

5.0 Other Information:

6.0 Security clearance required:

None

7.0 Period of Performance:

Planned start date:	7/1/96
Planned completion date:	6/30/97

8.0 NASA Technical Monitor:

Dr. Robert Piascik
M/S 188E
Phone: (804) 864-3483
Fax: (804) 864-8911

AF /SAERS Task Order Page

1. Task Order Number and Title Number: Revision:
   Title: Fiber optic sensor development and characterization

2. Purpose, Objective or Background of Work to be Performed:
   Fiber optic sensors are being developed by NASA for health monitoring of aerospace structures and vehicles. Present focus is on distributed fiber optic strain and temperature sensors. However, it is expected that this focus will expand to fiber optic sensor development for measurement of other physical and chemical properties.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

Part A:

The contractor shall conduct tests on a "test request" basis to evaluate the performance of fiber optic sensors under development in the optical NDE laboratories. The tests will be conducted with breadboard systems, modules and individual components of fiber optic systems for complete characterization of the electro-optics. The Government will submit approximately 100 written work requests. The tests will include the following types and quantities of measurements on fiber optic systems:

Attenuation(power loss/length) in optical fibers (One/week)
Percent reflectivity of Bragg gratings in fibers (3 tests/week)
Reflected wavelength of bragg gratings (3 tests/week)
Temperature of optical fiber from Raman scattering data (3 tests/week)
Strain measurements (3 tests/week)
Error analysis of fiber optic sensor measurements for various parameters(strain, temperature, chemical species concentration) (One/week)

Performance of these tests will require the contractor to interface the following instruments with computers to obtain test data and subsequently process the data: optical fiber sensor fabrication and characterization instrumentation which includes: fusion splicers, polishers, spectrum analyzers, distributed temperature sensors, lasers and photo diodes and other optical components for measuring attenuation as a function of wavelength, fluorescence spectra and Raman spectra.

Deliverables (for Part A):

- Written documentation of individual test procedures and results, with associated electronic data files.
- Summary of results, activity and updated plans in monthly reports
- Formal final report
- Apparatus for accurately measuring the percent reflectivity of multiple Bragg gratings in a single fiber

Performance Standards (for Part A):
Technical quality of written documentation
Quality of test data as determined by accuracy, scatter and statiscal analysis of error
Quality of electronic data files and documentation of the files
Soundness of plans and procedures
Quality of final report (meets NASA publication standards)

Part B:
The contractor shall design and fabricate electro-optic components on a "work request" basis to support development of fiber optic sensors for measurement of strain, temperature and chemical species. The Government will submit approximately 100 written work requests. Specific items to be fabricated/assembled and approximate quantities are listed below:
Optical fiber drawn from preforms(10 kilometers)
Multiple photo-induced Bragg gratings in single mode optical fiber(Fifty gratings/fiber; 200 fibers)
Electronidc circuits for driving laser diodes; approximately ten modules
Breadboard apparatus for real time readout of multiple Bragg strain sensors(Two)
Software for interfacing all test instruments with data acquisition systems
Prototype fiber optic sensors for strain, temperature and chemical species

The contractor shall interface the following optical fiber sensor fabrication and characterization instrumentation with computers to obtain test data and subsequently process the data: fiber draw tower, fusion splicers, polisher, spectrum analyzers, distributed temperature sensors, lasers and photo diodes, monochromaters and other dispersive elements and modular optical components for measuring emission and absorption of electromagnetic radiation as a function of wavelength.

Deliverables (for part B):
- Written documentation of individual test procedures and results, with associated electronic data files
- Written documentation detailing instrument/computer interfacing
- Summary of results, activity and updated plans in monthly reports
- Formal final report
- optical fibers with fifty Bragg gratings in each fiber
- Laser diode driving circuits

Performance Standards (for part B):
Technical quality of written documentation
Quality of test data as determined by accuracy, scatter and statiscal analysis of error
Quality of electronic data files and documentation of the files
Soundness of plans and procedures
Quality of final report (meets NASA publication standards)

ART/SAERS Task Order Page 2

1. Task Order Number and Title   Number: Revision:

   Title: Fiber optic sensor evaluation and characterization

   The task order number will be assigned by the COTR. The Task Order will be issued by the Contracting Officer pursuant to the terms and conditions of the contract. Expand the boxes below using as much space as needed to provide the COTR the pertinent task requirements and supporting information:

4. Government Furnished Items:

   examples: equipment, software, materials, facilities and office space, government data: Special government regulations will apply to government provided equipment (GFE). Contact the COTR for special instructions on providing GFE

   Access to the optical NDE laboratories and equipment, apparatus and instrumentation therein.

5. Other information needed for performance of task.

   examples: List essential travel required for successful performance of task, number of trips, duration, destination and the need for the travel.
   List any applicable documents and where or how they can be obtained.
   List any safety, environmental, legal, data rights, etc. issues

6. Security clearance required for performance of work:

   List all security issues, if the task description is to be classified special handling of the task will be required by the COTR before issued to the contractor.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Leland D. Melvin
   .M/S: 231   Phone: 804-864-7970

PRINTED: 6/12/96

DR. 18

1. Task Order Number and Title Number: Revision:
Title: Evaluation Inspection Techniques Aircraft Fuselages

2. Background
Research under the NASA Airframe Structural Integrity Program have focused on the development of NDE technologies for the inspection of commercial aircraft technologies. The purpose of this task is to further develop the instrumentation developed under this program and access improvements in the performance of the instrumentation.

3. Description of Work

a. The contractor shall design, fabricate, install and test the necessary circuitry to drive a government-furnished linear array probe from the SUSAN. The subsystem shall include an interface (either PCI or ISA, to be determined) with the SUSAN PC unit, with driver software. The beamforming device shall connect each of 128 transducer elements of a government-provided linear array transducer to one of six possible inputs; the pulse-echo port of the SUSAN unit presented through five different time delays or a dummy load impedence. The state of each connection shall be programmed from the SUSAN computer via the ISA interface. The beamforming circuitry shall be contained within an enclosure mounted to the SUSAN unit, maintaining the portability of the system. The beamformer shall mechanically and electrically mate with a linear transducer array probe being fabricated under separate contract.

Deliverables:
The contractor shall deliver three complete beamformer subsystems, comprising an interface board, Windows driver software, beamforming circuitry with enclosure, power supplies, and all necessary cabling, and full documentation for use. The contractor shall install each subsystem into a SUSAN unit, and shall provide test software to demonstrate its operation.

Performance Standards:
3 complete beamformer subsystems
Reports will meets NASA publication standards.

b. The contractor shall integrate a government-provided linear array probe into the SUSAN. The integration shall occur in three SUSAN units and shall include the following: upgrading existing 80486 mother boards to Pentium mother boards; upgrading display to operate from PCI bus; installing government provided DSP boards into SUSAN and making necessary code changes to implement the SUSAN algorithms on the DSP board; upgrading the government provided digitizer boards to include a high speed bus coupling them directly to the DSP boards; integrating the beamformer circuitry delivered in another subtask; assuring that system level resources (e.g. power supplies and cooling) are adequate; and modifying the government-provided software to provide user interface controls and appropriate display modules for the array probe results. The contractor shall modify the SUSAN operating manuals, including supporting documents required for training third party field testers, to reflect the modifications to the software and hardware. The contractor shall plan and conduct a laboratory demonstration of the array probe.

Deliverables:
The contractor shall deliver three upgraded SUSAN units. The contractor shall conduct the laboratory demonstration of the SUSAN with linear array subsystem and shall deliver commented source code and updated manuals.

Performance Standards:
3 complete beamformer SUSAN units
Manuals will meets NASA publication standards.

c. The contractor will fabricate two eddy current self-nulling rotating probe systems for detection of cracks under rivets in thin metallic structures. This will be sent to Boeing and Douglas for evaluation involve the development of algorithms for data acquisition and processing and system hardware. The contractor will provide operation manuals for the system..

Deliverables:
The contractor shall deliver two prototype self-nulling rotating probe systems for detection of cracks under rivets thin metallic structures and operation manuals.

Performance Standards:
Two prototype self-nulling rotating probe systems
Manuals will meets NASA publication standards

d. The contractor shall design, fabricate, and test the circuitry necessary to multiplex a 12 transducer AE system to four data acquisition channels. The system shall have adjustable threshold levels for the setting the desired sensitivity for AE signal and the duration of the AE event. In addition, the system shall provide for indicating which transducers are connected to the data acquisition inputs.

Deliverables
The contractor shall deliver one (1) complete instrument with documentation suitable for laboratory operation and demonstration.

Performance Standards:
1 instrument for multiplexing 12 AE transducers
Documentation will meets NASA publication standards

e. The contractor shall provide computer software for acquisition of CT data with stand alone microcomputer system which duplicates the current operation of system with VAX computer. Stand alone system will control the scanner, the acquire data and transfer data to remote computer. System will perform calibration runs, specimen scans at select positions without operator intervention.

Deliverables:
The contractor will deliver computer software for acquisition of CT data. The contractor will deliver documentation for software

Performance Standards:
Software for acquisition of CT which duplicates current VAX based system
Reports will meets NASA publication standards

f. The contractor shall perform CT scans on specimens provide by the government on a test request basis. Scans will be performed in a manner prescribed by the government in the written test request. The contractor will fabricate specialized sample holders as required for performing of the scans. There will be a minimum of 1 sample per week and 5 scans per day. The contractor shall also perform all require calibrations of the system.

Deliverables:
The contractor will deliver electronic record of CT data and calibration of system. The contractor will provide documentation on scans performed. The contractor shall deliver specialize sample holders.

Performance Standards:
Minimum of 5 scans per day
Minimum of 1 sample per week
Reports will meets NASA publication standards
Complete Lab Sheet (provided by government) for each scan

g. The contractor will integrate existing government lasers, interferometers, and related optical components into a working laser based ultrasound system. The laser for generating ultrasonic signals shall consist of a Laser Photonics 250 mJ/pulse, pulsed YAG, multimode laser. It shall be connected to a fiber optic system to enable delivery of the laser light to a test object 60 feet away. At the opposite end of the fiber optic system, the system will incorporate appropriate optics to deliver an ultrasonic generating beam of light to a part under test that is 8 to 15 inches away from a scanning bridge. The laser for detection the ultrasound shall consist of an Adlas diode pumped 400 mW CW doubled YAG laser. This shall also be coupled into a fiber optic system for delivery of the laser light to the test object 60 feet away. At the opposite end of the fiber optic system, the system will incorporate appropriate optics to deliver a beam of light for detecting the ultrasound generated from the part under test which is 8 to 15 inches away from a scanning bridge. Some of the reflected light which is scattered from the surface shall be focused onto a fiber optic system and directed through the fiber optic system to an UltraOptec Fabry-Perot Interferometer for detection of the ultrasonic signals. The ultrasonic signal from the surface that must be detected includes the ultrasonically scattered signal from the internal structures within the sample under test. The resulting signals from the interferometer shall be recorded by a PC based data acquisition system.

Deliverables: The contractor will provide a suitable demonstration or calibration of each of the three major components (generating laser, detection laser and the interferometer) and of the complete system by Aug. 15, 1996.

Performance Standards:
Successful demonstration by 8/15/96
The system shall be able to generate ultrasound on composite or aluminum samples which have been painted with retroreflective paint and detect the resulting diffusely scattered ultrasonic signals from as far off axis as 10o

h. The contractor will perform the necessary maintenance on the lasers, interferometers, and other system components to keep the systems in good operational order. Adequate records shall be maintained to insure proper maintenance of the system, and to allow for subsequent training of technician personnel.

Deliverables:
Maintain lasers, interferometers, and system components in working order after installation. Lab manuals shall be maintained and up to date.

Performance Standards:
The systems shall be maintained operational at least 80% of the time after installation, exclusive of factory required maintenance and repair. The lab manuals shall be updated on a daily basis and available at all times for informational purposes.

i. The contractor will operate the laser based ultrasound system to obtain research and development data. The contractor will obtain electronic records of the data. Data files representing scans shall be delivered within five working days of their acquisition to the task monitor.

Deliverables:
The contractor shall acquire data from five samples provided by Structures Div. The samples will be four D-box samples (approximately 3' by 2' scan areas), and one COLTS facility sample, with approximately twenty 3' by 2' scan areas. Data taken on provided samples shall be delivered to the task monitor in the form of usable electronic files, hard copy images of scans, and any related information pertinent to the scan.

Performance Standards:
Data files shall be delivered within five working days and be in a usable electronic form, with supporting hard copy images of scans and any related information pertinent to the scan.

j. The contractor will perform sample preparation on samples provided by the government in a manner specified by the government. The government will submit written test requests. The contractor will prepare samples at appropriate dimensions with the following surface preparation tolerances:

1. Surfaces shall be polished and lapped flat (±0.2μm across surface)
2. Two-surface samples shall have surfaces flat (±0.2μm across) and parallel (±12 arc-seconds)

The contractor will prepare a minimum of 10 samples per week. The contractor will provide etched and metallographically characterized surface analysis on aluminum samples. The contractor will shall measure surface hardness (Brinell, Vickers, etc) according to ASM, ASTM or locally- provided specifications. The contractor will perform heat treatments and quenching of samples according to ASM ASTM, and/or locally-provided specifications. Heat treatments shall be performed with tolerances of better than ±5°F, and heat treatment times of tolerances to better than ±10 sec. Heat and time records shall be taken and made available with heat-treated samples. Sample sets shall be provided within 1 week of request, unless otherwise specified.

Deliverables: The contractor will provide complete government supplied lab sheets for each of the samples. The lab sheets will include the results of testing and verification of preparation tolerances.

Performance Standards:
Complete labs sheets on minimum of 10 samples per week
Prepared samples

k. The contractor will perform SEM, SEAM and SAM scans on specimens supplied by the government. The government will submit written test requests. The contractor will provide either hard and electronic records of the scans at the request of the government

Deliverables:
The contractor will deliver either electronic or hard copies of the scans (4x5 negatives or 8x10 positives) as requested by the government. The contractor will provide completed government supplied lab sheets.

Performance Standards:
Completed lab sheets for each scan

4. Government Furnished Equipment

None

5. Travel will be required for testing of instrumentation at facilities such as the FAA Validation Center.

6. No security clearance is required for the task.

7. Period of Performance:
Plan start date: 7/1/96 Expected completion date: 9/30/96

8. NASA Technical Monitor: William P. Winfree
MS 231 Phone: 804-864-4963

1. Task Order Number and Title Number: DM33 Revision:

Title: Processing, Testing and Analysis of Advanced Metallic Materials

2. Purpose, Objective or Background of Work to be Performed:

The purpose of this task is to conduct metallic materials processing, mechanical testing and metallurgical analyses with the objective of establishing processing-microstructure-property relationships for advanced metallic materials for aerospace applications.

3. Tasks, Deliverables and or Products, and performance measurements (continued):

3.1 Near-Net-Shape Processing of Advanced Al Alloys

The Contractor shall formulate and execute a plan to evaluate near-net-shape processing methods, including roll forging, shear forming, and extrusion, for advanced aluminum alloys selected by the Government (alloy C415 and one to be determined). The Contractor shall process Government supplied ingot sections to produce shear formed cylinders, roll forged rings, and integrally-stiffened extruded panels. The overall shape and target dimensions of each formed component shall be negotiated with the Government based on available material and forming dies. The Contractor shall determine the mechanical properties of the alloys, which may include tensile, fracture toughness, fatigue and/or corrosion behavior (up to 100 tests). The Contractor shall perform metallurgical analyses on formed products to characterize microstructural features such as grain size/morphology, textural characteristics, second phase identification, distribution, and volume fraction (up to 50 specimens). Test matrices, specimen design and analysis plans shall be negotiated with the Government.

Deliverables (for 3.1):

- Plan for processing aluminum ingot sections provided by the Government. (5/27/97)
- Roll forged rings, shear formed cylinders and extruded panels (9/30/97)
- Written and oral summaries of the processing performed within 10 working days of delivery of the formed products.
- Plans for mechanical property testing and metallurgical analyses of roll forged rings, shear formed cylinders and extruded panels. (11/1/97)
- Tested specimens (with fracture surfaces intact and preserved) and informal written and oral reports of test results within 3 working days of completion of each set of tests. The reports will include a description of test procedures, test anomalies, and electronic data files where appropriate.
- Informal written and oral reports of analysis results within 5 working days of completion of each set of analyses. The reports shall include a description of analyses, interpretation of results and any photomicrographs, compositional analyses, x-ray and electron

diffraction data relevant to the microstructural characterization performed.
- Informal written monthly reports that discuss the schedule, testing and analysis results and any other pertinent issues.
- Final written report at the completion of this subtask.

Performance Standards (for 3.1):

MEETS:
- Adherence to schedule
- Conformance with specified product dimensions
- Adherence to ASTM or other relevant standards
- Publication quality data, figures and micrographs
- Quality of monthly and final reports (meets NASA standards)
- Cost

EXCEEDS:
- Delivery ahead of schedule
- Final report contains:
  - ◊ Correlation of processing, properties, and microstructure for each product form and alloy, including explanation of how specific processing parameters used during fabrication produced the observed microstructures and properties.
  - ◊ Correlation of fracture behavior (fracture surface morphology, fracture path, etc.) with microstructure and properties.
  - ◊ Recommendation (and basis for recommendation) for process modifications that will produce optimized microstructures and properties for each product form and alloy.

3.2 Superplastic Forming of Advanced Al Alloys

The Contractor shall formulate and execute a plan to evaluate the forming behavior of emerging superplastic aluminum alloys (alloys 2124 and 2424). The Contractor shall conduct parametric studies using uniaxial tensile testing (up to 200 tests) and biaxial cone testing equipment (up to 100 tests) to determine optimum forming parameters in terms of temperature, flow stress, and strain rate. The Contractor shall perform metallurgical analyses (up to 50 specimens) on deformed materials to determine cavitation levels, thickness uniformity, changes in microstructural features (including grain size/morphology) and textural characteristics as a function of forming strain, strain rate and temperature. Test matrices, specimen design and analysis plans shall be negotiated with the Government.

Deliverables (for 3.2):
- Plans for superplastic forming and metallurgical analyses of superplastically formed materials. (7/31/97)
- Tested specimens (with fracture surfaces intact and preserved where appropriate) and informal written and oral report of test results within 3 working days of completion of each set of tests. The report shall include description of test procedures, test anomalies, and electronic data files where appropriate.
- Informal written and oral reports of analysis results within 5 working days after completion of each set of analyses. The reports shall include a description of analyses, interpretation of results and any photomicrographs, compositional analyses, x-ray and

electron diffraction data relevant to the microstructural characterization performed.

- Informal written monthly reports that discuss the schedule, test and analysis results and any other pertinent issues.
- Final written report at the completion of this subtask.

Performance Standards (for 3.2):

MEETS:

- Adherence to schedule
- Publication quality data, figures and micrographs
- Quality of monthly and final reports (meets NASA standards)
- Cost

EXCEEDS:

- Delivery ahead of schedule.
- Final report contains:
  - ◊ Correlation of SPF processing parameters, properties, and microstructure for each alloy, including explanation of how specific processing parameters used during fabrication produced the observed microstructures and properties.
  - ◊ Correlation of fracture behavior (fracture surface morphology, fracture path, etc.) with microstructure and properties.
  - ◊ Recommendation (and basis for recommendation) for process modifications that will produce optimized microstructures and properties for each product form and alloy.

3.3 Advanced Joining Concepts for Aerospace Alloys

The Contractor shall formulate and execute a plan to evaluate advanced joining methods, including adhesive bonding, resistance welding, weld bonding and friction stir welding, for advanced aluminum alloys selected by the Government (up to 4 alloys). The Contractor shall determine the effect of joining technique on the tensile, fracture, fatigue and corrosion properties of the alloys (up to 50 tests). The Contractor shall perform metallurgical analyses (up to 25 specimens) on joints to characterize microstructural features such as grain size/morphology, textural characteristics, second phase identification, distribution, and volume fraction. Test matrices, specimen design and analysis plans shall be negotiated with the Government.

Deliverables (for 3.3):

- Plan for mechanical property testing and metallurgical analysis of adhesively bonded, resistance welded, weld bonded and friction stir welded joints (7/31/97)
- Tested specimens (with fracture surfaces intact and preserved) and informal written and oral reports of test results within 3 working days of completion of each set of tests. The reports shall include a description of test procedures, test anomalies, and electronic data files where appropriate.
- Informal written and oral reports of analysis results within 5 working days of completion of each set of analyses. The reports shall include a description of analyses, interpretation of results and any photomicrographs, compositional analyses, x-ray and electron diffraction data relevant to the microstructural characterization performed.

- Informal written monthly reports that discuss the schedule, testing and analysis results and any other pertinent issues.
- Final written report at the completion of this subtask.

Performance Standards (for 3.3):

MEETS:

- Adherence to ASTM or other relevant standards
- Publication quality data, figures and micrographs
- Quality of monthly and final reports (meets NASA standards)
- Cost

EXCEEDS:

•Final report contains:

- ◊ Correlation of processing, properties, and microstructure for each joining process and alloy, including explanation of how specific processing parameters used during fabrication produced the observed microstructures and properties.
- ◊ Correlation of fracture behavior (fracture surface morphology, fracture path, etc.) with microstructure and properties.
- ◊ Recommendation (and basis for recommendation) for joining process modifications that will produce optimized microstructures and properties for each alloy and joint configuration.

3.4 Sol-Gel Coatings for Adhesive Bonding of Titanium

The contractor shall assess the utility of sol-gel coatings and processes to prepare titanium alloy sheet and foil for adhesive bonding to fabricate Ti-PMC hybrid laminates and honeycomb structures.

3.4.1 Sol Gels

The contractor shall formulate up to 10 sol-gel coating chemistries and associated processes, use these coatings to bond titanium sheet specimens, and test and evaluate the bonded specimens as described below (Section 3.2.3). The ASM/NASA developed TPG may be one of the coatings. The contractor shall assess the potential of co-curing a sol-gel with the adhesive during the bonding operation.

3.4.2 Adhesive and Alloy

The adhesive to be used in all experiments is identified as FMX5 and the alloy to be used is Ti-15V-3Al-3Cr-3Sn (Ti-15-3-3-3). All adhesives and alloy sheet will be supplied by NASA.

3.4.3 Testing and Evaluation

3.4.3.1 *Screening Tests* - The contractor shall identify and conduct appropriate screening tests to select promising coatings chemistries and processes for more detailed evaluations.

3.4.3.2 *Overlap Shear Tests* - Coatings and processes selected for further investigation shall be used to fabricate tensile overlap shear test specimens, some of which shall be subjected to a water boil exposure, short term or long term thermal exposure. The contractor shall perform up to 150 tensile overlap shear tests at room temperature, on specimens with and without water boil exposure and with and without short term and long term thermal exposure, to determine the effects of the environment on bond strength and failure modes.

3.4.3.3 *Water Boil Tests* - Selected overlap shear test specimens shall be subjected to a 72 hour water boil test according to ASTM specifications. The performance of these specimens (bond strength & failure mode) shall be compared to the performance of those with no water boil exposure.

3.4.3.4 *Short Term Thermal Exposure* - Selected overlap shear test specimens shall be exposed to 750°F, in air, for 1 hour to simulate a secondary bonding operation. Specimens shall be tested, at room, temperature to determine the effects of the exposures on properties and failure modes.

3.4.3.5 *Long Term Thermal Exposure* - Up to 20 overlap shear specimens made from promising coatings and processes shall be exposed, in air, at temperatures up to 400°F for times up to 5000 hours. The performance of these specimens (bond strength & failure mode) shall be compared to the performance of those with no water boil exposure. Times and temperatures will be agreed upon by the contractor and NASA.

3.4.3.6 *Temperature Effects* - Tensile lapshear specimens fabricated from the most promising sol-gels and processes shall be tested at -65°F and 350°F. Up to 20 specimens shall be tested at each temperature.

3.4.3.7 *Microscopy* - Appropriate microscopy, optical and/or SEM shall be performed to characterize joint failures.

3.4.3.8 *Parameters* - As a minimum, the following parameters shall be measured and reported:

- Sol-gel composition and thickness.
- Time interval between titanium surface cleaning and sol-gel application.
- Time interval between sol-gel application and adhesive bonding.
- Adhesive bonding temperature, time, & pressure.
- Amount of water pick-up during water boil.
- Bond thickness before & after bonding and before & after water boil.

Deliverables: (for 3.4)

- Informal written monthly reports discussing activities, progress & issues.
- Tested specimens with associated electronic and/or hard copy test data files as they are generated.
- Six month report, 10/31/97, summarizing the surface preparation task to date, including activities, progress, pertinent data, and issues.
- Final Report summarizing the complete surface preparation task. This report shall include, but not necessarily be limited to coating chemistries and processes, bonding processes and test procedures, test results including overlap shear strengths, water pick-up results, bond thickness data, temperature effects, photomicrographs and any other pertinent information to describe the task and results. The report shall also include recommendations for further titanium surface preparation work.

Performance Standards: (for 3.4):

MEETS:

- Adherence to ASTM or other relevant standards
- Publication quality data, figures and micrographs
- Quality of monthly and final reports (meets NASA standards)
- Cost

EXCEEDS:

- Adhesively-bonded sol-gel coated Ti-15-3-3-3 joints meet or exceed HSR goals for as-fabricated joint strength.
- Adhesively-bonded sol-gel coated Ti-15-3-3-3 joints meet or exceed HSR goals for thermally-exposed joint strength .

3.5 Thermal Processing of Advanced Metallic Materials

The contractor shall, on a written request basis, subject aluminum and titanium alloy and Ti-PMC hybrid laminate specimens to heat treatments and thermal exposures (isothermal and cyclic). The government will provide all test materials and specimens in the required conditions.

The contractor shall conduct up to 15 thermal cycling exposures of selected materials in an air environment in the temperature range -65°F to 350°F. The government will provide the load-temperature-time profiles for the tests. The contractor shall conduct up to 15 isothermal exposures on selected materials, in air at temperatures up to 350°F for times up to 5000 hours. The contractor shall be responsible for inserting the specimens in appropriate furnaces, cataloging and tracking the specimens throughout the exposures, and removing the specimens from the furnaces at the appropriate times. The contractor shall expose specimens to pressure/load/temperature profiles using hot isostatic press equipment or vacuum hot press equipment (up to 6 runs total). The contractor shall deposit coatings of thermal-sprayed aluminum and titanium onto government-supplied substrates using plasma spray equipment (up to 5 runs). The contractor shall ensure equipment is operational prior to and after processing runs.

Deliverables (for 3.5):

- For each test request, thermally-processed specimens and an informal written and/or oral report of results to the Requester within 3 working days of completion of the tests. The report shall include description of processing procedures, calibrations, specimen dimensions, anomalies, and electronic data files for each processing run.
- Informal written monthly reports that discuss the schedule, results and any other pertinent issues.
- Written final report listing the total number of test requests submitted and a breakdown of the types of processing runs conducted.

Performance Standards (for 3.5):

MEETS:

- Adherence to ASTM or other relevant standards
- Quality of response to test requests (publication quality data, figures and micrographs)
- Efficiency (time to complete, accounting for complexity and competing requests)
- Work requests completed by requested due date
- Quality of monthly and final reports
- Cost

EXCEEDS:

- 75% of work requests completed at least 25% ahead of requested due date, as calculated by work days.

3.6 Surface Preparation of Metallic Materials

The Contractor shall conduct surface preparation of metallic materials on a written work request basis. The materials will comprise primarily aluminum- and titanium-based alloys, although other materials may be included on a limited basis. Product forms may include, but not be restricted to, foils, sheets, plates, rods, forgings and extrusions. Work assignments shall include chemical or electrochemical cleaning, etching, milling and plating. The Government will supply the specimens (up to 1000) limited to 36" x 12" in dimension, but usually 1" x 4" in size. The Contractor shall be responsible for ordering chemical supplies; maintaining chemical cleaning baths, monitoring, neutralizing, and coordinating disposal of hazardous materials, and maintaining a catalog of the appropriate materials safety data sheets.

Deliverables (for 3.6):

- For each work request, an informal written and/or oral report of the results to the Requester within 3 working days after completion of the work. The report shall include description of the surface preparation procedures, results, and anomalies.
- Informal written monthly reports that discuss the schedule, results and any other pertinent issues.

PRINTED: 5/27/97

- Final written report listing the total number of work requests submitted and a breakdown of the type of work performed.

Performance Standards (for 3.6):

MEETS
- Quality of response to work requests (publication quality data, figures and micrographs)
- Efficiency (time to complete, accounting for complexity and competing requests).
- Work requests completed by requested due date
- Quality of monthly and final reports (meets NASA standards)
- Cost

EXCEEDS
- 75% of work requests completed at least 25% ahead of requested due date, as calculated by work days.

3.7 Mechanical Testing

The Contractor shall conduct mechanical tests and data analysis on a written work request basis to determine the mechanical behavior of metallic materials from cryogenic to elevated temperatures, with the majority of tests being conducted at room temperature. The Government will supply the specimens machined from aluminum- and titanium-based alloys and composites, although other materials may be included on a limited basis. Product forms may include, but not be limited to, foils, sheets, plates, rods, forgings, and extrusions. The contractor shall ensure equipment is operational prior to and after tests. Specific tests and quantities are detailed below:
- Tensile and compression tests to measure strength, modulus, and elongation (up to 350).
- Fracture toughness tests using J-integral analysis of R-curves generated from compact tension, center-crack tension, and other specimen configurations (up to 100).
- Fatigue crack growth tests using compact tension specimens, center crack tension specimens, and other appropriate test specimen configurations (up to 25).
- S-N fatigue tests on notched and un-notched test specimens (up to 80).
- Subject loaded and unloaded corrosion specimens in salt solutions (up to 25).

Deliverables (for 3.7):
- For each test request, tested specimens (with fracture surfaces intact and preserved) and an informal written and/or oral report of results to the Requester within 3 working days of completion of the tests. The report shall include description of test procedures, calibrations, specimen dimensions, test anomalies, and electronic data files for each test.
- Informal written monthly reports that discuss the schedule, results and any other pertinent issues.
- Written final report listing the total number of test requests submitted and a breakdown of the types of tests conducted.

Performance Standards (for 3.7):

1. Task Order Number and Title Number: DM34 Revision:
   Title: Evaluation of the Long Term Durability of Polymer Composites

2. Purpose, Objective or Background of Work to be Performed:

As a part of the High Speed Research (HSR) program, the LaRC has been tasked to evaluate the long term durability of polymeric matrix composites (PMCs) after exposure to thermal/mechanical fatigue (TMF) environments expected on future high speed civil transport airframes. Exposure of some PMCs to TMF environments is already underway in Government-owned testing machines at LaRC. Portions of the material being exposed will be removed from test at various time intervals and cut into smaller specimens for residual mechanical property testing. The specific objective of the work is to determine the variation (if any) of mechanical properties of the materials as a function of exposure time. Maximum exposure times in the test program are expected to be at least 60,000 hours.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

(A) The Contractor shall maintain a log book documenting specimen exposure status, performance of the twenty Government-owned testing machines used for the long-term tests, and downtime required for calibrations, modifications, and repairs. The Contractor shall specify and direct the implementation of calibrations/repairs/modifications to the machines to assure maintenance of required testing capability. One major modification planned for the performance period is the conversion of two 20-kip machines into 50-kip machines.

Deliverables (for part A)
1. Monthly informal status reports on specimen exposures and testing machine performance. Status reporting shall include documentation of any load/temperature anomalies or any other deviations from the test plan.
2. Documentation of calibrations/repairs/modifications of the testing machines as these activities occur.

Performance Standards (for part A)
MEETS:
- Adherence to schedule and cost
- Content of documentation (see deliverables)

(B) The Contractor shall plan and conduct mechanical property tests of PMC materials that are currently undergoing exposure to TMF environments. Planning shall include specification of specimen/fixture designs and specimen/fixture fabrication plans. The mechanical properties to be determined shall include unnotched tensile and compressive strengths and Young's moduli, and open-hole tensile and compressive strengths. Mechanical property testing shall include: (1) testing of IM7/5260 and IM7/K3B materials after 0 and 5000 hours of tensile-stress exposure, and (2) testing of IM7/5260 and IM7/K3B materials after 15000 hours of tensile-stress exposure. All testing must conform to applicable ASTM and SACMA standards.

Deliverables (for part B)
1. Monthly informal status report on planning and testing activities.
2. Documentation of the test plans for the mechanical testing including specimen/ fixture designs and fabrication plans, instrumentation requirements, and data to be recorded. Delivery of documentation required before start of testing.
3. Documentation of the test data and data analysis. Delivery required by June 30, 1998.
4. Tested specimens, due upon completion of each set of tests.

Performance Standards (for part B)

MEETS:

- Adherence to schedule and cost
- Adherence to ASTM and SACMA standards
- Content of documentation (see deliverables)

EXCEEDS:

- figures, photographs, and charts in documentation meet NASA publication standards

(C) The Contractor shall initiate new long-term durability tests according to the plan developed under Task Order DM03 (1997) as testing machines become available. The Government will provide the time-temperature-load profiles for these tests.

Deliverables (for part C)

1. Monthly informal status report on testing activity.

Performance Standards (for part C)

MEETS:

- Adherence to schedule and cost
- Adherence to time-temperature-load profiles
- Content of documentation

1. Task Order Number and Title Number: DM34 Revision: Title: Evaluation of the Long Term Durability of Polymer Composites

4. Government Furnished Items: 1. PMC test specimens for the testing programs. 2. Twenty servohydraulic testing machines equipped with elevated temperature test chambers for the long-term testing. (Machines located in B.1205 at LaRC.) 3. All additional testing apparatus, equipment, and hardware needed to conduct the testing programs. (Test equipment located in B.1205 at LaRC.)

5. Other information needed for performance of task.

6. Security clearance required for performance of work: None

7. Period of Performance	
Planned start date: July 1, 1997	Expected completion date: June 30, 1998

8. NASA Technical Monitor: Edward P. Phillips .M/S: 188E Phone: 757-864- 3488

1. Task Order Number and Title Number: DM35 Revision:
Title: Fracture Testing of Cracked Aircraft Materials

2. Purpose, Objective or Background of Work to be Performed:
Purpose: Determine fracture properties of materials used in commercial aircraft.
Objective: Measure the load-crack extension and critical CTOA values of 2024 alloys.
Background: Five tests on unstiffened panels and five tests on stiffened panels are currently being conducted under DM01 for the FAA. The work under paragraph 2 in Section 3 is a continuation of the FAA work.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

The Contractor shall conduct fracture tests on laboratory specimens made of aluminum alloys under laboratory air and room temperature conditions with single and multiple-site damage (MSD) cracks to determine load-against-crack extension (by unloading compliance and visual readings at all crack tips, whenever possible) and load-against-displacement per ASTM E561 (Ref. 1), and the critical crack-tip-opening angles (CTOA) during stable tearing. CTOA shall be measured with a high-resolution camera and video system (see Ref. 2). Strain fields and plastic-zone sizes, between various MSD cracks, will be measured by the Government. All materials will be supplied and specimens will be machined by the Government. Guide plates (supplied by the Government) shall be used in all M(T) and C(T) tests, except where noted, and all tests shall be conducted under stroke control.

Two additional tests are being added to the FAA test series. Two 40-inch wide panels made of 2024-T3 (B = 0.063 inch) shall be prepared for testing. One of the specimens will be tested "without" guide plates to measure bucking-tearing behavior. The other 40-inch wide panel will be stiffened with 7075-T6 riveted stiffeners. The conditions for this test will be determined after the tests on the stiffened panels in DM01 have been completed (See Section 2). Guide plates shall "not" be used for either the unstiffened or stiffened panel tests and all tests shall be conducted under stroke control.

Aluminum alloy 2024-T3 (TL-orientation) shall be tested for one thickness (B = 0.063 inches) for M(T) specimens that are 24-inches wide. A total of 6 M(T) specimens shall be tested (4 with anti-buckling guides and 2 without anti-buckling guides) and a total of 6 tensile specimens shall be tested to measure the full stress-strain curve. Three (3) compact tension C(T) specimens (at least 4 inches wide and with the same orientation) shall be machined from a broken half of one of the M(T) specimens and tested with guide plates.

1. Task Order Number and Title — Number: DM35 — Revision:

Title: Fracture Testing of Cracked Aircraft Materials

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Deliverables: (due at completion of each set of tests, unless noted)

- tested specimens
- load-against-crack extension data (unloading compliance and visual measurement at all crack tips)
- load-against-displacement data
- CTOA against crack extension data on each specimen
- brief written summary of each test (noting any testing anomalies)
- brief informal written monthly report
- formal written contractor report at the end of the task.

Performance Standards:

MEETS

- adherence to schedule and cost
- adherence to test procedures
- test data reports
- analyses of test data provides information listed in task description
- final written Contractor report meets NASA editorial standards.

EXCEEDS:

- finite element analysis of data
- completion ahead of schedule

4. Government Furnished Items:
The Government will supply the testing machines, photographic equipment, and other equipment (strain gages, displacement gages, etc.) needed to conduct all of the fracture tests.

5. Other information needed for performance of task.

1. ASTM Standard Practice for R-Curve Determination, E561-94.
2. Dawicke, D.S. and Sutton, M.A., "Crack Tip Opening Angle Measurements and Crack Tunneling under Stable Tearing in Thin Sheet 2024-T3 Aluminum Alloy", NASA CR-191523, Sept. 1993.

6. Security clearance required for performance of work:
none

7. Period of Performance	
Planned start date: 7/1/97	Expected completion date: 9/30/97

8. NASA Technical Monitor: Dr. James C. Newman, Jr.
.M/S: 188E Phone: 804-864-3487

1. Task Order Number and Title Number: DM36 Revision:
Title: Evaluate Ultrasonic Sensors for Composite Manufacturing

2. Purpose, Objective or Background of Work to be Performed:

The Stitched/Resin Film Infused (RFI) wing structures program, which is part of the NASA Advanced Composites Technology Program, will require nondestructive evaluation technologies to succeed. The objective of this task is to evaluate the applicability of ultrasonic measurements as a potential tool for process monitoring and control. The emphasis will be to develop and evaluate reusable sensors that can be mounted in the tool during the manufacturing of integrated wing structures and provide precise information as to the state of the resin system during the fabrication process. Methods will be developed for mapping the output of the sensor to important processing parameters such as viscosity, resin location, part dimensions, and degree of cure. This effort will extend previously developed techniques to improve their applicability in tooling for fabrication of thick composites.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

1. The contractor shall measure the acoustic response of resin during cure at elevated temperatures.
- Set-up equipment:
The contractor shall set up parallel plate test cell with an ultrasonic transducer bonded to one of the outside faces and configure measurement system to transmit and receive ultrasonic signals through neat resin or resin with fibers. The contractor shall place cell in oven or press to control the temperature of the resin during the cure reaction.
- Write software:
The contractor shall write a routine for computer control of the temperature controller for the press or oven to within +/- 5 deg. F. The contractor shall write routines to read thermocouple output and convert reading to temperature, digitize and store the ultrasonic response of the transducer-plate system with the cell empty, digitize the acoustic response of the cell with the resin and store data with the time of measurement and the temperature of the cell The contractor shall write an analysis routine to separate the acoustic properties of the resin from the acoustic response of the cell and resin.
- Take data:
The contractor shall measure the ultrasonic response of the transducer plate system with the cell empty and digitize and store the acoustic response of the cell with the resin as a function of time and temperature. The contractor shall document the changes in acoustic properties of the resin as a function of cure time and temperature.

Deliverables (task 1):
• set up equipment and place test cell in oven or press by 8-1-97
• routines to control and read temperature, digitize and store ultrasonic response and separate acoustic properties of resin from cell by 9-15-97
• informal report documenting measured changes in acoustic properties of resin vs cure time and temperature by 10-31-97

Performance Standards (task 1):
MEETS
• adherence to schedule
• Reports will meet NASA publication standards
• Control oven temperature within +/- 5 deg F.

EXCEEDS
• complete tasks ahead of requested due date
• control oven temperature to better than +/- 5 deg. F.

2. The contractor shall correlate changes in velocity to changes in degree of cure.
- Set up equipment:
The contractor shall place a parallel plate cell with ultrasonic transducer in an oven or press to control the temperature of the resin during the cure reaction.
- Write software:
The contractor shall write a routine to measure velocity during cure of resin with fibers and correlate to degree of cure.
- Take data:
The contractor shall measure velocity during cure of resin with fibers and correlate to degree of cure.

Deliverables (task 2):
• place test cell in oven or press and set up measurement system by 11-29-97
• routine to measure velocity during cure & correlate to degree of cure by 1-3-98
• informal report documenting measured changes in velocity and correlating to degree of cure by 1-17-98

Performance Standards (task 2):
MEETS
• adherence to schedule
• reports will meet NASA publication standards

EXCEEDS
• complete tasks ahead of requested due date

3. The contractor shall configure high speed digitizing system to transmit data over DSPLINK to DSP card and perform signal averaging.
- Set up equipment:
The contractor shall place a parallel plate cell with ultrasonic transducer in an oven or press to control the temperature of the resin during the cure reaction.
- Write software:
The contractor shall develop code to allow real-time signal averaging using the DSP board linked to the digitizer by the DSPLINK.
- Take data:
The contractor shall perform measurements to demonstrate real-time signal averaging.

Deliverables (task 3):
• place test cell in oven or press and set up measurement system by 2-14-98
• code for real-time signal averaging using DSP board & DSP LINK by 3-21-98
• informal report documenting real-time signal averaging capability by 4-4-98

Performance Standards (task 3):
MEETS
• adherence to schedule
• reports will meet NASA publication standards

EXCEEDS
• complete tasks ahead of requested due date

4. The contractor shall determine if usable ultrasonic reflections can be received from resin/wetted preform interface and wetted/dry preform.
- Set up equipment:
The contractor shall place a parallel plate cell with ultrasonic transducer in an oven or

press to control the temperature of the resin during the cure reaction.
- Write software:
The contractor shall develop code to track interface reflections.
- Take data:
The contractor shall perform measurements to demonstrate tracking of interfaces as a function of time and temperature.

Deliverables (task 4):
- place test cell in oven or press and set up measurement system by 5-2-98
- code for tracking interface reflections by 6-13-98
- informal report documenting interface reflection tracking capability by 7-1-98

Performance Standards (task 4):
MEETS
- adherence to schedule
- reports will meet NASA publication standards

EXCEEDS
- complete tasks ahead of requested due date

1. Task Order Number and Title	Number: DM36	Revision:
Title: Evaluate Ultrasonic Sensors for Composite Manufacturing		

4. Government Furnished Items:

The government will provide access to computers, waveform generators, digitizers, software, oven and ultrasonic test cell with transducer. The government will provide LabView development software and manuals for program development and C-language tools. The government will provide access to Building 1238B where heated press and other equipment is available to support this task.

5. Other information needed for performance of task.

Work to be performed in B1238B where heated press and other equipment is available.

6. Security clearance required for performance of work:

No security clearance is required for this task.

7. Period of Performance	
Planned start date: June 15, 1997	Expected completion date: June 30, 1998

8. NASA Technical Monitor: Sidney G. Allison
M/S: 231 Phone: 757-864-4792

1. Task Order Number and Title Number: DM37 Revision:
Title: "Thermographic and Ultrasonic NDE for HSR"

2. Purpose, Objective or Background of Work to be Performed:

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

A. The contractor shall perform the following routine and advanced measurements and analyses on a written work request basis using specified methodologies and with NASA developed acquisition equipment and analysis software, in both the NDE laboratory and in in-situ settings:

- actively stimulated temperature histories for large field image scans and for fixed point and line scans (Avg. 2/month)
- temperature flux rate data reduction (Avg. 2/month)
- material thermal property data reduction (Avg. 2/month)
- ultrasonic image scans and multi-point measurements (Avg. 10/month)
- ultrasonic velocity, amplitude, and attenuation reduction. (Avg. 10/month)

The contractor shall prepare samples and develop specialized holders, stands, lamp enclosures and electrical modifications necessary for setup and performance of measurements.

Deliverables (part A):

- archived raw and processed data (electronic and hardcopy) for up to 30 tests per month with less than one week turn around.
- brief informal written and oral reports for each work request within 3 working days after completion of work request.
- Detailed formal written final report due upon completion of task.

Performance Standards (part A):

MEETS:

- adherence to schedule
- completeness of reports (including include archived raw and processed data, verification of system configurations and methodologies, difficulties encountered, and quality of data).
- work requests completed by requested due date

EXCEEDS:

- 75% of work requests completed at least 25% ahead of requested due date, as calculated by work days.

B. The contractor shall deliver data acquisition and analysis software modules on a work request basis using the LabView software development system to incorporate new pulser/receiver and digitizer boards into the existing and upgraded laboratory computers. (approx. 5 modules)

Deliverables (part B):

- data acquisition and analysis software modules incorporated into a graphical user interface
- documented source code and manuals.
- brief informal written and oral reports for each work request within 3 working days after completion of work request.
- Detailed formal written final report due upon completion of task.

Performance Standards (part B).

MEETS:

- user friendly graphical interface.
- software modules must meet performance specifications detailed in the written work request.
- adherence to schedule
- work requests completed by requested due date

EXCEEDS:

- 75% of work requests completed at least 25% ahead of requested due date, as calculated by work days.

C. The contractor shall maintain a monthly laboratory equipment maintenance log detailing condition of equipment, calibration state, and necessary repairs.

Deliverables (part C):

- log book for inspection.
- reports of necessary repairs and calibrations.

Performance Standards (part C):

- log book maintained in up-to-date status.
- reporting of repairs and calibrations
- repair reports contain description of requirement for repair, and repair actions taken
- calibration reports contain description of requirement for calibration, and calibration procedures used.
- calibrations conducted on schedule

ART (NAS1-96014) Task Order Page 2

1. Task Order Number and Title Title: "Thermographic and Ultrasonic NDE for HSR"	Number: DM37	Revision:

4. Government Furnished Items:

The government will provide access to computer workstations and printers for documentation, will provide parts, materials, and components for specimen mounting and preparation, and will provide access to the NESB thermography and ultrasonic laboratories and machine shop. The government will provide LabView development software and manuals for program development.

5. Other information needed for performance of task.

6. Security clearance required for performance of work:

The task is unclassified, however, it is subject to Limited Exclusive Rights Data (LERD) restrictions.

7. Period of Performance	
Planned start date: July 1, 1997	Expected completion date: June 30, 1998

8. NASA Technical Monitor: D. Michele Heath
.M/S: 231 Phone: 757-864-4964

ART Task Order Page 1

1. Task Order Number and Title Number: DM38 Revision:
   Title: **Analysis of MIDAS Ground Control Data**

2. Purpose, Objective or Background of Work to be Performed:
The Environmental Interactions Branch of the Materials Division is currently evaluating the effects of spaceflight on the electrical properties of high temperature superconductive films. The Materials In Devices As Superconductors (MIDAS) spaceflight experiment was designed, built, and flown on the Mir space station to perform a 90 day evaluation of 24 specimens. The critical transition temperature and critical current density properties of films produced by screen-printing, sputtering, and ion-assisted deposition were measured periodically throughout the 90 day period and compared to pre- and post-flight data. The thick film specimens (produced by screen-printing) showed no significant change in electrical properties due to the spaceflight. However, minor changes in the properties of the sputtered samples were found. Additionally, some changes in the non-superconductive resistance properties (i.e., >90K) of the films were discovered during post-flight testing. In order to further understand the causes of these changes, a ground control unit is being assembled. This system will employ the MIDAS flight hardware with similarly-produced specimens. It will operate autonomously for 90 days in a lab environment and the data will be compared to that obtained in the flight unit.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):
(A)- The contractor shall analyze the ground control data using the MIDAS data reduction software and determine the extent of degradation of the superconductive specimens due to the 90 day test. The contractor shall generate plots of performance and identify critical parameters. The contractor shall compare the data obtained from the ground control specimens with that obtained from the MIDAS flight specimens and generate comparison plots.

Deliverables (part A): [due 10/30/97]

- Electronic data files
- hard copies of characterization plots from the ground control data (Photographs of the ground control specimens shall also be included.)

Performance Standards (part A):

MEETS:

- graphs of resistance vs. temperature and current vs. voltage for a typical specimen
- table listing the critical transition temperature and critical current density of each LaRC-produced specimen at each iteration of the experiment (i.e., at the conclusion of each 30 day test increment)

EXCEEDS:

- table comparing the relative performance of the ground and flight specimens
- indication of correlation between specimen performance and specimen condition observed in part B
- graphs of system performance during 90 day test
- graphs of performance for specimens produced from the Moscow Institute of Electronic Equipment which will be tested in the same system

(B)-The contractor shall visually inspect the ground control specimens after completion of the 90 day test and removal from the hardware system. The contractor shall use optical microscopy and/or SEM analysis to document any microcracks or surface contamination.

Deliverables (part B): [due 10/30/97]

- Photographs of the ground control specimens.

Performance Standards (part B):

MEETS:

- Photographs are publication quality

EXCEEDS:

- Electronic version of photographs provided

Performance Standards (parts A and B):

MEETS:

- Adherence to schedule and cost

EXCEEDS:

- Task completion ahead of schedule and under cost.

ART Task Order Page 2

1. Task Order Number and Title   Number: Revision:

   Title: **Analysis of MIDAS Ground Control Data**

   The task order number will be assigned by the COTR. The Task Order will be issued by the Contracting Officer pursuant to the terms and conditions of the contract. Expand the boxes below using as much space as needed to provide the COTR the pertinent task requirements and supporting information:

4. Government Furnished Items:

Access to the Microelectronics Fabrication Facility (B1238A), Structures and Materials Lab (B1148), and the Light Alloy Lab (B1205). Access to the MIDAS ground control unit and the MIDAS data reduction software.

5. Other information needed for performance of task.

The MIDAS data acquisition software will be amended to allow the contractor access to the data after each 30 day period, as opposed to after the completion of the 90 day experiment.

6. Security clearance required for performance of work:

NONE.

7. Period of Performance	
Planned start date: 7/1/97	Expected completion date: 10/30/97

8. NASA Technical Monitor: Stephanie Wise
   .M/S: 188B   Phone: 804-864-8068

ART Task Order Page 1

1. Task Order Number and Title Number: DM39 Revision:
Title: **Characterization of Piezoelectric Actuators**

2. Purpose, Objective or Background of Work to be Performed:
The Environmental Interactions Branch of the Materials Division is currently characterizing high displacement piezoelectric actuators for use in aircraft and spacecraft systems. These actuators demonstrate very large displacements under applied electric fields, but exhibit only moderate load bearing capability. In order to determine their feasibility for application in demanding aerospace systems, researchers have characterized the performance of these devices under various operational conditions. These studies have focused on the effects of waveform shape, electric field strength, frequency, and continuous usage on displacement properties. The work performed in this task will supplement existing characterization data to further understand these new actuator materials.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):
(A)- The contractor shall produce and characterize rectangular RAINBOW (Reduced And INternally Biased Oxide Wafer) high displacement piezoelectric actuators. Actuators shall be fabricated from thin PZT-5A piezoelectrics supplied from multiple vendors, and the difference in performance due to the vendor used shall be evaluated. The devices shall be produced with dimensions of 2.5" x 1.5" x 0.010" which is the same size configurations as THUNDER (THin Layer UNimorph DrivER and sensor) actuators to provide comparison of properties between the two actuator devices. Performance at different electric field strengths and frequencies of operation shall be measured. Plots of actuator performance shall be generated.

<u>Deliverables (part A):</u> [due 10/30/97]

- RAINBOW devices that were fabricated and tested
- electronic copies and hard copies of graphs
- data on properties of the RAINBOW devices

<u>Performance Standards (part A):</u>

MEETS:

- At least 2 vendors of PZT-5A are utilized
- RAINBOW devices have same dimensions as THUNDER devices, within 10%
- Performance plots include displacement vs. electric field for typical specimens
- RAINBOW performance as function of PZT-5A vendor is documented

EXCEEDS:

- At least 3 vendors of PZT-5A are utilized
- Performance plots include displacement vs. static loads up to 500g

(B)- A method to non-destructively evaluate the piezoelectric thickness remaining in a RAINBOW device after chemical reduction has recently been developed. The contractor shall validate this technique using piezoelectrics of different composition, diameter, and thickness. The results shall be documented in a report.

Deliverables (part B): [due 1/31/98]

- formal report

Performance Standards (part B):

MEETS:

- report meets NASA publication standards
- report includes details of the validation process and results
- 2 piezoelectric compositions tested for validation

EXCEEDS:

- 4 piezoelectric compositions tested for validation

(C)-The contractor shall characterize the effects of temperature on standard piezoelectric and electrostrictive ceramics (including, but not limited to, PZT-5A, PZT-5H, PZT-4, and PLZT (9/65/35)). A temperature range of -150 to 250°C shall be used for all measurements. The resonance properties (impedance vs. frequency) of the materials shall be measured over the temperature range of interest, and piezoelectric coefficients (such as d33) shall be calculated from the data. The effects of temperature on the dielectric constant shall be measured. Alteration of ferroelectric hysteresis loop shape with temperature shall also be recorded. Finally, the change in electrical resistance/conductivity of the various piezoelectric compositions with temperature shall be evaluated. Data shall be stored in electronic format, and performance plots shall be generated.

Deliverables (part C): [due 6/30/98]

- data on the effects of temperature on the properties of piezoelectric and electrostrictive compositions
- Electronic files and hard copies of graphs

Performance Standards (part C):

MEETS:

- Measurements are taken at temperatures of -150°C, room temperature, and 250°C.
- performance plots include dielectric constant vs. temperature, remanent polarization vs. temperature, and electrical conductivity vs. temperature

EXCEEDS:

- Data taken in 50°C increments from -150 to 250°C
- performance plots include ferroelectric hysteresis loops at the different temperatures

Performance standards (Parts A,B, and C):

MEETS:

- adherence to schedule and cost

EXCEEDS:

- task completion ahead of schedule and under cost.

ART Task Order Page 2

1. Task Order Number and Title   Number: DM   Revision:

   Title: **Characterization of Piezoelectric Actuators**

   The task order number will be assigned by the COTR. The Task Order will be issued by the Contracting Officer pursuant to the terms and conditions of the contract. Expand the boxes below using as much space as needed to provide the COTR the pertinent task requirements and supporting information:

4. Government Furnished Items:

Access to the Structures and Materials Lab (B1148) and the Light Alloy Lab (B1205). Data on the performance of THUNDER actuator devices for comparison to rectangular RAINBOW actuators.

5. Other information needed for performance of task.

Drawing of THUNDER acuators, supplied by the Government

6. Security clearance required for performance of work:

NONE.

7. Period of Performance	
Planned start date: 7/1/97	Expected completion date: 6/30/98

8. NASA Technical Monitor: Stephanie Wise

   .M/S: 188B   Phone: 804-864-8068

1. Task Order Number and Title Number: DM40 Revision: Date:
Title: Optimization of NDE Techniques for Inspection of Aluminum Aircraft Fuselages

2. Purpose, Objective or Background of Work to be Performed:

Research under the NASA Airframe Structural Integrity Program has focused on the development of NDE technologies for the inspection of commercial aircraft technologies. The purpose of this task is to optimize the instrumentation developed under this program and access improvements in the performance of the instrumentation.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

a. The contractor shall develop hardware and software controller which interfaces Smart Ultrasonic System for Aircraft NDE (SUSAN) to 128 element ultrasonic array. The controller will enable an arbitrary independent or synchronized excitation and reception by the elements of the array. SUSAN will then perform real time reduction of the data to give state of bonding or disbonding and the thickness of the first layer when no bonding is present. The system will produce a 2D map characterizing the state of bonding and the thickness of the upper layer. The system will be tested on samples with known flaws and an accuracy of the system determined. The system will also be demonstrated on an aircraft fuselage.

Deliverables:
The contractor shall deliver software and hardware to control a to multi-element ultrasonic array which interfaces the array with SUSAN. The contractor shall provide documentation on the use of the controller and the design of the hardware. The contractor shall provide documentation on the performance of the system with the ultrasonic array.

Performance Standards:
MEETS:
Demonstration of system on aircraft fuselage
Controller capable of sweeping all the transducers in the array in 30 seconds
Reports will meets NASA publication standards.

EXCEEDS:
Demonstration of system at aircraft rework facility or FAA Validation Center
Controller capable of sweeping all the transducers in the array in 10 seconds

b. The contractor shall develop optimized lens configuration of the self-nulling probe to minimize the foot print of probe. The magnetic field lines will be focused to a region close to a rivet to reduce the interference of responses from layer edges with responses from cracks at rivets. The contractor shall design and fabricate multilayer riveted test panels with crack in the lower layers. Test panels will be representative of aircraft lap joints with tear straps. The contractor shall perform measurements on panels with known cracks to determine the probability of detecting small cracks in the second and third layer of the structure.

Deliverables:
The contractor shall deliver probes with optimized lens configuration and their design. The contractor shall deliver test panels with cracks at the rivets. The contractor shall deliver detailed report on results of testing of detection of small cracks in multilayer panel and the POD (Probability of Detection) curves for second and third layer cracks when using the new probes.

Performance Standards:
MEETS:
Reduction in foot print of the probe by 50%
Two test panels with 18 rivets each and cracks ranging for 30 to 100 mils

EXCEEDS:
Reduction in foot print of the probe by 75%
Four test panels with 18 rivets each and cracks ranging for 30 to 100 mils

c. The contractor shall provide computer simulations of advanced thermographic techniques. The contractor shall perform simulations of different thermographic inspection protocols as prescribed by the government. The simulations shall be both 2 dimensional and 3 dimensional representations of experimental configurations. The contractor shall provide methodologies for verification of the simulations and verify the simulations based on experimental data supplied by the government. From simulations, the contractor shall suggest optimal experimental protocol for different experimental configurations. Contractor shall also use simulations to estimate limits of the techniques for detection of flaws in structures. The contractor shall perform the analysis of at least one configuration a week.

Deliverables:
The contractor shall deliver detailed reports on the results of the simulations. The contractor shall deliver software for analysis of simulations and documentation on the analysis software. The reports shall detail expected capabilities of different thermographic technique, suggestion for optimization of techniques, probability of detection curves for different techniques.

Performance Standards:
MEETS
Complete analysis of one thermographic methodology for simple structure
Reports will meets NASA publication standards

EXCEEDS
Complete analysis of one thermographic methodology for complex structure including a representation of the rivets.
Development of software driver for thermal analysis package which incorporates the salient features of the thermographic systems and reduces expertise required to run simulations of thermographic system on commercial thermal analysis packages.

4. Government Furnished Items:

The government will provide a complete SUSAN system, comprising portable computer, data acquisition cards (with spares), printer, manual scanner, motorized scanner, and transducer array. The government will provide access to personal computers and printers for purpose of document preparation. The government will provide parts, materials and components for approved mechanical or electrical modifications. The government will establish appropriate memoranda of agreement with third party participants to enable full collaborative efforts. The government will supply software for performing the thermographic simulations and a workstation for running the simulations.

5. Other information needed for performance of task.

Travel will be required for testing of instrumentation at facilities such as the FAA Validation Center.

6. Security clearance required for performance of work:

none

7. Period of Performance

Planned start date: 7/1/97	Expected completion date: 6/30/98

8. NASA Technical Monitor: W. P. Winfree
.M/S: 231 Phone: 804-864-4963

1. Task Order Number and Title Number: D001 Revision: DATE; 5/29/97
   Title: **Pegasus Crossflow Transition Flight Experiment**

2. Purpose, Objective or Background of Work to be Performed:

The Pegasus Crossflow Transition Experiment has been defined to provide CFD (Computational Fluid Dynamics) code validation data for crossflow-induced transition from laminar to turbulent flow in the hypersonic Mach number regime. Due to the small model scale available and the high free stream disturbance level in hypersonic wind tunnels, it is currently not feasible to obtain this type of data in ground-based facilities.

Using current CFD techniques, a wing shape predicted to have high amplification of cross-flow instabilities/transition and damping of other types of transition has been designed. A steel 'glove' equipped with sensors for flow characterization is under installation on a spare delta wing set to be used on the first stage of an Orbital Sciences' Pegasus launch vehicle. The launch is done from captive flight underneath a Lockheed L-1011 flying at 40,000 feet. The experiment is planned to take place during the 90 second flight of the first stage of the Pegasus, while the vehicle accelerates to Mach 8 and reaches an altitude of approximately 180,000 feet.

Current plans call for the experiment to be performed during the Spring 1998, in conjunction with the SCD-2 (Brazil-Sat-2) payload. The flight is considered 'piggy-back' ; i.e. it is a secondary payload, and is denoted FX-1 in NASA planning documents. The FX-1 flight is intended to provide information to assess the existence of crossflow transition on the glove.

The project is managed from NASA Dryden, and is defined as an interactive project between
- -NASA Dryden (project office, glove physical design and manufacturing, instrumentation
- -NASA Langley (aerodynamic design, experiment definition, high frequency instrumentation, data analysis)
- -NASA Goddard (launch support)

The experiment is carried out through agreements with Orbital Sciences in the form of MOUs (Memoranda Of Understanding) and SOWs (Statement Of Work) defined within the framework of current contractual agreements between NASA Goddard and Orbital Sciences Corporation (OSC).

The task as defined herein constitutes the bulk of NASA Langley's remaining responsibility for the experiment. The aerodynamic design has been performed, and the experiment definition has been brought to the implementation stage. The high frequency instrumentation/data handling work is ongoing. Sensors have been delivered to NASA Dryden, and the DAPS (Data Acquisition and Processing Systems) delivered.

The work defined will provide NASA with the transition data needed for validation of currently existing laminar boundary layer stability codes for the hypersonic crossflow-dominated case.

3. Description of the Work to be Performed (list all Subtasks, Deliverables and/or Products, and Performance Measurements):

The task is split into two subtasks:
1. Concerns the validity of the experiment, in terms of ensuring that the trajectory, atmospheric conditions, vehicle flow field, glove surface quality and sensor signal conditioning are adequate.
2. Concerns the data analysis for the experiment.

SUB-Task 1. Experiment definition

Utilizing tools and techniques outlined below, the contractor shall:

3.1.1 Define the trajectory and vehicle attitude requirements for the experiment to provide crossflow-dominated transition data.
3.1.2 Define the glove shape, surface quality, atmospheric density and instrumentation requirements to ensure that cross-flow dominated transition data is obtained.
3.1.3 Estimate the loci of impinging shocks on the glove surface.

Deliverables / Metrics:

The deliverables in the task consist of formal reports and memoranda, documenting the following. The reports shall be issued according to the form specified by NASA Dryden and schedule set by needed dates relative to the launch (at this time launch date is TBD, but is anticipated in the late 1st qtr. or early 2nd qtr. of CY98 timeframe).

3.1.1 Specification of the trajectory requirements in terms of angle-of-attack, Mach number, altitude and expected transition locations for the glove area as functions of time from drop until staging, negotiation/iteration with the launch provider to meet desired trajectory given requirements of satellite being launched, and assessment of expected transition locations given final trajectory.

Performance Standards:

MEETS:
* Trajectory specified in sufficient time before launch date to ensure negotiation will occur
* Trajectory calculations during negotiations made so as to not delay negotiations
* Final trajectory meets minimum requirements for experiment

EXCEEDS:
* Final trajectory provides better than minimum requirements for experiment

3.1.2.1 A. Confirm the requirements as stated in the experiment's ORD (Objectives and Requirements Document) for the surface quality of the transition glove.
B. Define procedures for experimental verification of transition glove roughness and waviness (grid/orientation/sampling rate).
C. Within three months from glove buildup completion and surface quality documentation provide an assessment of transition locus based upon as-built test surface.
D. If the contractor determines that the surface quality requirements are not met, the report must include a DR (Discrepancy Report) for the CCB (Configuration Control Board).

Performance Standards:

MEETS:
* Requirements confirmed and procedures defined for surface quality measurements by glove build-up completion
* As-built surface quality assessed and reported within three months of glove completion

EXCEEDS:
* Requirements confirmed and procedures defined for surface quality measurements 2 weeks before glove build-up completion
* As-built surface quality assessed and reported within 10 weeks of glove completion

3.1.2.2 The contractor shall deliver to NASA a complete plan to acquire the appropriate atmospheric conditions of importance for the transition experiment. To include:

A. An assessment of measurement accuracy and reliability for standard (e.g. density sphere and radiosondes in combination with balloons) and modified meteorological rocket payloads (darts).
B. An assessment of allowable distance and time separation for launch of the various atmospheric measurement techniques relative to the Pegasus launch.

Performance Standards:
MEETS:
* Assessments made and reported 2 months before launch

EXCEEDS:
* Assessments made and reported 3 months before launch

3.1.2.3 A. The contractor shall establish instrumentation calibration techniques for the surface hot films and the fast pressure transducers.
B. The contractor shall confirm whether or not these techniques are being followed.
C. The gain and saturation consequences for both time-averaged and dynamic sensors must be documented, based on the stage 1 trajectory defined at the time the crossflow experiment becomes manifested.
while the assessment of gain and saturation consequences should be available within three months from when the experiment is manifested.

Performance Standards:
MEETS:
* The calibration techniques are made available by December 1, 1997
* The assessment of gain and saturation consequences are available within three months from when the experiment is confirmed on the Pegasus flight and the flight scheduled.

EXCEEDS:
* The calibration techniques are made available by November 1, 1997
* The assessment of gain and saturation consequences are available within two months from when the experiment is confirmed on the Pegasus flight and the flight scheduled

3.1.3 The contractor shall map the shock pattern expected to occur in the vicinity of the glove, based on information regarding geometry and trajectory obtained from Orbital Sciences, utilizing appropriate computational tools. These include utilization of Navier-Stokes solutions from the LAURA code in combination with blast wave theory.
In the report, the contractor shall describe vehicle geometry and protuberances of importance for the experiment, describe the predicted shock patterns and the techniques used to obtain the results, as well as make an assessment of the consequences for the experiment.

Performance Standards:
MEETS:
* The report made within 6 months of receipt of the information from Orbital Sciences

EXCEEDS:
* The report made within 4 months of receipt of the information from Orbital Sciences

Subtask 2. Data analysis

The contractor shall develop a plan for the data reduction and analysis of the data expected from the launch, as well as a reasonable time period before launch. The plan shall cover both time-averaged and high frequency information. It shall also include plans for utilization of OSCs Pegasus PCM-data and inclusion of the atmospheric data that is obtained in connection with the launch.

After launch, the contractor is expected to implement the plan, and this will be the subject of issuing a separate task.

Performance Standards:

MEETS:
* The report made 1 month before launch

EXCEEDS:
* The report made 2 months before launch

4. Government Furnished Items:

- Computer systems, and test equipment.

Documentation:

- Operation and maintenance documentation.
- Software previously developed for Pegasus FX-1 including prototype.
- Computer systems software.

5. Other information needed for performance of task.

Essential travel for performance of the task :

-Travel to NASA Dryden, NASA Goddard, NASA Wallops and Orbital Sciences, Dulles to participate in project reviews such as design reviews, peer reviews, configuration control board meetings.

-Travel to NASA Dryden and Vandenberg AFB, CA in the preparation for and during launch of the Pegasus.

-Travel to industries/organizations and meetings as required for successful development of the hardware and in order to produce the deliverables.

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Description of the experiment is given in:

Bertelrud, A., Graves, S., Young, R. and Anderson, B.: "Documentation of Crossflow Transition in Flight at Hypersonic Mach Numbers." AIAA Paper 95-6060, presented at the AIAA 6th Aerospace Planes and Hypersonic technologies Conference, 3-7 April, 1995, Chattanooga, TN.

Bertelrud, A., Bartlett, J.E., Young,R. and Chiles, H.R.: "Use of Dual Hot Films for the Measurement of Surface Mean Flow and Turbulence at High temperatures." presented at the 41st International Instrumentation Symposium, Denver, Colorado, May 7-11, 1995.

6. Security clearance required for performance of work:

None

The data obtained in the experiment is unclassified, and unless specified by NASA will be open to the public for unlimited distribution.

7. Period of Performance:	
Planned start date: June1, 1997	Expected completion date: May 1, 1998

8. NASA Technical Monitors:

Dennis M. Bushnell
MS 110 Phone: 757-864-5703

David E. Reubush
MS 117 Phone: 757-864-3749

DSx01

ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title — Number: — Revision:
   Title: Structural Mechanics Analysis and Testing

2. Purpose, Objective or Background of Work to be Performed:
   The Structural Mechanics Branch conducts analytical and experimental research on the response of complex structures subjected to static and dynamic loads. The research conducted by the Branch explores basic structural behavior, develops advanced methods of analysis and design, and confirms the validity of analysis by conducting tests of structural elements, panels and large-scale structural models. Structurally efficient, cost-effective structural concepts that exploit the benefits of advanced composite and metallic materials for advanced aircraft and spacecraft structural components are developed. Typical investigations concern stability, strength, damage tolerance, and structural integrity of aircraft and spacecraft structures, and tailoring of structures made from composite materials. Special emphasis is focused on identification of structural deformations and failure modes, development of verified failure analysis, development of structurally efficient composite and metallic structural concepts, and prediction of nonlinear and linear structural response phenomena of undamaged and damaged structures subjected to mechanical, pressure and thermal loads. New static and dynamic test techniques including combined loads are conceived. Current research programs include basic research for composite structures, the Advanced Composites Technology program, the Aircraft Structural Integrity program, and the High Speed Civil Transport program.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

Task 1. The Contractor shall develop 3 to 4 finite element models of stiffened composite and metallic panels tested by the government in the Pressure-Box test facility. The finite element models shall be detailed enough to represent the global and local response of the panels, to determine instrumentation patterns, and to determine test load and restraint conditions. The Contractor shall conduct nonlinear structural analyses of the panels using the finite element models for 4 to 5 different loading conditions for each panel configuration. The structural analyses shall include damage tolerance analyses of the panels with long cracks.

Deliverables: Finite element models and analytical results.

PRINTED: 6/12/96

Schedule: Finite element models and analytical results shall be provided by June 30, 1997.

Metrics: The analysis results shall accurately correlate with test results.

Task 2. The Contractor shall design test fixtures and develop test procedures for a semi-span wing-box specimen and for 3 to 4 associated design development panel specimens to be tested by the government. The Contractor shall coordinate test-specimen and test-fixture preparation for structural tests of the wing box and related panel specimens. The Contractor shall develop analytical models of the test specimens and conduct structural analyses. The Contractor shall reduce the test data for comparison with analytical results.

Deliverables: Test fixture and support fixture designs, and finite element models and analytical results.

Schedule: Analytical models and results, and test fixture and support fixtures designs shall be developed by June 30, 1997.

Metrics: Test fixture and support fixture designs shall be adequate to enable a competent machinist to fabricate the test fixtures and support fixtures. The analysis results shall accurately correlate with test results.

Task 3. The Contractor shall design test fixtures and coordinate test-specimen and test-fixture preparation for 10 to 15 structural element and panel tests that will be used to evaluate structural details and design features for composite structures. The Contractor shall also coordinate test-specimen preparation for 24 to 30 laboratory-scale composite cylindrical shells. The Contractor shall reduce the test data for comparison with analytical results. The tests will be conducted by the government.

Deliverables: Test specimens prepared for testing, and test fixtures and support fixtures.

Schedule: Test specimens shall be prepared for testing, and test fixtures and support fixtures shall be developed by June 30, 1997.

Metrics: Test specimens and test fixtures shall be adequate for testing in government testing machines with loaded ends prepared to assure adequate load introduction into the test specimens.

Task 4. The Contractor shall design a test fixture and coordinate fabrication and assembly of the test fixture for performing damage-initiation, damage-penetration, and damage-growth tests of laboratory-scale structural panel specimens subjected to combined loading conditions. The test fixture will be fabricated by the government.

Deliverables: A design for the test fixture and drawings submitted for fabrication of the test fixture.

Schedule: The test-fixture design shall be completed and test-fixture fabrication shall be in progress by September 30, 1996.

Metrics: The design for the test fixture shall be adequate for a competent machinist to be able to fabricate the test fixture.

Task 5. The Contractor shall develop analytical models to determine the low-speed impact response of flat and curved composite panels and shells subjected to combined loads, and to conduct supporting parametric studies. The Contractor shall also coordinate the preparation of 10 to 15 test specimens for testing.

Deliverables: Finite element models, analytical results, and test specimens prepared for testing.

Schedule: Finite element models, analytical results and test specimens prepared for testing shall be provided by September 30, 1996.

Metrics: The finite element models shall accurately represent the impact dynamics of composite structures subjected to low-speed impact damage.

Task 6. The Contractor shall develop analytical models and analyze the design for the COLTS COmbined Loads Test System for testing structures subjected to combined internal pressure, mechanical loads and thermal loads. The analytical models shall include modifications to the kinematic model and control system algorithms for COLTS to reflect design changes. The Contractor shall identify and resolve critical secondary load issues for COLTS, and prepare test procedures, plans and criteria for testing large structures and panels subjected to combined loads.

Deliverables: Finite element models and analytical results.

Schedule: Finite element models and results for the COLTS test facility shall be provided by September 30, 1996.

Metrics: The finite element models shall be representative of the COLTS test system for all loading conditions.

Task 7. The Contractor shall design test fixtures, and develop test procedures and plans for testing 2 to 4 biaxially loaded hat-stiffened panels with one load in tension and the other load in compression. The Contractor shall coordinate test-specimen and test-fixture preparation and reduce test data for comparison with analytical results. The tests will be conducted by the government.

Deliverables: Test fixture designs and test specimens prepared for testing.

Schedule: Test fixtures shall be designed, test plans developed, and preparation of test specimens for testing shall be initiated by June 30, 1997.

Metrics: Test fixture designs shall be adequate to enable a competent machinist the test fixtures.

Task 8. The Contractor shall develop 1 to 2 finite element models for the analysis of the Integrated Pathfinder-Shell full-scale and half-scale subsonic transport fuselage shells and associated panels. The models shall be refined enough to represent the local bending gradients in the shell. The Contractor shall conduct linear and nonlinear structural analyses with these models using the STAGS structural analysis code for up to 5 loading conditions and up to 3 structural configurations. The Contractor shall integrate crown, keel and side panel concepts into an integrated shell model and compare sandwich and stiffened-skin side-panel concepts.

Deliverables: Finite element models and analysis results.

Schedule: Finite element models and analytical results shall be provided by September 30, 1996.

Metrics: Finite element models shall have adequate fidelity to represent all critical response and failure modes for the shell structure.

Task 9. The Contractor shall develop finite element models, conduct structural analyses, and prepare test specimens for testing that represent 3 to 4 local critical detail design features of composite wing structures. These design detail features shall include such features as stiffener run-out details, local damage tolerance issues and internal load redistributions due to changes in the structure. The test specimens will be provided by the government and the tests will be conducted by the government.

Deliverables: Finite element models, analytical results, and test specimens prepared for testing.

Schedule: Finite element models, analytical results, and test specimens prepared for testing shall be provided by June 30, 1997.

Metrics: Finite element models shall have adequate fidelity to represent accurately all critical design details and corresponding structural responses. Test specimens shall be adequately prepared for testing in government test machines.

Task 10. The Contractor shall maintain the STAGS STructural Analysis of General Shells finite element analysis code on the local Langley computer system in the Structural Mechanics Branch and report errors in the code to the code developer as they are discovered. The Contractor shall install upgrades to the code on Langley computers when they are received from the code developer and distribute these upgrades to industry and university partners of the Structural Mechanics Branch as needed. The Contractor shall conduct analyses of 2 to 3 test cases which demonstrate the functionality of updated versions of the code and identify errors or shortcomings of the code. The Contractor shall provide user instructions for and documentation of new capabilities and releases of the code to Structural Mechanics Branch personnel and industry/university partners as needed. The Contractor shall provide consultation as needed to Structural Mechanics Branch personnel and industy/university partners on structural modeling and analyses using the upgraded versions of STAGS.

Deliverables: User instructions for STAGS and installed upgrades to the STAGS source code operational on the local Langley computer system in the Structural Mechanics Branch.

Schedule: The most current version of STAGS shall be operational on local Langley computers in the Structural Mechanics Branch by June 30, 1997.

Metrics: The latest version of the STAGS finite element code shall be operational on at least three local engineering workstations in the Structural Mechanics Branch.

Task 11. The Contractor shall create 1 to 2 simple cases to test the solution mapping algorithm between the STAGS finite element code and the FRANC3D Fracture Analysis code 3D structures for restarting nonlinear solutions with models that have been remeshed. The Contractor shall conduct 4 to 5 nonlinear structural analyses using STAGS and local models of damaged fuselage panels to test the curvilinear crack growth capability. The Contractor shall identify problems associated with mapping FRANC3D solutions to STAGS and identify possible causes for these problems.

Deliverables: Finite element models and analytical results.

Schedule: Finite element models and analytical results shall be provided by June 30, 1997.

Metrics: The finite element models shall have adequate fidelity to accurately represent the response of the structure.

Task 12. The Contractor shall develop 1 to 2 finite element models to simulate the local response of lap joints and other local structural details in pressurized fuselage shells. The Contractor shall conduct nonlinear structural analyses of the lap joints and other local details with and without damage using STAGS. The Contractor shall determine the effects of fastener flexibility and variations in local structural parameters on the response of the lap-joint and structural-detail models.

Deliverables: Finite element models and analytical results.

Schedule: Finite element models and analytical results shall be provided by June 30, 1997.

Metrics: The finite element models shall have adequate fidelity to accurately represent the response of the structure.

Task 13. The Contractor shall develop 1 to 2 finite element models to simulate test results for tension-loaded curved panels with cracks and conduct nonlinear analyses using STAGS. The Contractor shall recommend instrumentation and test procedures for the tests. The tests will be conducted by the government. The Contractor shall modify the finite element models to accommodate a new stable tearing algorithm for crack growth.

Deliverables: Finite element models and structural analysis results.

Schedule: Finite element models and analytical results shall be provided by June 30, 1997.

Metrics: The finite element models shall have adequate fidelity to represent all critical response and failure modes for the shell structure.

Task 14. The Contractor shall develop 1 to 2 finite element models of local structural details to simulate the load redistribution near the local details due to multi-site damage in a pressurized fuselage shell. The Contractor shall conduct nonlinear analyses of these models using STAGS. The Contractor shall assess the effects of fastener flexibility and changes in model parameters on the response of the models.

Deliverables: Finite element models and structural analysis results.

Schedule: Finite element models and analytical results shall be provided by June 30, 1997

Metrics: The finite element models shall have adequate fidelity to represent all critical response and failure modes for the shell structure.

Task 15. The Contractor shall design test fixtures and coordinate test-specimen and test-fixture preparation for 3 to 5 stiffened and unstiffened panels and 15 to 18 laboratory-scale unstiffened shells with damage and various structural details subjected to combined pressure and mechanical loads. The Contractor shall reduce the test data for comparison with analytical results. The tests will be conducted by the government. The Contractor shall develop finite element models to simulate the response of the test specimens and to determine instrumentation patterns. The Contractor shall vary structural parameters such as stiffener dimensions and crack orientations to determine the response of the specimens due to changes in structural parameters.

Deliverables: Finite element models and analysis results.

Schedule: Structural analyses of test specimens with support fixtures shall be developed by June 30, 1997

Metrics: Analytical results shall correlate with the test results..

Task 16. The Contractor shall develop 1 to 2 finite element models of a HSR fuselage shell section and 3 to 5 finite element models of fuselage panels for nonlinear structural analysis with the STAGS structural analysis code. The models shall include metallic and composite structural concepts and stiffened-skin and sandwich panels. The Contractor shall prepare 3 to 4 user written subroutines to represent skin and stiffener properties and prepare load and boundary condition input for a STAGS analysis of the shell.

Deliverables: Finite element models and analysis results.

Schedule: Finite element models and user written subroutines shall be provided by June 30, 1997.

Metrics: The finite element models shall have adequate fidelity to represent all critical response and failure modes for the shell structure.

Task 17. The Contractor shall design test fixtures for testing 6 to 8 polymeric composite stiffened-skin and sandwich structural elements and panels and titanium sandwich structural elements and panels subjected to thermal and mechanical loads. The Contractor shall coordinate test-specimen and test-fixture preparation. The specimens will be tested by the government. The Contractor shall develop a finite element model of the specimens and conduct structural analyses of the specimens. The Contractor shall recommend instrumentation patterns for the specimens.

Deliverables: Finite element models, structural analysis results, specimens prepared for testing, and instrumentation patterns.

Schedule: Analytical results and test-fixture designs shall be provided by June 30, 1997.

Metrics: Finite element models shall have adequate fidelity to represent all critical response and failure modes for the shell structure.

Task 18. The Contractor shall design test fixtures for damage-tolerance testing of 6 to 8 polymeric composite stiffened skin and sandwich panels subjected to thermal and mechanical loads. The Contractor shall coordinate test-specimen and test-fixture preparation. The specimens will be tested by the government. The Contractor shall develop finite element model ands of the specimens and conduct structural analyses of the specimens. The Contractor shall recommend instrumentation patterns for the specimens.

Deliverables: Finite element models, structural analysis results, specimens prepared for testing, and instrumentation patterns.

Schedule: Analytical results and test-fixture designs shall be provided by June 30, 1997.

Metrics: Finite element models shall have adequate fidelity to represent all critical response and failure modes for the shell structure.

Task 19. The Contractor shall design test specimens for an energy-absorbing composite keel-beam concept and up to 2 other structural concepts for general aviation aircraft. The Contractor shall develop a simple analytical model to aid in the design of the concept. The Contractor shall coordinate the preparation of the test specimens for testing. The tests will be conducted by the government.

Deliverables: Drawings of structural concepts, analytical models and results, and test specimens prepared for testing.

Schedule: Analytical model and results, and test specimen designs shall be provided by December 31, 1996.

Metrics: The structural concepts shall improve the energy absorption capabilities of a fuselage shell without unnecessarily increasing structural weight.

Task 20. The Contractor shall design test fixtures for the crash test of a modified full-scale Starship airplane to asses its crashworthiness. The Contractor shall reduce test data from the test for comparison with analytical results. The test will be conducted by the government.

Deliverables: Test fixture designs and reduced test data.

Schedule: Test fixture designs shall be provided by, and test data shall be reduced by December 31, 1996.

Metrics: The test fixtures shall adequately introduce loads into the test section.

1. Task Order Number and Title | Number: | Revision:

Title: Structural Mechanics Analysis and Testing

3. Tasks, Deliverables and or Products, and performance measurements (continued):

Task 21. The Contractor shall design test fixtures for the crash tests of 2 to 3 scaled composite structural models that are designed to absorb energy from crash-type loads. The Contractor shall reduce test data from the tests for comparison with analytical results. The tests will be conducted by the government.

Deliverables: Test fixture designs and reduced test data.

Schedule: Test fixture designs shall be provided by, and test data shall be reduced by December 31, 1996.

Metrics: The test fixtures shall adequately introduce loads into the test section.

4. Government Furnished Items:

Test specimens

Test specimen instrumentation

STAGS nonlinear structural analysis code

Computer CPU time for structural modeling and analyses

Office space

5. Other information needed for performance of task.

Travel to Sagus, CA for the COLTS control system, 5 days, Task 6

Travel to Seattle, WA and Long Beach, CA to present short course on the use of STAGS, 5 days, Task 10

6. Security clearance required for performance of work:

None.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: James H. Starnes, Jr.

M/S: 190 Phone: 804-864-3168

ART (NAS1-96014) Task Order Page 3

Note: the following information will not be provided to the contractor but is required to allow the COTR to determine a preliminary cost estimate. This page will be replaced with negotiated final funding information and limitations at time of task initiation.

1. Task Order Number and Title Title: Structural Mechanics Analysis and Testing	Number:	Revision:

12. Funding information:
H15192, 537-06-35-20
R20948, 505-63-10-13
R19615, 538-02-10-02
R20865, 538-07-12-01
R19613, 505-63-50-08

DSx02

ART (NAS1-96014) Task Order Page 1

1. Task Order Number and Title — Number: — Revision:

Title:

Computational Mechanics Testbed (COMET) systems computer code implementation, maintenance, enhancement, development and applications

2. Purpose, Objective or Background of Work to be Performed:

The objective of this task is to provide implementation programming, maintenance, enhancement, development and applications for the Computational Mechanics Testbed (COMET) system of computer programs. The COMET system consists of hundreds of thousands of lines of code, most of it written in FORTRAN. COMET provides a means for implementing new methods of computational structures and mechanics in a full structures analysis framework so that they may be assessed, demonstrated and validated. The five functions of this task, namely, implementation, maintenance, enhancement, development and applications are defined as follows: implementation refers to programming functions in which newly developed or newly available methods are inserted into the COMET system; maintenance refers to the function of correcting discovered code and documentation deficiencies,upgrading software for new compilers and porting software to other computer hardware platforms; enhancement refers to the function which includes adding new I/O capabilities, database upgrades, improving data handling, creating data translators between the COMET system and other software codes, improving existing capabilities, and improving user friendliness; the development function includes creating a new graphical user interface (GUI), creating structural models for assessing or validating software, and creating new software to enable new capabilities; the applications function refers to the creation of models consistent with the Advanced Composites Technology program and the NEXTGRADE Program, their successful execution and the documentation of results.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

The contractor shall provide engineering and software support functions for the the Computational Mechanics Testbed (COMET) software system. These support functions are: implementation of computational structures and mechanics analytical methodologies into quality working code; code maintenance which includes correction of problems in both methods and software in the existing code, discovered code and documentation deficiencies, upgrading software for new compilers, and porting software to other computer hardware platforms; code enhancement including the addition of new I/O capabilities, database upgrades, improved data handling, creation of data translators between the COMET system and other software codes, and improved user friendliness; code development which includes the creation of a new graphical user interface (GUI), creation of structural models for assessing or validating software, and creation of new software to enable new capabilities; and applications which includes the creation and computer analysis execution of models consistent with the Advanced Composites Technology (ACT) program and the Next Generation Revolutionary Analysis and Design Environment (NEXTGRADE) Program.

The contractor shall carry out the following specific functions:

i. **Performance Requirement:** Implement new methodologies derived from the ACT, HSR, High Performance Computing and Communications Program, and the NEXTGRADE Program into COMET.

PRINTED: 6/12/96

Measurement: The number of methods implemented shall be monitored. Also, the number of software errors in the implementation and the time needed to correct the errors shall be monitored.

ii. **Performance Requirement:** Maintain, make available through the Langley network, and protect the COMET software system by ensuring that applicable software management techniques are applied. Reports shall be prepared summarizing changes made to the code and the testing done to ensure the correctness of the corrections.

Measurement: The number of COMET executions that are processed shall be monitored monthly. The number of COMET errors and change requests shall be monitored. Effectiveness of software management techniques shall be tracked and evaluated. The number of repeat requests from users for the same changes shall be monitored.

iii. **Performance Requirement:** Develop enhancements for the COMET system as required for new analysis methods. New enhancements shall include nonlinear finite elements for composite analysis, modifications to interface technology developments for the ACT and HSR projects, and sparse matrix solver technology, thermal stress analysis methodology, and general performance improvements.

Measurement: Number of user executions using new capabilties shall be monitored and user feedback on the improvements shall be sought through periodic surveys. Improvements to run-time shall be monitored and documented.

iv. **Performance Requirement:** Provide applications support to structural analysts in converting models from other finite element programs to COMET. Translators shall be developed and validation models to include at least two ACT models and one HSR Model shall be developed and executed.

Measurement: COMET runstreams shall be delivered for converted finite element models. Validation results for translators shall be documented. Repeat requests from users for conversion of the same models shall be monitored.

v. **Performance Requirement:** Provide finite element models of ACT components and NEXTGRADE focus applications. Carry out analysis execution and present results in engineering graphs and tables, and document results.

Measurement: The number of models created shall be monitored. The time to derive application results shall be monitored.

vi. **Performance Requirement:** Software and documentation distribution shall be carried for the COMET software system executing on the following platforms: Convex, Silicon Graphics, Hewlett Packard, Digital Equipment Corporation, IBM RS6000, and Windows PC-based version. Source code shall not be distributed unless specially requested in writing by the contract monitor.

Measurement: Software shall be delivered to at least 5 but not more than 25 sites to include both upgrades and new installations.

vii. **Performance Requirement:** Software changes shall be communicated to Applied Research Associates who are under separate NASA contract to update COMET documentation.

Measurement: The number and nature of documentation change requests shall be monitored.

Reporting Requirements:

Monthly reports shall be prepared concerning problems and distributions. Quarterly reports shall be prepared on software enhancement, documentation change requests, and applications support.

Deliverables:

1. Periodic updated COMET software in identified new versions.
2. Verification data derived from execution of standard verification suites.
3. Reports on code and documentation changes

Schedule: COMET software versions shall be released on a semiannual basis unless the number of changes and their significance warrant additional releases. Software releases shall be made February 1997 and July 1997. Reports shall be prepared as specified.

DSx04

AR₁ (NAS1-96014) Task Order

1. Task Order Number and Title: Title: Aeroelastic Analysis and Testing	Number:	Revision:

2. Purpose, Objective or Background of Work to be Performed:

The contractor will perform tasks that support the Aeroelasticity Branch's core research program and it's activities to maintain and upgrade the experimental and analytical tools used in the Transonic Dynamics Tunnel (TDT). The contractor will perform tasks that support the: 1) development of basic knowledge and understanding of aeroelastic phenomena associated with fixed wing and rotary wing vehicles and the complex steady and unsteady aerodynamic flows that contribute to the aeroelastic phenomena, especially in the transonic speed range; 2) development of analytical capabilities to accurately predict aeroelastic phenomena associated with fixed-wing and rotary-wing flight vehicles, including flutter, buffet, buzz, limit cycle oscillations, and gust response; 3) development of analytical codes to accurately predict complex aerodynamic flow phenomena including vortex flows, separated flows, transonic nonlinearities, and unsteady shock motions; and 4) investigation and development of unique active control concepts that employ smart materials and/or aerodynamic control surfaces. The contractor will also perform tasks to enhance digital active feedback controllers and on-line data acquisition systems for quick data acquisition, reduction, analysis, and evaluation. For most tasks, the contractor will be expected to provide either informal reports (in contractor-specified formats) or formal contractor reports that summarize the results of each task.

In addition, the contractor will perform tasks in support of the branch's High Speed Research (HSR) activities. NASA Langley is attempting to advance the technology readiness status for building a High-Speed Civil Transport through the HSR program. As part of the HSR program, an effort has been jointly undertaken by NASA Langley, Boeing, McDonnell-Douglas Aerospace, and Northrop-Grumman to evaluate technology readiness with respect to aeroelasticity. A major portion of this aeroelasticity effort is aimed at verifying analytical flutter predictions by correlating analysis with experimental results. A series of experimental testbeds are being built and tested in the TDT to obtain a high quality data base for correlation with analysis.

3. Description of the Work to Be Performed (List all Tasks, Deliverables and/or Products, and Performance Measurements):

<u>Task 1:</u> Complete the documentation of an analytical study (performed in 1994 by Lockheed Martin Engineering and Sciences Company (LMES)) of CFD flutter predictions of a typical business jet wind-tunnel model.

Deliverables: Final draft of formal technical report which documents the analytical study using the CAP-TSD and CFL3D unsteady aerodynamic codes to predict flutter for a typical business jet wind-tunnel model.

Performance Measurement: The final draft must be complete, understandable, and professionally written and in a form ready for editorial review and subsequent publication as a NASA Contractor Report.

Schedule: The final draft shall be submitted to NASA by 30 September 1996.

<u>Task 2:</u> Document the build-up and testing of the ARES II (Aeroelastic Rotor Experimental

System) testbed in the TD'. ‿alibration Laboratory. (LMES particip d in this activity in 1995.)

Deliverables:
(1) Informal technical report that includes: a detailed description of the test set-up and operation of the computer interface used to control the ARES II; any problems encountered in the development of the controller and the solutions to these problems; results of the tests conducted; and recommendations for improvements to the system. (2) Clarification of any details described in the report shall be addressed and discussed with NASA.

Performance Measurement: The report must be complete, understandable, and professionally written in a contractor-specified form.

Schedule: (1) The report shall be delivered to NASA by 16 August 1996 for review. (2) A request for clarification of any details described in the report shall be addressed and discussed with NASA by 30 September 1996.

Task 3: Complete the documentation of an analytical model (developed in 1993 by LMES) that simulates the interactions between piezoelectric actuators and a composite wing structure in support of the PARTI (Piezoelectric Aeroelastic Response Tailoring Investigation) wind-tunnel test project.

Deliverables: Final draft of formal technical report which documents and summarizes the results of this study.

Performance Measurement: The final draft must be complete, understandable, and professionally written and in a form ready for editorial review and subsequent publication as a NASA Contractor Report.

Schedule: The final draft shall be submitted to NASA by 30 September 1996.

Task 4: Document the analysis and testing of a full-span SST aeroelastic wind-tunnel model in the TDT. (LMES participated in this activity in 1995.)

Deliverables: Informal technical report that summarizes the results of: sting, free-free, and cable-mounted vibration and flutter analyses; cable stability analysis (GRUMCBL); CAP-TSD modeling, analyses, and stability derivative predictions; and linear (doublet-lattice) aerodynamic model stability derivative predictions.

Performance Measurement: The report must be complete, understandable, and professionally written in a contractor-specified form.

Schedule: The final report shall be submitted to NASA by 30 September 1996.

Task 5. Complete development of a higher-harmonic-control-type active digital controller for the WRATS (Wing and Rotor Aeroelastic Test System) tiltrotor model, based on the Bell-Helicopter Multipoint Active Vibration Suppression System (MAVSS) code, as modified in-house by NASA. (LMES began this task in 1995 and the task is about 30% complete.) This digital controller will have as its basis a Heurikon VME real-time control system with OS/9 real-time UNIX operating system software. The controller has been assembled in a mobile cabinet currently located in B647.

Deliverables: (1) Demonstration of a harmonic analysis code, as required to perform tasks of the Labview-based version of MAVSS, on the Heurikon VME system. (2) Demonstration of the MAVSS-based software implemented on the Heurikon VME real-time control hardware using the 1/10-scale V-22 full-span model.

Performance Measurement: The control system must be able to: 1) send out sinusoidal forcing signals to 3 individual shakers attached to the model; 2) accept and record multiple response-point information from model strain gages and accelerometers (4 response points as a minimum); 3) reduce the vibration level at the response points to a level equal to or better than the Labview-based implementation of the control system; and 4) have the flexibility for user to change the harmonic, rotor frequency, and objective function used for vibration reduction on-line.

Schedule: Demonstrate (1) to NASA by 30 August 1996; demonstrate (2) to NASA by 30 September 1996

Task 6: Document the Labview-based user interface for the ESP-8400 cyclical steady pressure data acquisition system. (LMES participated in maintenance and code enhancements to the user interface in 1995 and 1996.)

Deliverables: (1) Software reference manual describing the subroutine functions of the Labview-based user interface; (2) User's guide of the Labview-based user interface.

Performance Measurement: Both reports must be complete, understandable, and professionally written in a contractor-specified form.

Schedule: (1) The software reference manual shall be delivered to NASA by 30 September 1996; (2) the user's guide shall be delivered to NASA by 30 September 1996.

Task 7: Document work performed toward creating a near-real-time system identification method which would use data acquired during TDT wind-tunnel tests for on-line analysis and control law design. (LMES participated in this activity in 1995 and 1996.)

Deliverable: An informal report which describes work performed to date, including a description of the system identification method.

Performance Measurement: Report must be complete, understandable, and professionally written in a contractor-specified form.

Schedule: Final report shall be delivered to NASA by 30 September 1996.

Task 8: A verified technique or existing product shall be identified for the direct measurement of the speed of sound. This device (technique) must be suitable for installation in the TDT. Preferably, the device will be installed in the plenum surrounding the test section and will provide a simple, continuous, electronic signal that is proportional to the speed of sound. It must be able to measure the speed of sound in gas mixtures. Normal TDT operations will require measuring the speed of sound in air and in nearly pure R-134a (small percentage of air in gas mixture).

Deliverables: Written recommendation of technique or product for the direct measurement of speed of sound.

Performance Measurement: The device shall allow for periodic calibration that can be completed with relative ease within an hour. Calibration shall not be required more frequently than about every two days. If the purchase price of this device exceeds $100,000, then the anticipated annual maintenance costs shall not exceed five percent of the purchase price.

Schedule: The identification of this device, or verified technique if an existing device is not available, shall be completed by 30 September 1996.

Task 9: Reduce and document test data from the HSR Rigid Semispan Model (RSM) test (TDT test 520). Test data anomalies shall be removed or corrected in accordance with established procedures. The data base to be reduced and provided to NASA shall include load measurements made via a five-component balance, steady fuselage pressure measurements, and steady wing pressure measurements at all test conditions/configurations for which such measurements were made. Additionally, unsteady wing pressure time history records shall be statistically summarized and documented at all test conditions for which control surface oscillation measurements were made.

Deliverables: Reduced data summarized: (1) in an electronic data file; and (2) in an informal report.

Performance Measurement: The electronic file and the written report must be complete and understandable; the report shall be professionally written and can be in a contractor-specified form.

Schedule: (1) The electronic file of the full set of reduced data shall be provided to NASA by 30 August 1996. (2) The informal report describing and documenting these data shall be provided by 30 September 1996.

Task 10: Reduce and document test data from the HSR Flexible Semispan Model (FSM) test (TDT test 521). Test data anomalies shall be removed or corrected in accordance with established procedures. The reduced data base shall include load measurements made via a five-component balance, steady fuselage pressure measurements, and steady wing pressure measurements at all test conditions/configurations for which such measurements were made. Additionally, unsteady wing pressure time history records shall be statistically summarized and documented at all test conditions for which control surface oscillation measurements were made. The summary report shall include technical information, observations, and data obtained during the flutter testing for the model. If the testing involved the acquisition of unsteady pressure, strain, and/or accelerometer measurements during the flutter testing, these data shall also be reduced in a similar fashion to other unsteady experimental data obtained. All of these results shall be included in an informal report written after the completion of the data reduction.

Deliverables: Reduced data summarized: (1) in an electronic data file; and (2) in an informal report.

Performance Measurement: The electronic file and the written report must be complete and understandable; the report shall be professionally written and can be in a contractor-specified form.

Schedule: (1) The electronic file of the full set of reduced data shall be provided to NASA by 30 August 1996. (2) The informal report describing and documenting these data shall be provided by 30 September 1996.

Task 11: Generate CAP-TSD models for the RSM on the Pitch and Plunge Apparatus (PAPA) mount, conduct flutter analyses, and prepare an informal report summarizing the analysis results. The flutter analysis shall be based on the primary RSM PAPA design concept and the current finite element model of the RSM PAPA system.

Deliverables: An informal report summarizing the description of analysis methods used and results obtained. In addition, the report shall describe the flutter characteristics of the RSM PAPA model with emphasis on the transonic characteristics and shall include comments relative to what might be predicted by the CAP-TSD analysis and perhaps missed by linear aeroelastic codes.

Performance Measurement: The report must be complete, understandable, and professionally written in a contractor-specified form.

Schedule: The final report shall be submitted to NASA by 30 September 1996.

Task 12: Develop a single-zone Euler/Navier-Stokes (E/N-S) grid for a preliminary Flexible Full-Span Model (FFM) concept that includes the wing, fuselage, horizontal tail, and vertical tail components of the model. The grid shall be made available to NASA in an electronic data file and documented in an informal report. The report shall include a full written description of the grid generation process and graphical representations of the grid.

Deliverables: E/N-S grid: (1) provided in an electronic data file; and (2) summarized in an informal report.

Performance Measurement: The electronic file and the written report must be complete and understandable; the report shall be professionally written and can be in a contractor-specified form.

Schedule: The electronic file and the informal report shall be submitted to NASA by 31 December 1996.

Task 13: Establish the techniques and strategies for computing stability derivatives using CFD codes. Using these strategies, perform E/N-S and CAP-TSD aeroelastic analyses of a preliminary FFM concept using the grids developed in Task 12 to generate stability derivatives compatible for use in GRUMCBL analyses. Stability derivatives shall be predicted for the flexible FFM and for a theoretically rigid FFM. An informal report shall be prepared summarizing the results of the analyses.

Deliverables: An informal report summarizing the predicted flexible and rigid stability derivatives, and the work leading to their determination.

Performance Measurement: The report must be complete, understandable, and professionally written in a contractor-specified form.

Schedule: The final report shall be submitted to NASA by 30 April 1997.

Task 14: Conduct GRUMCBL analyses using information from Task 13 for the HSR FFM installed on the TDT 2-cable model mount system. The results shall include a stability assessment of the planned FFM, suggestions to improve model stability, recommendations for testing the FFM derived from the analysis, and a description of possible hardware for implementing a passive stability augmentation system. Parametric variations shall be provided including at least the effects of cable geometry variations, model center of gravity position, support cable tension effects, pulley friction effects, snubber system effects, and drag effects. GRUMCBL calculations shall also be conducted to assess the differences in model stability for testing in an air medium and in an R-134a medium. The analyses shall be performed at representative tunnel envelope dynamic pressures (q) and Mach numbers (M) ranging from 100 psf to 500 psf for q and from 0.7 to 1.2 for M. An informal report shall be prepared summarizing the results of this study.

Deliverables: An informal report summarizing the GRUMCBL stability results for the preliminary FFM concept with recommendations regarding model modifications for improved stability, suggestions for cable geometry to be used for testing, and suggestions for test procedures based on the findings of the stability analysis. Suggestions for a remote, rapidly actuated passive stability augmentation system, shall also be described in the report.

Performance Measurement: The report must be complete, understandable, and professionally written in a contractor-specified form.

Schedule: The final report shall be submitted to NASA by 30 June 30 1997.

<u>Task 15:</u> Perform supersonic flutter analysis using current state-of-the-art linear theories for the HSR FSM. The analyses shall be conducted for Mach numbers ranging from 1.1 to 2.4. Analysis shall be provided for both the clean wing configuration and the wing with engine nacelles configuration. An informal technical report summarizing the results of this study shall be prepared.

Deliverables: An informal report summarizing the predicted flexible and rigid stability derivatives, and the work leading to their determination.

Performance Measurement: The report must be complete, understandable, and professionally written in a contractor-specified form.

Schedule: The final report shall be submitted to NASA by 31 December 1996.

<u>Task 16:</u> Perform supersonic flutter analysis using current state-of-the-art linear theories for the HSR FFM. The analyses shall be conducted for Mach numbers ranging from 1.1 to 2.4. Analysis shall be provided for both the clean wing configuration and the wing with engine nacelles configuration. An informal technical report summarizing the results of this study shall be prepared.

Deliverables: An informal report summarizing the predicted flexible and rigid stability derivatives, and the work leading to their determination.

Performance Measurement: The report must be complete, understandable, and professionally written in a contractor-specified form.

Schedule: The final report shall be submitted to NASA by 30 June 30 1997.

4. Government Furnished Items:

   Heurikon VME system in B647 (Task #5)

5. Other Information Needed for Performance of Task:

   None.

6. Security Clearance Required for Performance of Work:

   None.

7. Period of Performance:	
Planned Start Date: 1 July 1996	Expected Completion Date: 30 June 1997

8. NASA Technical Monitor: Thomas E. Noll
M/S: 340 Phone: 804-864-2820

10. Other Direct Cost Estimates:
None.

DSx03

1. Task Order Number and Title | Number: | Revision:

Title:

Support for Structural Dynamics Branch

2. Purpose, Objective or Background of Work to be Performed:

The support provided by the contractor to the Structural Dynamics Branch involves the following aspects of the branch program: analytical and experimental structural dynamics and controls research for the purpose of developing and validating improved methods to predict, verify, and control complex aircraft and space structures dynamic responses. Validating of approaches by conducting tests on full-scale structures, structural elements and scaled structural models. Testing and experimentation in the Dynamics and Testing Research Laboratory, the Structural Dynamics Research Laboratory, and the 16m thermal vacuum chamber all located in Building 1293.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

The contractor shall:

1. Provide structural dynamics analysis and testing support as listed below.

1.1 Perform finite element analysis of active instrument mount system. Provide a set of eigenvalues, mass normalized eigenvectors, orthogonalized Ritz vectors, and the mass and stiffness matrices. Report results within two months of task initiation

1.2 Instrument and test three active instrument mount concepts. Test results shall provide frequency response functions, time response data, and experimentally determined analytical state-space models. Report results within two months of task initiation

2. Provide real-time software support as listed below.

2.1 Evaluate digital controllers, provided by NASA personnel, on the SDB IBM 6000 real time computer. Controllers will be provided in state space form with orders ranging from 2 to 100. Provide stability information using root locus or singular value plots of all implemented controllers. Three sets of controllers will be provided during the task-- one set at the beginning of the task: a re-designed set provided after the evaluation of the first set; and a final re-designed set. Each set will consist of ten fixed-gain controllers. Report results within two-months of task initiation.

2.2 Convert real time control and data acquisition FORTRAN code presently operating on the SDB IBM 6000 to run on the SDB GATEWAY 486 multi-processor computer. The main code contains about 2000 lines not including system specific input/output subroutines. All system specific subroutines must be replaced with appropriate vendor supplied subroutines.
Deliver converted code with sample outputs from the program within two-months of task initiation.

2.3 Convert adaptive control code presently operating on the SDB IBM 6000 to run on the SDB GATEWAY 486 multi-processor computer. Perform(for a benchmark problem) timing studies to determine maximum sampling rate as a function of the number of input and output channels used. Maximum number of outputs channels is 16 and input channels is 8. Deliver converted code and report results within three months of task initiation.

2.4 Add Fuzzy Logic Supervisor Controller to adaptive control code developed in task 2.3. The Fuzzy Logic Supervisor Controller rules will be provided to the contractor at the beginning of the task. The number of rules would vary anywhere from 1 to 2000. The contractor shall deliver the resulting source code with the NASA furnished control algorithms within three months of the initiation of the task.

2.5 Develop real time computer program to read sensor data and command the actuators in the SDB EOS test bed. For more details on the testbed refer to NASA TM 109059. Deliver software user's guide within three months of the initiation of the task. The user's guide should provide enough information for anyone to operate the system.

3. Provide support in the use of MSC/NASTRAN as listed below.

3.1 Install the latest release of MSC/NASTRAN on DEC ALPHA and Silicone Graphics workstations and distribute documentation. Installation shall be completed within one month of the MSC/NASTRAN release.

3.2 Develop MSC/NASTRAN model and compute modal characteristics of the latest High Speed Civil Transport HSCT full-scale aircraft configuration. The MSC/NASTRAN model must produce modal properties which agree with at least 8 significant digits of those from the ELFINI model for the same configuration. Deliver modal data within three months of the initiation of the task.

3.3 Write a FORTRAN code to translate HSCT finite element models from ELFINI to MSC/NASTRAN. Document code usage in user guide and deliver source code and documentation within two months of the initiation of the task

Deliverables: Defined in each task.
Metrics for deliverables:

Software will be evaluated on the basis of both accuracy and efficiency:

Accuracy: Code must be able to duplicate results for a set of benchmark problems specified by the technical monitor. All benchmark problems wil be provided at task initiation time.

Efficiency: All real-time code will be evaluated on the basis of speed of execution. Maximum sampling rates will be compared to those of existing code. Sampling rate of new code must be equal to or exceed that of existin code when executed on comparable computers. Current sampling rate is a function of the test configuration but is less than 1000 Hz.

Modal test data will be evaluated in terms of the Consistent-Mode Indicator (CMI) criterion. Each measured mode must have a CMI of at least 80%.

Modal analysis results (except for task 3.2) will be evaluated in terms of their agreement with test data. Frequencies of the first eight flexible modes must be within ten percent of the measured frequencies

1. Task Order Number and Title	Number:	Revision:
Title: **Support for Structural Dynamics Branch**		

3. Tasks, Deliverables and or Products, and performance measurements (conti

SEE PAGE 1

4. Government Furnished Items:

NONE

5. Other information needed for performance of task.

NONE REQUIRED

6. Security clearance required for performance of work:

NONE REQUIRED.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Howard M. Adelman
.M/S: 230 Phone: 804-864-2804

ART (NAS1-96014) Task Order Page 3

Note: the following information <u>will not</u> be provided to the contractor but is required to allow the COTR to determine a preliminary cost estimate. This page will be replaced with negotiated final funding information and limitations at time of task initiation.

1. Task Order Number and Title	Number:	Revision:
Title: **Support for Structural Dynamics Branch**		

11. Other Direct Cost Estimates:
NONE

PRINTED: 6/12/96

1. Task Order Number and Title   Number: 1   Revision:
   Title: Thermal Structures Branch RLV and HSR Analyses, Design and Modeling

2. Purpose, Objective or Background of Work to be Performed:
   The purposes of the work for the Thermal Structures Branch are to: 1.) determine the feasibility of heat-pipe-cooled leading and nose caps for reusable vehicles which must be durable enough to potentially fly through rain. Current nose cap concepts proposed by RLC contractors will not survive repeated flights through the rain; 2.) develop a lighter-weight metallic TPS for the leeside of a RLV which is highly operable; 3.) perform analysis of wing structures components in support of analytical evaluation of HSR wing subcomponent designs and prediction of the behavior of HSR wing test specimens; 4.) perform analyis to predict the behavior of HSR wing test specimens, and to perform analysis of HSR wing joints; 5.) Conduct Structural Analyses of Cryogenic Pressure Box Test Specimens ; 6.) develop designs for test fixtures, ovens, and other testing paraphenalia needed to test HSR wing structure specimens; 7.) develop designs for test fixtures, ovens, cryogenic test fixtures and other testing paraphanalia needed to test HSR wing structure specimens and 8.) develop an improved method of modeling aerospace vehicle structures, including internal structural arrangements and elements.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

SUBTASK 1: Feasibility Studies of Metallic and Refractory-Composite Heat-Pipe-Cooled Leading Edges and Nose Caps for Reusable Launch Vehicles (RLV) and Aerobrake Vehicles

1. The contractor shall conduct steady-state and transient thermal analyses of several leading edge and nose-cap concepts. The finite element thermal models shall be parametric in nature and thus enable changes to design variables to be made easily. Design variables can include but not be limited to: heating distributions and histories, heat-pipe spacing, heat-pipe sizing, refractory-composite architecture and material (2-D, 3-D, C-C, C-SiC, SiC/SiC, etc.), metallic materials (PM2000, Inconel 617, etc.), etc.
   Deliverables: Parametric thermal finite element models which simulates heat-pipe heat transfer in leading edges and nose caps (one for each concept studied). Report of analytical results of trade studies for heat-pipe and non-heat-pipe concepts.
   Performance Measurements: The finite element models shall accurately represent refractory-composite heat-pipe-cooled leading edges and nose caps for the RLV and aerobrake vehicles.

2. The contractor shall conduct thermal stress analysis of selected leading-edge and nose-cap concepts based on the results of the thermal trade studies. Parametic structural finite element models will be developed with design variables similar to, but not limited to, those listed above.
   Deliverables: Parametric structural finite element models which simulate structural behavior of a heat-pipe leading edge wing and nose cap. Loading conditions will include thermal, mechanical, and aerodynamic conditions. Report of structural trade studies of selected concepts.
   Performance Measurements: The finite element models shall accurately represent refractory-composite heat-pipe-cooled leading edges and nose caps for the RLV and aerobrake vehicles

3. The contractor shall conduct heat-pipe sizing studies to determine wick configurations, cross-sectional heat-pipe dimensions, working fluid, etc. The contractor shall analyze heat-pipe startup from the frozen state and calculate heat pipe limits such as: wicking limit, sonic limit, boiling limit, etc. and insure that selected designs are well within operational limits. The contractor shall develop designs which are fail safe and

PRINTED: 7/3/96

can tolerate single heat pipe failures without catastrophic consequences.

Deliverables: Startup analysis code which includes heat-pipe limit determinations during transient startup from the frozen state. Report of research results of heat-pipe sizing and startup analysis.

Performance Measurements: The analysis code shall accurately represent the heat-pipe startup process and provide accurate heat pipe design limits.

4. The contractor shall design and estimate the cost of several sub-component test articles and tests to demonstrate heat-pipe concept feasibility.

Deliverables: Test article designs and cost estimates.

Performance Measurements: The test article designs shall be adequate to enable a competent machinist to fabricate the test articles. The cost estimates shall adequately reresent the costs to fabricate the test articles.

Schedule: Completed by June 30, 1997

SUBTASK 2: ConductThermal-Structural Analysis and Design Studies of a Lightweight Metallic Thermal Protection System (TPS) for the Leeside of a Reusable Launch Vehicle (RLV)

1. The contractor shall conduct thermal parametric trade studies of Titanium TPS for the leeside of an RLV. Calculate weights of competitive concepts around the vehicle circumference including locations representative of cryogenic tank and dry-bay substructure. Compare 1-D analyses with 2-D detailed analyses to assess the effect of heat shorts on various concepts. Include ceramic TPS concepts in comparisons.

Deliverables: Parametric thermal finite element models which include design details such as fasteners. Report of analytical results of trade studies of TPS concepts.

Performance Measurements: The finite element models shall accurately represent Titanium TPS for the leeside of an RLV vehicle including areas with cryogenic tanks and dry-bay structure.

2. The contractor shall conduct thermal-stress analyses and design studies of Ti TPS subject to aero, acoustic, thermal, and mechanical loading conditions representative of an RLV. Response quantities of interest include displacements, buckling loads, strains, and stresses. Investigate various options for attachments, internal insulation, materials, etc.

Deliverables: Parametric structural finite element models which simulate structural behavior of TPS concepts. Loading include thermal, mechanical, acoustic, and aerodynamic conditions. Report of structural trade studies of TPS concepts.

Performance Measurements: The finite element models shall accurately represent Titanium TPS for the leeside of an RLV vehicle inclucing aero, acoustic, thermal, and mechanical loading conditions.

3. The contractor shall conduct thermal-structural analyses and design studies of integrated TPS/cryogenic tank systems for use on /RLV.

Deliverables: Report of analysis and weight trades of various metallic TPS and cryogenic tank system concepts.

Performance Measurements: The trade study results shall accurately represent the various metallic TPS and cryogenic tank system concepts.

Schedule: Completed by June 30, 1997

SUBTASK 3: Analysis of HSR Wing Structures

1. The contractor shall construct finite element models and conduct structural analyses of main wingbox subcomponent designs defined by HSR industry participants. Concepts will include PMC and metallic sandwich structure. Static and buckling analysis will be performed, as well as damage tolerant structural optimizations.

Deliverables: Structural finite element models, analysis results, structural optimization sizings, and modifications to optimization runstreams/routines necessary to perform work. Report of analytical and optimization results. Report on modifications to runstreams/routines.

Performance Measurements: The analysis shall have adequate fidelity too resolve the response of interest.

2. The contractor shall conduct structural and thermal stress analysis of selected main wingbox element test configurations.

Deliverables: Structural finite element models, analysis results, and short letter reports of results.

Performance Measurements: The analysis shall accurately correlate with test results.

Schedule: Completed by June 30, 1997

SUBTASK 4: Analysis of HSR Wing Structures and Joints

1. The contractor shall conduct structural and thermal stress analysis of selected HSR wing element test configurations.

Deliverables: Structural finite element models, analysis results, and short letter reports of results.

Performance Measurements: The analysis shall accurately correlate with test results.

2. The contractor shall construct finite element models and conduct structural and thermal-structural analyses of HSR wing joint designs defined by NASA and HSR industry participants. Joints will include bolted and adhesively bonded joints. The contractor shall generate and compare results from more approximate design methods to the finite element analysis results to assist in their validation.

Deliverables: Structural finite element models and analysis results. Report of analytical results and comparisons between methods.

Performance Measurements: The analysis shall have adequate fidelity too resolve the response of interest.

Schedule: Completed by June 30, 1997

SUBTASK 5: Conduct Structural Analyses of Cryogenic Pressure Box Test Specimens

1. The contractor shall construct structural and thermal finite element models and conduct thermal-structural analyses of specimens to be tested in the Cryogenic Pressure Box test apparatus. The analyses shall include the 5 x 6 ft. test specimen and associated load introduction structure. The structural analyses shall be used for comparisons with experiments.

Deliverables:. Report analytical results of trade studies cryogenic pressure box test specimens.

Performance Measurements: The analysis shall accurately correlate with test results.

Schedule: Completed by June 30, 1997

SUBTASK 6: Design of HSR Wing Strcutres test Fixtures

1. The contractor shall develop designs and CAD drawings of the required fixtures based on the requirements for each specific test..
   Deliverables: CAD drawings of fixture designs.
   Performance Measurements: The design for the test fixtures shall be adequate for a competent machinist to be able to fabricate the test fixture.

2. The contractor shall be responsible for coordinating the successful fabrication of the designed fixtures through the LaRC fabrication system.
   Deliverables: Coordination meetings with task order initiator. Successful implementation of designs into hardware.
   Performance Measurements: The fixtures shall be delivered to the Thermal Structures Lab in a timely manor.

Schedule: Completed by June 30, 1997

SUBTASK: 7 Design of Reusable Launch Vehicle (RLV) Structures Test Fixtures

1. The contractor shall develop designs and CAD drawings of the required fixtures based on the requirements for each specific test..
   Deliverables: CAD drawings of fixture designs.
   Performance Measurements: The design for the test fixtures shall be adequate for a competent machinist to be able to fabricate the test fixture.

2. The contractor shall be responsible for coordinating the successful fabrication of the designed fixtures through the LaRC fabrication system.
   Deliverables: Coordination meetings with task order initiator. Successful implementation of designs into hardware.
   Performance Measurements: The fixtures shall be delivered to the Thermal Structures Lab in a timely manor.

Schedule: Completed by June 30, 1997

SUBTASK 8: Complete of SMART Structural Modeling Tool Development and Documentation

1. The contractor shall complete the development of the SMART Structural modeling code and document results via a user report.
   Deliverables: SMART Structural Modeling Code and associated user documentation.
   Performance Measurements: The SMART Structural Modeling Code and user documentation shall be adequate for an experienced analysis unfamiliar with the code to use without additional help.

Schedule: Completed by June 30, 1997

1. Task Order Number and Title Title: Thermal Structures Branch RLV and HSR Analyses	Number: 1	Revision:

4. Government Furnished Items:

The Government shall provide office space, laboratory facilities/equipment, Macintosh computer and software (EAL, NASTRAN, PATRAN, Pro-Engineer, SMART, etc.).

5. Other information needed for performance of task.

The contractor will be authorized to take up to three trips to assess the state of the art in heat-pipe manufacture and test. Each of the trips shall be no longer than four days and should be restricted to the continental United States. Travel will be associated with Subtask 1 only. Other sub tasks will not require travel.

6. Security clearance required for performance of work:

None.

7. Period of Performance	
Planned start date: July 1, 1996	Expected completion date: June 30, 1997

8. NASA Technical Monitor: Charles Camarda
M/S: 396 Phone: 804-864- 5436

ART (NAS1-96014) Task Order Page 1

1. Task Order Number:: DS 06 Revision: Date: 11-18-96
   Title: HSR Fuselage Structural Analyses

2. Purpose, Objective or Background of Work to be Performed:

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

The contractor shall develop analytical models and perform nonlinear analyses of high speed civil transport (HSCT) aircraft fuselage structures and subcomponents. The fuselage analysis (Subtask 1) will consist of not more than two basic 4 ft. x 4 ft. panel designs with two damage scenarior and approximately four loading conditions for each panel.

1.0: Fuselage Analysis
The Contractor shall perform pre-test failure prediction analysis for HSR fuselage flat generic panels of two types; skin/stringer construction and honeycomb sandwich construction. Panel geometry, material properties, lay-up details and test loading conditions will be supplied by NASA. The contractor shall develop finite element models to perform nonlinear analyses that address key structural strength, stability and damage tolerance issues. The test predictions shall be carried out utilizing the STAGS code. Analyses will include panel damage features to be tested, such as notch and disbond damage, in order to validate the analysis methodology. Failure mechanism, failure load and residual strength shall be determined analytically for test loads and boundary conditions utilizing currently available failure criteria and load redistribution algorithms. The calculated loads will then be correlated with the test results to be provided by NASA.

Deliverables:

1.1. Written bi-monthly informal technical progress reports. Analytical models, analysis results and summaries of structural trade studies to be delivered with specifics listed below by 5-30-97:

1.1.1. STAGS analysis of generic test panels, including damage, subjected to test loads

1.1.2. Post test evaluation and correlation of STAGS analyses with test results

Metrics for Tasks:

Metrics for Tasks:
Minimum Acceptable Performance Standards: At a minimum, the finite element models and test prediction analysis and comparison for the panels should be completed within 6 months of the commencement of Subtask 1.

Significantly exceeds Minimum Acceptable Performance: For Subtask 1, a second analysis, corrected to better correlate with test results would exceed the minimum acceptable performance standard. This would entail insight into the physics of the test failure and modifying the model to better capture the physics.

ART (NAS1-96014) Task Order Page 2

1. Task Order Number:: DS06	Revision:	Date: 11-12-96
Title: HSR Fuselage Structural Analyses		

4. Government Furnished Items:Contractor will have access to our computer network and two terminals and the structural analysis software required to complete the task

5. Other information needed for performance of task.

6. Security clearance required for performance of work:
None.

7. Period of Performance	
Planned start date: November 25, 1996	Expected completion date: May 31, 1997

8. NASA Technical Monitor: Phil Bogert
.M/S: 190 Phone: 804-864-3188

1. Task Order Number: #-/ Revision: Date of Revision:
Title: **Provide structural modeling support for the HPCCP's multidisciplinary design effort.**

2. Purpose, Objective or Background of Work to be Performed:

The High Performance Computing and Communications Program (HPCCP) is developing the FIDO computing code as a pathfinder for multidisciplinary design involving aerodynamics and structures. The code requires as input, knowledge of the wing's wetted surface and internal and external structure. Presently, the external surface is provided by the ADVMOD code and the internal and external structure is provided through utilization of the SMART code. Whereas, the SMART code served a valuable purpose up to this point in the Program, it is now desirable to move to the Pro-Engineer commercial code which provides greater modeling flexibility, has been widely accepted by the user community, and is maintained and supported. The purpose of this task is to replace the function of SMART with Pro-Engineer. This task, therefore, includes the following sub-tasks:

1. A software interface shall be developed which translates ADVMOD parametric nurb surface definition (derived from a wave drag deck) to Pro-Engineer. The software shall be validated and demonstrated, as described below.

2. A software interface shall be developed which translates Pro-Engineer data into PATRAN acceptable input. The software shall be validated and demonstrated as described below.

3. Performance data shall be developed which demonstrates the process of going from ADVMOD to Pro-Engineer and then to PATRAN.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

The contractor shall develop software specifications for procedures and/or processors that will integrate those routines that will culminate in the generation of a finite element model based on an aerodynamically defined external surface. Previous applications of the SMART solid modeling code will be used to develop baseline configurations, including external and internal structural arrangements, to validate and verify the Pro-Engineer capabilities. The initial effort will be directed toward the geometrical properties of the FEM. Whenever possible, provisions will be made in the routine to incorporate other data such as loads, constraints, and physical data (section and material properties).

The contractor shall carry out the following specific functions:

1. Task 1: The contractor shall develop the procedure for writing an output file in ADVMOD that can be interpreted by Pro-Engineer. This file may have an IGES format.

   Measurement: Any peculiarities between this output file and the input format required for Pro-Engineer will be noted. Documentation will be prepared which provides user instructions for preparing the output file and then inserting the file in Pro-Engineer. At least one example will be provided.

2. Task 2: The contractor shall evaluate and document the capabilities of Pro-Engineer to generate internal structural arrangements within the external shapes of aerospace vehicles

used in prior SMART exercises.

Measurement: The report will document the deficiencies of Pro, and suggestions will be made to resolve them. Particular attention will be directed to improving user productivity in creating and modifying these structural arrangements. At least one example demonstrating user productivity will be provided.

3. Task 3: The contractor shall develop software specifications for a Pro-Engineer procedure to describe how the user can generate and/or modify internal structural arrangements within previously defined external shapes in a timely manner. The geometrical description of these structural arrangements will be of a form that can be formatted for input into the PATRAN finite element modeler.

   Measurement: The deliverable design specification report, which describes the creation and/or modifications of the geometrical definition of the external and internal structural arrangements and the subsequent transfer of this geometry to PATRAN, will contain at least two examples; one example for external structural arrangement and one example for internal structural arrangement.

Deliverables:

1. Documentation for files management as described in Task 1. Documentation will be prepared which provides user instructions for preparing the output file and then inserting the file in Pro-Engineer.

2. Documentation for generation of structural arrangements through Pro-Engineer as specified in Task 2. The report will document the deficiencies of Pro and suggestions will be made to resolve them.

3. Software design specification report for the Pro-Engineer Structures Generation procedure which describes the creations and/or modifications of the geometrical definition of the external and internal structural arrangements and the subsequent transfer of the geometry to PATRAN.

4. Monthly progress reports which describe progress, issues, concerns, accomplishments, and next month expectations.

Schedule:

Deliverable 1: June 30, 1997
Deliverable 2: July 31, 1997
Deliverable 3: August 31, 1997
Deliverable 4: Monthly

4. Government Furnished Items:
COMET-AR software code and Pro-Engineer software code

5. Other information needed for performance of task.
examples: List essential travel required for successful performance of task, number of trips, duration, destination and the need for the travel.
List any applicable documents and where or how they can be obtained.
List any safety, environmental, legal, data rights, etc. issues

6. Security clearance required for performance of work:
No special security clearance is required.

7. Period of Performance: February 24, 1997 through September 30, 1997	
Planned start date: February 24, 1997	Expected completion date: September 30, 1997

8. NASA Technical Monitor: Dr. Jerrold M. Housner
.M/S: 240 Phone: 804-864-2907

 DSK, 1139

1. Task Order Number: #2 Revision: Date of Revision:

Title: Next Generation Analysis and Design Tools

2. Purpose, Objective or Background of Work to be Performed:

The objective of this task is to perform COMET/AR finite element analyses of the NEXTGRADE (Next Generation Revolutionary Analysis and Design Environment) focus applications. The NEXTGRADE program is developing advanced computational tools which will shorten design cycle time, reduce life cycle costs, reduce insertion time for new technology, and improve product performance.

These analyses are being performed as part of the effort to assess, validate, and demonstrate the developed computational tools. The assessment of the computational tools involves checking the accuracy, efficiency, and robustness of the tool to changes in input. The validation of the computational tool involves generating or assembling validation data from test, literature and reports, reference solutions, and identifying discrepancies between the results of the new computational tools and the validation data. The demonstration involves preparing, generating, and post-processing analyses in a real-time visual environment.

3. Description of the Work to be Performed (list all Tasks, Deliverables and/or Products, and Performance Measurements):

3.1 Database for mechanical and thermal load environments -

3.1.1 The contractor shall develop and propose to NASA, data base storage specifications for spacecraft mechanical and thermal loads. With NASA concurrence on the specifications, the contractor shall create the data base.

3.1.2 The contractor shall collect mechanical and thermal load data for NEXTGRADE focus applications using published literature, government agency and industry reports, and direct contact with other NASA Centers and industry.

3.1.3 The contractor shall store the mechanical and thermal loads data of sub-task 3.1.2 into the data base of sub-task 3.1.1

Measurement: Data base shall contain at least 2 examples for mechanical loads and 2 for thermal loads. Mechanical loads shall be for launce and operations.

3.2 Validation and assessment of COMET-AR thermal analysis capability - The contractor shall validate and assess the use of COMET-AR and its limitations in thermal state and stress analyses. A set of validation cases shall be selected by the contractor with the concurrence of NASA. These cases shall make use of the mechanical and thermal loads data base of Task 3.1 and will be used to validate and assess the thermal analysis capabilities of COMET-AR. The contractor shall collect or derive the validation data which will be used to measure the accuracy of the COMET-AR derived results. The contractor shall perform the analysis of each validation case and supply the raw and comparative data to NASA, including graphic and tabulated results and full documentation defining each case. The results, the output data and conclusions reached with supporting rationale. The contractor shall also identify COMET-AR deficiencies and propose fixes and improvements to correct the deficiencies. With concurrence from NASA, these improvements shall be communicated to Applied Research Associates which is under separate contract to NASA for making designated COMET-AR improvement.

Measurement: Validation suite shall contain at least 4 documented cases.

3.3 **Development of smart spacecraft component FEM models -** The contractor shall create smart spacecraft component FEM models of selected spacecraft.

3.3.1 The contractor shall create spacecraft component FEM models of selected spacecraft by de-assembling FEM models of the selected spacecraft. The selected spacecraft shall include: Lewis, EOS-AMI, Next Generation Space Telescope (NGST) and two other spacecraft comparable in size and complexity to those listed herein.

3.3.2 The contractor shall create smart spacecraft component FEM models from the FEM models of Task 3.3.1. The smart models know their connection points with other models and the types of connections. A definition of the smart model characteristics will be provided.

Measurement: Minimum of selected spacecraft defined in Task 3.3.1. Number of connection points operating on component models.

3.4 **Software support in the development of a user-friendly interface -** A graphical applications for visualization of NEXTGRADE finite element models and analysis results will be developed on Windows NT and UNIX platforms utilizing the C++ programming language and portable visualization tool kits/libraries such as Open Inventor and OpenGL. Existing graphical applications to implement new software and data requirements will be modified and will be interactive and menu-driven, as appropriate, The Motif/X-windows/PVM application (MIDAS) will be converted from SUN platform to IBM RS6000, SGI, and Windows NT platforms. The NEXTGRADE code will be converted from Windows NT to IBM RS6000 and SGI platforms.

Measurement: User friendly interface operating on a minimum of spacecraft components as defined in Tasks 3.1 to 3.3.

Deliverables:

1. Data base specifications, data base software and full documentation.
2. Validation data for COMET-AR thermal capability including raw and comparative validation data in the form of graphs and tables.
3. Smart component software, models, and full documentation.
4. User-friendly interface software and full documentation.
5. Monthly reports providing progress, issues, concerns, results, and interim demonstrations.

Schedule:

Deliverable 1: June 20, 1997
Deliverable 2: August 31, 1997
Deliverable 3: August 31, 1997
Deliverable 4: August 31, 1997
Deliverable 5: Monthly progress reports.

4. Government Furnished Items: NEXTGRADE software, MIDAS software code, and COMET-AR code

5. Other information needed for performance of task. *examples: List essential travel required for successful performance of task, number of trips, duration, destination and the need for the travel.* *List any applicable documents and where or how they can be obtained.* *List any safety, environmental, legal, data rights, etc. issues*

6. Security clearance required for performance of work: No special security clearance is required

7. Period of Performance: February 24, 1997 through Setpember 30, 1997	
Planned start date: February 24, 1997	Expected completion date: September 30, 1997

8. NASA Technical Monitor: Dr. Jerrold M. Housner .M/S: 240 Phone: 804-864-2907