NASA	CONTRACT	1. DPAS DO-C9	2. PPC	3. Init. Ofc. 23	4. Page 1 of 14
5. Contract No. NAS1-98035	6. Effective Date MAR 03 1998	7. Procurement Request No. DSJ.1224			8. Vendor Code

9. Issued By Code 126

National Aeronautics and Space Administration
Langley Research Center
9A Langley Boulevard, Bldg. 1195A, Rm. 123
Hampton, VA 23681-2199

10. Contractor Name and Address

Alson E. Hatheway, Inc.
595 East Colorado Boulevard, Suite 400
Pasadena, CA 91101

Name and Telephone No. of Contract Administrator:

Alson Hatheway
(626) 795-0514

11. Administered By Code 126

Acquisition Division, Mail Stop 126
NASA Langley Research Center
9A Langley Blvd., Bldg. 1195B
Hampton, VA 23681-2199
LaRC Administrator: Cynthia K. Cowan, (757)864-2546

12. Payment Will Be Made By Code –

Financial Management Division, M/S 175
NASA Langley Research Center
Hampton, VA 23681-2199

13. Submit Invoices To Code 175

(4 copies unless otherwise specified)
the address shown in Block 12.

14. Accounting and Appropriations Data

PR DSJ.1224;R2.3305; $41,000 (Partial)

15A. Contract Type R&D Fixed Price

15B. Incremental Funding [ ]

TABLE OF CONTENTS

17. Items Awarded Under This Contract

NEXT GENERATION SPACE TELESCOPE (NGST) CRYOGENIC ACTUATOR

THIS CONTRACT IS AWARDED UNDER THE NASA/LARC MIDRANGE PILOT TEST PROGRAM APPROVED BY THE OFFICE OF FEDERAL PROCUREMENT POLICY AUGUST 22, 1994

BVS [X] TPA Code: 22

18A. Discount Terms	18B. Total Amount of Contract	Firm-Fixed Price
NONE		$ 41,006.00

19. Name and Title (Type or Print)	20. Name of Contracting Officer
Alson E. Hatheway, President	CYNTHIA K. COWAN

21. Signature (of person authorized to sign)	22. Signature
Alson E. Hatheway 2/16/98	Cynthia K Cowan 3/3/98
Contractor Date	United States of America Date

LaRC P-320 (June 1994)

FILE COPY

FULL-TEXT CLAUSES

1. SUPPLIES AND/OR SERVICES TO BE FURNISHED

The Contractor shall provide all resources (except as may be expressly stated in this contract as furnished by the Government) necessary to furnish the required supplies and/or services in accordance with the Statement of Work/Specification set forth in Paragraph 16 below.

2. FIRM FIXED PRICE (NASA 1852.216-78) (DEC 1988)

The total firm fixed price of this contract is $41,000.00.

3. DELIVERY AT SITE (LaRC 52.211-94) (APR 1993)

Delivery shall be f.o.b. destination:

National Aeronautics and Space Administration
Langley Research Center
4 West Taylor Street, Bldg. 1293B
Hampton, VA 23681-2199

Attn: Garnett C. Horner, (757) 864-6489

4. MATERIAL INSPECTION AND RECEIVING REPORT (1852.246-72) (OCT 1988)

(a) At the time of each delivery under this contract, the Contractor shall furnish to the Government a Material Inspection and Receiving Report (DD Form 250 series) prepared in an original and three (3) copies.

(b) The Contractor shall prepare the DD Form 250 in accordance with NASA FAR Supplement 1846.672-1. The Contractor shall enclose the copies of the DD Form 250 in the package or seal them in a waterproof envelope which shall be securely attached to the exterior of the package in the most protected location.

(c) When more than one package is involved in a shipment, the Contractor shall list on the DD Form 250, as additional information, the quantity of packages and the package numbers. The Contractor shall forward the DD Form 250 with the lowest numbered package of the shipment and print the words "CONTAINS DD FORM 250" on the package.

5. FINAL INSPECTION AND ACCEPTANCE (LaRC 52.246-94) (OCT 1992)

Final inspection and acceptance of all items specified for delivery under this contract shall be accomplished by the Contracting Officer or his duly authorized representative at destination which is NASA Langley Research Center.

6. PERIOD OF PERFORMANCE

The period of performance of this contract shall be four (4) months from the effective date of this contract.

7. PLACE OF PERFORMANCE (LaRC 52.211-98) (OCT 1992)

The places of performance shall be the Contractor's facility located in Pasadena, CA.

8. PAYMENT

Payment of the contract price will be made as set forth below:

A.	Concept Design Review and Business Plan	$ 20,500.00 [50 percent of contract price]
B.	Completion of Base Effort	$ 20,500.00 [50 percent of contract price]

9. ORAL PRESENTATIONS (LaRC 52.211-100) (AUG 1991)

The Contractor shall make oral presentations under this contract at the approximate times and locations identified below:

	Description	Months from Effective Date of Contract	Location
1.	Technical Interchange Meetings (TIMs)	Periodic	At the Contractor's facility
2.	Concept Design Review	3 months	NASA LaRC

The specific dates of some of the presentations denoted above shall be mutually selected by the Contracting Officer Technical Representative and the Contractor. The presentation(s) shall include a review of all work accomplished during contract performance. The presentations, shall also include a brief summary of reportable items under the FAR 52.227-11 clause entitled, "Patent Rights – Retention by the Contractor," or 1852.227-70 clause entitled, "New Technology."

10. RIGHTS TO PROPOSAL DATA (TECHNICAL) (FAR 52.227-23) (JUN 1987)

Except for data contained on pages 1-10 of original Proposal Number 93516V2 and _____ of the proposal revisions, it is agreed that as a condition of award of this contract, and notwithstanding the conditions of any notice appearing thereon, the Government shall have unlimited rights (as defined in the "Rights in Data - General" clause contained in this contract) in and to the technical data contained in the proposal dated November 18, 1997 and its revisions dated _____, upon which this contract is based.

11. INCORPORATION OF REPRESENTATIONS AND CERTIFICATIONS BY REFERENCE

The Representations and Certifications dated November 18, 1997 are hereby incorporated herein BY REFERENCE.

12. ADVANCE APPROVAL FOR RELEASE OF TECHNICAL INFORMATION (LaRC 52.227-92) (OCT 1993)

The Contractor shall not release technical information based on or containing data first produced in the performance of this contract and describing the work performed under this contract unless prior written approval is given by NASA. The Contractor shall submit technical information regarding the contract effort, such as journal articles, meeting papers, and technical documents, to the Contracting Officer Technical Representative (COTR) for review and concurrence with subsequent approval by the cognizant NASA Headquarters Program Office prior to establishing claim to copyright, publication, presentation, or release to others. The Contractor may proceed upon receipt of written concurrence by the COTR as though approval also had been received from the cognizant NASA Headquarters Program Office, unless directed otherwise in the COTR concurrence letter.

13. OPTION

The Contractor hereby grants to the Government an option to extend the term of the contract for an additional fourteen (14) months. Such option is to be exercisable by issuance of a unilateral

modification no later than four (4) months from the effective date of this contract. The total duration of this contract, including the exercise of this option, shall not exceed eighteen (18) months.

Upon exercise of such option by the Government, the following items will be modified as follows:

A. FIRM-FIXED PRICE

The firm-fixed price cited in Paragraph 2 will be increased by $107,000.00 from $41,000.00 to $148,000.00

B. PERIOD OF PERFORMANCE

The period of performance cited in Paragraph 6 will be extended by fourteen (14) months from four (4) months for a total of eighteen (18) months.

C. PLACE OF PERFORMANCE (LARC 52.211-98) (OCT 1991)

The place of performance cited in Paragraph 7 will be modified to add the following places of performance:

Jet Propulsion Laboratory
Pasadena, CA

NASA Langley Research Center
Hampton, VA

D. DELIVERY/PAYMENT CONDITIONS

The information cited in Paragraph 8 will be modified to include the payment schedule set forth in Appendix B to the contract.

E. ORAL PRESENTATIONS (LaRC 52.211-100) (AUG 1991)

The oral presentations cited in Paragraph 9 will be modified to add the following line item presentations identified below:

	Description	Approximate Months from Effective Date of Contract	Location
3.	Design Review	6 months	NASA LaRC
4.	1998 NGST Technology Challenge Review	6 months	Pasadena, CA
5.	Final Review	17 months	NASA LaRC

Upon exercise of such option by the Government, the following items will be added:

F. LIST OF GOVERNMENT-FURNISHED FACILITIES

For the performance of work under this contract, the Government will make available to the Contractor certain Government Facilities located at the Jet Propulsion Laboratory (see Appendix A), NASA Langley Research Center, and at other locations on a no-charge-for-use basis. The Contractor shall use the facilities denoted below in the performance of this contract and at other location(s) as may be approved by the Contracting Officer:

JPL Cryogenic Test Facility

NASA Langley Smart Actuator Research
Laboratory Bldg. 1293B

These facilities will be available from approximately six (6) months from the effective date of the contract through sixteen (16) months from the effective date of the contract, but only after design approval. The JPL facility will be made available on two occasions for testing.

G. WORK SCHEDULE--ON-SITE ONLY (LaRC 52.211-103) (JUL 1991)

In order that the necessary and proper inspection of the Contractor's work may be effectively accomplished, and to assure the availability of required Government interface, the Contractor shall schedule work performance so as to be compatible with the established workweek and hours of work observed by the Government organization having cognizance over the work being performed, which is 8:00 a.m. to 4:30 p.m., Monday through Friday.

H. OBSERVATION OF REGULATIONS AND IDENTIFICATION OF CONTRACTOR'S EMPLOYEES (LaRC 52.211-104) (MAR 1992)

A. Observation of Regulations--In performance of that part of the contract work which may be performed at Langley Research Center or other Government installation, the Contractor shall require its employees to observe the rules and regulations as prescribed by the authorities at Langley Research Center or other installation.

B. Identification Badges--At all times while on LaRC property, the Contractor shall require its employees, subcontractors and agents to wear badges which will be issued by the NASA Contract Badge and Pass Office, located at 1 Langley Boulevard (Building No. 1228). Badges shall be issued only between the hours of 6:30 a.m. and 4:30 p.m., Monday through Friday. Contractors will be held accountable for these badges, and may be required to validate outstanding badges on an annual basis with the NASA LaRC Security Office. Immediately after employee termination or contract completion, badges shall be returned to the NASA Contract Badge and Pass Office.

14. CLAUSES INCORPORATED BY REFERENCE (52.252-2) (JUN 1988)

This contract incorporates one or more clauses BY REFERENCE, with the same force and effect as if they were given in full text. Upon request, the Contracting Officer will make their full text available.

NOTICE: The following clauses are hereby incorporated BY REFERENCE.

A. FEDERAL ACQUISITION REGULATION (48 CFR CHAPTER 1) CLAUSES

52.202-1	Definitions (Oct 1995)
52.203-3	Gratuities (Apr 1984)
52.203-5	Covenant Against Contingent Fees (Apr 1984)
52.203-6	Restrictions on Subcontractor Sales to the Government (Jul 1995)
52.203-7	Anti-Kickback Procedures (Jul 1995)
52.203-8	Cancellation, Rescission and Recovery of Funds for Illegal or Improper Activity (Jan 1997)
52.203-10	Price or Fee Adjustment for Illegal or Improper Activity (Jan 1997)
52.203-12	Limitation on Payments to Influence Certain Federal Transactions (Jun 1997)
52.204-4	Printing/Copying Double-Sided on Recycled Paper (Jun 1996)
52.209-6	Protecting the Government's Interest When Subcontracting with Contractors Debarred, Suspended, or Proposed for Debarment (Jul 1995)
52.211-5	New Material (Oct 1997)
52.211-7	Other Than New Material, Residual Inventory and Former Government Surplus Property (May 1995)
52.211-15	Defense Priority and Allocation Requirements (Sep 1990)
52.215-2	Audit and Records -- Negotiation (Aug 1996)
52.215-8	Order of Precedence (Oct 1997)
52.215-14	Integrity of Unit Prices (Oct 1997)
52.215-17	Waiver of Facilities Capital Cost of Money (Oct 1997)

52.215-21	Requirements for Cost or Pricing Data or Information Other Than Cost or Pricing Data - Modifications (Jan 1997)
52.219-8	Utilization of Small, Small Disadvantaged and Women-Owned Small Business Concerns (Jun 1997)
52.222-1	Notice to the Government of Labor Disputes (Feb 1997)
52.222-3	Convict Labor (Aug 1996)
52.222-4	Contract Work Hours and Safety Standards Act - Overtime Compensation (Jul 1995)
52.222-26	Equal Opportunity (Apr 1984)
52.222-35	Affirmative Action for Special Disabled and Vietnam Era Veterans (Apr 1984)
52.222-36	Affirmative Action for Handicapped Workers (Apr 1984)
52.222-37	Employment Reports on Special Disabled Veterans of the Vietnam Era (Jan 1988)
52.223-2	Clean Air and Water (Apr 1984)
52.223-6	Drug-Free Workplace (Jan 1997)
52.223-14	Toxic Chemical Release Reporting (Oct 1996)
52.225-11	Restrictions on Certain Foreign Purchases (Oct 1996)
52.225-18	European Union Sanction for End Products (Jan 1996)
52.225-19	European Union Sanction for Services (Jan 1996)
52.227-1	Authorization and Consent (Jul 1995) -- Alternate I (Apr 1984)
52.227-2	Notice and Assistance Regarding Patent and Copyright Infringement (Aug 1996)
52.227-3	Patent Indemnity (Apr 1984)
52.227-9	Refund of Royalties (Apr 1984)
52.227-11	Patent Rights -- Retention by the Contractor (Short Form) (Jun 1989) -- As Modified by NASA FAR Supplement 1852.227-11
52.227-14	Rights in Data--General (Jun 1987) -- As Modified by NASA FAR Supplement 1852.227-14
52.227-16	Additional Data Requirements (Jun 1987)
52.229-3	Federal, State and Local Taxes (Jan 1991)
52.229-5	Taxes - Contracts Performed in U.S. Possessions or Puerto Rico (Apr 1984)
52.232-2	Payments under Fixed-Price Research and Development Contracts (Apr 1984)
52.232-9	Limitation on Withholding of Payments (Apr 1984)
52.232-17	Interest (Jun 1991)
52.232-23	Assignment of Claims (Jan 1986)
52.232-25	Prompt Payment (Jun 1997) (Insert 30th day in subparagraph (b)(2))
52.232-33	Mandatory Information for Electronic Funds Transfer Payment (Aug 1996)
52.233-1	Disputes (Oct 1995) -- Alternate I (Dec 1991)
52.233-3	Protest After Award (Aug 1996)
52.242-2	Production Progress Reports (Apr 1991)
52.242-13	Bankruptcy (Jul 1995)
52.242-15	Stop-Work Order (Aug 1989)
52.243-1	Changes -- Fixed Price (Aug 1987) -- Alternate V (Apr 1984)
52.244-5	Competition in Subcontracting (Dec 1996)
52.244-6	Subcontracts for Commercial Items and Commercial Components (Oct 1995)
52.245-2	Government Property (Fixed-Price Contracts) (Dec 1989)
52.246-7	Inspection of Research and Development -- Fixed-Price (Aug 1996)
52.246-16	Responsibility for Supplies (Apr 1984)
52.246-23	Limitation of Liability (Feb 1997)
52.247-34	F.O.B. Destination (Nov 1991)
52.249-2	Termination for the Convenience of the Government (Fixed-Price) (Sep 1996)
52.249-9	Default (Fixed-Price Research and Development) (Apr 1984)
52.252-6	Authorized Deviations in Clauses (Apr 1984)
52.253-1	Computer Generated Forms (Jan 1991)

B. NASA/FAR SUPPLEMENT (48 CFR CHAPTER 18) CLAUSES

1852.208-81	Restrictions on Printing and Duplicating (Aug 1993)
1852.215-84	Ombudsman (Oct 1996) NASA LaRC: Belinda Adams, direct inquires to Sandra S. Ray, (757) 864-2428 NASA HQS/WASH DC: Deputy Administrator for Procurement, (202) 358-2090

1852.219-74 Use of Rural Area Small Businessess (Sep 1990)
1852.219-76 NASA 8 Percent Goal (Jul 1997)
1852.227-72 Designation of New Technology Representative and Patent Representative

Title	Office Mail Stop	Address
New Technology Representative	212	NASA Langley Research Center Hampton, VA 23681-2199
Patent Representative	212	NASA Langley Research Center Hampton, VA 23681-2199

1852.235-70 Center for AeroSpace Information (Nov 1992)

15. REPORTS OF WORK

A. **Monthly Technical Letter Progress Report**--The Contractor shall submit monthly technical letter progress reports describing progress of the program to date, noting all technical areas in which effort is being directed and indicating the status of work within these areas. Reports shall be in narrative form, brief and informal in content. These reports shall include:

1. A narrative statement of work accomplished during the report period.

2. A statement of current and potential problem areas and proposed corrective action.

3. A discussion of work to be performed during the next report period.

The monthly progress report shall be submitted within ten (10) days after the end of each calendar monthly report period. A monthly progress report shall not be required for the period in which the final report is due. This submittal shall be subject to the provisions of the FAR clause 52.242.-2 entitled, "Production Progress Reports."

Electronic submission of this report is preferred; however, all electronic submittals shall be compatible with Microsoft Word 6.0.

B. **Report of Government-Owned/Contractor-Held Property (NASA Form 1018) (Option Period)** - The Contractor shall submit the NASA Form no later than October 31 of each year in accordance with the NFS 1852.245-73 clause entitled, "Financial Reporting of NASA Property in the Custody of Contractors."

C. **Oral Presentation Materials**—The Contractor shall provide copies, including slides, of the material used for each/all oral presentations conducted under this contract.

D. **Other Documentation**—The Contractor shall provide written records of work performed. Specific documentation shall include the following:

	Delivery from Effective Date of the Contract
Base Period	
Concept Design Review Package and Business Plan	3 months
Option Period	
- Design Review package	6 months
- As-run Test Procedures (For Approval)	16 months
- Test Data and Requirements Verification Matrix	18 months
- As-built Drawings including Electrical Circuit Designs	18 months
- Supporting Analyses (for each actuator)	18 months
- Users' Manual and Code Documentation for Analytical	18 months

Model

E. **Informal Final Report (Option Period)**--The Contractor shall submit an informal final report which documents and summarizes the results of the entire contract work. The final report shall include tables, graphs, diagrams, curves, sketches, photographs and drawings in sufficient detail to explain comprehensively the results achieved under the contract. Also, the final report shall include the supporting analyses for each actuator developed under this contract. The Contractor shall submit two (2) copies of a draft report to the Government for review/approval on or before sixteen (16) months from the effective date of this contract.. The approved copy of the final report shall be delivered eighteen (18) months from effective date of the contract.

F. **Federal Contractor Veterans Employment Report**--In compliance with 52.222-37 clause entitled, Employment Reports on Special Disabled Veterans and Veterans of the Vietnam Era, the Contractor shall submit the Federal Contractor Veterans Employment Report (VETS-100) as required by this clause.

G. **Reports Distribution**

Unless otherwise specified elsewhere in this contract, reports and other documentation shall be submitted f.o.b. destination as specified below, addressed as follows:

National Aeronautics and Space Administration
Langley Research Center
Attn: _____, Mail Stop _____
Contract NAS1-
Hampton, VA 23681-2199

The following letter codes designate the recipients of reports and other documentation which are required to be delivered to Langley Research Center by the Contractor:

A--Contract Administrator
Attn: Mail Stop 126

B--Contracting Officer Technical Representative (COTR)
Attn: Mail Stop 230

C--Patent Counsel, Mail Stop 212

D—New Technology, Mail Stop 212

E—Property Administrator, Mail Stop 377

F--According to Instructions on Form

The following are the distribution requirements for reports and other documentation required to be delivered f.o.b. destination. The numeral following the letter code specifies the number of copies to be provided:

DOCUMENT	LETTER CODE AND DISTRIBUTION
Monthly Technical Letter Progress Reports	A-1, B-2, C-1, D-1
Patent Rights Report	A-1, B-2, C-1, D-1
New Technology Report	A-1, B-2, C-1, D-1

Property Reporting (NASA Form 1018)	A-1, E-4
Oral Presentation Materials, including slides	A,* B-2
Federal Contractor Veterans Employment Report (VETS-100 form)	F-1
Other Documentation	
Base Period	
- Concept Design Review Package and Business Plan	A,* B-2
Option Period	
- Design Review package	A,* B-2
- As-run Test Procedures	A,* B-2
- Test Data and Requirements Verification Matrix	A,* B-2
- As-built Drawings including Electrical Circuit Designs	A,* B-2
- Supporting Analyses	A,* B-2
- Users' Manual and Code Documentation for Analytical Model	A,* B-2
Preliminary Draft Copies of Informal Final Report (Review Copies)	A-1, B-5
Informal Final Report	A-1, B-5 (1 reproducible original, 4 copies, and a 3.5 diskette)

* When the Contract Administrator (A) is not designated above to receive a copy of a report or document, the Contractor shall furnish a copy of the report/document transmittal letter to the Contract Administrator.

16. STATEMENT OF WORK/SPECIFICATION

16.1 Background

The Next Generation Space Telescope (NGST) Study was initiated as a result of the astronomical research opportunities identified in the report of the Dressler Committee, "HST and Beyond" (Reference 1). In the summer of 1996, three teams of scientists and engineers evaluated requirements and developed mission and system concepts for the NGST. The concepts developed included a telescope with a six meter diameter monolithic primary mirror and two deployable telescopes with eight meter diameter segmented primary mirrors. The telescopes were designed to have diffraction limited performance at 2 microns with a total wavelength coverage requirement of 1 to 5 microns with a goal of 0.5 to 20 microns. The results are documented in Reference 2.

In the development of the NGST Study Concept, key technologies were identified that required development in order to meet cost and performance specifications (References 1 and 2). This procurement is focused on one of these areas, the development of the cryogenic actuators.

NGST must have a significant increase in primary mirror size over that of the Hubble Space Telescope (HST) in order to fulfill the science requirements described in the Dressler Report. In addition, it must be significantly lighter in weight than HST. In HST, the classical optical design rule for mirror aspect ratio was implemented where the thickness of the primary mirror was approximately one sixth of the diameter. Built using standard mirror materials, the result was a workable mirror design, but one that was at the upper limit of permitted design weights for space based applications. Parametric design studies have shown that the primary mirror is one of the main weight components of any space telescope design and the other masses involved are proportional with it. The 2.4 meter HST required the largest (and most expensive) launch vehicle available. If the 6-8 meter NGST were designed using the same approach, the weight would be prohibitive. Therefore, a thinner mirror with an adjustable optical figure is required.

Clearly, in response to this need, new techniques for actuation of reflective optics are necessary which can adjust a thin optical mirror surface to achieve a low wavefront error. Additionally, the thermal environment chosen for the spacecraft locates the actuators in a 20-60K environment and these new actuators are expected to operate without introducing heat load into the mirror or surrounding structure. New actuators must also withstand the rigors of launch, have very low mass, and be affordable.

Expected operational modes include an observatory mode (OM) and a calibration mode (CM). When the telescope is in the observatory mode, all actuator systems hold position with negligible heat dissipation. Between observations, the telescope will be slewed to point at the next target. After transient dynamics have decayed and thermal equilibrium reached, the telescope goes to a calibration mode and re-positions the optics, utilizing a set of precision actuators, based upon a calibration algorithm. The telescope is now ready to go back to the observatory mode. Observation times while in the observatory mode could be as long as 6 weeks or as short as a few hours.

16.2 Overview

16.2.1 Technical Objective

The technical objective of the effort is for the Contractor to design, fabricate, test and deliver a Type 2 cryogenic actuator prototype system which satisfies the NGST actuator requirements in Section 16.4 and prove it can be produced at an acceptable cost and schedule commensurate with the cost-to-build goal of $500M with a 2007 launch.

16.3 Scope of Tasks

16.3.1 System Definition

The actuator system shall consist of the actuator with all electrical, mechanical and control components needed to demonstrate that it meets the requirements of Section 16.4.

16.3.2 Actuator Type Definition

The basic set of actuator requirements is identified in Section 16.4. Type 2 performs mirror position displacement on the large primary mirror itself.

16.4 Requirements and Goals

In the table below, there is a requirement and a goal column for the actuator Type 2. The values in the requirement column are minimum acceptable values, while the values in the goal column are the desired values. These values apply only to the actuating component of the system. Actuator designs shall be capable of being space qualified. They shall not contaminate a space based infrared telescope through out-gassing of the materials.

Table: Position Control Actuator Requirements

	Type 2	
Property	Requirement	Goal
Resolution (nanometer)	≤20	≤10
Lifecycles	≥10,000	≥1,000,000
Stroke (mm)	≥6	≥10
Operating temperature range, (Kelvin)	20-60	20-300
CM Heat dissipation, (milliwatts)	≤5	≤0.5
OM Heat dissipation, (milliwatts)	≤0.05	≤0
Mass (grams)	≤40	≤20
Outside Diameter, (cm)	≤5	≤1
Creep, OM (nm/day)	≤0.1	≤0.01
Thermal stability, OM (nm/K) *	≤50	≤20
Axial Force, set & hold, OM (N)	≥0.5	≥1
Power Consumption, CM, (watt)	≤1	≤0.1
Axial Stiffness, (N/micron)	≥1	≥1
Stowed Axial Length, (cm)	≤10	≤10

* Thermal dimensional stability is defined to be the change in length between the two attachment points of the actuator per degree Kelvin. These two attachment points are the actuator structural mounting point and the point of contact of the actuator end-effector.

16.5 Task Descriptions

16.5.1 Phase 1

Tasks 1 - Actuator Conceptual Designs and Analyses

For the actuator type, the Contractor shall develop a comprehensive actuator system design that meets or exceeds the minimum requirements stated in Section 16.4 above. Supporting analyses shall also be provided for the actuator system design to demonstrate that the design meets or exceeds the requirements set forth in 16.4. In addition, actuator failure mechanisms shall also be identified. The Contractor shall provide a business plan that documents the Contractor's fabrication, assembly, and test capability for large quantities of actuators. The Contractor may also bread board critical components during this phase. Documentation provided during this phase will be used to select candidate actuator concepts for Phase 2.

16.5.2 Phase 2 - Option

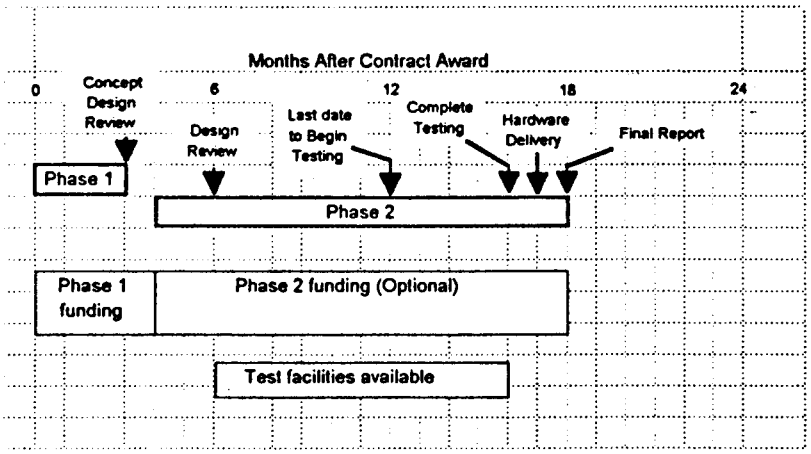
16.5.2.1 Task 2 - Actuator System Fabrication and Test

The Contractor shall fabricate and deliver a complete actuator prototype system, develop a cryogenic test plan for approval that is consistent with the JPL Cryogenic Actuator Test Facility requirements and capabilities, deliver the system to the JPL Cryogenic Actuator Test Facility, participate in installation and cryogenic testing, and perform analyses of the test results. Iterative cycles of modification and re-test may be needed and shall be accommodated. Details of the JPL Cryogenic Test Facility are contained in Appendix A.

16.5.2.2 Task 3 - Analytical System Model

An analytical model of the actuator system shall be developed and validated. A through-the-system force model of the actuator, starting with the command input and ending with the actuator output, shall be developed which predicts the performance of the actuator system over the entire force range. This model shall include the electronics, cabling, power required, and the actuator mechanism, if any. The intent is to use this model as part of a system simulation. The model shall have a bandwidth of at least 10 Hz and shall be accurate to resolution divided by two. The model shall provide for inputs from thermal disturbance and external force disturbances.

16.6 Contract and Milestone Schedule



Basic Contract Period - Phase 1
Start of Contract (SOC)

3 months after SOC, Concept Design Review Package and Business Plan
4 months after SOC, Exercise of option, if applicable.

Option Period - Phase 2
6 months after SOC, CDR
No later than 12 months after SOC, Begin Cryogenic Testing
No later than 16 months after SOC, Complete Cryogenic Testing
18 months after SOC , Deliver Final Report.

REFERENCES:

1. "Exploration and the Search for Origins: A Vision for Ultraviolet-Optical-Infrared Space Astronomy (Report of the HST and Beyond Committee," Alan Dressler, Editor) Association of Universities for Research in Astronomy (AURA), May 15, 1966. (Also available as PDF file at URL http://ngst.gsfc.nasa.gov/project/bin/HST Beyond.PDF)

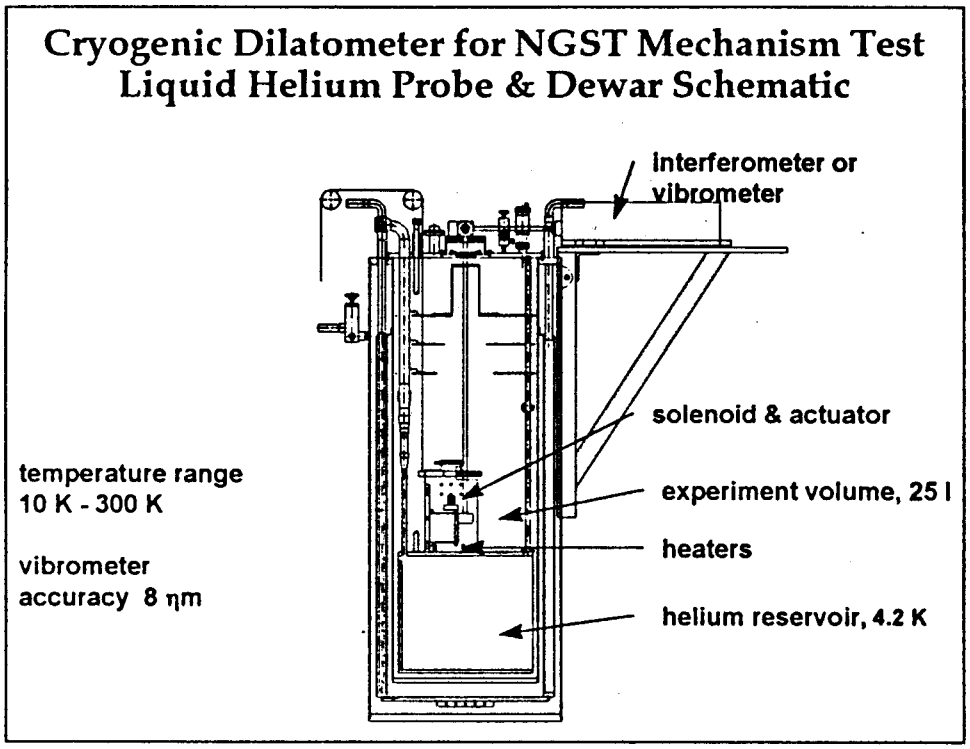
2. "The Next Generation Space Telescope - Visiting a Time When Galazies Were Young," H. S. Stockman, Editor, AURA, June 1997.

APPENDIX A

JPL Cryogenic Test Facility Description

A central problem in the development of new actuators for NGST is to provide accurate cross comparison between the performance of designs provided by different vendors participating in development work. NASA intends to make the JPL Cryogenic Test Facility available to provide a uniform set of test circumstances for all actuator designs.

The Cryogenic Test Facility at JPL has been in operation for two years. The facility provides a controlled cold test environment and a laser vibrometer for NIST traceable measurements of linear actuator motion accurate to tens of nanometers. A schematic of the facility is shown below.



Selected operational and interface parameters are given below:

• experiment volume: (approx. 25cm diameter by 25cm long test chamber)	25 liters
• optical axis: on center line of experiment volume	
• vibrometer accuracy:	8nm
• temperature range:	10 to 300K
• temperature stability:	milli-Kelvin
• mechanical load:	0 to 100 lbf
• bulkhead connector:	Deteronics (DTIH-14-19PN)
• probe cable harness:	9 twisted pair (22 gage)

APPENDIX B

SCHEDULE OF PARTIAL PAYMENTS

ITEM NO.	MONTH FROM EFFECTIVE DATE OF THE CONTRACT	DELIVERABLE	PAYMENT AMOUNT
1.	5	Monthly Progress Report	$ 5,350.00 (5 percent of firm-fixed price)
2.	6	Concept Design Review Package and Business Plan	$ 10,700.00 (10 percent of firm-fixed price)
3.	7	Monthly Progress Report	$ 5,350.00 (5 percent of firm-fixed price)
4.	8	Monthly Progress Report	$ 5,350.00 (5 percent of firm-fixed price)
5.	9	Monthly Progress Report	$ 5,350.00 (5 percent of firm-fixed price)
6.	10	Monthly Progress Report	$ 5,350.00 (5 percent of firm-fixed price)
7.	11	Monthly Progress Report	$ 5,350.00 (5 percent of firm-fixed price)
8.	12	Hardware Testing	$ 10,700.00 (10 percent of firm-fixed price)
9.	13	Monthly Progress Report	$ 5,350.00 (5 percent of firm-fixed price)
10.	14	Monthly Progress Report	$ 5,350.00 (5 percent of firm-fixed price)
11.	15	Monthly Progress Report	$ 5,350.00 (5 percent of firm-fixed price)
12.	16	Hardware Testing Complete Receipt of Draft Final Report	$ 10,700.00 (10 percent of firm-fixed price)
13.	17	Hardware Delivery	$ 16,050.00 (15 percent of firm-fixed price)
14.	18	Acceptance of Final Report	$ 10,700.00 (10 percent of firm-fixed price)