



<b>NASA</b>		<b>CONTRACT</b>		1. DPAS DO-C8	2. PPC	3. No. 23	4. Page 1 of 14
5. Contract No. NAS1-98031			6. Effective Date FEB 12 1998		7. Procurement Request No. DSJ.1225		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 23681-0001			10. Contractor Name and Address  American Superconductor Corporation Two Technology Drive Westborough, MA 01581  Name and Telephone No. of Contract Administrator: Tom Ross, Controller Phone: (608) 838-4200				
11. Administered By Code 126 Acquisition Division, Mail Stop 126 NASA Langley Research Center 9A Langley Blvd., Bldg. 1195B Hampton, VA 23681-0001 LaRC Administrator: Cynthia K. Cowan, (757)864-2548			12. Payment Will Be Made By Code --  Financial Management Division, M/S 175 NASA Langley Research Center Hampton, VA 23681-0001				
13. Submit Invoices To Code 175  (4 copies unless otherwise specified) the address shown in Block 12.			14. Accounting and Appropriations Data PR: DSJ.1225; R23305; \$18,750 (Partial)				
15A. Contract Type R&D Fixed Price *				15B. Incremental Funding [ ]			
<b>TABLE OF CONTENTS</b>							
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17. Items Awarded Under This Contract  <b>NEXT GENERATION SPACE TELESCOPE (NGST) CRYOGENIC ACTUATOR</b>  <b>THIS CONTRACT IS AWARDED UNDER THE NASALARC MIDRANGE PILOT TEST PROGRAM APPROVED BY THE OFFICE OF FEDERAL PROCUREMENT POLICY AUGUST 22, 1994</b> BVS [X] TPA Code: 22							
18A. Discount Terms Net 30			18B. Total Amount of Contract			Firm-Fixed Price \$18,750	
19. Name and Title (Type or Print)  Gregory J. Yurek President & CEO				20. Name of Contracting Officer  CYNTHIA K. COWAN			
21. Signature (of person authorized to sign)   2/11/98 Contractor Date				22. Signature   2/12/98 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 \$18,750.

### 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 23681-0001

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 Westborough, MA.

8. PAYMENT

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

- A. Concept Design Review and Business Plan \$9,375
- B. Completion of Base Effort \$9,375

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:

<u>Description</u>	<u>Months from Effective Date of Contract</u>	<u>Location</u>
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 None, 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, 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 \$87,500 from \$18,750 to \$106,250.

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:

<u>Description</u>	<u>Approximate Months from Effective Date of Contract</u>	<u>Location</u>
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

<u>Title</u>	<u>Office Mail Stop</u>	<u>Address</u>
New Technology Representative	212	NASA Langley Research Center Hampton, VA 23681-0001
Patent Representative	212	NASA Langley Research Center Hampton, VA 23681-0001

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:

<u>Base Period</u>	<u>Delivery from Effective Date of the Contract</u>
Concept Design Review Package and Business Plan	3 months
<b><u>Option Period</u></b>	
- 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 Model	18 months

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 Govt. 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 NAS1-98031  
Hampton, VA 23681-0001

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:

<u>DOCUMENT</u>	<u>LETTER CODE AND DISTRIBUTION</u>
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 4 cryogenic actuator prototype system which satisfies the NGST actuator requirements in Section 16.4 and proves 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 4 is an array of actuators used in small deformable mirrors (DMs). The actuator array deforms the mirror surface at which an image of the primary mirror is formed and thereby corrects residual wavefront errors resulting from uncorrected distortions in the primary mirror.

## 16.4 Requirements and Goals

In the table below, there is a requirement and a goal column for actuator Type 4. 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: Deformable Mirror Actuator Array Requirements**

Property	Type 4	
	Requirement	Goal
Resolution (nanometer)	≤5	≤3
Lifecycles	≥100,000	≥1,000,000
Stroke (μm)	≥5	≥50
Operating temperature range, (Kelvin)	20-60	20-300
CM Heat dissipation, (milliwatts)	≤5	≤0.5
OM Heat dissipation, (milliwatts)	≤0.05	≤0
Mass (grams)	≤20	≤10
Array column & row spacing, (mm)	≤5	≤3
Array size, number of actuators	(≥10)x(≥10)	(≥50)x(≥50)
Creep, OM (mN/day)	≤0.6	≤0.3
Thermal stability, OM (nm/K) *	≤100	≤20
Axial Force, OM, (Newton)	≥0.5	≥1
Power Consumption, CM, (watt)	≤1	≤0.1



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:

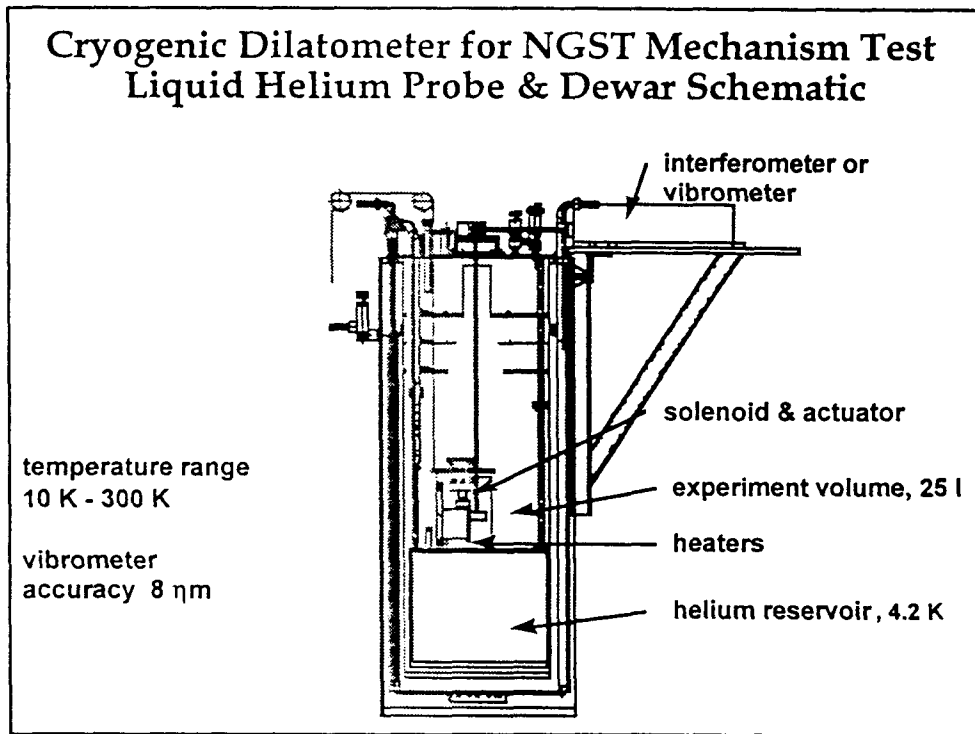
1. "Exploration and the Search for Origins: A Vision for Ultraviolet-Optical-Infrared Space Astronomy (Report of the HST and Beyond Committee," Alan Dressler, Editor) Association of Universities for Research in Astronomy (AURA), May 15, 1966. (Also available as PDF file at URL [http://ngst.gsfc.nasa.gov/project/bin/HST\\_Beyond.PDF](http://ngst.gsfc.nasa.gov/project/bin/HST_Beyond.PDF))
2. "The Next Generation Space Telescope - Visiting a Time When Galaxies 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:	25 liters
(approx. 25cm diameter by 25cm long test chamber)	
• 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

<u>ITEM NO.</u>	<u>MONTH FROM EFFECTIVE DATE OF THE CONTRACT</u>	<u>DELIVERABLE</u>	<u>PAYMENT AMOUNT</u>
1.	5	Monthly Progress Report	\$ 4,375
2.	6	Concept Design Review Package and Business Plan	\$ 8,750
3.	7	Monthly Progress Report	\$ 4,375
4.	8	Monthly Progress Report	\$ 4,375
5.	9	Monthly Progress Report	\$ 4,375
6.	10	Monthly Progress Report	\$ 4,375
7.	11	Monthly Progress Report	\$ 4,375
8.	12	Hardware Testing	\$ 8,750
9.	13	Monthly Progress Report	\$ 4,375
10.	14	Monthly Progress Report	\$ 4,375
11.	15	Monthly Progress Report	\$ 4,375
12.	16	Hardware Testing Complete Receipt of Draft Final Report	\$ 8,750
13.	17	Hardware Delivery	\$13,125
14.	18	Acceptance of Final Report	\$ 8,750