

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE (DD-MM-YYYY)		2. REPORT TYPE Technical Papers		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER 1011	
				5e. TASK NUMBER 0062	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Research Laboratory (AFMC) AFRL/PRS 5 Pollux Drive Edwards AFB CA 93524-7048				8. PERFORMING ORGANIZATION REPORT	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Research Laboratory (AFMC) AFRL/PRS 5 Pollux Drive Edwards AFB CA 93524-7048				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT A	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Leilani Richardson
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER (include area code) (661) 275-5015

f80 811

6 Separate items are enclosed



10110062 FILE

MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO)

29 Mar 2001

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2001-071**
Holmes, Michael R., "~~Solar Thermal Propulsion HPRPT Program~~" (VuGraphs)

S615

12th Advance Propulsion Workshop
(Huntsville, AL, 2-6 Apr 2001) (Deadline: 02 Apr 2001)

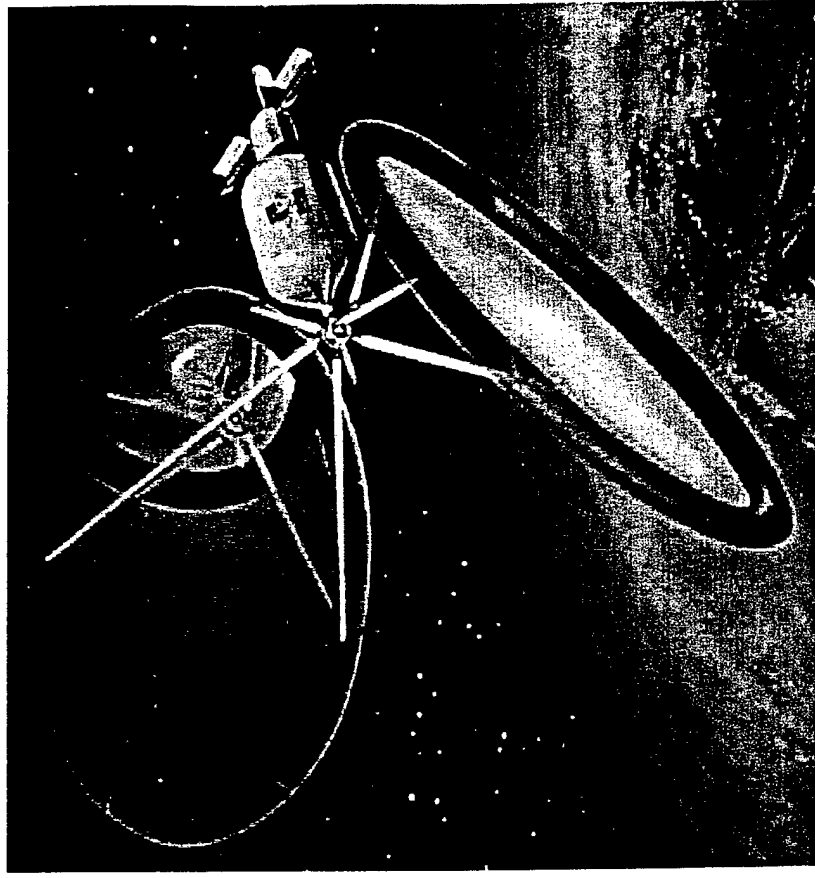
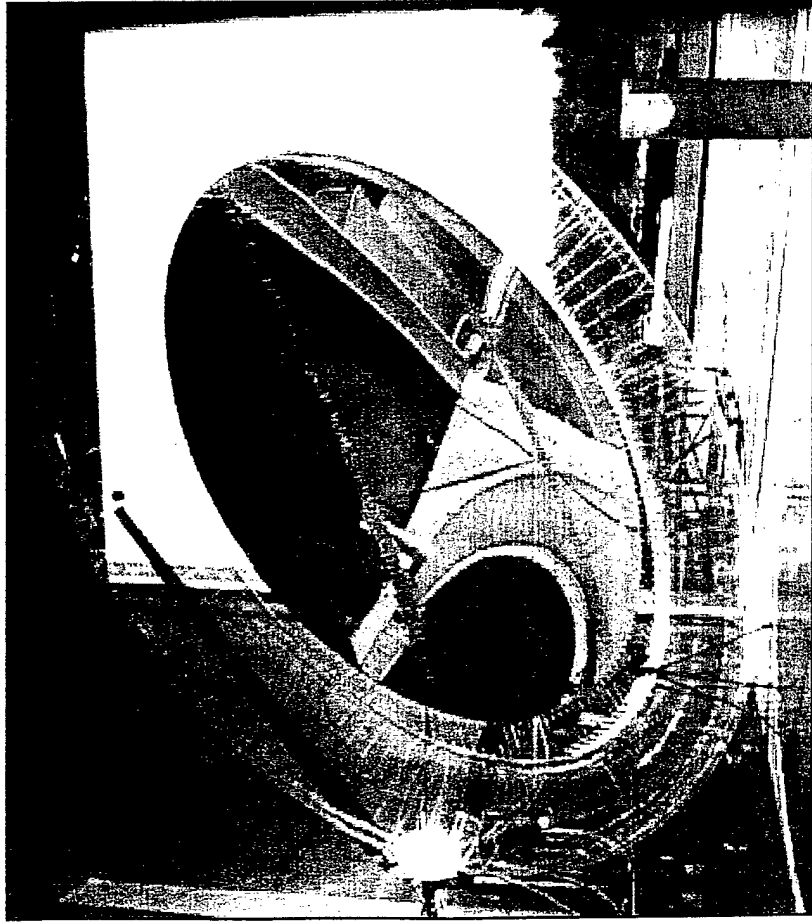
(Statement A)

SOLAR ROCKET PROPULSION

Ground and Space Technology

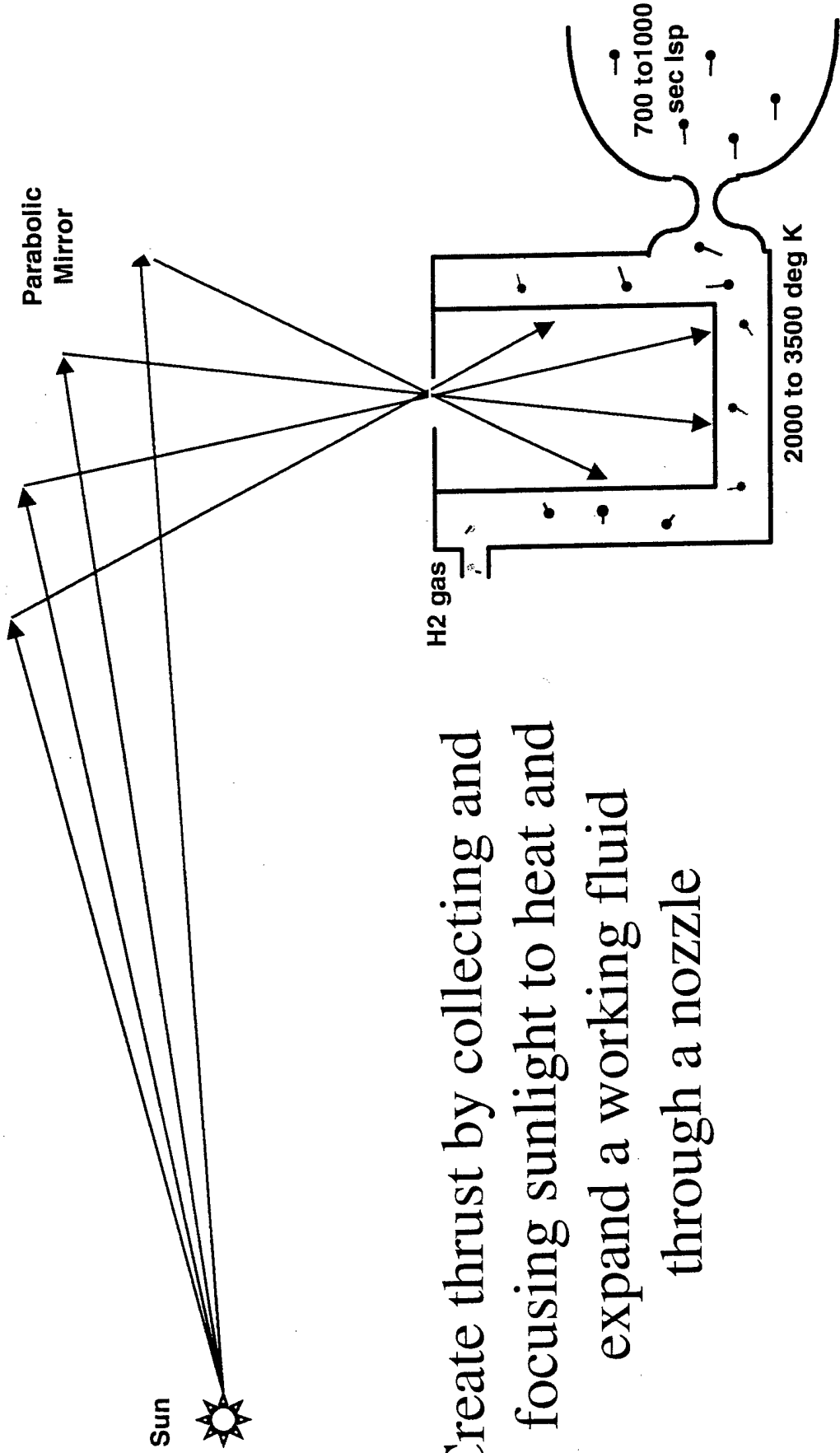
20021118 084

Demonstration



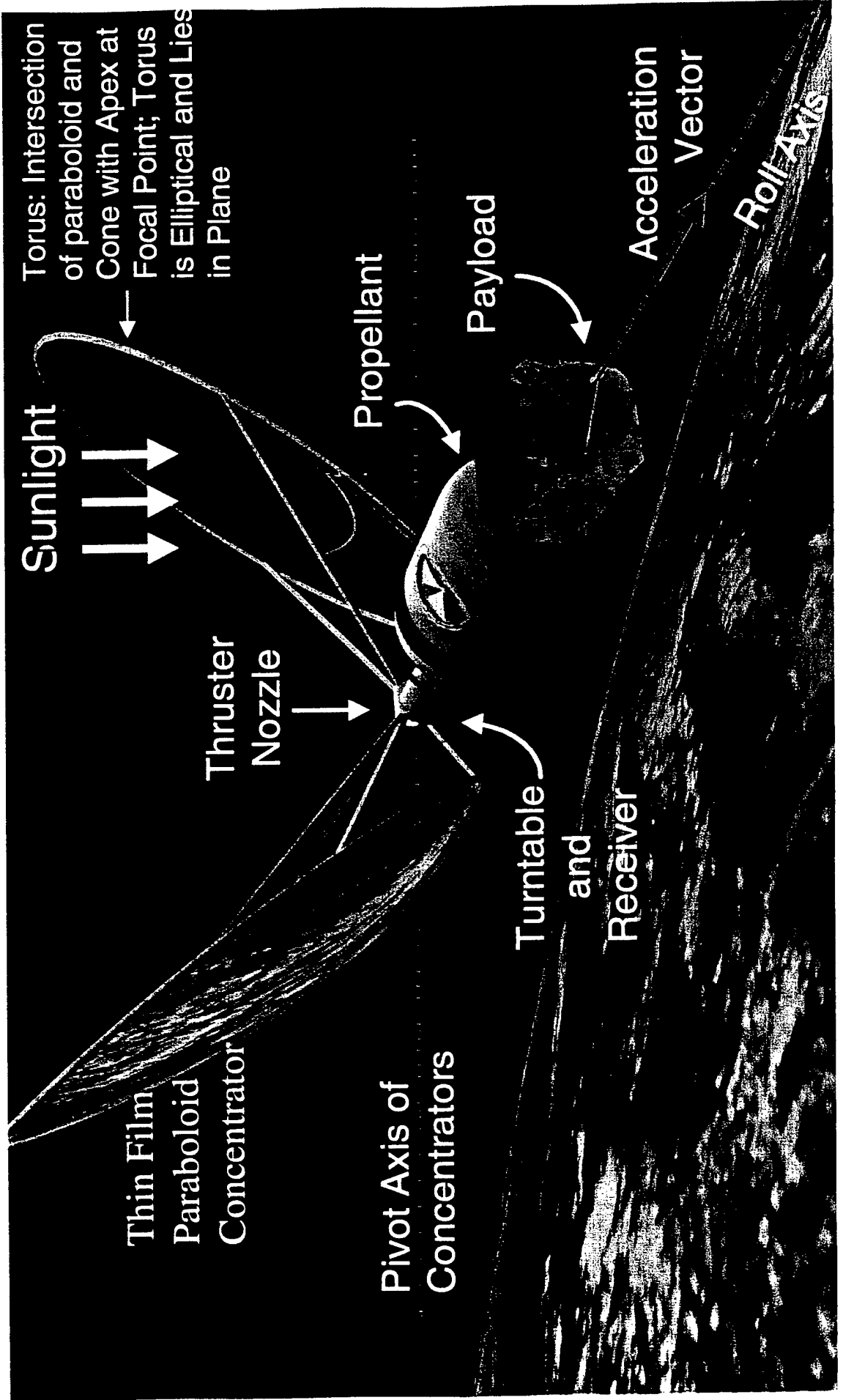
Dr. Michael Holmes, AFRL/PRSS

Solar Thermal Propulsion Concept



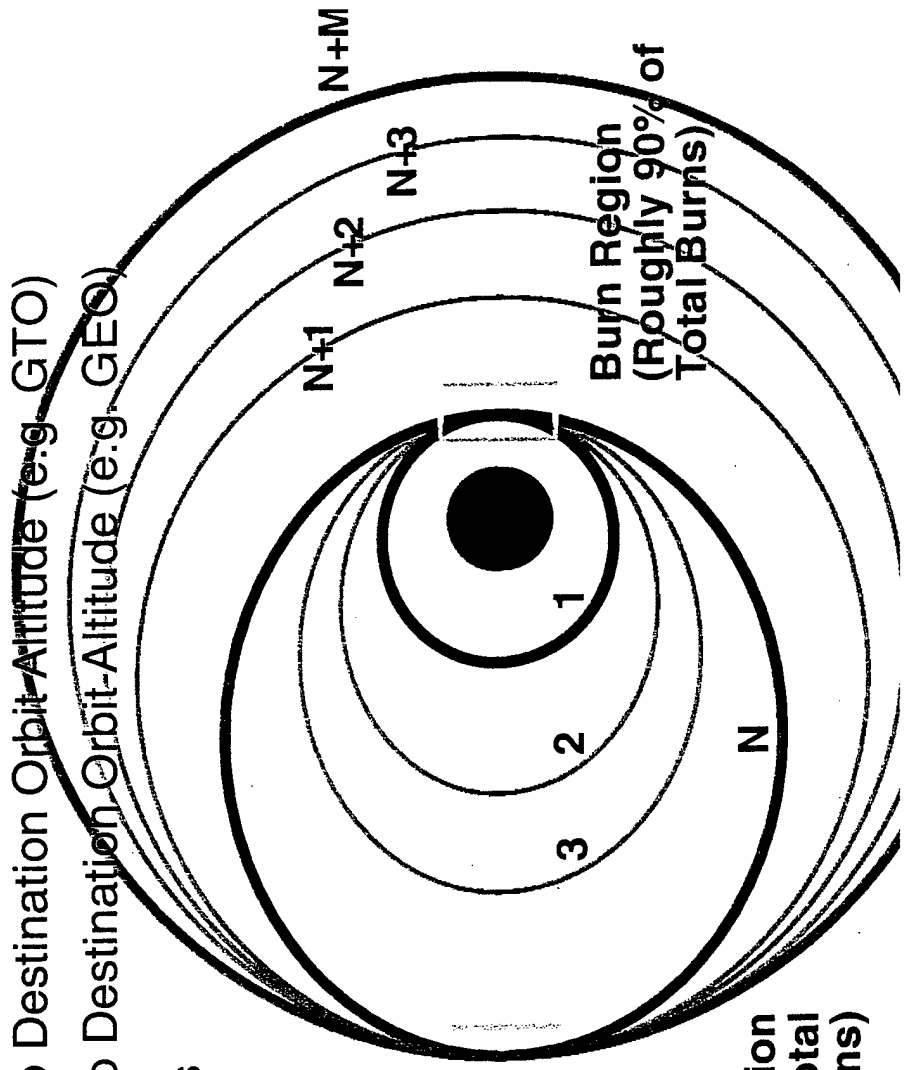
Create thrust by collecting and focusing sunlight to heat and expand a working fluid through a nozzle

Solar-Thermal System Concept



Solar Thermal Propulsion Orbit Transfer Scenario

- Maximum Delta V Thru Multi-Burn Transfer
 - Solar Thermal OTV to LEO by Ground Launch
 - N Perigee Burns to Raise Apogee to Destination Orbit-Altitude (e.g. GTO)
 - M Apogee Burns to Raise Perigee to Destination Orbit-Altitude (e.g. GEO)
 - Trip Time = Sum of N+M Orbit Periods
 - Higher Thrust Reduces N+M
 - Requires More Power, or
 - Reduces Delta V
 - Longer Burns Reduces N+M
 - Can Decrease Delta V by Gravity Losses
 - N+M=2 for Chemical Thruster
 - N+M~200 for Solar Propulsion
- Burn Region
(Roughly 10% of Total Burns)**



STP Doubles Payload in Reasonable Trip Time From LEO

Solar Propulsion

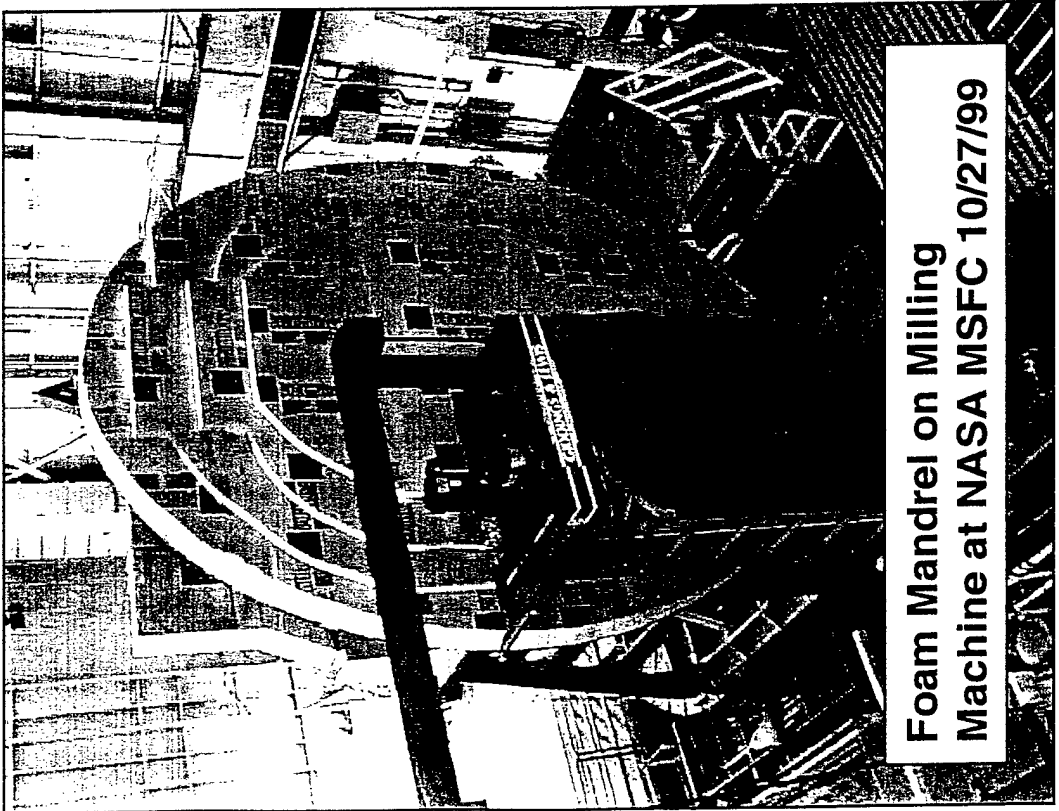
IHPRPT Goals

GOALS	BASELINE	PHASE I GOAL	PHASE II GOAL	PHASE III GOAL
Isp	720 sec	792 sec 10 %	828 sec 15 %	864 sec 20 %
Mass	.66	.696	.722	.749
Fraction R_m		5%	9%	13%
dry Mass fraction		15%	25%	35%

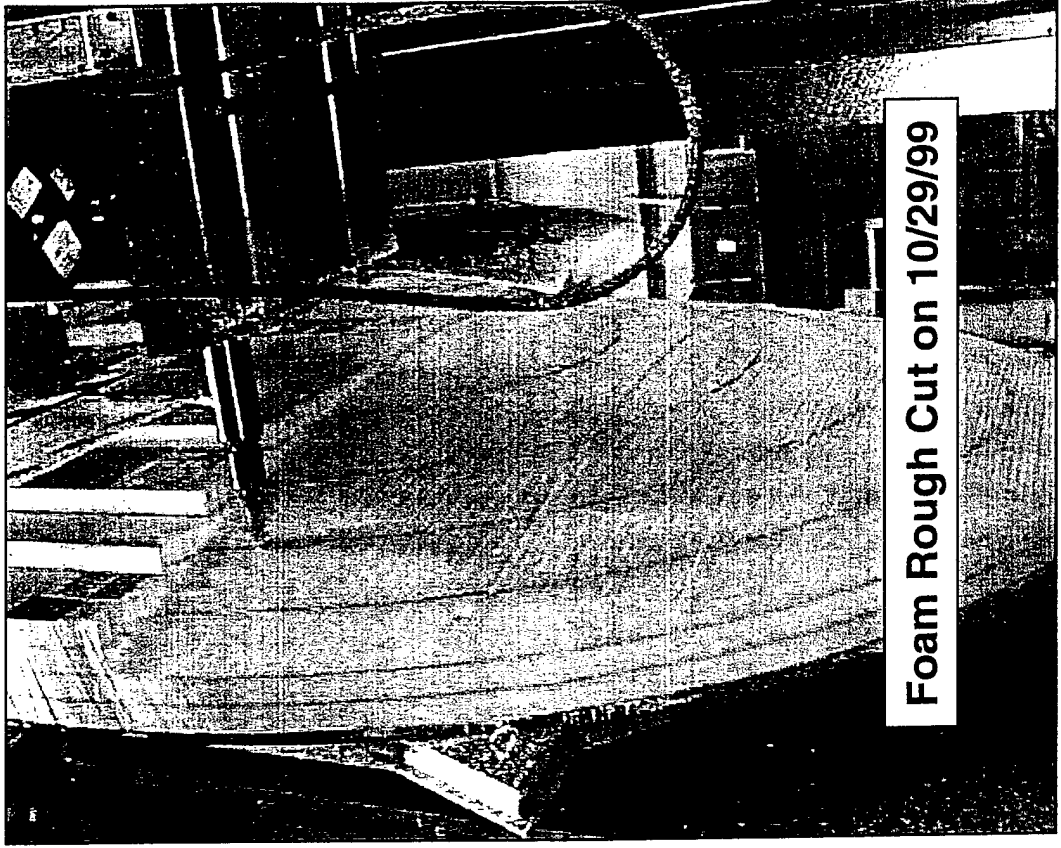
Mission : LEO to GEO (250nm at 28deg) ~30day

Foam Mandrel

10/29/99



**Foam Mandrel on Milling
Machine at NASA MSFC 10/27/99**



Foam Rough Cut on 10/29/99

Flight Scale Concentrator (FSC)

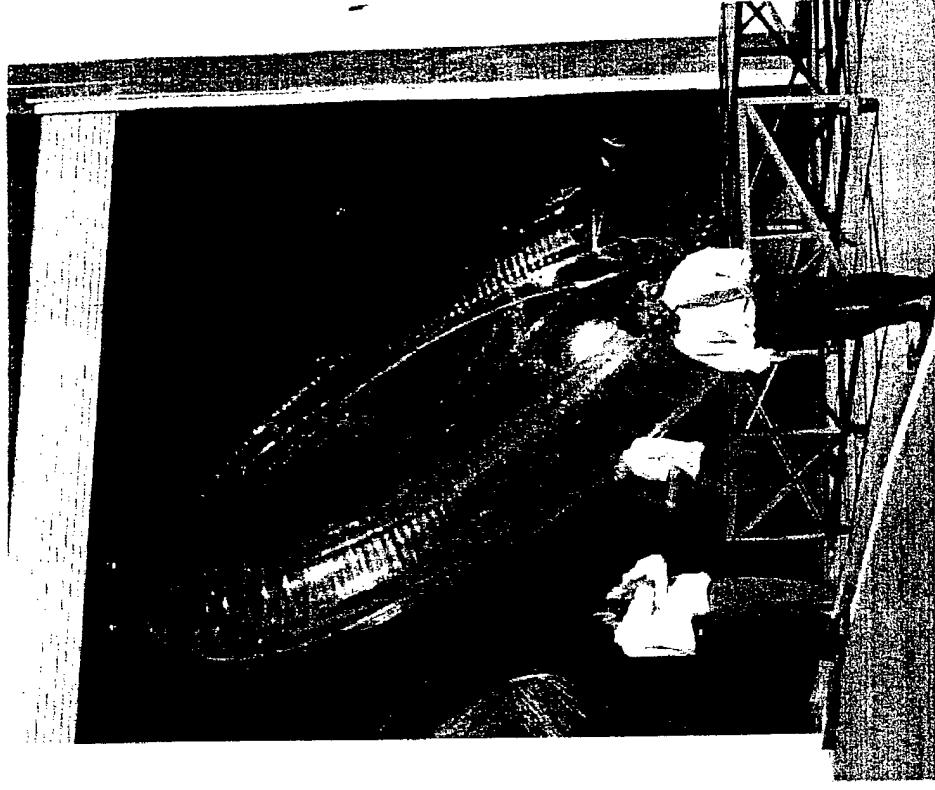
- FSC Mandrel Machined and Measured (Jan 00)
- SRS Modeled and Generated CNC

Machining Code

- NASA MSFC Machined Mandrel
- FSC-2 Using Foam Mandrel With Teflon Coating

- FSC-1 Fabricated (May 00)
- Method Developed to Deposit, Cure, and Release Film on Foam Mandrel
- FSC-2 (Optical Quality) Currently Being Fabricated

FSC-1

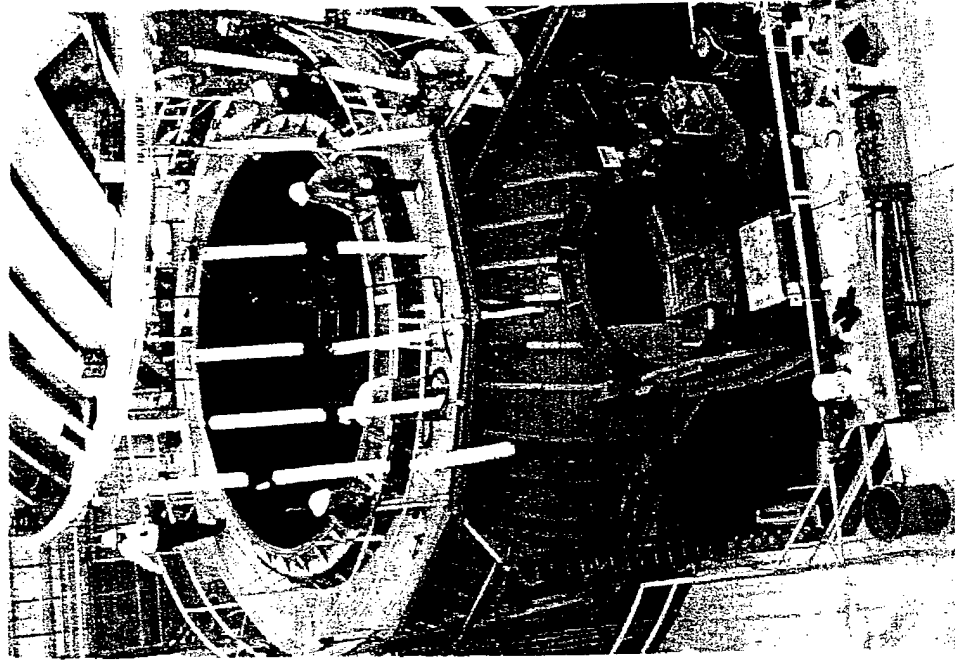


Concentrator Deployment Repeatability Demonstrated in IT-4 & 5

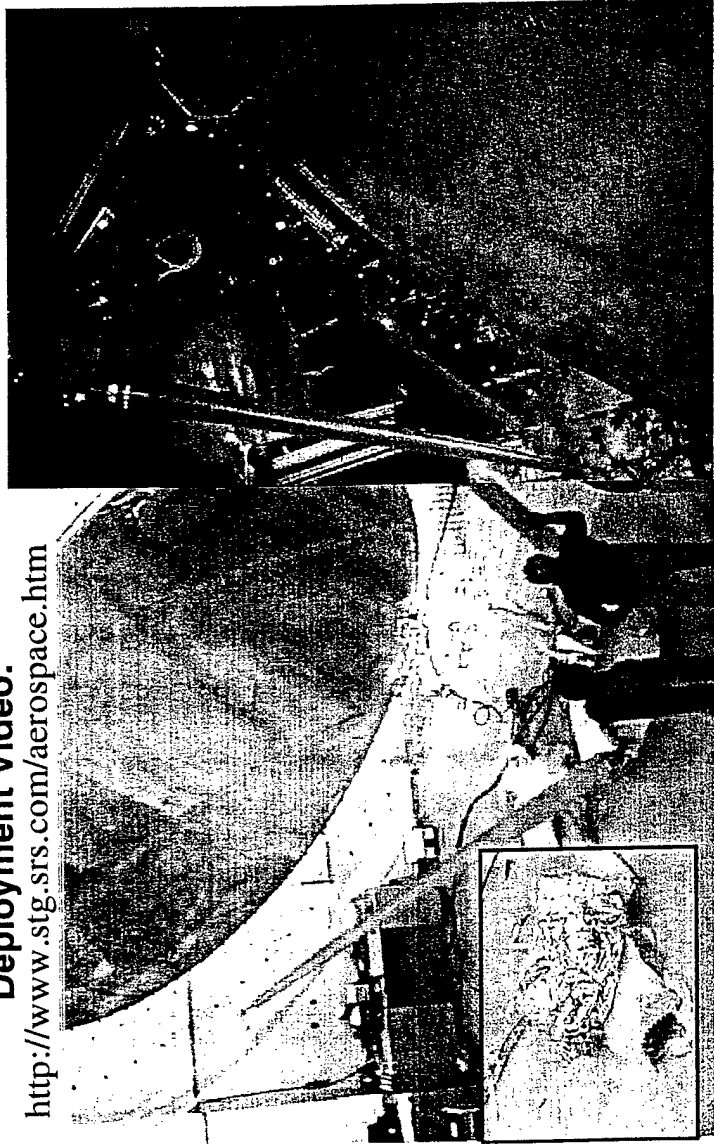
- Deployment fold pattern / packaging concept verified
- Measured < 0.5 inches variation in global geometry over 4 deployments
- No difference in global geometry observed between ambient pressure and vacuum (10^{-6} torr) deployment

Deployment Video:

<http://www.stg.srs.com/aerospace.htm>



AFRL's Space Environmental Test Facility



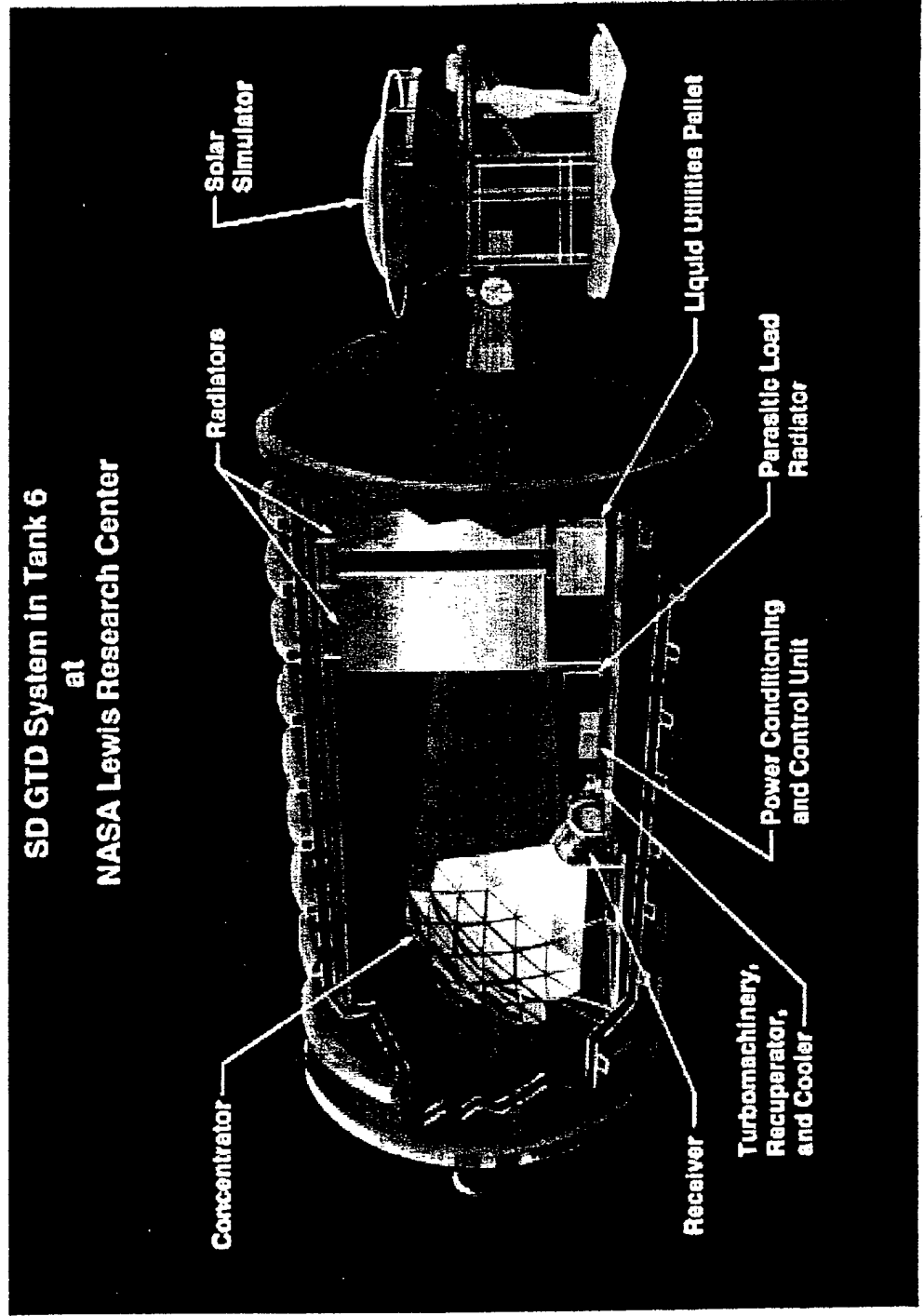
Flight Scale Concentrator Ambient Deployment

Flight Scale Concentrator inside SPEF Chamber

TA-1 Tank 6 Apparatus

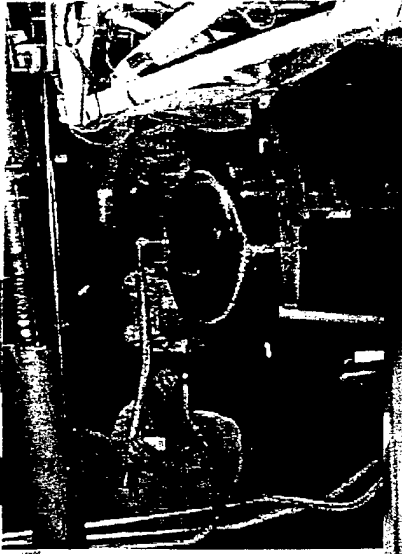
Thermal Vacuum Testing

- NASA GRC Tank 6 Simulates Space Thermal Environment
- Concentrator Shape and Position Verified under Mission Eclipse Cycling



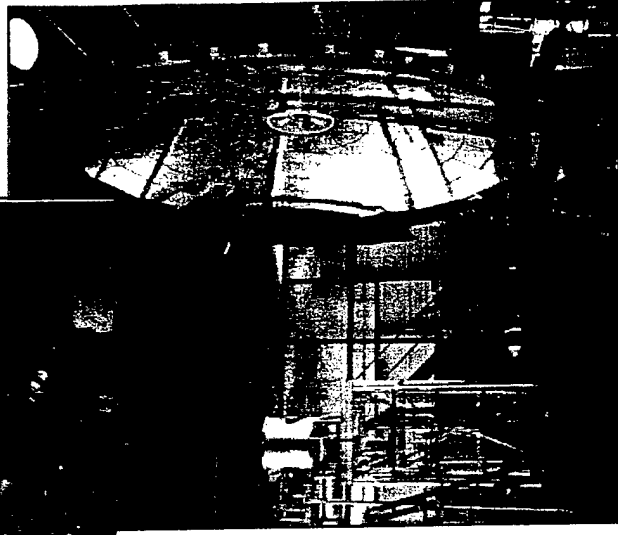
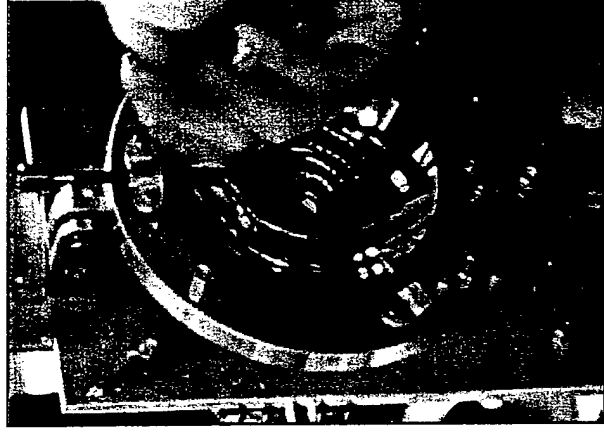
Propellant Management System Experiment

- New Approach to Cryogenic Propellant Management
 - Control Tank Pressure by,
 - Remove Vapor -> Lower Pressure
 - Remove Liquid -> Raise Pressure
 - Acceleration Pulls Liquid to “Bottom” of Tank
 - Advantages
 - Large Heater Eliminated
 - Thermodynamic Vent System (TVS) Eliminated
 - Mixer Eliminated
 - Simplified Control Software
 - Lower Pressure Tank -> Lower Weight
 - Preliminary Results Very Good
 - SRS and MSFC have Models and will Compare to Data
- Thiokol Composite Tank Reduces Tank Fraction



Solar-Thermal Propulsion Thiokol/SRS Thruster Design

- Well Tuned to Input Light Distribution
- Beam Fractionating
 - Highest Intensity at Hottest Propellant
 - Pointing Error Tolerant
 - Lowest Intensity at Coolest Propellant
- Optical Blackbody Cavity
 - Minimize Insulation
 - Secondary Mirror Cooled by Incoming Propellant
- Capable of Meeting Phase II IHPRPT Goals
- Technologies Extensible to Phase III
- Proven in Short Duration Testing (<10 hours)
- Working on 3-D Model

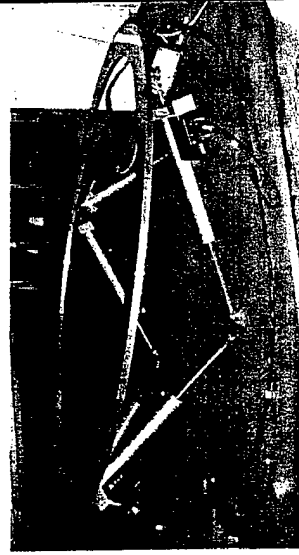


First Ever Integrated Test Of Solar Thermal Propulsion System This Summer

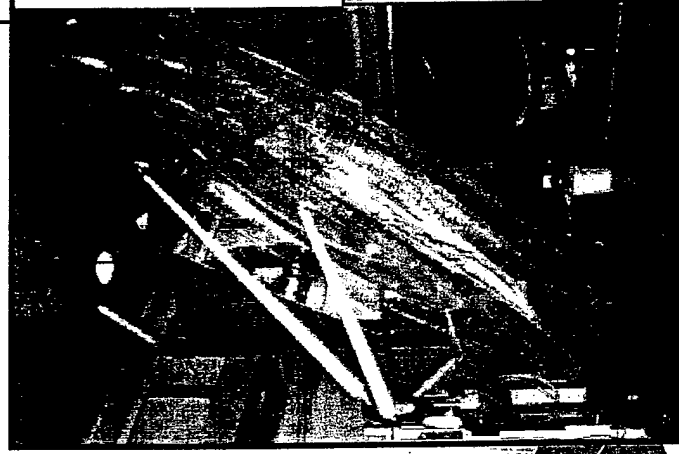
- Concentrator will track sun
- Matches flux profile but not power of space system
- Thruster in vacuum chamber
- 792 sec Isp will be shown by analytical correction of:
 - 25% atmospheric loss
 - 10% window loss



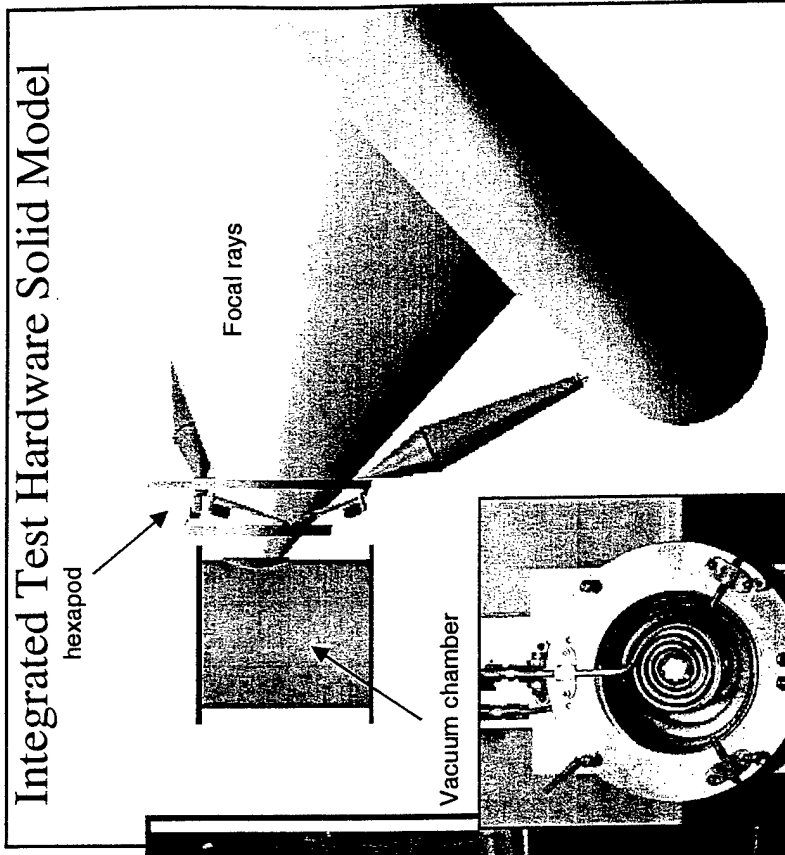
Hexapod Focusing Model



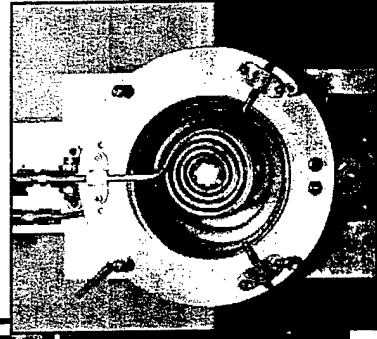
Hexapod Focusing Test Bed



Concentrator Assembly



Integrated Test Hardware Solid Model



Direct Gain Engine