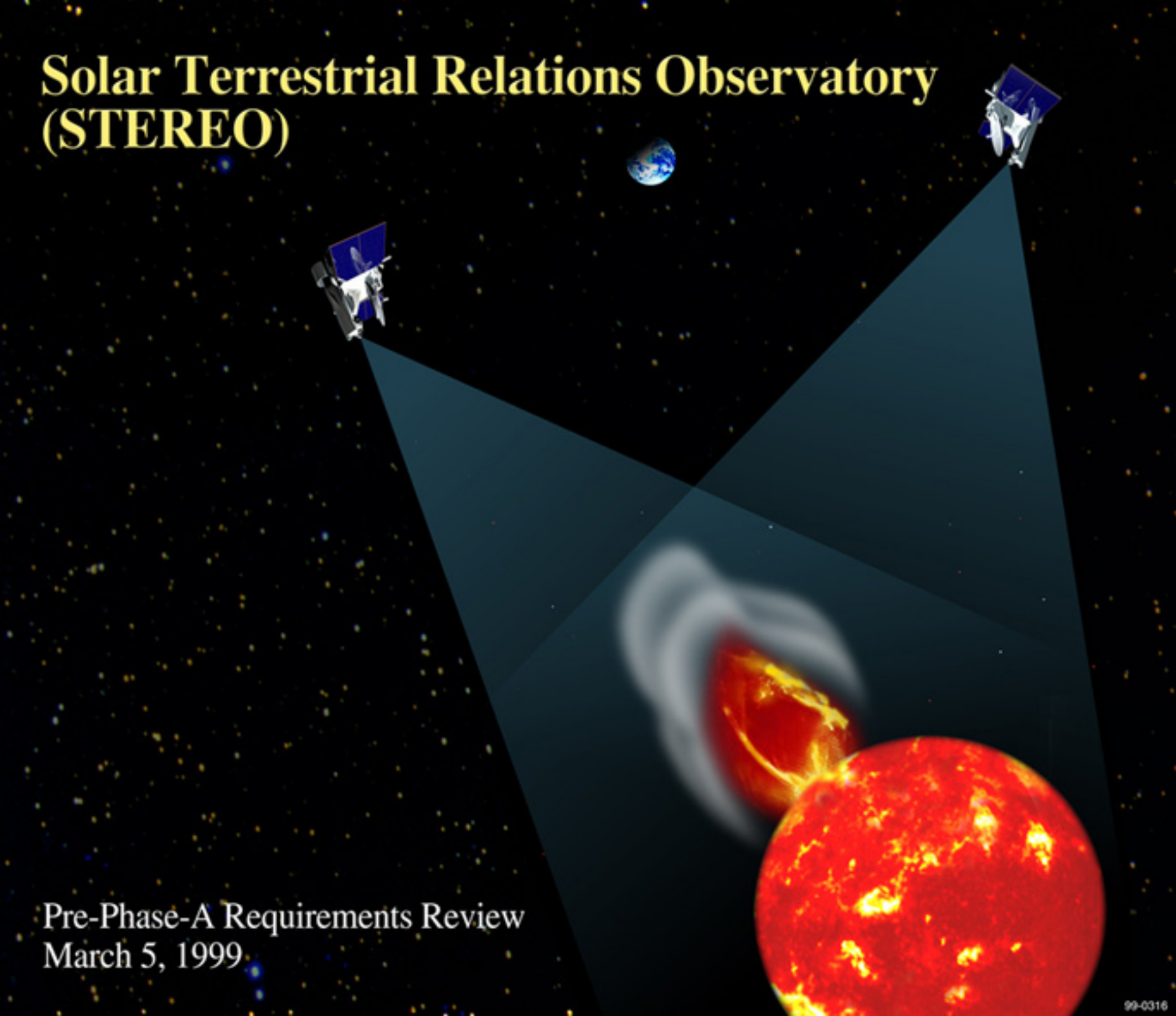
Solar Terrestrial Relations Observatory (STEREO)



Pre-Phase-A Requirements Review
March 5, 1999

99-0316

Solar Terrestrial Relations Observatory (STEREO)
Pre-Phase-A Requirements Review

PART II of II

Power Subsystem	J. E. Jenkins
Mechanical	H. M. Kreitz, Jr.
Structural Analysis	T. M. Betenbaugh
Thermal	C. J. Ercol
Propulsion	L. E. Mosher
Launch Vehicle Update	L. E. Mosher
Integration and Test	G. E. Baer
Mission Operations	D. A. Ossing

Power Subsystem

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Overall

- The power subsystem shall provide an unregulated 22 to 35 volts to the spacecraft. Load shedding of instruments at 25 volts
- The power subsystem shall support a nominal maximum power of 393 watts and 484 watts peak during propulsion event.
- Power system electronics and battery designs shall be identical between both spacecraft. Solar array mechanical and electrical interfaces shall be identical between both spacecraft.

Power System Electronics

- Shall not require continuous ground intervention for normal operation
- Capabilities shall be incorporated in the power system to ON/OFF control the power to the instruments

Solar Array

- Shall support two-year operation with all systems powered with maximum off-Sun pointing of 5°.
- The solar arrays of the two spacecraft shall support spacecraft to Sun distance variations between 0.85 and 1.03 AU for the leading spacecraft and between 0.99 and 1.18 AU for the trailing spacecraft.
- Total radiation dosage at maximum power point with 6 mil CMX cover glass: 1.4E+14, 1-Mev electron equivalent.
- Shall be tolerant to being partially shadowed.
- Shall have no gimbals and no intra-panel hinge.
- Electrostatic cleanliness requirement to be defined.

Battery

- Shall not restrict launch window
  - Desired time from final reconditioning to launch <14 days
  - Required time from final reconditioning to launch <28 days
- Shall provide power through T –3 min to acquisition +10 min
- Shall support the solar array in providing the peak load requirements of the spacecraft

Load Power Budget

Stereo Power Budget Revision 7 11 Nov 1998				
Subsystem/ Component	Average power	Aggregate power	Solar only peak normal ops	Battery required propulsion events
Instruments	**52**	**70**	**70**	**70**
EPD	2	2	X	X
HI	15	20	X	X
Mag	2	2	X	X
RBT	4	12	X	X
SCIP	15	20	X	X
SWPA	2	2	X	X
SWPA Electronics	2	2	X	X
DPU	10	10	X	X
IEM	**57**	**61.6**	**67.0**	**67.0**
C&DH Processor		10.4	X	X
C&T Subsystem		2.7	X	X
SSR (3 of 3)		16.5	X	X
Downlink Subsystem		5.0	X	X
Uplink Subsystem		7.0	X	X
RIU (5 of 5)		1.5	X	X
DC/DC Conv. (70% eff)		18.5	18.5	18.5

Subsystem/ Component	Average power	Aggregate power	Solar only peak normal ops	Battery required propulsion events
RF	**80.8**	**80.8**	**80.8**	**80.8**
SSPA	80	80	X	X
USO	0.8	0.8	X	X
G&C	**74.5**	**125.5**	**74.5**	**125.5**
AIE	7	7	X	X
G&CC	20	20	X	X
RWA	9	60	9	60
ST	12.5	12.5	X	X
Gyro	25	25	X	X
Sun Sensor	1	1	X	X
Propulsion	**3.5**	**56**	**6.0**	**51.0**
Pressure sensor (2 of 2)	1	1	X	X
HPLV	0	25	non-simultaneous	
Thrusters (1 of 4)	0	25		2
Tank heater	2.5	5	X	
Thermal	**5**	**20**	**20**	**0**
Heaters	5	20	X	
Power	**13.1**	**19.3**	**19.3**	**19.3**
PSE	13.1	19.3	X	X

System total	**328**	**404**
Allocated margin	**20.0%**	**20.0%**
Required total	**393**	**484**

Power Architecture Trade-Off

Ongoing trade-offs:

- Power system topology: Peak power tracker (baseline) versus regulated direct energy transfer (DET) system.
- Multi-junction versus single junction GaAs/Ge solar cells
- NiCd (baseline) versus Li-ion
- Evaluating electrostatic cleanliness (conductive array surfaces) requirements impact

IEM Power Converter

- The IEM power converters shall be on cards which plug into the IEM motherboard.
- The output voltages, regulation and power requirements are to be determined

Mechanical

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Mechanical Design Objectives

- Spacecraft bus requirements
- Candidate launch vehicle evaluations
- Science instrument suite
- Spacecraft mass statement

Spacecraft Bus Requirements

- Two identical Sun-pointing spacecraft
- Two-year total mission lifetime, five year expendables
- Fit within dynamic envelope of Athena II (92" fairing) launch vehicle
- Maximum payload weight of 350 kg (Athena II capability)
- Spin balanced for orbit injection by STAR 37 solid rocket motor
- Gimballed high-gain antenna capable of 115° of rotation
- 3-axis stabilized on-orbit
- Balanced to minimize separation of center of pressure and center of mass
- Provide thermal and mechanical environments for science instruments

Candidate Launch Vehicle Evaluations

- Taurus XL (92" fairing)
- Delta II (114" fairing)
- Athena II (92" fairing)
- Space Shuttle

Science Instrument Suite

- Chromosphere and Low Coronal Imager
- Coronagraph
- Radio Burst Tracker
- Heliosphere Imager
- Solar Wind Analyzer
- Magnetometer
- Solar Energetic Particle Detector

Solar Coronal and Imagering Package (SCIP)

- Chromosphere and Low Corona Imager
  - Positioned for Sun pointing
  - Clear field of view of 180°
  - Optical field of view of 15° × 15°
  - 2π steradian view of space for CCD radiator (–70°C)
  - Three kinematic mounts
  - Thermally isolated from mounting structure
  - Integral electronics
- Coronagraph
  - Part of Chromosphere and Coronal Imager above

Heliosphere Imager (HI)

- Positioned at 90° to the spacecraft-Sun line
- Optical field of view of $165° \times 165°$
- 2π steradian view of space for CCD radiator (–70°C)
- Integral electronics

Solar Wind Plasma Analyzer (SWPA)

- One Faraday Cup Sun pointing, Second Faraday Cup 90° to Sun Pointing Cup and Third Faraday Cup (TBD) position to be determined
- Field of view of ±60°
- Remote electronics
- Thermally coupled to mounting surface

Magnetometer

- Sensor deployed by boom to a distance of 3-6 meters from spacecraft
- Sensor positioned along anti-Sun line
- Remote electronics
- Sensor thermally isolated from boom mounting surface

Solar Energetic Particle Detector (EPD)

- Positioned at 45° angle to the spacecraft-Sun line
- Field of view of detector is ±35°
- Rotary actuator required for repositioning detectors

Radio Burst Tracker (RBT)

- Boom antennas (3) deployed to a length of 10 meters
- Boom antennas mutually perpendicular to one another
- Boom antennas not parallel to spacecraft-Sun line
- Boom antennas thermally coupled to mounting surface
- Remote electronics

Spacecraft Component Weights List

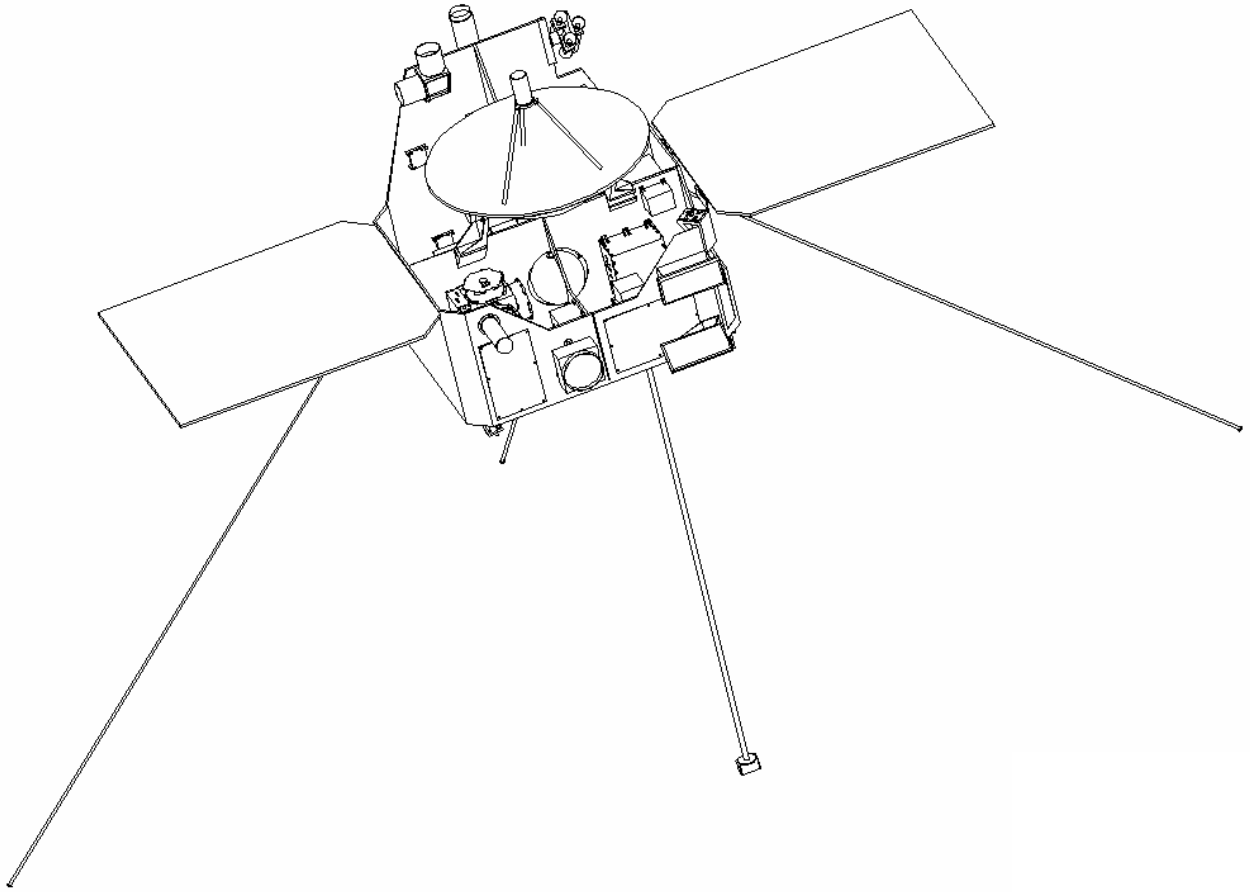
	MASS (kg)	
Power Subsystem		58.20
Ga-As Solar Array (2 wings, 36 sq.ft.)	16.40	
Super Nickel-Cadmium Battery (21 amp-hr)	23.80	
Power Switching Unit (PSE)	13.50	
Peak Power Tracker (PPT)	4.00	
Power Shunt/Fuse Box	0.50	
Attitude Control Subsystem		47.00
NEAR Inertial Measurement Unit	5.50	
NEAR Reaction Wheel (3 required) and Electronics	12.90	
TIMED Star Tracker	6.40	
TIMED Attitude Flight Computer (AFC)	2.40	
TIMED Attitude Interface Unit (AIU)	6.60	
Cold Gas Storage Tank and Thruster System (4 thrusters)	11.00	
Adcole High Resolution Sun Sensor and Electronics	1.00	
Adcole Sun Sensor (2 heads required) and Electronics	1.20	

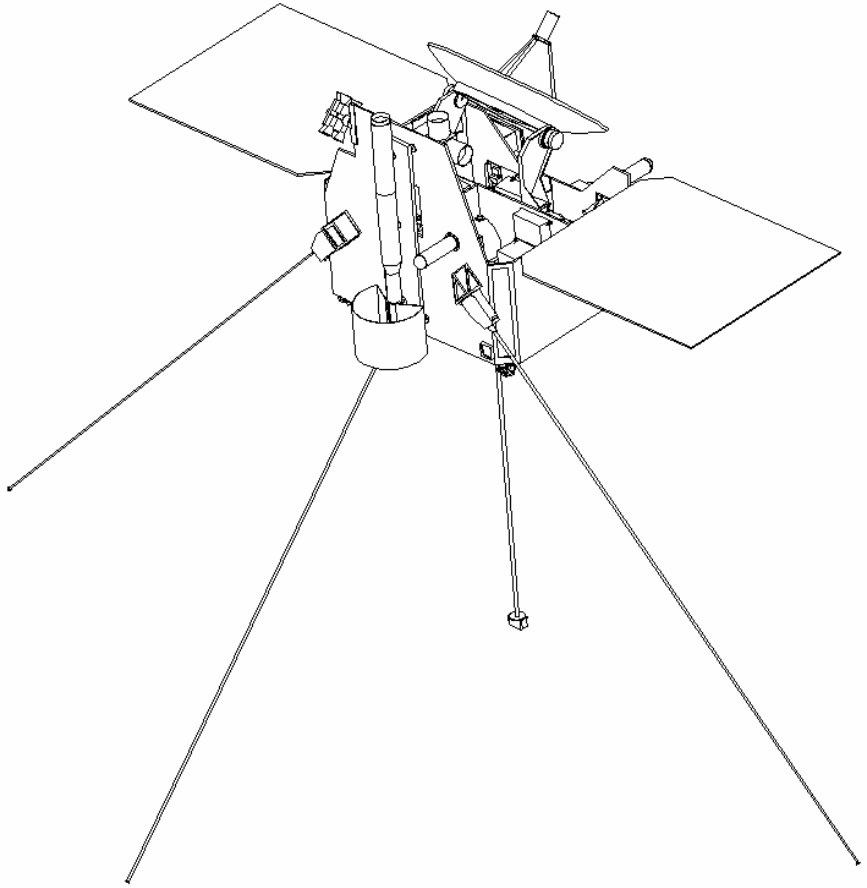
Spacecraft Component Weights List (con't)

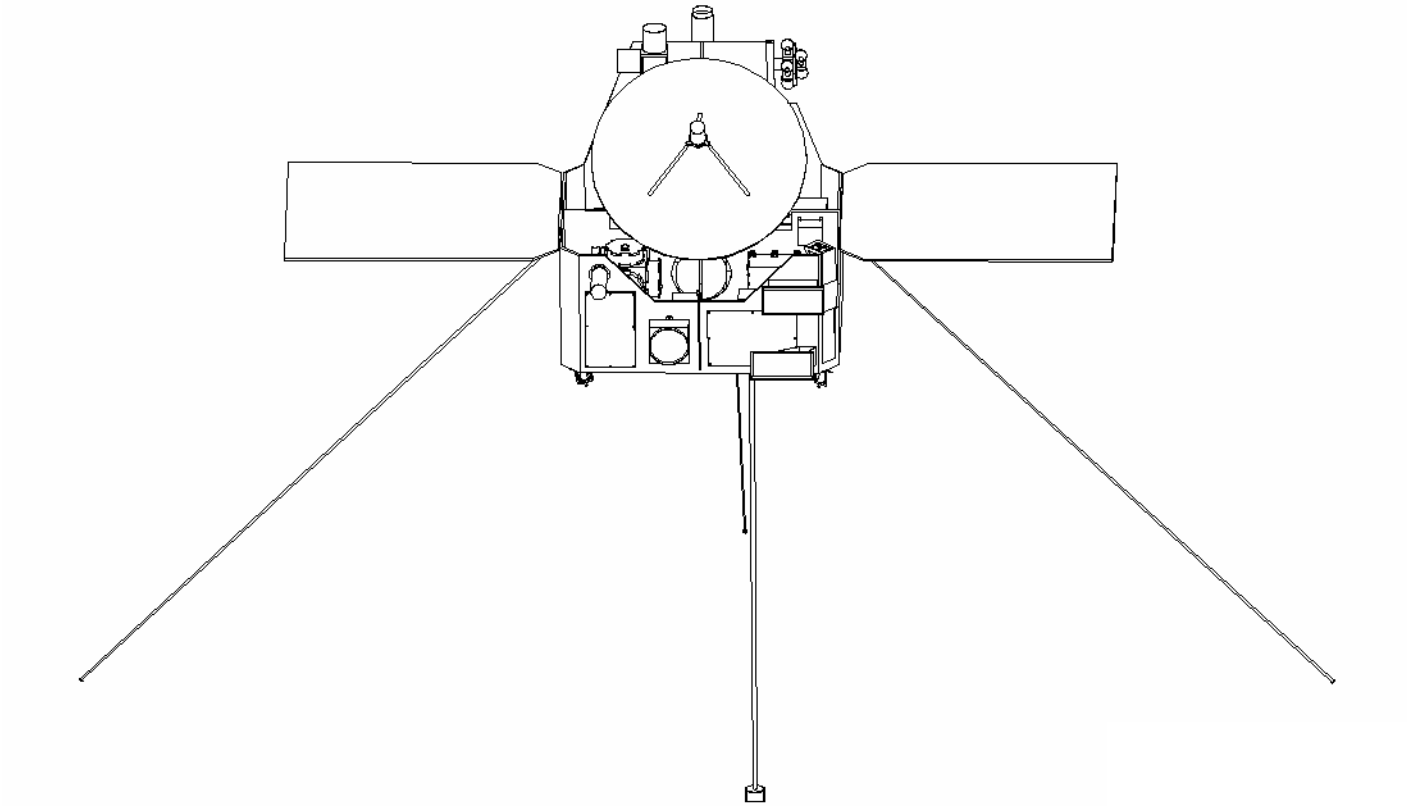
RF Subsystem		21.00
High Gain X-Band Dish Antenna (1.1 m dia)	6.50	
Antenna Gimbal Drive and Electronics (90°)	4.50	
X-Band Amplifier (TWTA w/power supply)	3.60	
RF Coax Switch (3 required) Assembly and Flex Cables	3.70	
RF Diplexer	0.20	
Mid Gain X-Band Fan Beam Antenna (2 required)	1.00	
Low Gain X-Band Patch Antenna (2 required)	1.50	
Avionics Subsystem		12.80
TIMED IEM (9 card design)	12.30	
MSX type Ultra Stable Oscillator	0.50	
Thermal Subsystem		17.10
MLI Blankets, Heaters and Thermostats	16.00	
TIMED Remote Interface Unit (RIU) (5 required)	1.10	

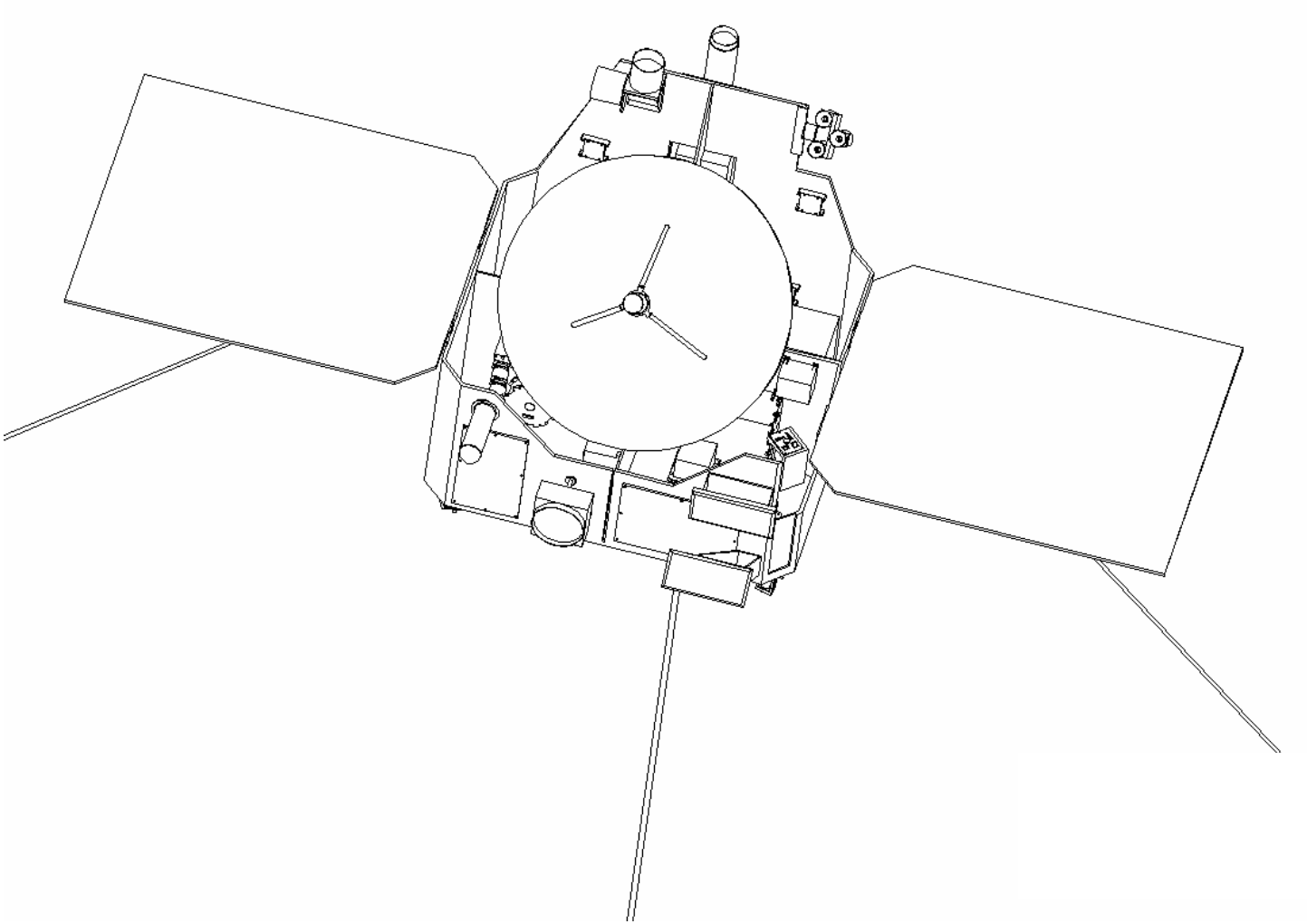
Spacecraft Component Weights List (con't)

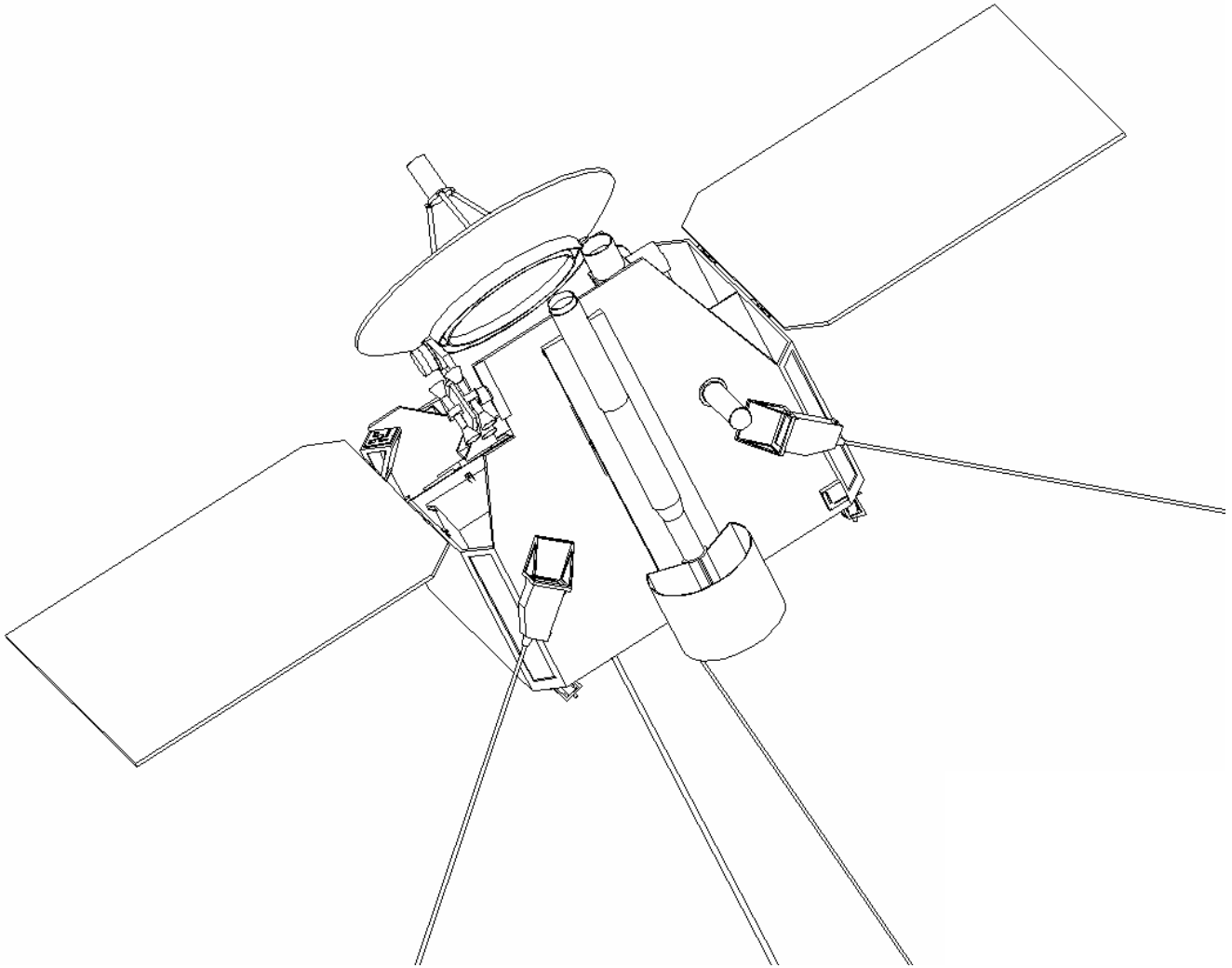
Instrument Subsystem		66.00
Solar Coronal Imaging Package (SCIP)	30.00	
Energetic Particle Detector (EPD)	3.00	
Solar Wind Plasma Analyzer (SWPA) and Electronics	7.00	
Radio Burst Tracker (RBT) Electronics	4.00	
Hingelock 621 Deployer (10 meter) for RBT (3 required)	4.00	
CME Heliospheric Imager (HI)	6.80	
GSFC Magnetometer and Electronics	2.00	
Astro Bi-Stem Actuator (6 meter) for Magnetometer	4.00	
Instrument Bench (SCIP and IMU)	5.20	
Spacecraft Bus Subsystem		64.80
Primary and Secondary Structure		
@ 12% of 350 kg (max. launch mass)	42.00	
Wiring Harness @ 5% of 350 kg (max. launch mass)	17.50	
Spin Balance Weights @ 1.5% of 350 kg (max. launch mass)	5.30	
TOTAL =		286.90
Contingency Based on 350 kg (max.) =		18%

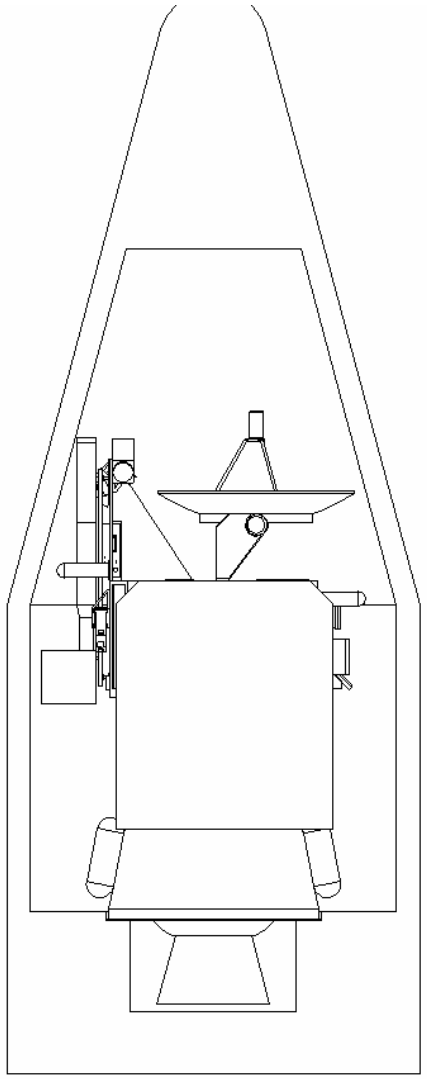












Structural Analysis

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Preliminary Spacecraft Design Requirements– Athena II

Lockheed Martin Proprietary

Structural Analysis Requirements

Structural Design Loads (factor of safety × limit load)

Test	1.25 × limit load
Yield strength	1.4 × limit load
Ultimate strength	1.8 × limit load
Buckling	2.0 × limit load
Composites	2.0 × limit load

Coupled Loads Analysis (2)

Fracture Mechanics Analysis (if Shuttle)

Preliminary Athena II Spacecraft Center of Gravity (CG) Load Factors

Lockheed Martin Proprietary

Preliminary Athena II Sine Vibration Amplitudes at Low Frequencies

Lockheed Martin Proprietary

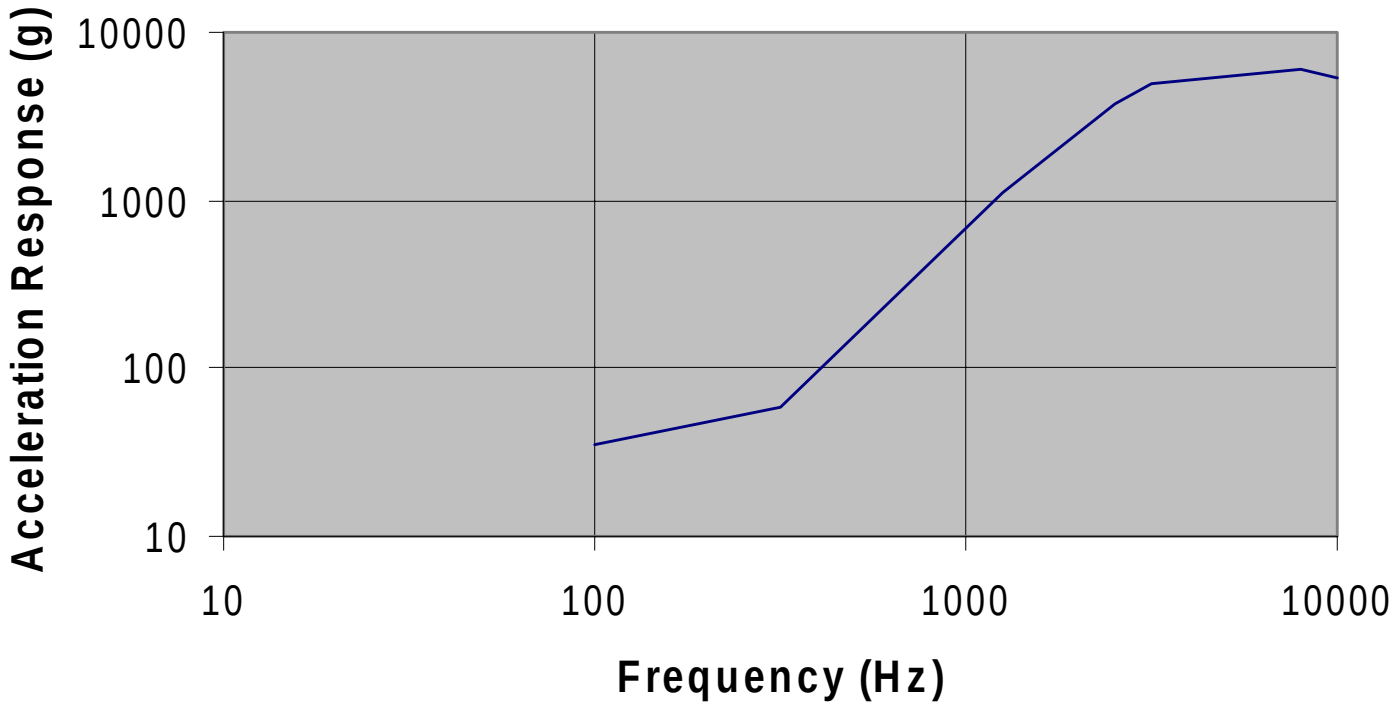
Preliminary Athena II Random Vibration Environment at S/C Interface

Lockheed Martin Proprietary

Athena I and II Acoustic Levels, OASPL = 139.2 dB

Lockheed Martin Proprietary

Shock Environment at STEREO SC/SIS Interface



Athena II Shock Environment at LV/SV Interface

Lockheed Martin Proprietary

Testing Philosophy

Proto-flight test program

No engineering model of spacecraft

Qualification levels (max expected +3dB) at acceptance duration

Load testing and sinusoidal vibration test combined

Sine input levels increased over small bandwidth to reach proto-flight level

Load/sine vibration and random vibration testing performed on instruments and spacecraft components at "box" level

Instruments are qualified prior to observatory integration

Random vibration test to simulate acoustic response of spacecraft panels

Proposed Spacecraft Mechanical Verification Testing

Component vibration testing at JHU/APL

Combined component tests if possible, generally one day/component

Spacecraft sine vibration testing at JHU/APL

Two spacecraft tested in series, estimated test time of two weeks

Acoustic and Shock testing at GSFC

Two spacecraft tested in series, estimated test time of three days
(spacecraft functional tests not included)

Mass property measurements and spin balance at GSFC If required (depends on separation requirements)

Two spacecraft tested in series, estimated test time of six days

Spin balance at Kennedy Space Center (KSC) if required (most likely)

Two spacecraft tested in series, estimated test time of two days

Jitter

SCIP jitter requirement

1.5 Arc Sec, 0.1 Hz to TBD

Primary spacecraft modes may fall in this range (depending on "TBD")

A primary source of jitter is reaction wheel assembly

Assembly has been located at some distance from SCIP to help dissipate inputs to SCIP

Vibration isolation of either wheel assembly or SCIP is possible but not preferred

Isolation systems are custom designs, which could be costly

Prefer either acceptance of jitter at spacecraft fundamental modes or limiting wheel speeds to those that will not excite spacecraft modes

Thermal

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Spacecraft Thermal Requirements

- The spacecraft thermal design must accommodate:
  - Solar distance variation between 0.85 and 1.18 AU
  - Solar pointing attitude ±5°
  - Constant electrical loads
  - Two year mission life
  - Off pointing from sun during STAR-37 firing
- Identical thermal designs for both Spacecraft
  - ESD coating on MLI to limit surface charging
  - No louvers or heat pipes
  - Class 100,000 cleanliness
    - May be reduced to 10,000 when instruments are integrated

Instrument Thermal Requirements

- Thermally isolated thermal approach
  - Simplifies sub-system level testing
  - Allows for wide interface temperature range
- Instrument team to provide thermal design and analysis
  - Spacecraft will accommodate radiator field-of-views as needed
- Correlated instrument thermal models to be provided to the spacecraft

Launch Vehicle Thermal Requirements

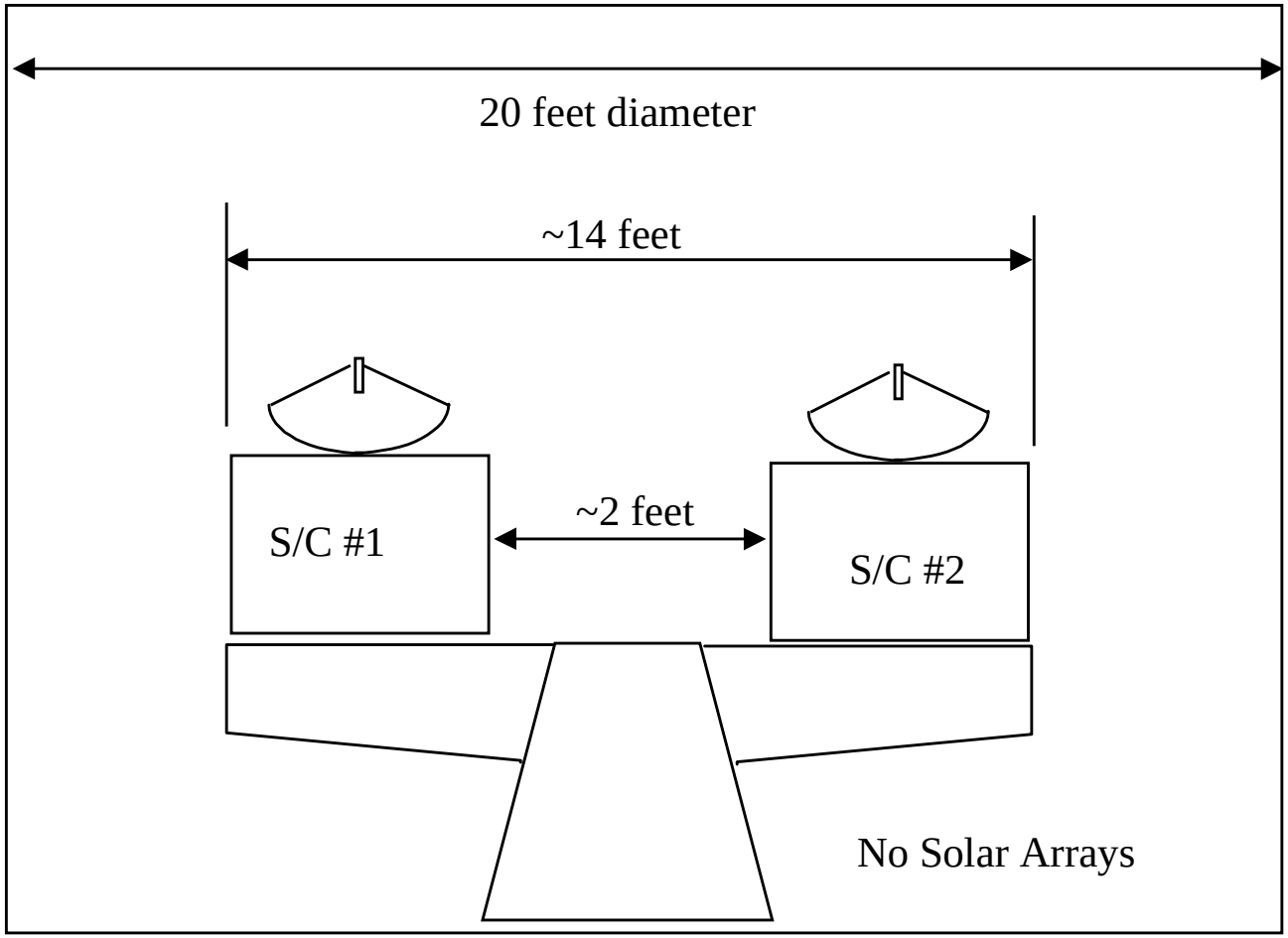
- Athena Launch does not impose any foreseeable special requirements
- Space Shuttle Launch requires very rigorous analysis
  - Potentially severe hot conditions
  - Limited power cold conditions
  - Reduced thermal models required

    Results iterated by SST/STEREO thermal personnel

Thermal Vacuum Testing

- Components tested per STEREO Component Environmental Test Plan
- Integrated spacecraft level testing (instruments included)
  - Dual spacecraft configuration using GSFC chamber 290
  - Thermal balance
  - Thermal cycles
    - Minimum 3-hot and cold cycles
    - Minimum 108 cumulative hours at each temperature extreme

Test Configuration in Chamber 290



Propulsion

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System Level Requirements

- Provide forces and torques for tip-off rate negation and 3-axis momentum dumping (Presently no requirement for injection correction, de-spin or orbit adjust forces or torques)
- Provide sufficient expendables for a five year mission including a 10% leakage allowance
- Total external leak rate $\leq 1 \times 10^{-5}$ scc/s
- Provide an indication of propellant remaining
- Meet the safety requirements of EWR-127-1

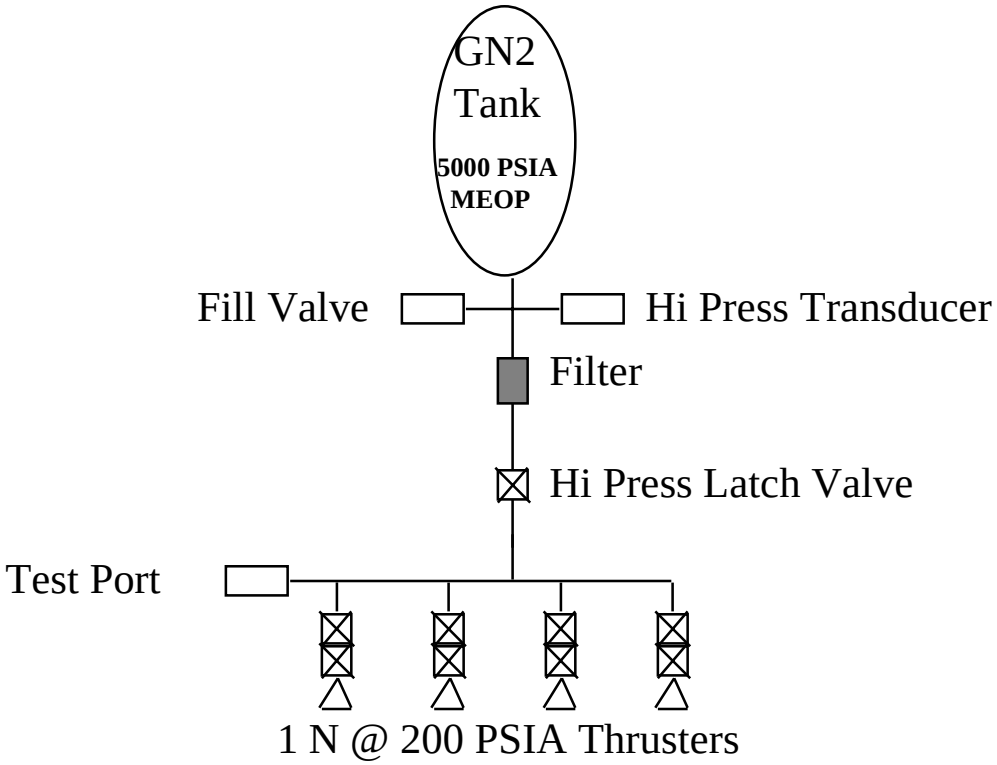
Subsystem Flowdown Requirements

- Operate with 28 ±6 VDc
- Operate over a temperature range of 0 to 40°C
- Operate after exposure to the launch environments

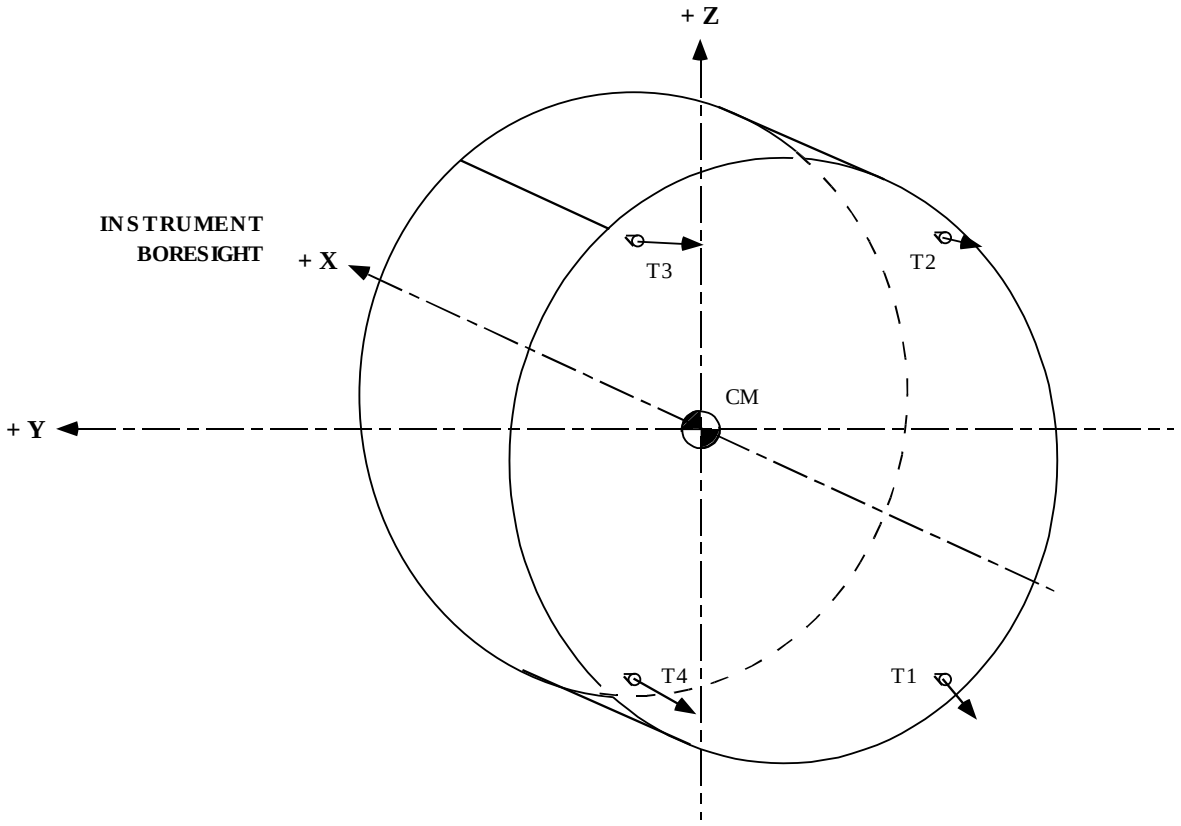
Subsystem Derived Requirements

- Schematic and thruster arrangement per the next two charts
- Minimum tank volume – 8.0 liters (490 in^3)
- Nominal gas storage pressure – 4700 psia
- Maximum expected operating pressure (MEOP) – 5000 psia
- Max min thrust level – 5.0 to 0.2 N (1.1 to 0.05 LB_f)
- Common inlet pressure thruster-to-thruster thrust tolerance ± 3.0%
- Research grade GN2 gas per Mil-P-27424
- Cleanliness requirements (To assure leak tight integrity)
  - All components and manifolds cleaned to Level 100A of ATC-STD-4940E
  - All manifolds internally electropolished
  - Valve savers on all fill valves prior to launch
  - Inlet and outlet filters on all thruster valves
- If redundancy is required, increase to eight thrusters (allowable leakage must double), then two latch valves, then two pressure transducers

Subsystem Schematic



Baseline Thruster Arrangement



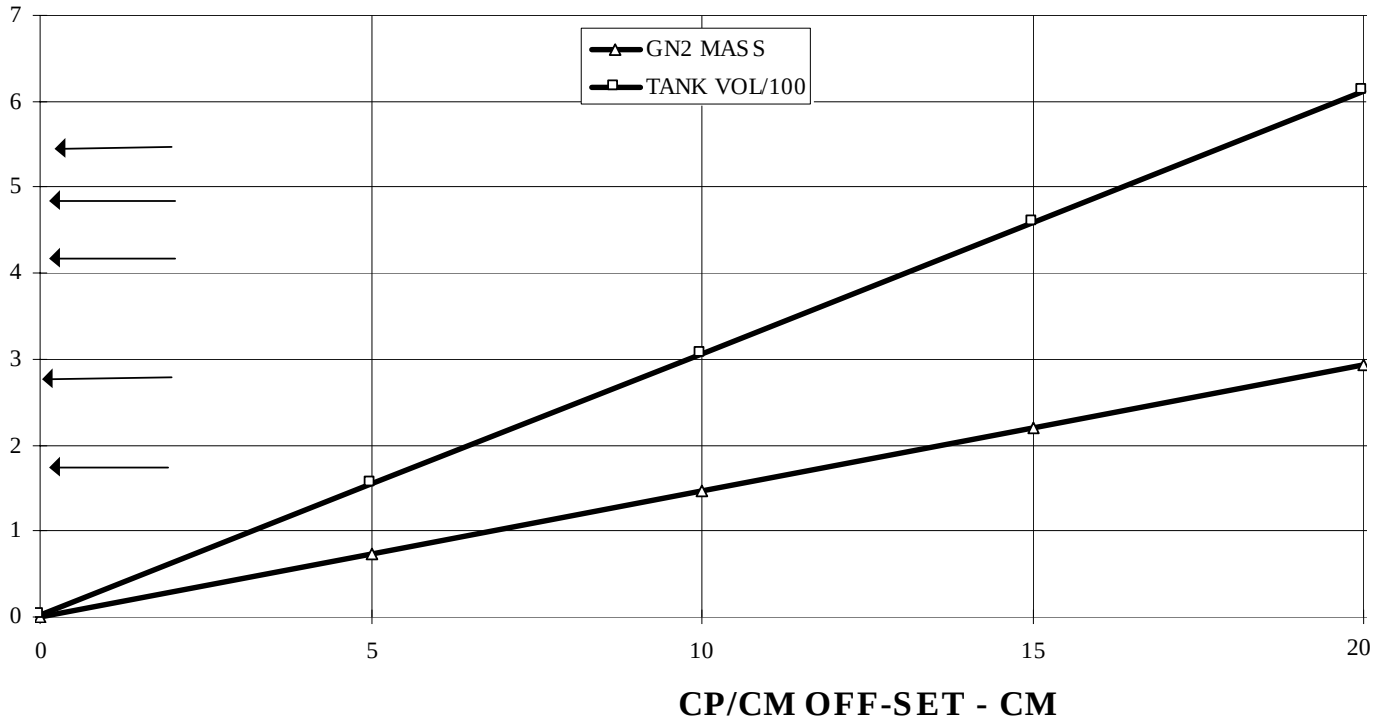
15° double canted 4 thruster set provides pitch, yaw, roll and 1 axis ΔV

Thruster	Torque	Axis
T2T3	+P	Around Y
T1T4	–P	Around Y
T1T2	+Y	Around Z
T3T4	–Y	Around Z
T2T4	+R	Around X
T1T3	–R	Around X

Thruster	Force
T1234	+X

- Requires thruster matching and alignment to minimize cross coupling
- Torque capability around X axis is diminshed. Other axis have two thruster torque

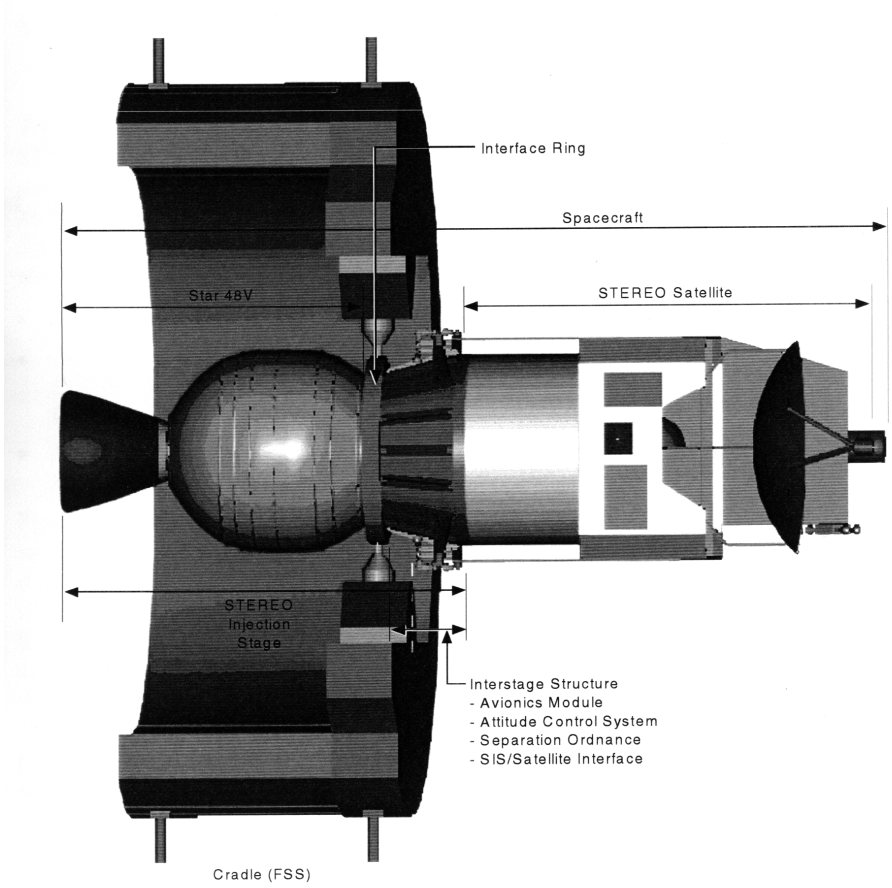
Tank Volume and GN2 Mass versus CP/CM Off-Set
(Five years, 4.6×10^{-6} N/m^2 Solar Press, 5000 PSIA MEOP)



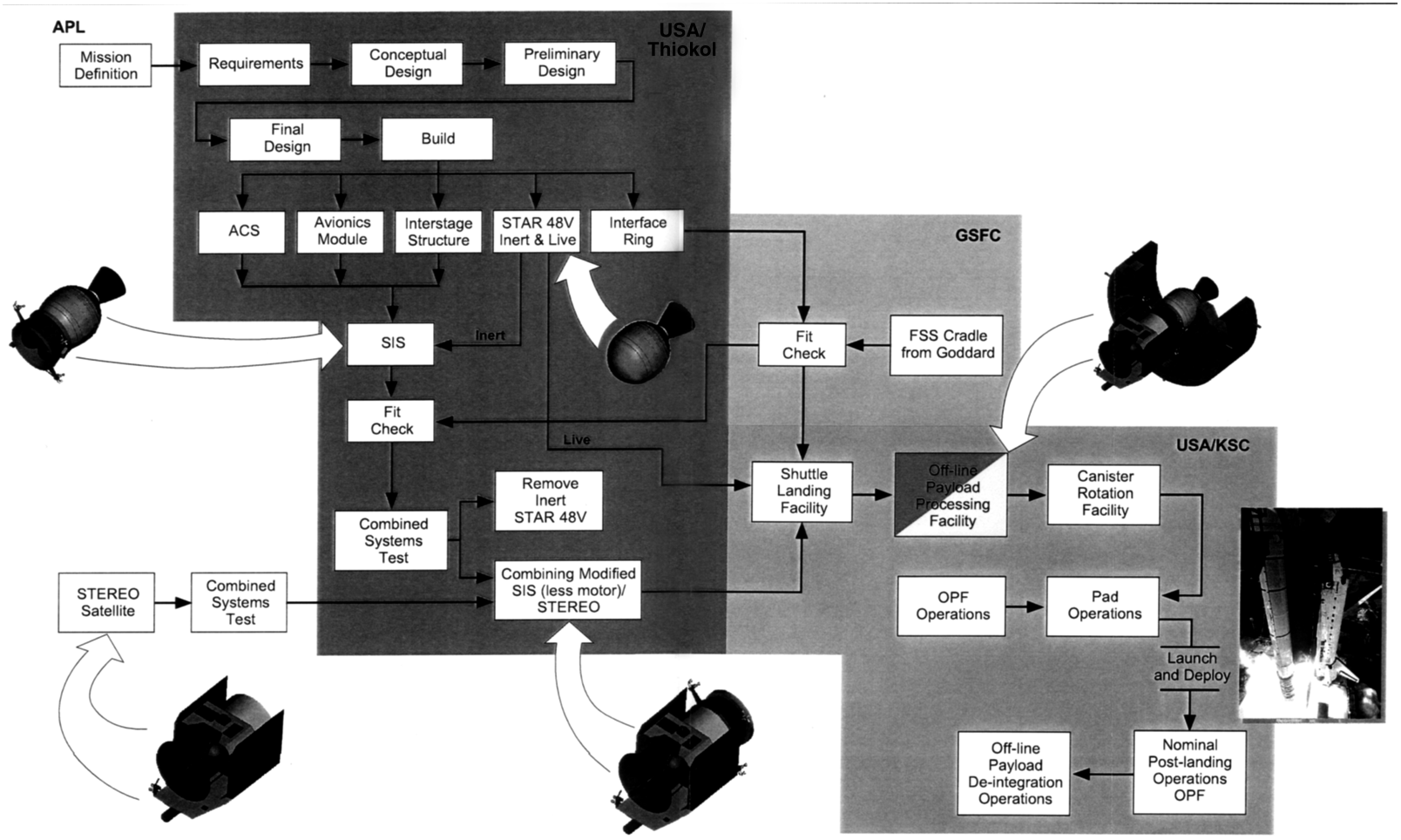
Keys To Meeting the Underlying Low Cost Requirement

- Minimum number of components
- Flight qualified, off-the-shelf design components
- Build clean, keep clean to minimize late leaks
- Factor of safety ≥ 4.0 during all testing to minimize safety documentation
- Buried, protected graphite composite overwrapped pressure vessel installation to minimize range safety documentation requirements
- RFP's to at least three qualified vendors to assure competitive bids

Cargo Element Nomenclature



Solar Terrestrial Relations Observatory (STEREO)
Pre-Phase-A Requirements Review



Launch Vehicle

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System Requirements

- Lift 350 kg to a C3 of 1.0 km^2/sec^2
- Launch inclination – 28.5 to 57°
- Accommodate the size of the STEREO spacecraft
- Accommodate a ≥1.1 m (39.4 in) diameter high-gain antenna
- Provide power, purge, and air conditioning interfaces
- Single launch
  - Earliest launch dates October 2002 and December 2002
  - Latest launch dates October 2004 and December 2004
- Dual launch
  - Earliest launch date October 2002
  - Latest launch date December 2004

Launch Vehicles Considered

- Taurus
- **Athena II**
- Delta II
- **Shuttle**
- Ariane
- DNEPR

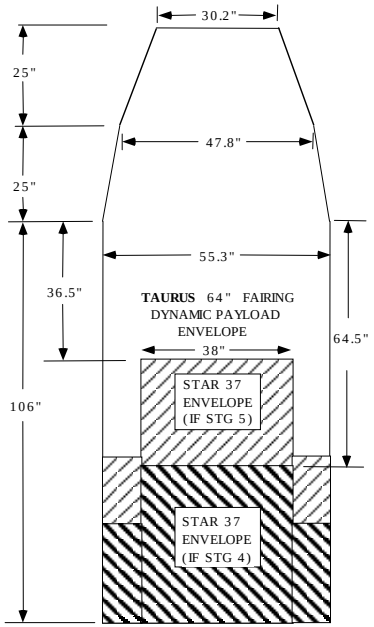
Taurus

Version	kg to C3 = 1.0 Fairing size	
	63”	**92”**
Std 4 Stg	289	242
XL 4 Stg[1]	343[2]	296
XL 5 Stg[1]	374[2]	327

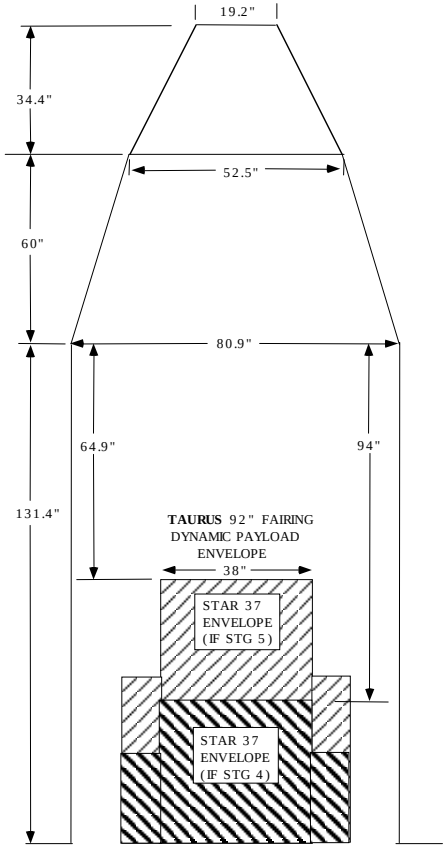
[1]Not qualified

[2]Estimated

63” FAIRING



92” FAIRING

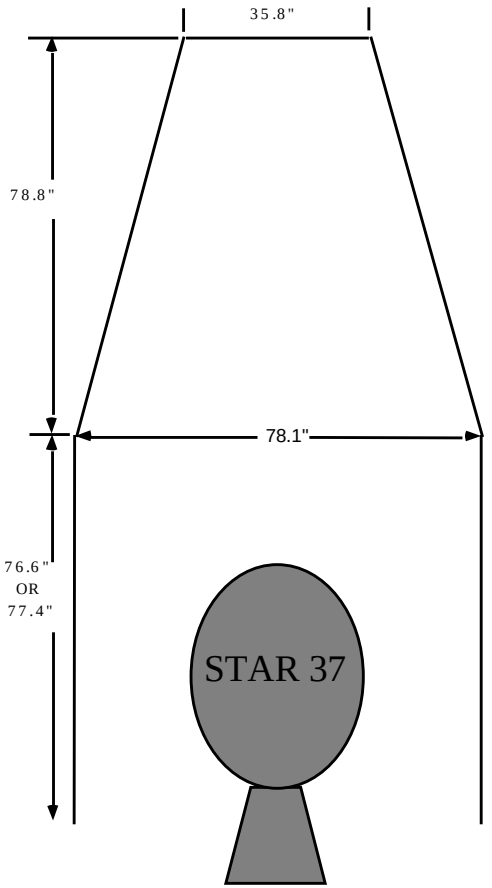


Athena

Version	kg to C3 = 1.0
II 6T MP w STAR 37V[1]	300
II 6T MP w STAR 37FM[2]	350
II 6T MP w STAR 48AV[1]	420

[1]Not qualified

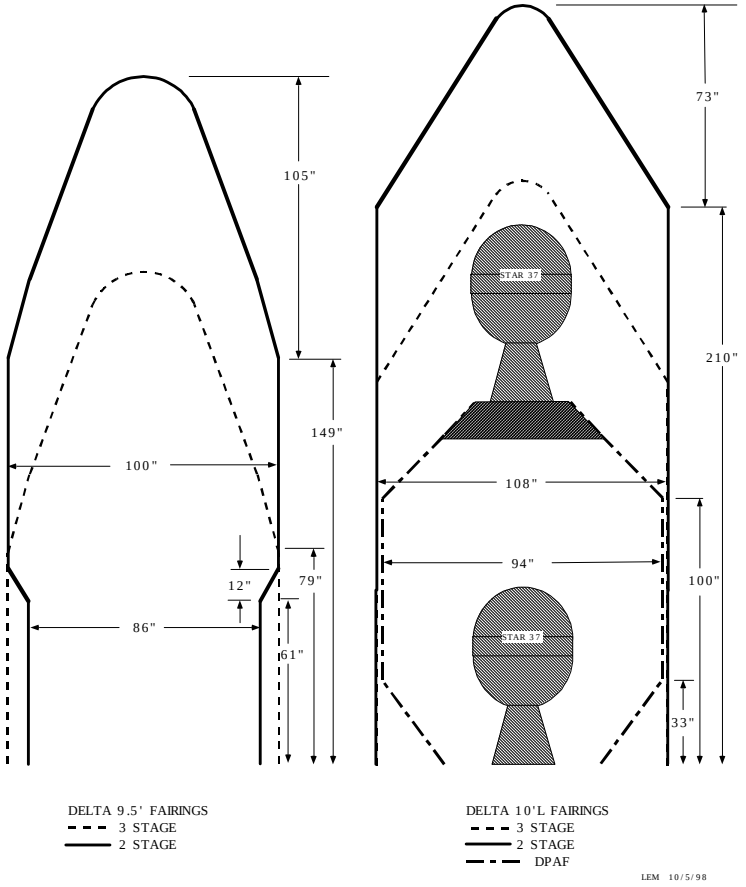
[2]Lunar Prospector configuration



Delta II

Version	kg to C3 = 1.0
Single S/C per launch	
7326-9.5 (STAR 37FM)	600[1]
7920-9.5[4]	650[1]
7325-9.5	710
7925-9.5	1300
Dual S/C launch	
7920-10L DPAF[2]	413(4970[3])
7320-10L DPAF[2]	413(2735[3])

[1]OLS number
[2]To 100 nmi park orbit
[3]3450 kg required for 3310 m/sec
[4]3-axis stabilized release

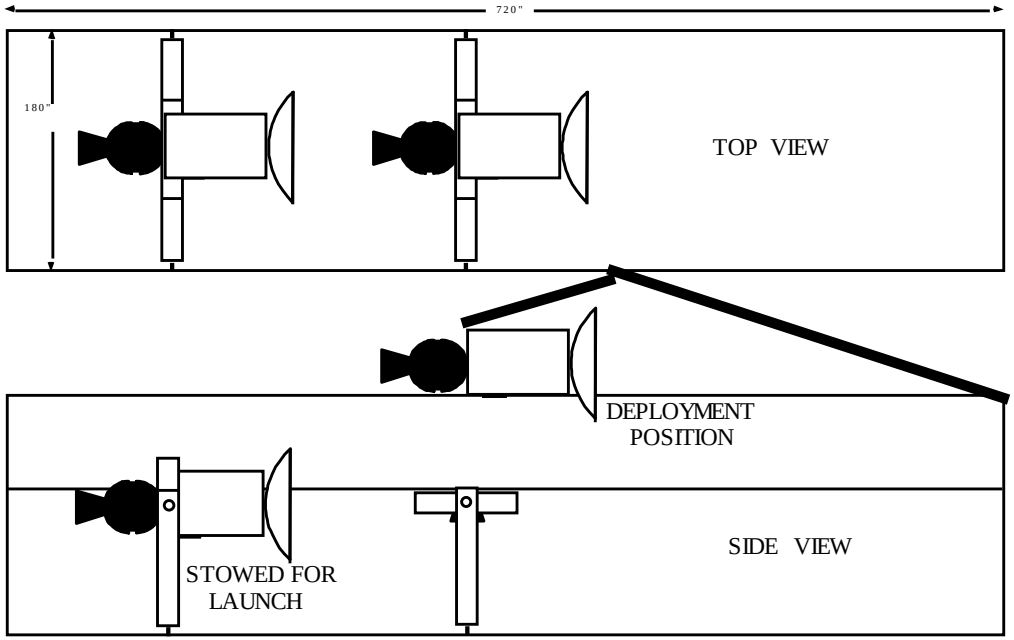


Shuttle

kg to Version	C3 = 1.0
STAR 37FM[1]	<350[2]
STAR 48V	500[2]

[1] GSFC FSS cradles for STAR 48 exist but require modification

[2] 3310 m/sec from 100 nmi park orbit



Other Options Considered

- Ariane 44L + SPELDA

  No detailed data but would be similar to Delta II + DPAF

- DNEPR

  Not qualified in time for STEREO

Requirements Compliance So Far

- Two Delta II 7326-9.5's meet all requirements, but their cost would exceed the allocated launch vehicle dollars.
- Two Delta II 7920's would provide a 3-axis release.
- Taurus XL in a 92" fairing falls about 25 kg short on payload and requires qualification. Pegasus XL has flown successfully 12 times.
- Athena II, Delta II DPAF, and Shuttle options require the spacecraft to be built around or on a separate injection solid. Only the Athena II Lunar Prospector Star 37FM Stage has flight heritage.
- Athena II and Delta II DPAF fairing height is severely limited by the injection solid. Longer Athena II fairing requires qualification and would eat into payload capability.
- Shuttle option requires refurbished FSS cradles for STAR 48V.

There is no clear winner, but the Pre-Phase A Report will make a recommendation.

Integration and Test

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I&T Assumptions

- I&T in JHU/APL clean rooms.
- Vibration testing performed at JHU/APL.
- Thermal vacuum testing performed at Goddard.
- Test philosophy based on documents SDO 2387-1, MIL-STD-1540B, and GEVS-SE Rev A.
- Test it as we fly it.

I&T Objectives

- Test the two STEREO spacecraft under ambient conditions and simulated environments expected to occur during launch and in orbit.
- Establish correct operations of all subsystems and instruments when interconnected as a spacecraft.
- Validate spacecraft system performance through functional and performance test on each spacecraft under mission level environmental stress.
- Autonomy and fail safe modes will be tested at the spacecraft level.

I&T Top Level Requirements

- No engineering units to be installed on spacecraft.
- Test and operate two spacecraft simultaneously.
- Decoupled Instrument Operations.
- Collect, process, and transmit instrument commands from the STEREO instrument GSE and SOC to the instruments.
- Transmit science telemetry data to the instrument developers and coordinate with the instrument developers to assure the capability of the instruments to perform as required on the spacecraft.
- Maintain UT on each spacecraft to within 0.5 seconds of UT.

I&T Flow Down Requirements

- Develop a Ground Support System for the testing and operation of two simultaneous spacecraft.
  - GSS will remain at JHU/APL for all phases of I&T, Launch Site Operations, and Mission Operations.
  - Collect and archive all raw telemetry during I&T.
  - Process and evaluate all spacecraft, non-science, telemetry during I&T.
  - Maintain command and telemetry dictionaries during I&T.
- Prepare a comprehensive Integration & Test plan and schedule.
- Ground support equipment must support the simultaneous Integration and Test and Launch Site Operations of the two spacecraft.
- Subsystems and instruments delivered to spacecraft flight qualified along with GSE for checkout and operation.

I&T Concepts

- **Two spacecraft will be handled as one spacecraft with a side A and B.**
- Require the two spacecraft be identical in form, fit, function and interface. Differences will be addressed at the program level.
- The Mission Operations team will be combined with the I&T team during I&T and launch operations.
- GSS will remain at JHU/APL through launch. Only the minimal set of equipment will accompany the S/C to thermal vacuum and the launch site.

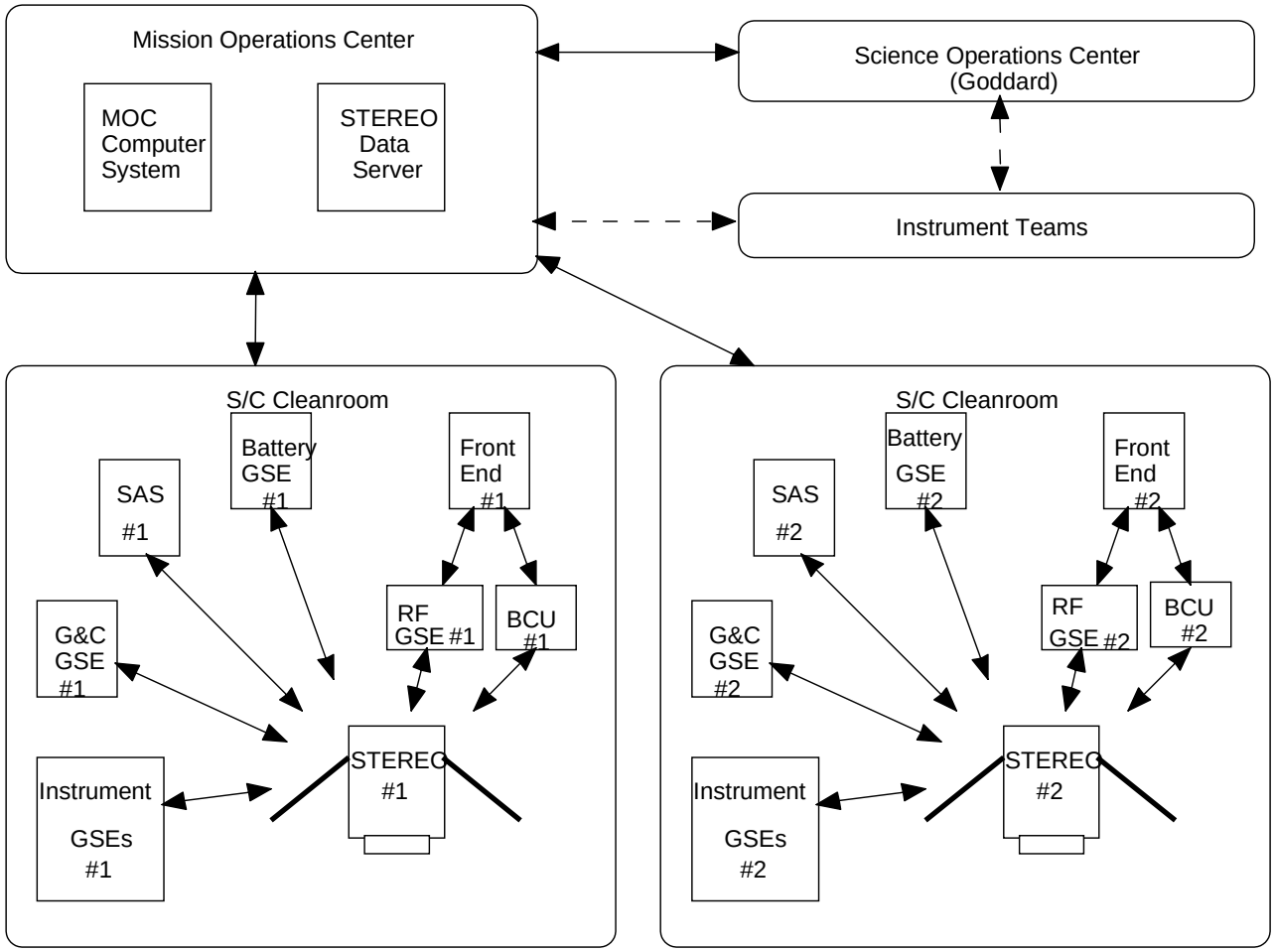
GSS Flow Down Requirements

- Perform remotely from JHU/APL the following on two spacecraft, individually or simultaneously.
  - Decommutate and display housekeeping telemetry from DSN, clean room, environmental testing, or Cape Canaveral
  - Send commands via DSN, clean room, environmental testing, or Cape Canaveral
  - Store all housekeeping telemetry
  - Maintain memory maps
  - Telemetry alarm processing

GSS Flow Down Requirements (con't)

  - Data plotting and trending
  - Contact planning
  - Maintain spacecraft clocks to within 0.5 second
  - Pass ephemeris data for antenna pointing to DSN
  - Receive instrument commands, verify, pass to spacecraft
  - Decommutate IEM memory dumps
- Autonomous contact operations
- Support SSR data playbacks

STEREO I&T Conceptual Block Diagram



Harness

- Requirements – TIMED like
  - 1553
  - Power
  - Thermal
- Built to JHU/APL Harnessing Guidelines
- Additional TBD requirements to follow
- Study – Remote I/O chip impact

I&T Schedule

- Integration will take place over a seven month period for both spacecraft
  - I&T starts with the delivery of the flight qualified power system.
  - After successful I&T of the flight qualified power system on spacecraft A, then spacecraft B will have the flight qualified power system installed.
  - Process continues for each subsystem and instrument on spacecraft A & B.
  - Integration is complete when both spacecraft have all subsystems and instruments installed, a performance test has been successfully completed, and the spacecraft are ready for environmental test.
- Environmental testing will take place over a three month period for both spacecraft. At the conclusion both spacecraft will be ready to ship to the launch site.

I&T Schedule

Integrate STEREO S/C A (side A) & STEREO S/C B (side B)	Environmental Testing STEREO S/C A STEREO S/C B

0 Months 7/ 8 Months 10

Mission Operations

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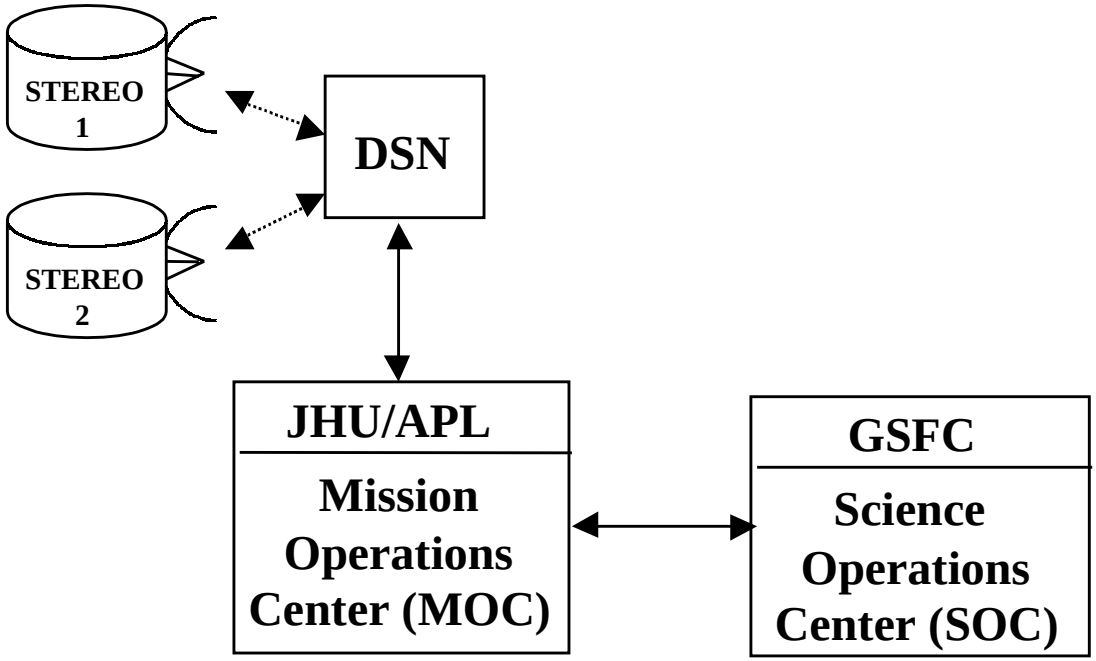
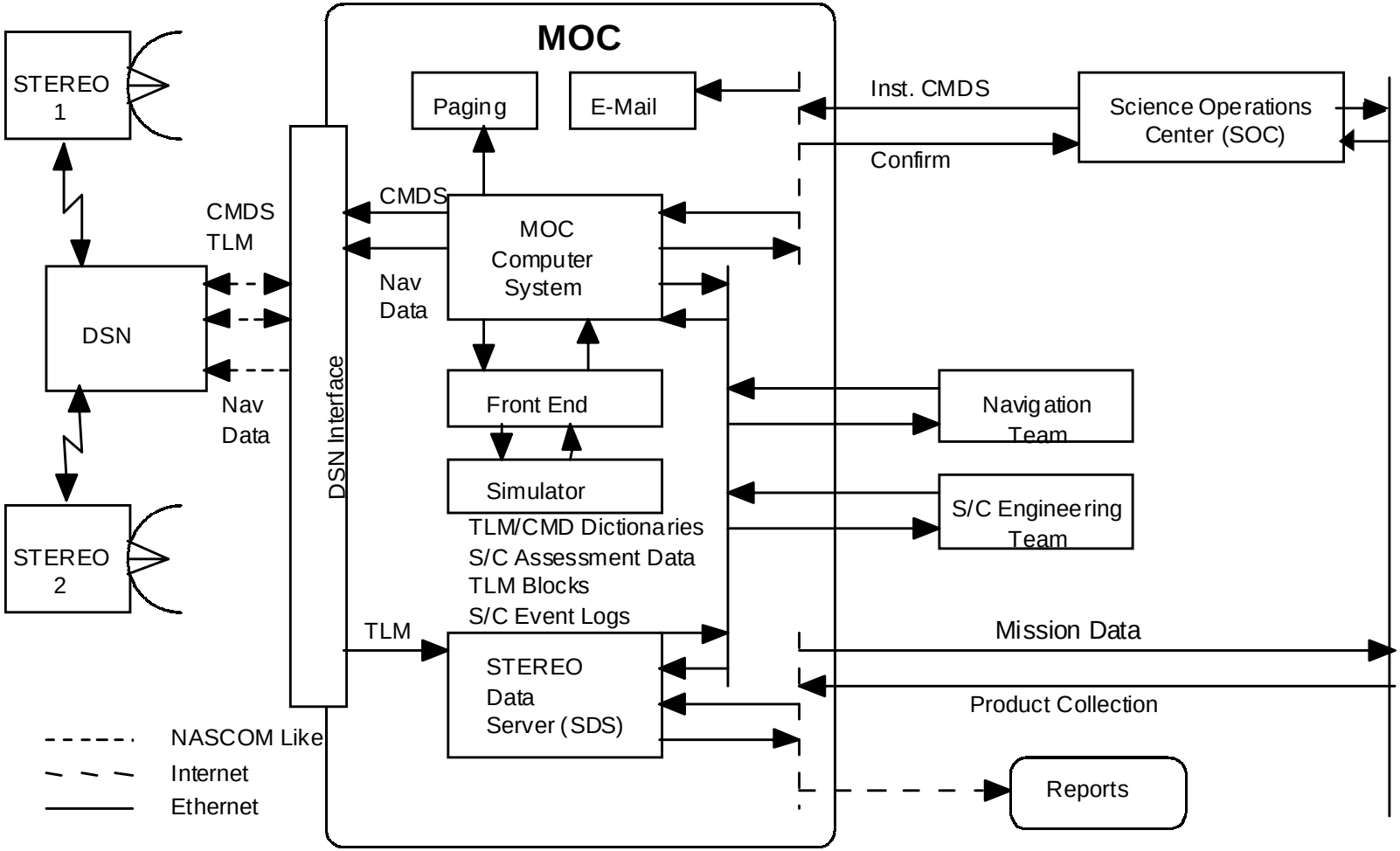
Requirements

- Designed to support I&T, launch, and two years on orbit
- Plan, control, and assess the subsystem bus on both S/C
- Decoupled instrument operations
- One contact/day/vehicle
- Playback SSR data on each pass
- Support operations for two concurrent S/C
- Maintain MET correlation to UTC within 0.5 seconds and provide correlation data to SOC
- Support near real-time and bent-pipe instrument commanding, and provide bent-pipe telemetry to SOC for each pass

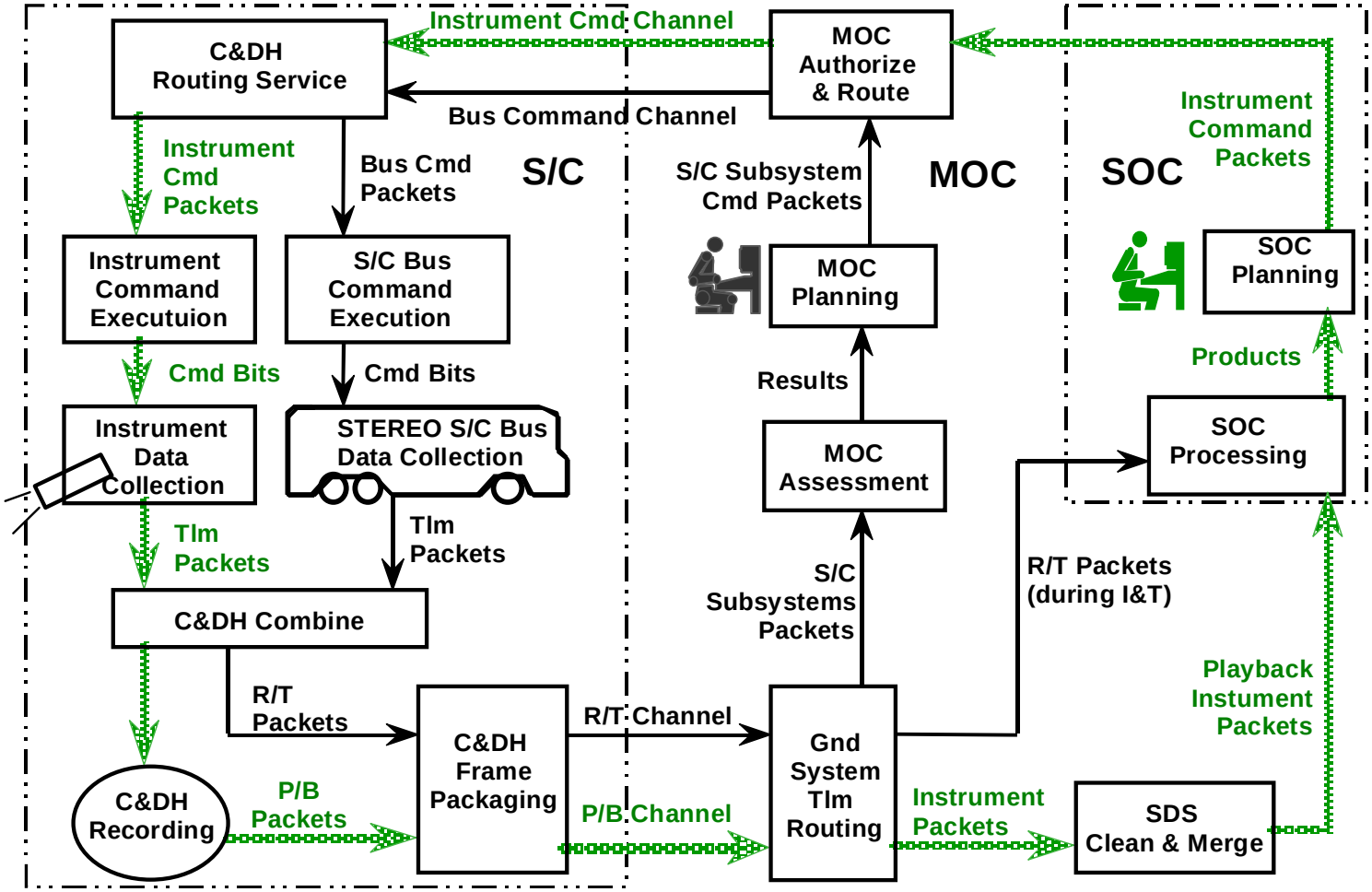
Mission Operations System Architecture



Mission Operations Center Interfaces



Data Flow


Instrument Cmd Channel
C&DH Routing Service
MOC Authorize & Route
Bus Command Channel
Instrument Cmd Packets
Bus Cmd Packets
S/C
S/C Subsystem Cmd Packets
MOC
SOC
Instrument Command Packets
Instrument Command Executuion
S/C Bus Command Execution
MOC Planning
SOC Planning
Cmd Bits
Cmd Bits
Results
Products
Instrument Data Collection
STEREO S/C Bus Data Collection
MOC Assessment
SOC Processing
Tlm Packets
Tlm Packets
S/C Subsystems Packets
R/T Packets (during I&T)
C&DH Combine
R/T Packets
C&DH Frame Packaging
R/T Channel
Gnd System Tlm Routing
Playback Instument Packets
C&DH Recording
P/B Packets
P/B Channel
Instrument Packets
SDS Clean & Merge

Tasks

- Operations Planning
  - Contact scheduling (NEAR)
  - Maintenance activity scheduling (TIMED)
  - Managing the uplinking of instrument commands (TIMED)
  - SSR management
  - Timekeeping management (NEAR)
  - Navigation management
  - Contact plan generation
- Operations control
- Performance assessment

Daily Timeline

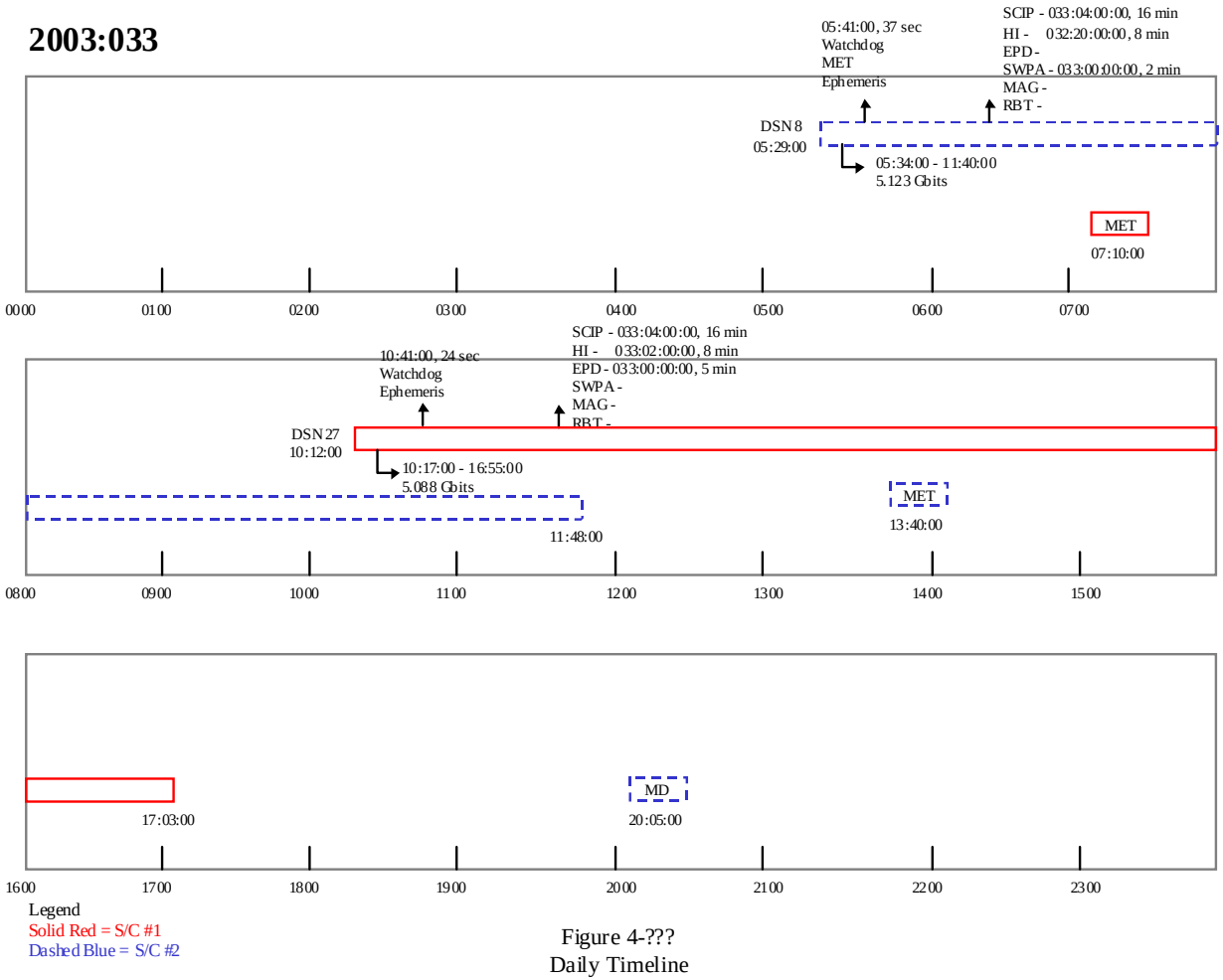


Figure 4-???
Daily Timeline

DSN Support

- Program Service Level Agreement has been submitted
- Require one contact/day/vehicle using 34 m BWG antennas
- Navigation management of S/C to be done by JHU/APL

Staffing

- Normal operations: Business hours, five days/week
- Seven staff total + support staff
  - Flight Manager
  - Spacecraft Specialists (4, 2/vehicle)
  - DSN Scheduler
  - System Maintenance Engineer
- Training
  - Prior to launch, Spacecraft Specialists will be part of I&T
  - After launch, use S/C Simulator for training new staff

Autonomous Operations

Mission well suited for implementing various autonomous operations:

- S/C will have embedded autonomy (TIMED)
- Unattended contacts (TIMED)
- Use automated paging for alarms with supplemental email with detailed information (TIMED)
- Many routine operational tasks will be automated

Design Drivers/Trade Studies

- Autonomous HGA pointing
- Lockheed Martin Space Mission Systems (CSOC) management of DSN