1512

SPACECRAFT GLOW AND THE EISG/SKIRT EXPERIMENT

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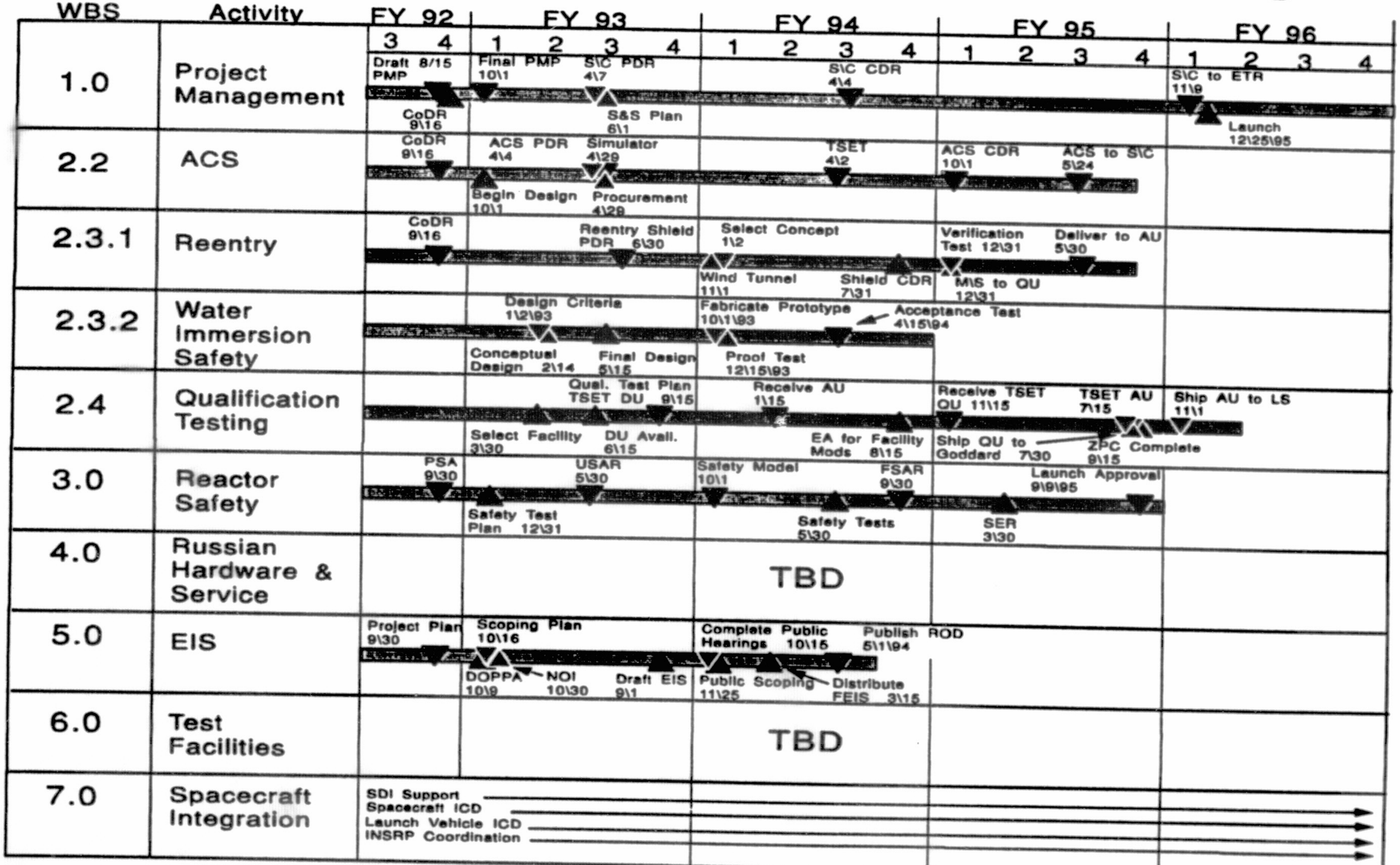
STIG Meeting
October 7, 1992

Preliminary Topaz II Reactor
Program Schedule

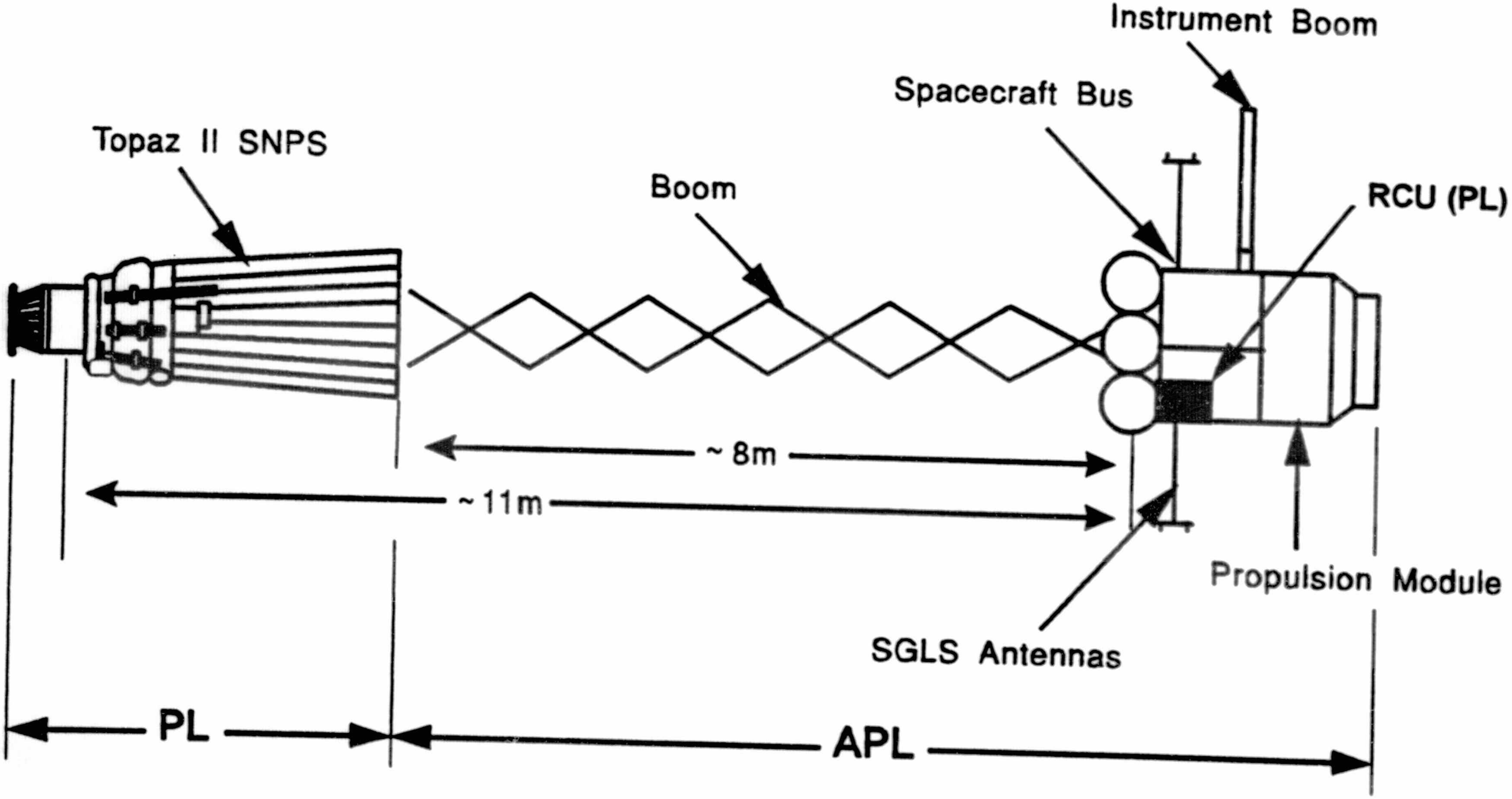


WBS	Activity	FY 92	FY 93	FY 94	FY 95	FY 96
		3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
1.0	Project Management	Draft PMP 8/15 CoDR 9\16	Final PMP 10\1 S\C PDR 4\7 S&S Plan 6\1	S\C CDR 4\4		S\C to ETR 11\9 Launch 12\25\95
2.2	ACS	CoDR 9\16	ACS PDR 4\4 Simulator 4\29 Begin Design 10\1 Procurement 4\29	TSET 4\2	ACS CDR 10\1 ACS to S\C 5\24	
2.3.1	Reentry	CoDR 9\16	Reentry Shield PDR 6\30	Select Concept 1\2 Wind Tunnel 11\1 Shield CDR 7\31	Verification Test 12\31 Deliver to AU 5\30 M\S to QU 12\31	
2.3.2	Water Immersion Safety		Design Criteria 1\2\93 Conceptual Design 2\14 Final Design 5\15	Fabricate Prototype 10\1\93 Acceptance Test 4\15\94 Proof Test 12\15\93		
2.4	Qualification Testing		Qual. Test Plan TSET DU 9\15 Select Facility 3\30 DU Avail. 6\15	Receive AU 1\15 EA for Facility Mods 8\15	Receive TSET QU 11\15 TSET AU 7\15 Ship QU to Goddard 7\30 ZPC Complete 9\15	Ship AU to LS 11\1
3.0	Reactor Safety	PSA 9\30	USAR 5\30 Safety Test Plan 12\31	Safety Model 10\1 FSAR 9\30 Safety Tests 5\30	Launch Approval 9\9\95 SER 3\30	
4.0	Russian Hardware & Service			TBD		
5.0	EIS	Project Plan 9\30	Scoping Plan 10\16 DOPPA 10\9 NOI 10\30 Draft EIS 9\1	Complete Public Hearings 10\15 Publish ROD 5\1\94 Public Scoping 11\25 Distribute FEIS 3\15		
6.0	Test Facilities			TBD		
7.0	Spacecraft Integration	SDI Support Spacecraft ICD Launch Vehicle ICD INSRP Coordination				

Mission Profile

- Launch into Low Earth Orbit (LEO)
(nominal orbit 1,600 km @ 28.5°)
- Confirm nuclear safe orbit (by ground skin track radar)
- Start up TOPAZ 2 reactor (by ground command)
- Evaluate performance of reactor and spacecraft bus
- Begin electric propulsion orbit raising;
spiral out with thrust vector parallel to velocity vector
- Test each type of engine for 1,000 hours
- Duty-cycle thrusters to separate reactor measurements from thruster measurements; ~97% duty cycle
- Perform life testing on selected engine types; use high thrust engines first, low thrust engines later
- Above 6.6 R_E, begin twice per orbit yaw maneuver to change inclination, simultaneously raising orbit

NEP Satellite Configuration



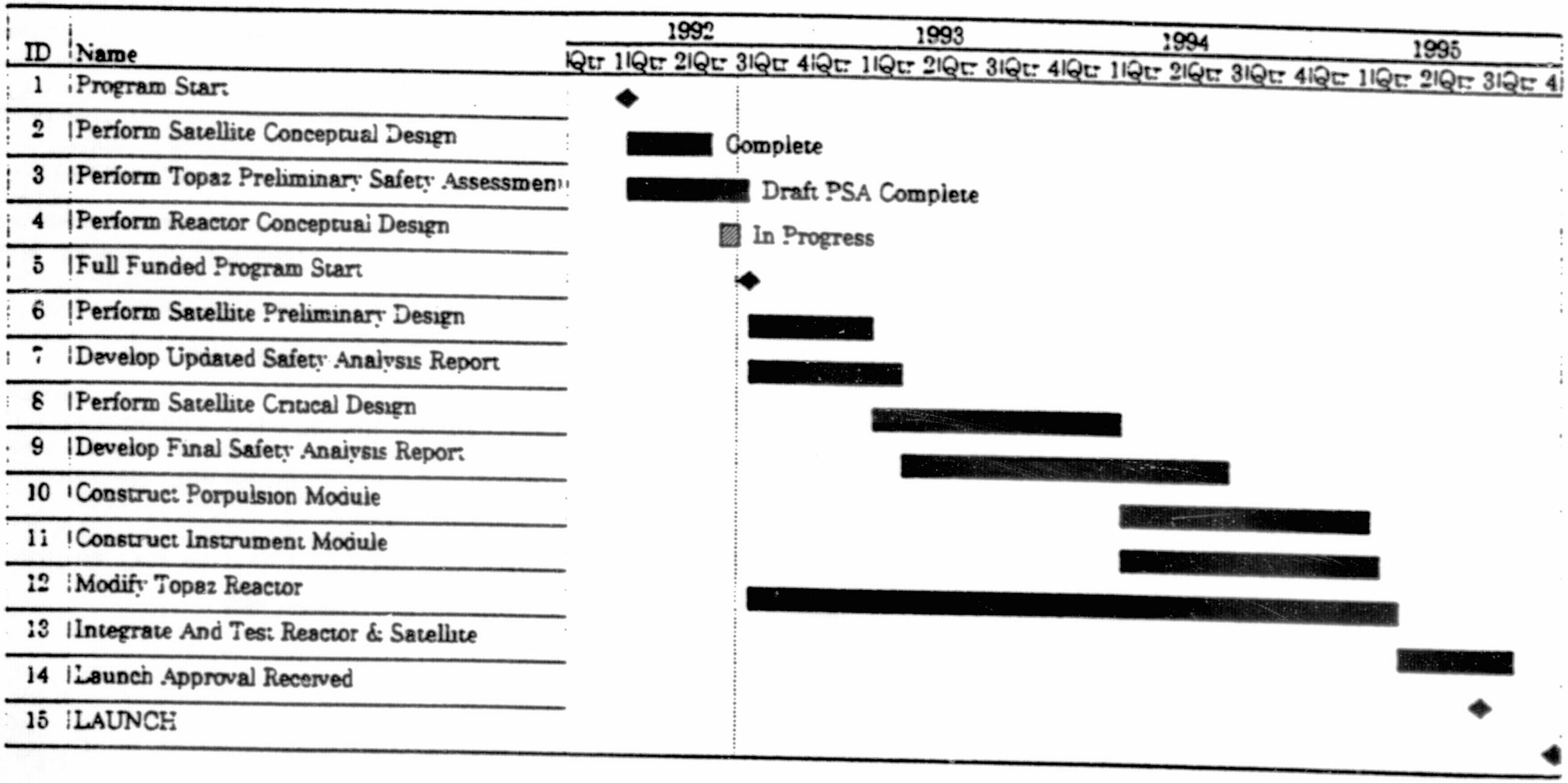
Major Milestones For The NEP Space Test Program

✓August 92	Satellite Conceptual Design Review
✓September 92	Reactor Conceptual Design Review
✓September 92	Topaz II Preliminary Safety Assessment Complete
October 92	Full Funded Start
April 93	Satellite Preliminary Design Review
May 93?	Updated Safety Analysis Report Complete
April 94	Satellite Critical Design Review
September 94	Final Safety Analysis Report Complete
April 95	Propulsion Module Complete
May 95	Instrument Module Complete
May 95	Reactor Modifications Complete
September 95	Topaz II Modifications Complete
September 95?	Launch Approval Received
December 95	Launch

PHILLIPS LABORATORY

NEP Space Test Program Schedule

ТОПАЗ
TOPAZ



ID	Name
1	Program Start
2	Perform Satellite Conceptual Design
3	Perform Topaz Preliminary Safety Assessmen
4	Perform Reactor Conceptual Design
5	Full Funded Program Start
6	Perform Satellite Preliminary Design
7	Develop Updated Safety Analysis Report
8	Perform Satellite Critical Design
9	Develop Final Safety Analysis Report
10	Construct Porpulsion Module
11	Construct Instrument Module
12	Modify Topaz Reactor
13	Integrate And Test Reactor & Satellite
14	Launch Approval Received
15	LAUNCH

NEP Space Test Program Fact Sheet

Summary

The NEP Space Test Program is sponsored by SDIO. The objective of the program is to launch an NEP satellite powered by a Russian Topaz II reactor by December 1995 for a cost of $150M, excluding the cost of the launch vehicle costs. The cost distribution is $80M for the satellite and $70M for the power system. The Applied Physics Lab (APL) is responsible for the satellite and the Phillips Lab (PL) is responsible for the power system.

Key Terms and Acronyms

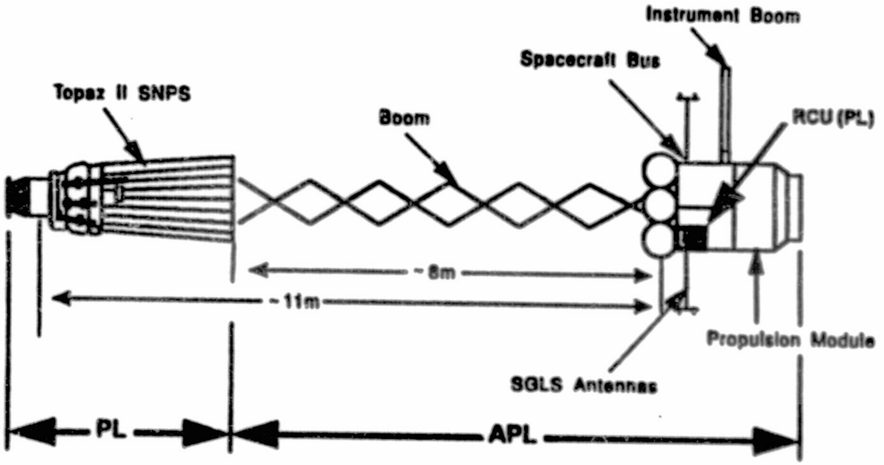
Topaz II: 6 kWe, Russian SNPS based on thermionic conversion
NEP: Nuclear Electric Propulsion
SNPS: Space Nuclear Power System
SDIO: Strategic Defense Initiative Organization
PL: Phillips Lab
APL: Applied Physics Lab
SNL: Sandia National Laboratories
LANL: Los Alamos National Laboratories
CDBMB: Central Design Bureau for Machine Building
(St. Petersburg,)
KIAE: Kurchatov Institute of Atomic Energy (Moscow)
CoDR: Conceptual Design Review
PDR: Preliminary Design Review
CDR: Critical Design Review
PSA: Preliminary Safety Assessment (of the Topaz II)

Status

The Topaz Program was begun in April 1992. To date, the following milestones have been reached:

- Satellite CoDR (APL)
- Reactor CoDR (PL)
- Draft Topaz PSA (PL)

A program plan has been established for reaching the objective of launching the NEP satellite by December 1995.



Topaz Satellite Configuration

Topaz Modifications

Four modifications will have to be made to the Topaz II power system:

- A reentry shield will be added to ensure the system meets the safety requirement of an essentially intact reentry (SNL),
- A neutron poison may be added to the core to prevent criticality in accident scenarios involving water immersion and flooding (LANL),
- A new reactor control system will be added because the Russian system is not space qualified and does not meet US safety standards (PL, SNL), and
- US fuel may be used because of difficulties associated with obtaining special nuclear material from Russia (LANL).

NEP Space Test Program Goals

Primary Goals

- Demonstrate The Feasibility Of Launching A Space Nuclear Power System In The United States
- Demonstrate An Orbit Adjust Capability Using Nuclear Electric Propulsion
- Evaluate The In-Orbit Performance Of The Topaz II Reactor And Selected Electric Thrusters
- Measure, Analyze, And Model The NEP Self-Induced Environment

Secondary Goal

- Conduct A Space Science/Engineering Mission Compatible With The Primary Mission Requirements

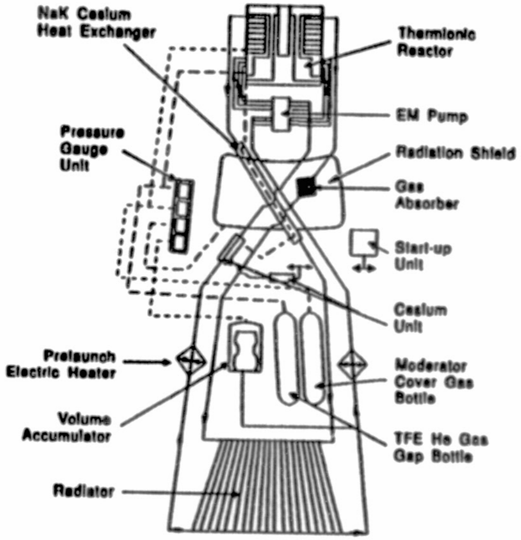
Topaz II Description Fact Sheet

Summary

The Topaz II is a Russian built thermionic space nuclear reactor. It is a single-cell design that has several advantages over multi-cell designs including: it permits full system qualification testing using electric heaters in place of nuclear fuel, it doesn't require early commitment of expensive enriched uranium (96% U-235), it allows removal of fuel for shipping and storage which improves the safety and safeguards environment, and the open cavity of the single-cell design facilitates fission gas escape (mitigating fuel swelling). The reactor is an epithermal system. The fuel loading is low (<27 kg). The output of the reactor is 28 VDC when operating at 135 kWth and 6 kWe. The reactor is cooled by flowing liquid NaK. The coolant loop is susceptible to single-point failures.

Key Terms and Acronyms

Thermionic: The physical process whereby heat energy is converted directly into electric energy via the mechanism of electron emission from an emitter to a collector.
TFE: Thermionic Fuel Element. The structure which contains the components required to produce and utilize the thermionic conversion process.
TSET: Thermionic System Evaluation Test. The facility used to perform full scale Topaz II system tests using electric heaters in place of nuclear fuel in the TFEs.
Single-cell/Multi-cell: Differing designs of the thermionic fuel elements where the TFE consists of a single energy converter versus several energy converters connected in series much as batteries stacked in a flashlight.
NaK: Eutectic composition of sodium and potassium metals which is used as the primary coolant in the Topaz II reactor.
Moderator: ZrH blocks that surround the TFEs and reduce neutron energies down to thermal equilibrium levels.
Reflector: Beryllium blocks above and below the moderator, and segments and drums which surround the reactor vessel that "reflect" neutrons back into the core region.
Core: The central region of the reactor consisting of the fuel, TFEs and moderator where the peak neutron flux exists.
Radiator: A skirt consisting of small pipes, welded to copper plates, carrying the NaK coolant which radiates the excess heat from the coolant to space.
Radiation Shield: Lithium hydride filled stainless steel casing that is used to reduce the level of neutron and gamma ray radiation intensity in the direction along the boom.



Topaz II System Diagram.

Key Facts

The Topaz II system consists of three principal components: the reactor, the radiation shield and the radiator/frame structure. Additionally, there are four fluidic systems used to support the Topaz operation: NaK coolant, cesium in the TFE interelectrode gap, and two bottled gas systems.

TFE emitter temperature is ~1600 C during operation and the collector temperature is ~900 C. There are ~11 liters of NaK coolant in the Topaz system at temperatures ranging between 500 C at the reactor inlet and 600 C at the outlet. The cesium system is designed to provide 2 torr of pressure within the TFE interelectrode gap, thus enhancing the thermionic conversion process.

The reactor mass is 290 kg, that of the radiation shield is 390 kg, and the radiator mass is 50 kg (filled with coolant). The frame structure has a mass of 45 kg.

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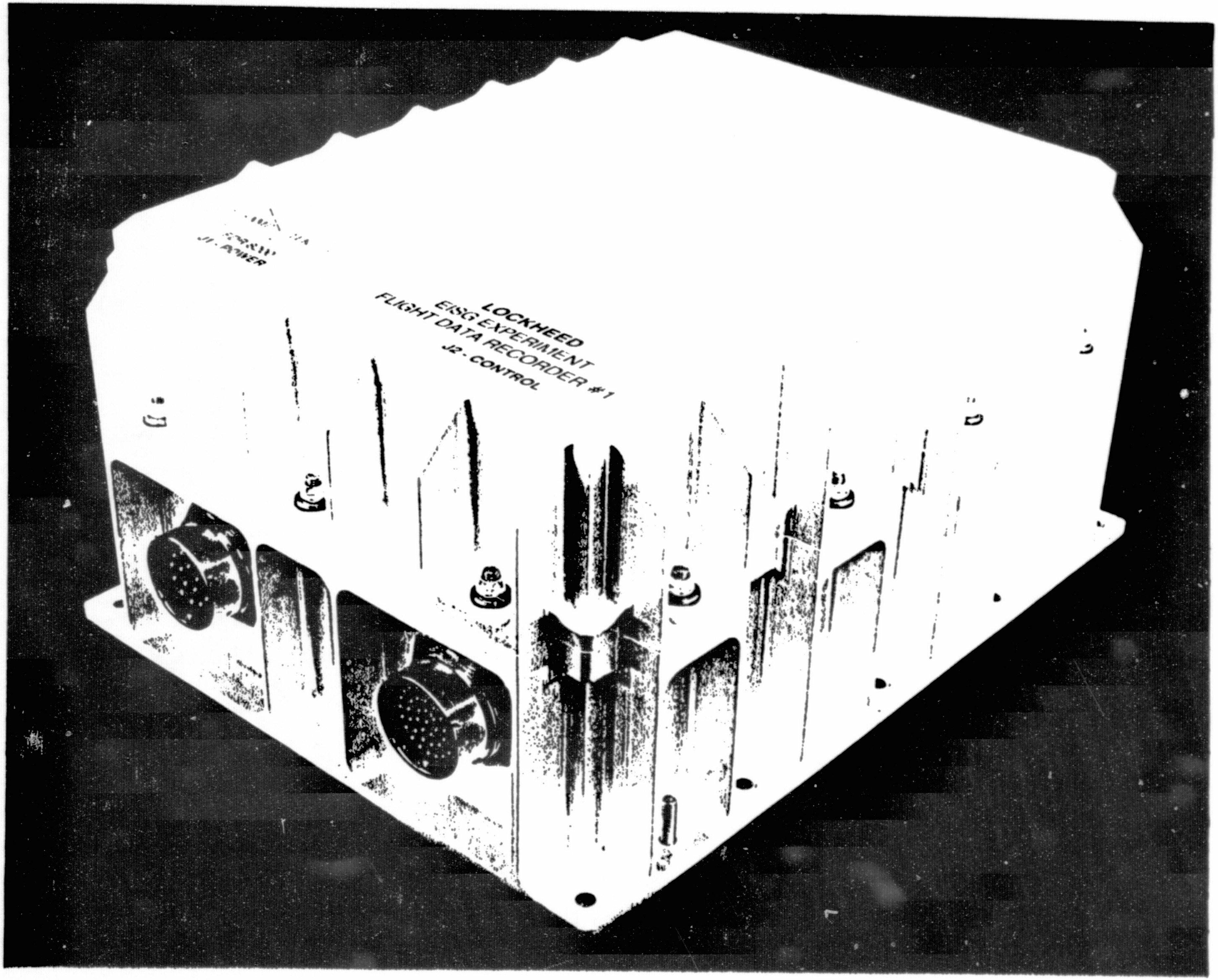

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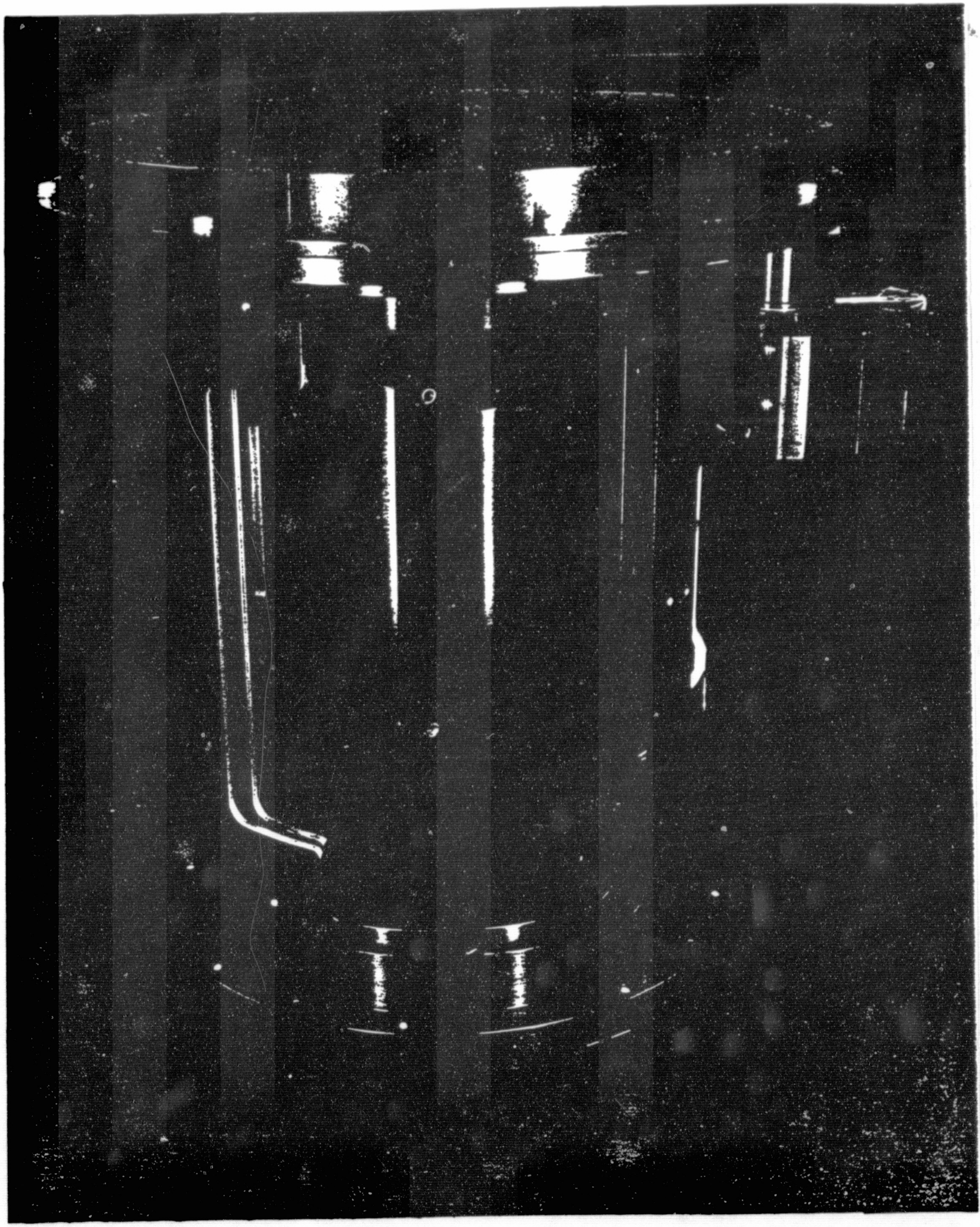

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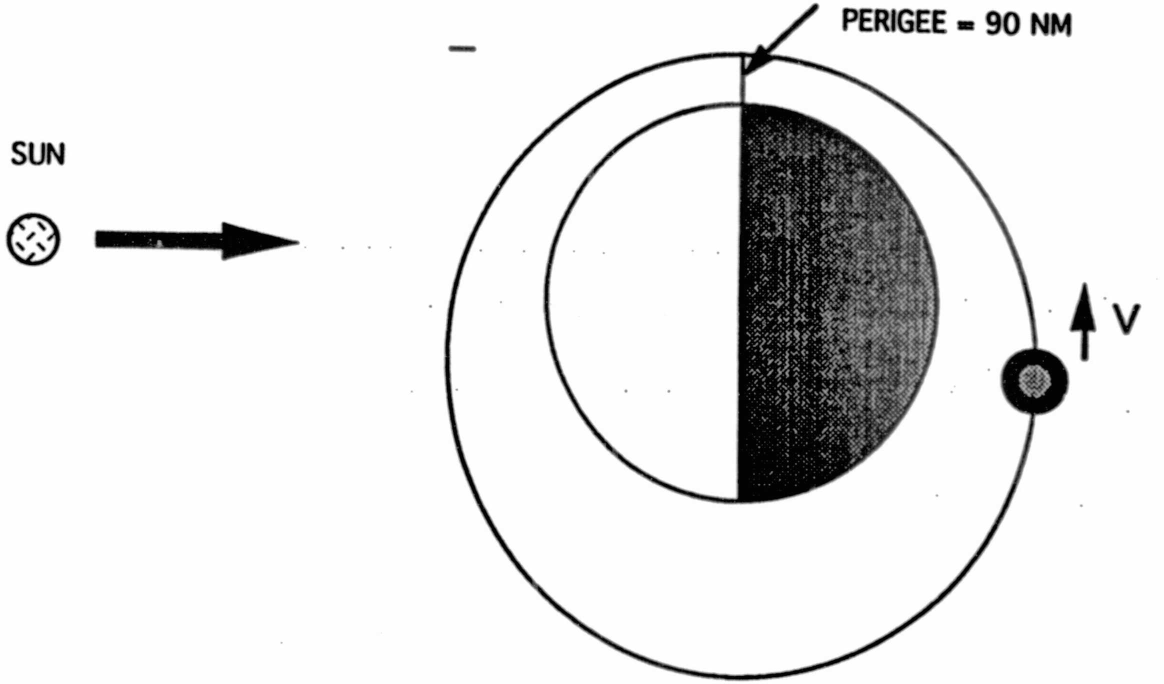
EXPERIMENTAL INVESTIGATION OF SPACECRAFT GLOW

OPERATIONS DURING FOUR ORBITER DARKNESS PERIODS IS DESIRED, AT LOW EARTH ORBIT (LEO). TWO CIRCULAR ORBITS (<140 NM) AND TWO ELLIPTICAL ORBITS (WITH PERIGEE ~90 NM) ARE DESIRED. IT IS REQUESTED THAT FOR THE TWO ELLIPTICAL ORBITS, PERIGEE BE TARGETED FOR THE SUNRISE TERMINATOR. THE INTENT IS TO MAKE MEASUREMENTS ON THE SHADOW PORTION OF THE ORBIT, TO OBSERVE THE EFFECT OF THE ATMOSPHERIC DENSITY CHANGE (WITH ALTITUDE) ON SPACECRAFT GLOW.

ELLIPTICAL ORBIT GEOMETRY



MISSION OPERATIONS (PRIMARY SCIENCE)

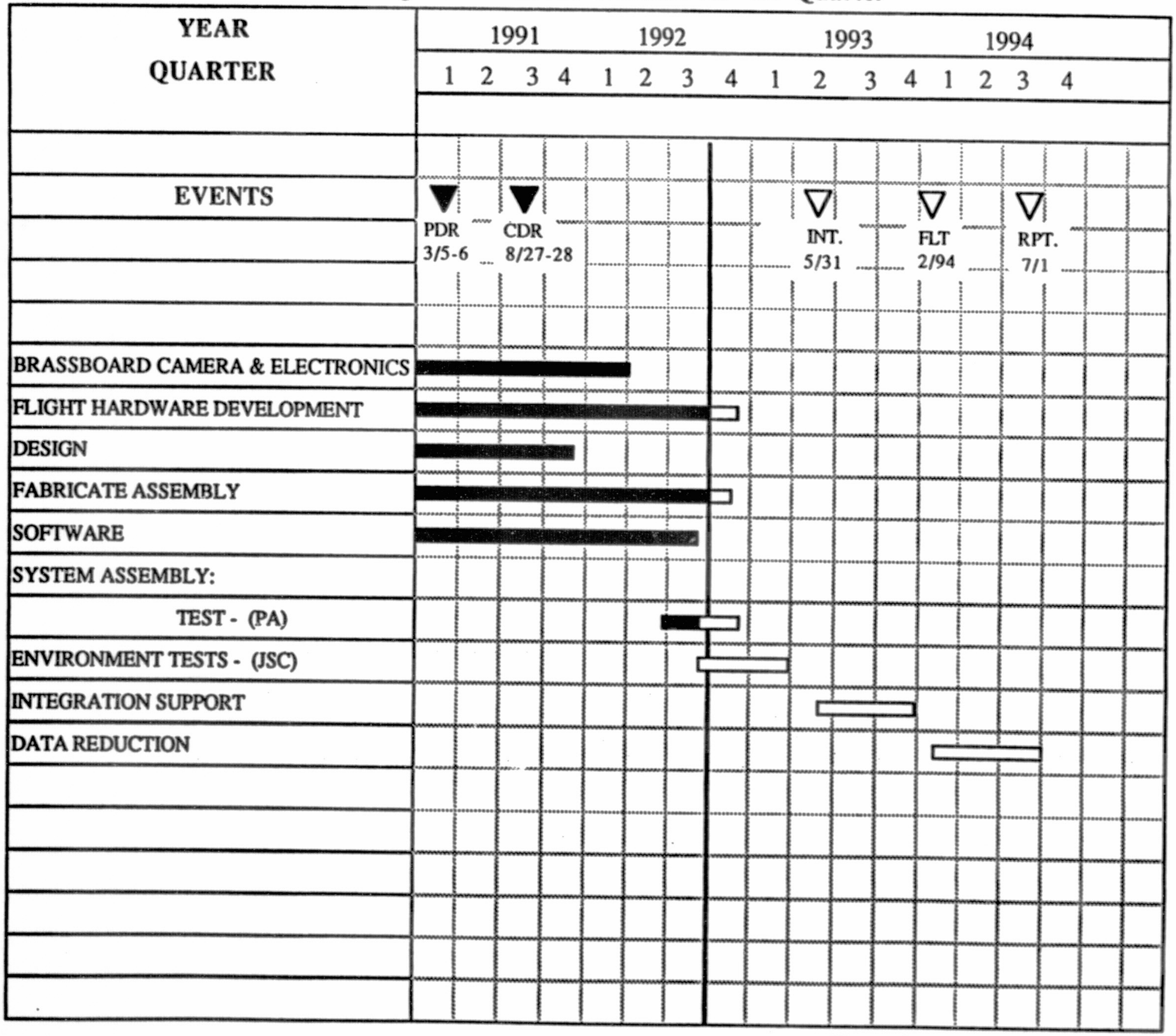
ORBITS

- -4 SHADOW PERIODS IN LOW EARTH ORBIT (LEO)
  - -2 ORBITS CIRCULAR
    - -ALTITUDE <140 NM
  - -2 ORBITS ELLIPTICAL, PERIGEE 90 NM (OR AS LOW AS POSSIBLE)
    - -PERIGEE AT ORBITER SUNRISE
- -ATTITUDES PRIMARILY WITH BAY TO RAM WITH THERMAL CONDITIONING

OPERATIONS

- -GROUND ACTIVATION OF POWER/THERMAL
- -UPLINK COMMANDS TO PREP EXPERIMENT
- -DOWNLINK DATA S-BAND (SAMPLE) AND KU BAND (ALL DATA) WITH TAPE RECORDER BACKUP
- -TAPE RECORDER PLAYBACKS ON ORBIT PLANNED
- -HANDHELD CAMERA OPERATED BY CREW

EISG Program Milestone Schedule for 4th Quarter



Tuesday, October 6, 1992