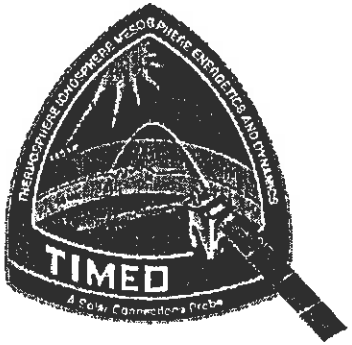
TIMED

Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics

Critical Design Review (CDR)

2-4 December 1997



SAFETY

Shirley K. Dion

Hernandez Engineering, Inc. (HEI)

Tel: (301) 731-8698

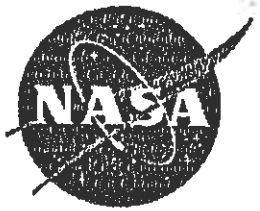
Fax: (301)731-8603

email: Shirley.K.Dion.1@gsfc.nasa.gov

TOPICS OF DISCUSSION

- Safety Overview
- Safety Requirements
- Safety Compliance Documents
- TIMED Safety Documents
- Spacecraft Safety Hazards

TIMED



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SAFETY OVERVIEW

The TIMED Spacecraft has limited hazards:

- TIMED does not have a Propulsion system
- There are no hydraulic systems associated with the TIMED Spacecraft
- The only cryogen system is Liquid Nitrogen used for purges
- There are no acoustic hazards associated with the integration of the Spacecraft
- Pyros are category B (Non-Hazardous) / Class C
- The laser used for SABER GSE is a Class 1 (non-hazardous) sealed unit; the beam travels via fiber-optic cable

SAFETY REQUIREMENTS

- All Integration and Test activities at APL, GSFC, and at the launch site shall be conducted according to approved test procedures and in accordance with the TIMED Program Safety Plan
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- The Spacecraft must be in compliance with the 31 March 1995 version of the Eastern Western Range (EWR) 127-1 Safety Requirements Document

SAFETY COMPLIANCE DOCUMENTS

APL Safety Document	S30-93-04 Space Integration and Test Facility
DOT Standards	49 CFR parts 300-399, 800-899
EWR 127-1	Eastern and Western Range Safety Requirements, 31 March 1995 version, including referenced documents
EPA Standards	40 CFR parts 1-799
GSFC Safety Document	Engineering Service Division Safety Manual

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SAFETY COMPLIANCE DOCUMENTS

(continued)

OSHA	Fed-OSHA Title 8 Administrative Code, 29 CFR 1910 Cal-OSHA Chapter 4
MDC H32240	Delta II Payload Planner Guide
MDC 92H0909	Delta II Program Safety Guide
Mil-STD-882C	System Safety Program Requirement
Mil-STD-1576	Electroexplosive Subsystem Safety Requirements for Space Systems
Mil-STD-461B	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference

SAFETY COMPLIANCE DOCUMENTS

(continued)

AFJMAN 240204	Preparing Hazardous Materials For Military Air Shipment
NMI 1700.8	Policy to limit Orbital Debris Generation
NSS 1740.14	Guidelines and Assessment Procedures for Limiting Orbital debris
30 SWI 40-201	30 SW Radiation Protection Plan

TIMED SAFETY DOCUMENTS

- Safety Program Plan 8/97 *(Completed)*
- Orbital Debris Assessment 12/97 *(In progress)*
- Preliminary Missile System Pre-Launch Safety Package (MSPSP) 04/98
- Safety Inputs to Hazardous Procedures
  - Environmental Testing Procedures 2/99
  - Launch Facility Procedures 6/99
- Final Missile System Pre-Launch Safety Package (MSPSP) 7/99
  - Seismic Analysis 7/99

TIMED SAFETY PROGRAM PLAN

- Signed on 8/6/97
- Safety Program Plan begins at the design phase and ends at launch
- Establishes safety organization relationships, responsibilities, and management/engineering requirements to assure a comprehensive safety assessment for the entire life cycle of the TIMED spacecraft
- The safety program plan provides the following:
  - Detailed description of tasks and activities of safety required to identify, evaluate, eliminate and/or control hazards throughout the program
  - List of safety compliance documents
  - Defines System Safety Analysis to be completed on TIMED
  - Defines Mishap Reporting

TIMED ORBITAL DEBRIS ASSESSMENT

- NMI 1700.8, Policy to Limit Orbital Debris Generation, requires each earth-orbiting spacecraft program to conduct a formal assessment of the potential to generate orbital debris

- NSS 1740.14 , NASA Safety Standard Guidelines and Assessment Procedures For Limiting Orbital Debris, requires assessment of the following debris generation scenarios:
  - Debris generated during normal operations
  - Post-mission orbital lifetime and disposal procedure
  - Debris generated by on-orbit collisions
  - Reentry survivability of debris
  - Debris generated by explosions and intentional breakups

DEBRIS GENERATED DURING NORMAL OPERATIONS

- Guideline Requirements:
  - Total object-time product ≤ 100 object - yr
  - Total area-time product ≤ 0.1 m^2 - yr

- The SABER cover is the only planned release of debris from the TIMED spacecraft
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- Assuming Insertion Orbit Range of 600 to 650 km, analysis result:
  - Total object-time product is between 1.1 and 2.3 object - yr
  - Total area-time product is between 0.024 and 0.052 m^2 - yr
  -
- TIMED is in compliance with NSS 1740.14 for debris generated during normal operations

POST-MISSION DISPOSAL PROCEDURE AND ORBITAL LIFETIME

- Guideline Requirements:
  - Reliable post-mission disposable procedures
  - S/C lifetime at end of operational mission ≤ 25 yrs

- Disposal by atmospheric reentry:
  - At end of operational mission, loss of power will cause the spacecraft to tumble
    - » Center of pressure off-set by 3 to 10 cm from center of gravity along x-, y-, z-axis
  -

- Disposal procedure is reliable and does not require any must-work functions.
-
- The spacecraft Orbital Lifetime is between 8 and 18 years
-
- TIMED is in compliance with NSS1740.14 for post-mission disposal procedure and orbital lifetime

DEBRIS GENERATED BY ON-ORBIT COLLISION

- Guideline Requirements:
  - Probability of collision with large objects (≥ 10cm) during normal mission is ≤ 0.001
  - Collision with small objects (≤ cm) during normal mission phase will not affect post-mission disposal

- Assumptions:
  - Insertion orbital altitude = 625 km
  - Inclination = 74.1 °
  - Operational lifetime = 2 yrs
  - Avg X-sectional area = 10.275 m^2
  - Solar activity = 130 sfu
  - Launch date = 2000

- Large debris analysis result:
  - Man-made debris = 8×10^{-5}
  - Meteoroids = 4.5×10^{-9}

DEBRIS GENERATED BY ON-ORBIT COLLISION (con't)

- Collision with small debris will not affect TIMED spacecraft ability to exit LEO in less than required 25 years
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  - Disposal procedure relies on the TIMED spacecraft post-mission flight dynamic characteristics
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- TIMED is in compliance with NSS 1740.14 for on-orbit collision with large and small debris

REENTRY SURVIVABILITY OF DEBRIS

- Guideline Requirements:
  - Total casualty area for components and fragments surviving reentry ≤ 8 m^2
  -
- Assuming folded array spacecraft configuration at reentry interface, analysis results are as follows:

Object Surviving Reentry

Object Description	Area (m^2)	Quantity	Total Area (m^2)
SABER	2.0628	1	2.0628
Solar Array Dr. Mot.	0.5008	2	1.0016
Torque Rod	1.0290	3	3.0720
Star Camera Bkt.	0.4151	2	0.8302
TIDI Telescope Bkt.	0.5538	4	2.2152

Total Debris Casualty Area = 9.1818 m^2

TIMED MISSLE SYSTEM PRE-LAUNCH SAFETY PACKAGE (MSPSP)

- Demonstrates compliance with Chapters 3 (Flight and GSE hardware design) and Chapter 6 (Operations) of EWR 127-1
  - Tailor EWR 127-1 with all subsystem Lead Engineers
- Only applies to operations at VAFB
- Provides detailed description of flight and GSE hardware design, as well as integration, tests, and inspections at VAFB.
  - The MSPSP consists of the following:
    - Introduction
    - Flight hardware description
    - GSE hardware description
    - Ground operations
    - Safety analysis

Spacecraft SAFETY HAZARDS

- Pyrotechnic Devices
- Battery
- RF/EMI
- Lasers
- High Voltage
- Electrical GSE
- Ionizing Radiation Sources
- Lifting Material Handling
- Purge
- Pressure System
- Hazardous Materials
- ESD

Spacecraft Safety Hazards

Pyrotechnic Devices

- Spacecraft Solar Arrays (2) each contains 2 sets of redundant EED's (8 Hi-Shear PC 23 total)
- Optical Bench contains 1 primary and 1 redundant EED (2 Hi-Shear PC 23 total)
- GUVI payload contains 1 primary and 1 redundant EED (2 Bellows Actuator pin release total)
- TIDI payload contains 4 primary and 4 redundant EED's (8 Wire Cutters total)

Safety Considerations

- 2 separation switches
- Flight Arming Plug
- Enable relay
- Fire relay
- Pyros are category B (Non-Hazardous) / Class C
- EED's will be handled at an ESD free workstation
- Wrist grounding straps will be used
- EED's will be stored in static free containers.
- Components will be grounded

Spacecraft Safety Hazards

Battery

- Two half batteries
- 22 NiH2 cells (total)
- 50 amp/hr capacity
- Sealed cells
- Maximum Operating Pressure is 800 psig

Safety Considerations

- Battery GSE is designed to control and monitor temperature, current, voltage, and pressure
- Cells cooled during ground operations
- Manufacturer has a 3:1 safety factor for design
- Manufacturer has qualification tested design
- Battery cells will be proof tested to 1.5 X MOP
- Batteries are "leak before burst" according to the manufacturer
- Flight cells will be cycle and capacity tested

Spacecraft Safety Hazards

RF and EMI/EMC

- Transmitter for the bus operates at 2215 MHz at an RF output power level of 3 watts (S-band)
- Antennas
  - 2 shaped - beam Bifilar-Helix, Zenith pointing antennas (4dBic)
  - 2 hemispheric coverage Quadrifilar-Helix, Nadir pointing antennas (4dBic)
  - 2 Zenith pointing GPS antennas (L-band patch antennas) for receiving only

Safety Considerations

- Hat couplers will be used during ground testing
- Safe distance will be calculated, measured, and maintained during testing

Spacecraft Safety Hazards

Lasers

- SABER will use a Class I Laser for GSE Operations
- Laser is a particle counter containing an internally sealed HeNe or diode type laser
- Laser power output is 50 mW

Safety Considerations

- Lasers are contained in GSE housing- housing cannot be opened
- Laser GSE was used on the MSX Program
- Laser output travels via a fiber-optic cable

Spacecraft Safety Hazards

High Voltage

- Gyro subsystem internal voltage ranges from 200-300 V
- TIDI HV supply for calibration lamps 800 V (peak-to-peak) at 5 MHz
- SEE EGS CODACON detector operates at -2 KV max
- SEE krypton calibration lamps 800 V max at 100 MHz
- SEE GSE ion pump for EGS operator at 3.5KV
- GUVI two detector tubes operating at 4.5 KV each

Safety Considerations

- Primary control is that all circuitry is grounded and contained
- Power is fused in the bus
- All high voltage sources operate at low current

Spacecraft Safety Hazards

Electrical GSE

- Computer Work Stations
- Spacecraft Blockhouse Control Unit
- Bus Subsystem GSE
- Battery Charger
- Battery Chiller
- Power supplies
- Ion pump GSE fixture (SEE)
- Test Lamps (GUVI)

Safety Considerations

- Electrical GSE will be inspected to ensure NEC Code Compliance and/or UL listing
- EGSE used on the pad after second stage fueling will be explosion proof (within 100 ft)

Spacecraft Safety Hazards

Ionizing Radiation

- TIDI has (2) 1 μCi of Europium- 152 (Eu -152)
- SABER has (1) 10 milliCi of Polonium- 210 (Po-210) source is contained in an ESD ionizer (GSE)

Safety Considerations

- TIDI sources are contained in a delrin holder inside an aluminum lamp housing cover
- TIDI sources are identical to sources that have flown previously on UARS/HRDI
- SABER GSE source is contained within the ESD ionizer - source is encapsulated
- The GSE ESD ionizer on SABER was used on the MSX Program

Spacecraft Safety Hazards

Lifting and Handling Flight Hardware

- Spacecraft materials handling equipment is currently TBD
- SEE, SABER Sensor, and TIDI will require a sling for installation on the spacecraft

Safety Considerations

- All slings and handling hardware will meet safety requirements:
  - Proof tested to 2 times rated load
  - Analyzed for an Ultimate Load with a factor of ≥ 5.0 and a Yield Load with a factor of ≥ 3.0
  - All Single Failure Points (SFP) will be NDI'ed
  - Personnel will not work under a suspended load

Spacecraft Safety Hazards

Purge Subsystem

- Spacecraft GSE provides nitrogen purge to all instruments
- Nitrogen back-fill operation for EGS component of SEE
- K-Bottles of nitrogen are required for battery chiller GSE

Safety Considerations

- Spacecraft nitrogen purge GSE
  - Used on ACE and MSX programs
  - System is designed to meet range safety requirements
  - Nitrogen purge dewar will meet DOT Standards
- All purges will have regulators

Spacecraft Safety Hazards

Pressurized System

- SABER contains a cooler that uses He refrigerant at a nominal pressure of 400 psig
- The system contains 35.5 milliliters of He
- Internal pump is a piston pump

Safety Considerations

- Refrigerant system is completely enclosed
- Refrigerant system is designed and tested to MIL-STD-1522A

Spacecraft Safety Hazards

Hazardous Materials

- Cleaning fluids, solvent: Isopropyl alcohol
- Epoxy/staking material and lubricants
- Pyro devices
- Nitrogen purge (if used in a confined space)
- GSE lamps for GUVI contain small amounts of mercury
- Nitrogen backfill for SEE
- NiH2 Battery (KOH, H2 generation)

Safety Considerations

- Cleaning fluids, epoxies, and lubricants will be applied and discarded properly
- Mercury vapor lamps are sealed units
- Nitrogen will be used in a ventilated area (an oxygen depletion analysis will be conducted if used in a confined space)
- Pyro device circuitry design is at least 2 fault tolerant
- Battery cells are sealed

Spacecraft Safety Hazards

Electrostatic Discharge (ESD)

- Program objective is to reduce potential exposure to ESD
- Proper storage of EED's

Safety Considerations

- Use wrist grounding straps
- Payload instruments and bus components are grounded
- EED's must be stored at all times in static free containers
- EED's will be handled at an ESD free workstation