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INTEGRATION AND TEST

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- *Integration & Test (I&T) Requirements*
- *Test Plan*
- *Subsystem/Spacecraft Testing*
- *S/C Electrical Tests*
- *S/C Test Flow*
- *Documentation*

I & T Requirements

The below requirements were derived for the TIMED System Requirements, 7363-9001 Rev. B:

- Prepare a comprehensive integration and test plan to meet the program schedule requirements
- Plan and execute effective Integration and Test operations in accordance with the objectives established in the I&T Plan
  - Command the S/C from arrival of the first subsystem to launch
  - Maintain command and telemetry dictionaries during I&T
  - Process and evaluate all spacecraft telemetry data during I&T
  - Collect and archive all raw telemetry during I&T
  - Transmit all science telemetry data to the instrument Test Payload Operations Centers (TEST POCs) and coordinate with the instrument providers to assure the capability of the instruments to perform as required
  - Collect, process, and transmit instrument commands from the TIMED Mission Operations Center (MOC) to the instruments

I & T Requirements

- Plan and execute effective Integration and Test operations in accordance with the objectives established in the I&T Plan (Cont.)
  - •• Identify unexpected interactions among system/subsystem elements
  - •• Assure that all components are operated beyond their "infant mortality" regime prior to launch
    - Spacecraft bus units have a requirement of 500 hours of burn-in-time prior to launch with the last 100 hours being failure free
    - Instrument units have a requirement of 250 hours burn-in-time prior to launch with the last 100 hours being failure free
  - •• Establish standard procedures and tools for spacecraft integration, testing, and operation

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Test Plan (7363-9020)

PURPOSE :

- specify the types of tests that the TIMED Spacecraft shall be subjected to during ground processing beginning with the integration of primary and support subsystems and ending with the MOC launch readiness verification;
- organize all system-level test activities that involve the spacecraft into a cohesive, performance-oriented test program;
- provide high confidence that the spacecraft will satisfy its performance and mission life requirements, i.e., that it meets its design objectives and reliability goals;
- assure that individuals with program test responsibilities coordinate with one another frequently to avoid information gaps, interface problems and misunderstandings that would lead to interruptions in test flow or jeopardy to the spacecraft;
- provide a test documentation structure from which detailed procedures and schedules can be derived.

Test Plan (7363-9020)

SCOPE

The Test Plan is a top level document that discusses in general terms:

- test equipment, facilities and environmental conditions;
- quality assurance and test procedure sign-off protocol;
- maintenance of daily records during any test period;
- discrepancy reporting;
- failure criteria and re-qualification;
- test flow;
- subsystem integration;
- functional testing (at APL and NASA-GSFC);
- software testing;
- processing at VAFB;
- the Mission Operations Readiness Demonstration (MORD)

STATUS

- Released as of September 23, 1997

Test Matrix

- The test matrix is part of the TIMED Test Plan 7363-9020.
- For each spacecraft component and subsystem, the adequacy of the design to perform in these environments will be established through a verification test plan (which incorporates the requirements of the above specification)
- The verification matrix summarizes the TIMED hardware versus the test program for subsystem and spacecraft levels.

TEST MATRIX

Subsystem	Component	Component Level Testing							Spacecraft Level Testing									
		Vib	Align	TV	Deploy	EMC	Cal	Bake	Integ	Funct	Perf	Deploy	Align	EMC	Vib	Acoustic	Shock	TV
G&C	Star Tracker 1,2	•	•	•		•			•	•			•	•	•	•	•	•
	FOG 1,2	•	•	•		•			•	•			•	•	•	•	•	•
	RWA 1-4	•	•	•		•			•	•	•		•	•	•	•	•	•
	RWCU	•		•		•			•	•	•			•	•	•	•	•
	FC, 1,2	•		•		•			•	•	•			•	•	•	•	•
	AIU 1,2	•		•		•			•	•	•			•	•	•	•	•
	Mag	•		•		•			•	•	•		•	•	•	•	•	•
	Torque Rods 1-3	•		•		•			•	•			•	•	•	•	•	•
	Sun tracker System	•		•	•				•	•	•	•	•	•	•	•	•	•
Power	Battery Assembly	•		•		•			•	•	•			•	•	•	•	•
	PSE/DU	•		•		•			•	•	•			•	•	•	•	•
	PPT Conv	•		•		•			•	•	•			•	•	•	•	•
	Solar Array Drive System	•		•	•	•			•	•	•			•	•	•	•	•
	Solar Array Drive Conv	•		•		•			•	•	•			•	•	•	•	•
	Solar Arrays	•		•	•	•			•	•	•	•	•		•	•	•	
Thermal	MLI							•								•		
	Heaters & Thermostats								•	•	•			•	•	•	•	•
	Deutsch Block								•	•				•	•	•		
Structure	Primary Structure		•					•							•	•	•	•
	PLA															•	•	•
	Secondary Structure							•							•	•	•	•
	RW Brackets 1-4												•		•	•	•	•
	Ant Mast 1-4												•		•	•	•	•
	GPS Ant Mast		•			•		•					•		•	•	•	•
	Optical Bench		•					•					•		•	•	•	•
	Secondary Brackets etc														•	•	•	•
	SA Hinge/Caging/Lock	•			•			•				•			•	•		•
Harness	S/C							•	•	•	•			•	•	•	•	•
	1553							•	•	•	•			•	•	•		•
Ordnance	Sep Switch											•			•	•		•
	Pyros	•		•	•	•			•		•	•			•		•	
RF	Diplexor 1,2	•		•		•			•	•	•			•	•	•	•	•
	Zenith Ant Assy 1-2	•		•					•	•	•			•	•	•	•	•
	Nadir Ant Assy 1-2	•		•					•	•	•			•	•	•	•	•
	Coaxial Switch Unit, 1,2	•		•					•	•	•			•	•	•	•	•
GPS	GPS Ant Assy 1-2	•	•	•					•	•	•			•	•	•	•	•
IEM	IEM 1,2	•		•		•			•	•	•			•	•	•	•	•
	SSR 1,2	•		•		•			•	•	•			•	•	•	•	•
	C&DH 1,2	•		•		•			•	•	•			•	•	•	•	•
	GPS 1,2	•		•		•			•	•	•			•	•	•	•	•
	DC/DC Cnvtr #1 1,2	•		•		•			•	•	•			•	•	•	•	•
	DC/DC Cnvtr #2 1,2	•		•		•			•	•	•			•	•	•	•	•
	RF uplink 1,2	•		•		•			•	•	•			•	•	•	•	•
	RF Dwnlk 1,2	•		•		•			•	•	•			•	•	•	•	•
	IEM #1 RIU 1-7	•		•		•			•	•	•			•	•	•	•	•
	IEM #2 RIU 1-7	•		•		•			•	•	•			•	•	•	•	•
GUVI	EC U	•		•		•	•	•	•	•	•		•	•	•	•	•	•
	SIS	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•
	SIS Electronics	•		•		•	•	•	•	•	•		•	•	•	•	•	•
	FPE 1-2	•		•		•	•	•	•	•	•		•	•	•	•	•	•
	HVPS 1-2	•		•		•	•	•	•	•	•		•	•	•	•	•	•
SABER		•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•
SEE		•	•	•		•	•	•	•	•	•		•	•	•	•	•	•
TIDI	Elec	•		•		•	•		•	•	•		•	•	•	•	•	•
	Profiler	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•
	Telescopes 1-4	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•

Subsystem/Spacecraft Testing

- Subsystem Mini-MOC Testing
- Spacecraft Integration and Testing
- Spacecraft Field Testing

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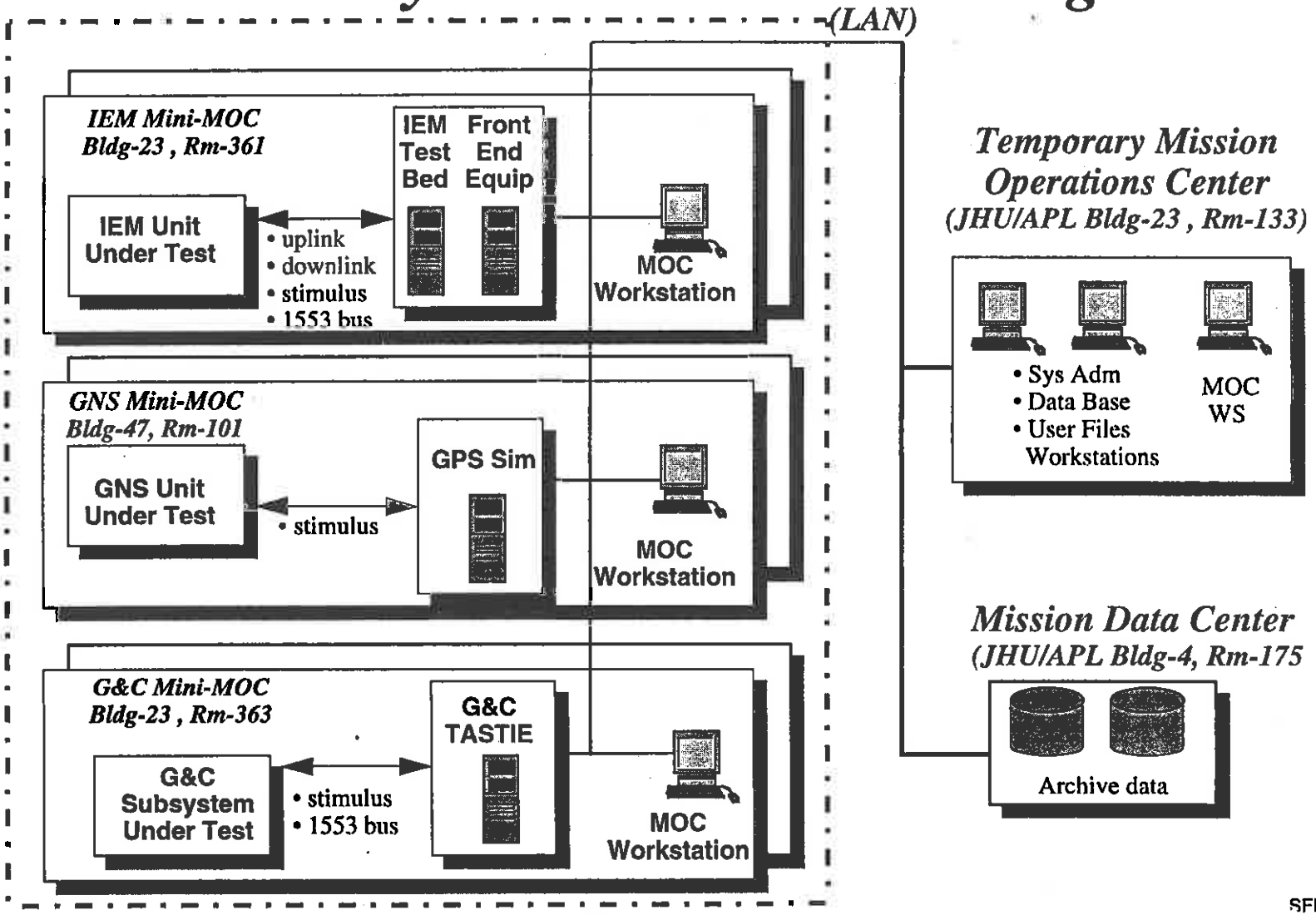
Subsystem Mini-MOC Testing



Mini-MOC Objectives

- *Use of the MOC hardware and software to perform subsystem level testing that provides heritage for system lever testing and on-orbit operations*
- *Populate the MOC command and telemetry dictionaries and, thereby, maintaining a "one-common" database from subsystem and spacecraft testing to mission operations*
- *Generate telemetry display pages applicable for I&T and Mission Operations*
- *Generate common test scripts applicable for subsystem and spacecraft testing as-well-as initial on-orbit system checkout*
- *Spacecraft Specialists assisting subsystem teams and, thereby, becoming knowledgeable of subsystem operations prior to S/C testing*

Spacecraft Integration and Testing

Spacecraft will undergo three phases of Integration and Test

- *initial integration at APL*
- *environmental testing at APL and at NASA-GSFC*
- *field testing/launch at Vandenberg Air Force Base (VAFB)*

S/C "Integration" Test Configuration

Initial integration will be performed at APL Building-23 Rm-137 Clean Room and will consist of the following support areas:

- -- Integration Facility
- -- Mission Operations Center (MOC)
- -- Mission Data Center (MDC)
- -- Instrument Test Payload Operations Centers (Test POCs)
- -- Instrument Flight Payload Operations Centers (Flight POCs)

S/C level test equipment:

- -- Test conductor command/telemetry workstations
- -- Assistant test conductor backup command/telemetry monitor
- -- General purpose monitor
- -- System administration/data base management workstation
- -- Blockhouse control unit (BCU)
- -- Front end (bit and frame sync)

S/C subsystem GSE:

- -- S/C subsystem specific (power, RF, G&C, GPS)
- -- S/C subsystem telemetry monitors
- -- C&DH 1553 Bus monitor

Instrument test equipment:

- -- Instrument specific GSE
- -- Instrument command/telemetry workstations located at APL (Test POC)
- -- Instrument command/telemetry workstations located at PI institution (Flight POC)
- -- Instrument stand-alone GSE
  (Instrument GSE required to perform an instrument aliveness or functional test without being electrically interfaced to the spacecraft)

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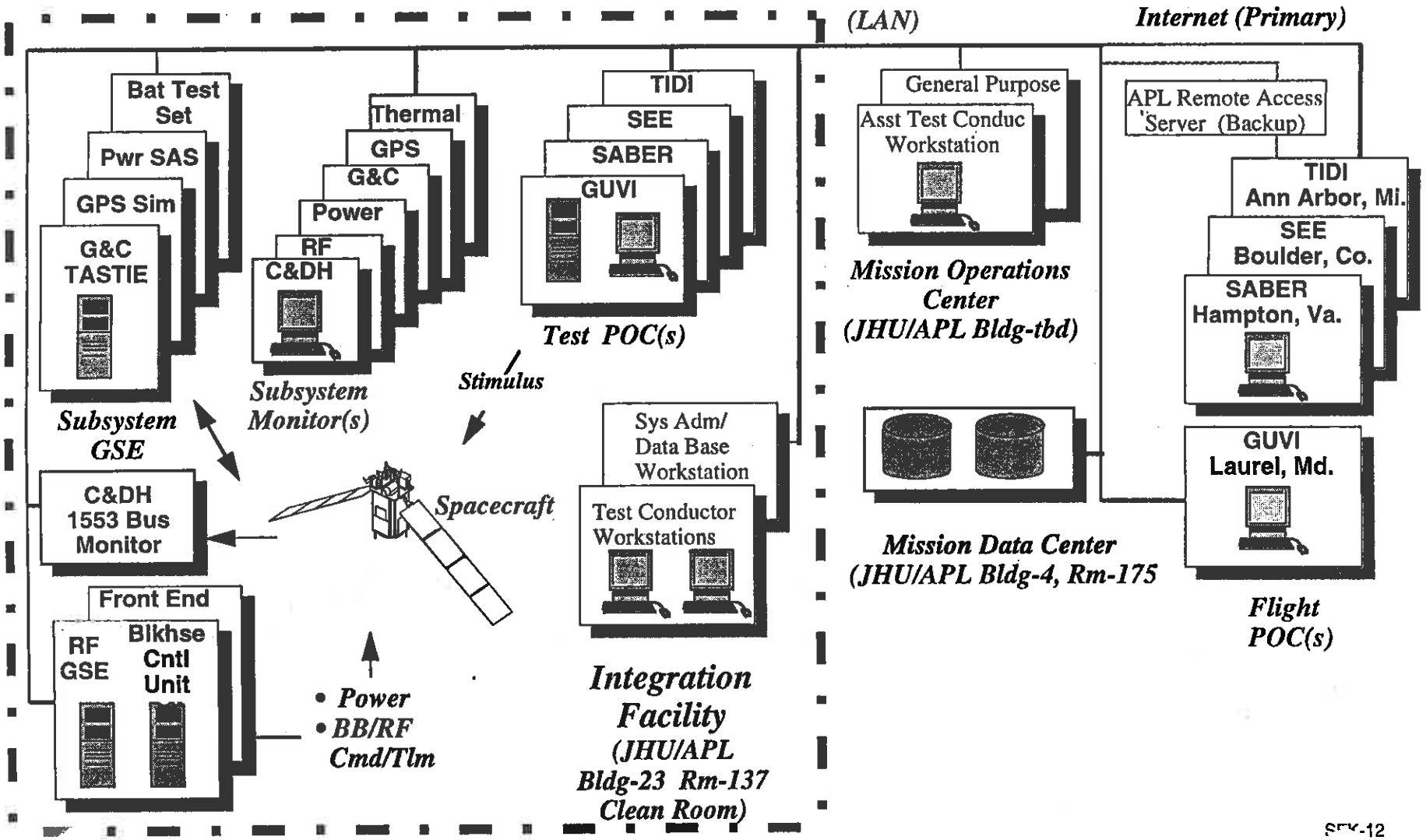
S/C "Integration" Test Configuration



S/C "Integration"

- Spacecraft integration will be performed in APL Building-23 Clean Room
- Integration procedures will verify safe-to- mate connections of subsystems and instruments to the spacecraft
- An instrument stand-alone test will be performed on each of the instruments prior to spacecraft integration
- A Pre-Integration Review will be conducted for each of the subsystems and instruments prior to spacecraft integration
- As part of the overall integration, a functional test of the subsystem or instrument will be performed
- Initial instrument integration will utilize the instrument "test" POC
- Specific test periods during spacecraft integration will be allocated to checkout of the instrument "flight" POC

Spacecraft "Field" Testing

- Equipment to be physically relocated to support remote facilities at GSFC and VAFB) testing:

  -- Assistant Test Conductor Backup command/telemetry workstation
  -- General purpose workstation
  -- Blockhouse Control Unit (BCU)
  -- Front end (Bit/frame sync)
  -- Thermal subsystem telemetry monitor
  -- S/C subsystem specific GSE
  (Power Battery Test Simulator and Solar Array Simulator, RF Control Unit, G&C TASTIE, GPS Simulator, C&DH 1553 Bus Monitor)
  -- Instrument specific GSE
  -- Instrument stand alone GSE

- Additional manpower must be provided for GSE support in the field if the requirement of remote controlling of GSE cannot be implemented.

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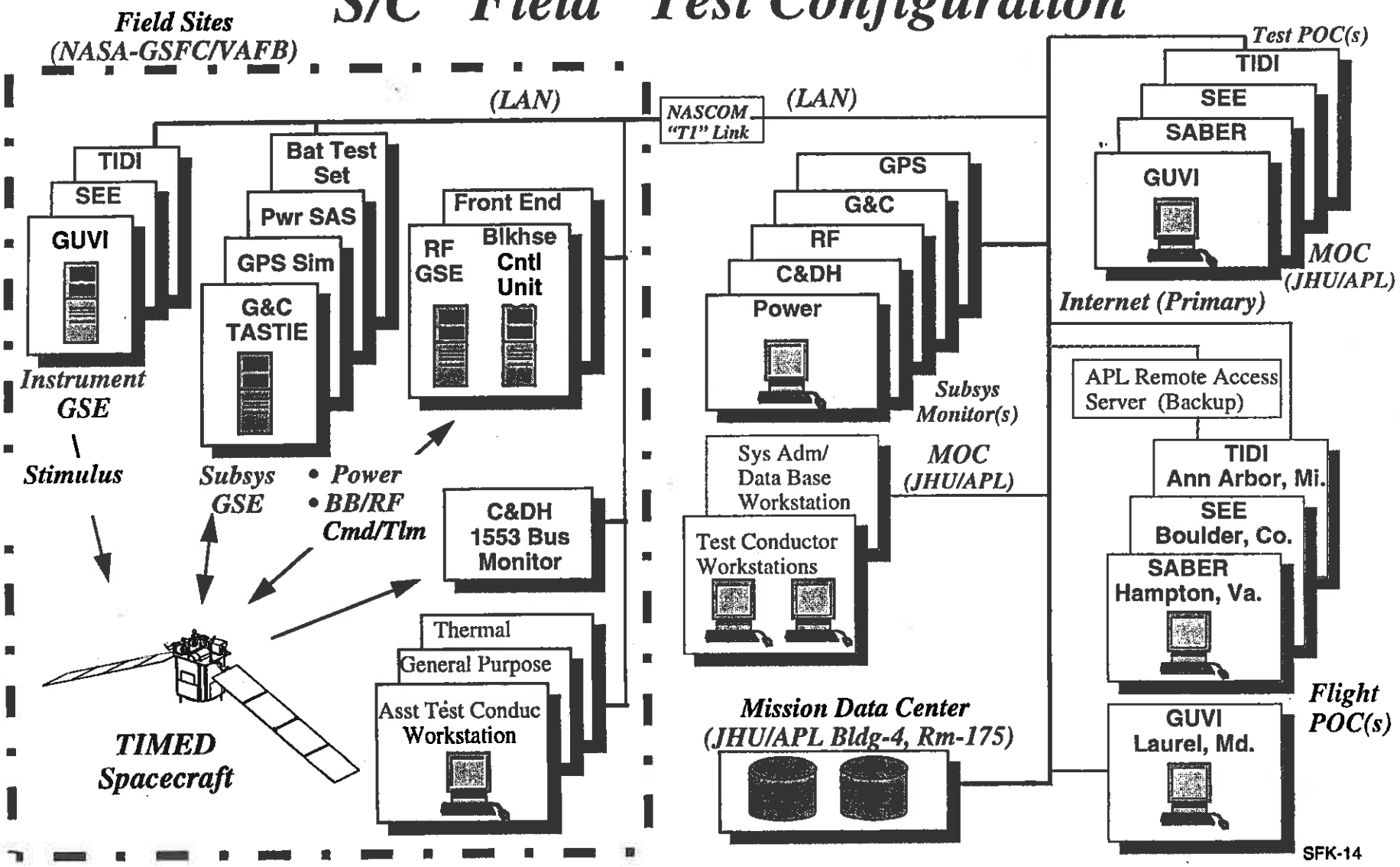
S/C "Field" Test Configuration



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Spacecraft "Field" Testing

- After spacecraft integration has been completed (and before the initial spacecraft performance test), the GSE will be reconfigured to a field/MOC layout at APL. This will allow for early resolutions of possible operations problems that might have been realized in the field.

- Specific pieces of ground support equipment will be physically relocated to the field sites

- All ground support equipment will have the capability of being remotely computer controlled

- All facilities (MOC, POCs, NASA-GSFC, VAFB) will be synchronized to Universal Time Coordinated (UTC) to within 1 second

- Ground Support System will log all C&DH 1553 bus monitor activities for a 24 hour period

- Remote facilities (Flight POCs, NASA-GSFC, VAFB) will be interconnected to the MOC via reliable data and voice communication links

S/C "Field" Testing (Cont.)

- Starting with the initial spacecraft performance test, all testing will be under the control of the S/C Test Conductor located in the Mission Operations Center at APL

- The Test Conductor's terminal (located at APL) and the Assistant Test Conductor's terminal (located at the field location) will have the capability to bring the entire S/C power-down in an orderly fashion. This also includes commanding the instruments to a safe condition prior to powering them off
  - •• Instruments will be required to internally initiate an instrument safing sequence after instrument safing command is issued

"Decoupled" Instrument Testing

- A "Test" Payload Operations Center (Test POC) capable of instrument commanding, telemetry display, automated testing and limited science data processing will be required for each of the instruments

- Starting with S/C-instrument integration, these Test POCs will be required to perform all instrument tests and be physically located in the general vicinity of the test conductor's console. The Test POCs will be staffed by instrument personnel.

→ • The POCs will provide the MOC with an ASCII output of their test scripts prior to test execution. These scripts will be annotated with line numbers. (Reference GIIS Paragraph 8.2.3.2, *Test Scripts*)

- The test conductor would not be able to command the instruments other than to send the instrument relay power "on/off" commands and initiate an instrument safing sequence

- The test conductor will have the means to enable/disable the individual instrument POC ground command link

→ **Denotes change since PDR**

"Decoupled" Instrument Testing (Cont.)

→ • The MOC will include instrument command status in its time tagged Event Log display. (Reference GIIS Paragraph 8.2.3.1, *Command Messages*)

• The only instrument telemetry available on the test conductor's monitor will be the instrument power relay "on/off" status, instrument current monitor reading, external instrument temperature monitors and a 64 bit instrument status word

• The MOC will have the ability to receive and display the instrument 64 bit status words whenever the instrument is powered. (Reference GIIS Paragraph 8.2.6.1, *Instrument Status Word Definitions*)

→ • During S/C I&T, the POC's will provide the MOC with alarm logs indicating any alarm that occurred during a test. These logs will be provided to the MOC after each test. (Reference GIIS Paragraph 8.2.3.3, *Alarm Log*)

→ Denotes change since PDR

"Decoupled" Instrument Testing (Cont.)

- For all instrument tests, instrument POCs will be required to process on-line, sufficient instrument science data acquired in the Mission Data Center to verify operation of the instrument.

- Instrument personnel will be responsible for maintaining a "Flight POC" located at the respective instrument facility. During S/C testing, specific test periods will be defined, whereby, a particular instrument Flight POC will take control over from the instrument Test POC and perform that particular instrument test. Confidence in the Flight POCs command capability, science data processing and voice communication link checkout will be increased

→ • Occasionally, time-merged spacecraft and instrument housekeeping data will be requested by the test conductor to initiate problem resolutions. The test conductor will inform the POCs of what type of housekeeping items need to be included in the log file: (Reference GIIS Paragraph 8.2.3.4, *Ad Hoc Housekeeping Log*)

→ **Denotes change since PDR**

"Decoupled" Instrument Testing (Cont.)

- If instrument time critical commands need to be executed from the instrument flight POCs, high reliability, high availability, uniform delay command and telemetry links will be required from the POCs to the MOC .
  - •• Minimize delays in testing
  - •• Meet latency requirements

  Note: The present link (command and data) between the SABER, SEE and TIDI flight POCs to the MOC is via Internet (primary) and modems (backup)

- Voice communication links between the flight POCs and the MOC will be via dial-up phone lines

- If it is deemed necessary to isolate a possible instrument problem anytime in the field (JHU-APL, NASA-GSFC or VAFB), instrument personnel and instrument ground equipment must be available to support an instrument stand-alone test

Spacecraft Electrical Tests

- **Functional Test**
- **Performance Test**
- **Spacecraft Special Test**
- **Spacecraft Mission Simulations**

- **Abbreviated Pad Functional Test**

Performance Test:

- **Verifies subsystem and system performance to specification values**
- **Much more in-depth testing of subsystems including software**
- **Meant to be a "extensive" test to verify spacecraft is working**
  - **Complete spacecraft performance test (including instrument performance tests) will take approximately 12 hours**
- **Performed at various times throughout the spacecraft test cycle, thereby, allowing for data comparison and trending from the initial spacecraft performance test**

Spacecraft Special Tests:

- **Performed periodically to search for signs of performance degradation**

Spacecraft Subsystem Special Tests:

- Low voltage trip point tests
- Battery Capacity
- IEM Contingency switch over test
- IEM/GPS time steps
- RF Watchdog Timer
- GNS reset command (reboot ~ 2 minutes)
- GNS sky search mode
- GNS automatic acquisition
- G&C reaction wheels spin down test
- G&C data structure loads and dumps
- Pyro firing test sequence
- System Test Pattern
- Autonomy
- Plugs Out
- Polarity Test of Attitude Sensors & Actuators

Instrument Special Tests:

- SABER Door Deployment
- SABER EMI Compatibility during S/C Thermal Vacuum test

Spacecraft Mission Simulations:

- **These tests will be in essence, a ground-based "orbital shakedown"**

Mission Simulations:

- **Separation Sequence**
  - **>> Attitude Capture**
  - **>> GPS acquisition sequence**
- **Sun safe**
- **Yaw maneuver**
- **Nadir Track**
- **Safe mode and recovery**
- **Event driven operations (e.g., terminator crossing)**
- **Contingency testing**
- **Nominal Daily Ground Contact**
- **Autonomous ground contact operation**

Abbreviated Pad Functional Test:

- **Due to the limited accessibility of the spacecraft through the Dual Payload Attach Fitting (DPAF), an abbreviated functional test will be performed on the launch pad.**

Note: Physical access to the instruments on the launch pad will not be available.

Spacecraft Integration & Initial Baseline Performance

Spacecraft Test Flow

Harness testing will consist of the 1st. harness ringout for continuity and shorts on the s/c mockup; harness bakeout; and a 2nd harness ringout for continuity and shorts on the s/c structure.

Before any flight hardware is installed on the spacecraft for integration and test, a Pre-Integration Review will be conducted to confirm that the following conditions have been met:

- All hardware has been approved for spacecraft level integration in accordance with individual specifications or requirements, including exposure to vibration and thermal-vacuum environments.
- All connectors have been labeled and proven compatible with APL drawings.
- All packages have been approved by the Spacecraft Mechanical Engineer for correctness of the envelope, mounting location and footprint.
- All pin allocations have been verified to agree with the system cable and harness assembly drawings.
- All subsystems/sensors requiring optical alignment have had optical cubes installed and mapped to the boresight.

Each component will inspected and cleaned prior to entering the cleanroom. It will then be weighed and have bonding measurements made prior to harness connection.
Bonding shall comply with the requirements of MIL-B-5087B.
A maximum bonding resistance of 2.5 milliohms will be maintained.

Each subsystem and instrument will be tested as identified in the test plan and by detailed integration procedures and computerized scripts.

Spacecraft Environmental Test Flow

Spacecraft Environmental Test Flow

The Modal Survey Test verifies that the spacecraft structure meets the design requirements for stiffness. Accelerometers are placed around the spacecraft and monitored while the structure is excited with a small shaker. The result of exciting the spacecraft will be compared to the analytical model. The spacecraft will be unpowered for this test.

Spacecraft three (3) axis sinusoidal vibration testing will be conducted at the APL Vibration Laboratory. The spacecraft will be powered in the launch mode for each of the axis of vibration.

The shock and separation tests will be conducted at the APL Vibration Laboratory. The spacecraft deployment devices will be fired twice. The spacecraft will be powered in the launch mode for these tests.

For the PAF/S-C Separation Test, Boeing personnel shall attach the PAF, and install and arm the separation system pyros. Boeing will manually fire the separation pyros while the spacecraft is being monitored for all telemetered separation indicators by the Spacecraft MOC personnel.

Spacecraft functional electrical tests will be performed after each environmental exposure. Functional testing confirms the spacecraft meets its functional requirements for all prime and redundant components with limited performance measurements. An automated script will configure the spacecraft for selected modes (primary/redundant/cross-strap) and verify performance of subsystems and instruments during these various test modes.

Spacecraft Field Testing & Launch Operations

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Field Test Flow

TIMED S/C & TIMED GSE Arrival at VAFB

TIMED S/C
- Off load spacecraft and place in NASA Bldg-1610 Clean Room
- Uncan
- Install on work stand
- Unbag & inspect
- Setup local GSE
- Setup purge
- Checkout communications

TIMED GSE
- Off load GSE @NASA Bldg-1610
- Setup and checkout field GSE
- Field GSE to MOC comm and data links verification
- Verify ground software operation

General
- Begin APL daily meetings

TIMED S/C Initial Operations & Optical Alignment Verification

- Install the SEE Instrument EUV Grating Spectrograph
- Remap SEE Instrument EGS to SEE Platform
- Optical Alignment verification
  - Spacecraft coordinates remapped into master optical cube
  - Instrument cubes/boresights remapped into master cube
  - Guidance and control devices remapped into spacecraft coordinates
- Start battery reeconditioning (~3 days)
- Initial S/C power up
- RF health physics checks (NASA VAFB health physics officer will be requested to witness)

TIMED S/C Electrical Performance Test

- Spacecraft FIELD Electrical Performance Test consisting of
  - -- S/C Functional Tests
  - -- S/C Performance Tests
  - -- S/C Mission Simulations
  - -- S/C Special Tests

TIMED Spacecraft Located in the VAFB-NASA Bldg-1610 Facility

Field Test Flow

Mission Integration Readiness Tests (MIRT) will be conducted to verify all communications required to support the launch are in place. A minimum of one of these test will require the spacecraft in the loop.

Mission Operations Readiness Demonstration (MORD) will demonstrate the Mission Operations capability to perform the spacecraft count-down, launch and flight operations.

Solar panels will be installed and a flood light test performed to verify panel operations.

During the flight build, the EED's will be tested and installed. All spacecraft ordnance devices are Category B. Installation of these devices will be performed under proper controls and procedures.

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Field Test Flow

TIMED S/C MIRT & MORD Tests

- Mission Integration Readiness Test (MIRT)
  - Verify all communications required to support the launch are in place
- Mission Operations Readiness Demonstration (MORD)
  - Simulate countdown, launch and separation
  - Simulate flight operations for 1 day.

TIMED S/C Flight Build

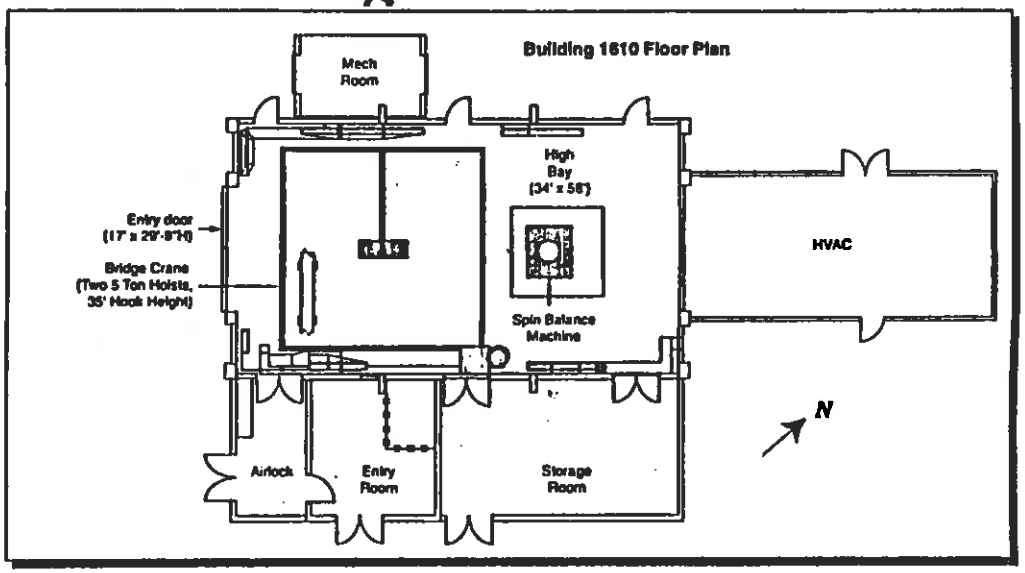
- SEE Instrument GSE Vacuum Ion Pump (VIP) removed and SEE-EGS backfilled with GN_2
- SEE Instrument activate launch lock mechanism
- SEE Instrument HV & Vacuum Door Arming plug installed
- Perform SA flood lamp test (using SA adapter cables)
- Install solar panels
- Alignment verification
- Install ordnance devices; Safe Pyro Plug installed
- S/C cleaning; level 750
- Final blanket dressing
- Final Inspection
- Red tag removal
- Closeout photographs
- Double bag TIMED Spacecraft
- Place TIMED S/C into APL shipping container
- Maintain purge

TIMED GSE Relocated

- Relocate required GSE to SLC-2W EEB and NASA Bldg-836
- Checkout links
  - Bldg-836 to EEB
- Checkout pad wiring
  - SLC-2W EEB to L/V Umbilical Connectors

TIMED Spacecraft Located in the VAFB-NASA Bldg-1610 Facility

Boeing DPAF Operations-Bldg 1610



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Field Test Flow

JASON-1 S/C Propulsion Loading Bldg-1610

JASON-1 S/C
- JASON-1 S/C placed in shipping container @ NASA Bldg-836
- JASON-1 S/C transported from NASA Bldg-836 to NASA-Bldg-1610
- Off load JASON-1 spacecraft and place in NASA Bldg-1610 Clean Room with TIMED S/C
- Uncan JASON-1 S/C
- Install on work stand
- Unbag & inspect
- Setup local GSE
- Proceed with JASON-1 propulsion loading
- Obtain S/C flight weight

Maintain TIMED S/C Bldg-1610

TIMED S/C
- Maintain purge

Boeing Dual Payload Attach Fitting (DPAF) Operations Bldg-1610 (T-16->T-12 days)

TIMED S/C Operations
- Remove S/C from APL shipping container
- TIMED S/C flight battery reconditioning(~3 days)
- Obtain S/C flight weight
- Boeing to install lower flight PAF and clamp-band
- Post S/C PAF installation RF Nadir antennas electrical checkout (minimum RF-GSE required)
- Remove s/c double bag
- Maintain purge and battery charging

JASON-1 S/C Operations
- Boeing to install upper flight PAF and clamp-band
- Maintain battery charging

Boeing DPAF Operations
- Mate TIMED S/C lower PAF to lower cone of DPAF
- Mate DPAF upper cone/cyclinder
- Install separation system
- Mate JASON-1 S/C upper PAF to DPAF
- Install JASON-1 and TIMED L/Vumbilical wire harnesses
- Install Direct Mate Adapter (DMA)
- Install handling can sections
- Hook-up GN_2 to handling can
- Install road cover (baggie)

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Spacecraft Environmental Test Flow

EMC Testing
- Launch Pad "Abbr. Functional Test"Configuration
- S/C "Coast" (Plugs Out) Configuration Test

- Launch Pad Abbr. Functional Test
  - S/C mounted on Vibration Table (w/solar panels installed)
  - S/C powered through umbilical connector(s)
  - Baseband uplink and downlink
  - S/C Pad Abbr. Functional Test performed
- S/C "Coast" Configuration Test
  - S/C re-located to APL clean room high-bay
  - S/C mounted on spacecraft dolly (w/solar panels installed)
  - S/C "plugs out" test (with s/c isolated from any signal or ground paths via GSE)
  - S/C operating on battery power
  - Verify s/c communication uplink and downlink via RF links
  - Verify acquisition of RF GPS L1 link

Pack & Ship (to NASA-GSFC)

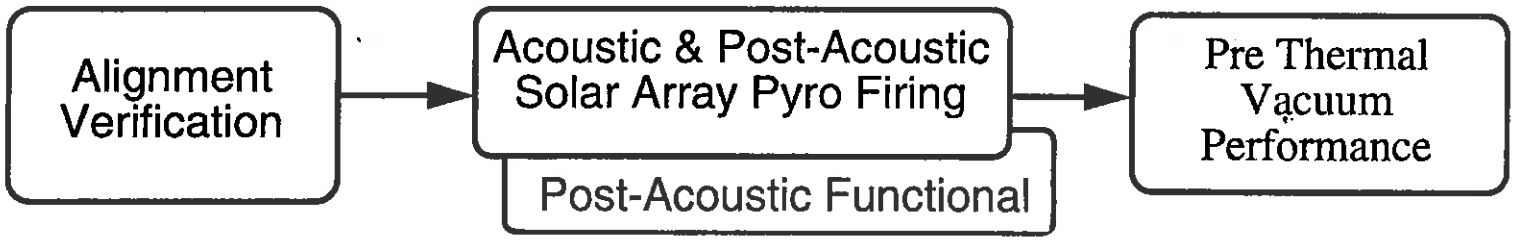
- S/C will be shipped with solar arrays and thermal blankets
- Discharge flight battery
- SEE Instrument GSE Vacuum Ion Pump (VIP) removed and SEE-EGS backfilled with GN_2
- Bag spacecraft
- Place S/C in APL shipping container
- Arrangements for shipping will comply with the provisions established in the TIMED Transportation Plan

Pre Acoustics Functional (*)

- Remove S/C from TIMED shipping container
- S/C will remain bagged
- Charge flight battery
- Pre-Acoustic Functional Test
- Flight build
  - Install flight pyros and arming plug per approved procedures
- SEE Instrument GSE Vacuum Ion Pump (VIP) removed and SEE-EGS backfilled with GN_2
- SEE Instrument activate launch lock mechanism

(*) To be conducted at NASA-GSFC Facility

Spacecraft Environmental Test Flow



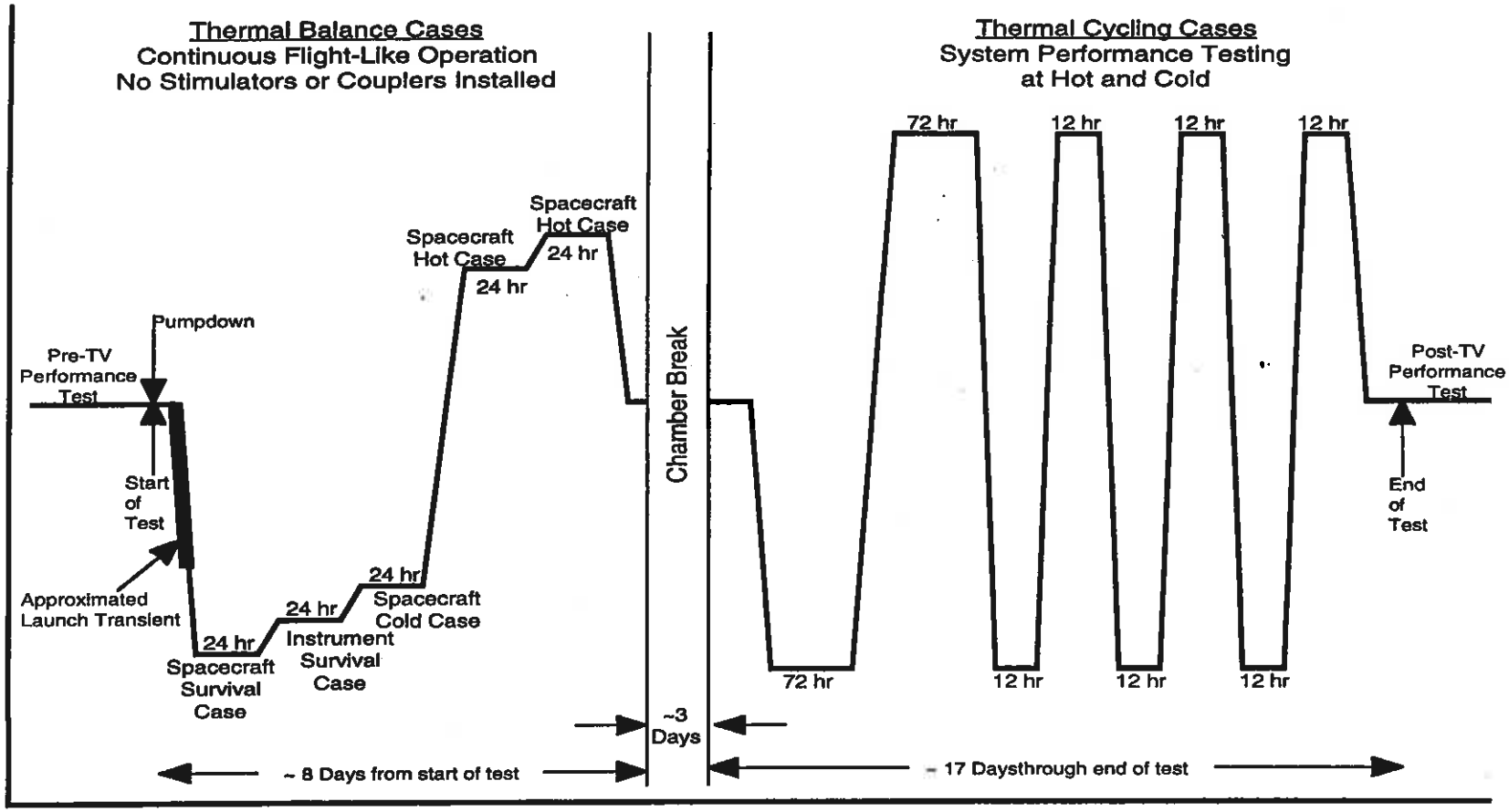
- Optical Alignment Verification
  - Spacecraft coordinates remapped into master optical cube
  - Instrument cubes/boresights remapped into master cube
  - Guidance and control devices remapped into spacecraft coordinates

All of the above tests to be conducted at NASA-GSFC Facility

- SEE Instrument GSE Vacuum Ion Pump (VIP) removed and SEE-EGS backfilled with GN_2
- SEE Instrument activate launch lock mechanism
- Arming plug installed
- S/C powered and configured for launch mode
- Protoflight acoustic levels +3dB above predicted launch vehicle levels,one minute duration
- Solar Array pryros fired, only
- Remove fired and unfired pyros
- Inspect spacecraft
- Post Acoustic Functional Test
- Remove Solar Arrays
- Thermal blankets will remain on s/c

- A pre- and post-thermal vacuum electrical performance test will be performed to verify non-degradation of spacecraft performance due to the thermal vacuum environment exposure.
- After completion of the pre-thermal vacuum electrical performance test, the TIDI Instrument radiator will be installed (bench cooler removed). There is no requirement to re-install the bench cooler to support TIDI field tests.

TIMED Spacecraft Thermal Vacuum Test Profile

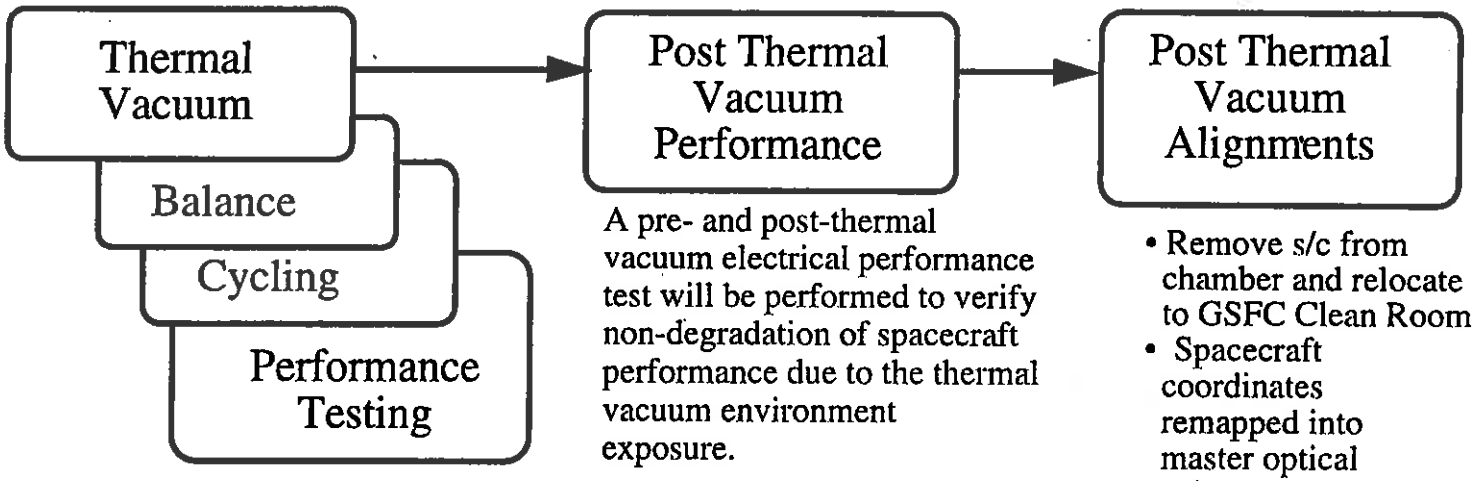


Tests will be performed during spacecraft thermal vacuum to include:

- performance of the spacecraft during pump down (baseband telemetry, only)
- execution of the launch vehicle separation sequence
- performance of the thermal and power system at both full sun and maximum eclipsed orbits
- performance of the thermal system at spacecraft survival conditions
- electrical performance of the spacecraft subsystems and instruments while cycling temperatures to hot and cold levels by running a full spacecraft performance test at the hot and cold temperatures.

SFK-36T

Spacecraft Environmental Test Flow



- Reference text page for T.V. test profile
- Chamber will be pumped down and thermal balance test will commence
- After thermal balance, chamber will be returned to ambient and spacecraft thermal blankets removed
- Chamber will then be pumped down, again, and thermal cycling phase will be initiated

A pre- and post-thermal vacuum electrical performance test will be performed to verify non-degradation of spacecraft performance due to the thermal vacuum environment exposure.

- Remove s/c from chamber and relocate to GSFC Clean Room
- Spacecraft coordinates remapped into master optical cube
- Instrument cubes/ boresights remapped into master cube
- Guidance and control devices remapped into spacecraft coordinates

All of the above tests to be conducted at NASA-GSFC Facility

Spacecraft Test Flow *(Cont.)*

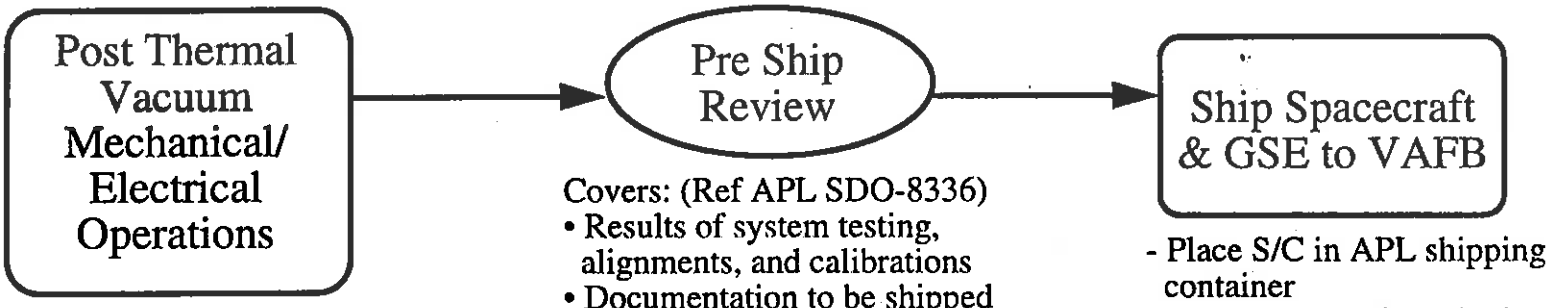
The flight battery will be discharged prior to shipping the spacecraft to VAFB.

The SEE Instrument EUV Grating Spectrograph will be removed from the spacecraft and sent to the NIST Facility for calibration. The calibration is expected to take from 7 to 10 days. This unit will be reintegrated prior to spacecraft performance testing at VAFB.

All test discrepancies and anomalies must be resolved by the Test Review Board and results presented to the TIMED Program Management and the Sponsor. The Sponsor shall provide the consent to ship.

The spacecraft shall be maintained at an ambient environment with nitrogen purges in place and the TIMED Contamination Control Plan in effect until the consent to ship is given.

Spacecraft Environmental Test Flow



- Discharge flight battery
- Remove SEE Instrument EUV Grating Spectrograph for calibration at NIST
- Double bag s/c

Covers: (Ref APL SDO-8336)

- Results of system testing, alignments, and calibrations
- Documentation to be shipped with unit
- Review all discrepancies and anomalies, waivers and deviations
- Field operation and post-launch plans
- Range documention sign-off completed
- Sponsor required to provide consent to ship

- Place S/C in APL shipping container
- Arrangements for shipping will comply with the provisions established in the APL Transportation Plan

The above test and operations will be conducted at NASA-GSFC Facility

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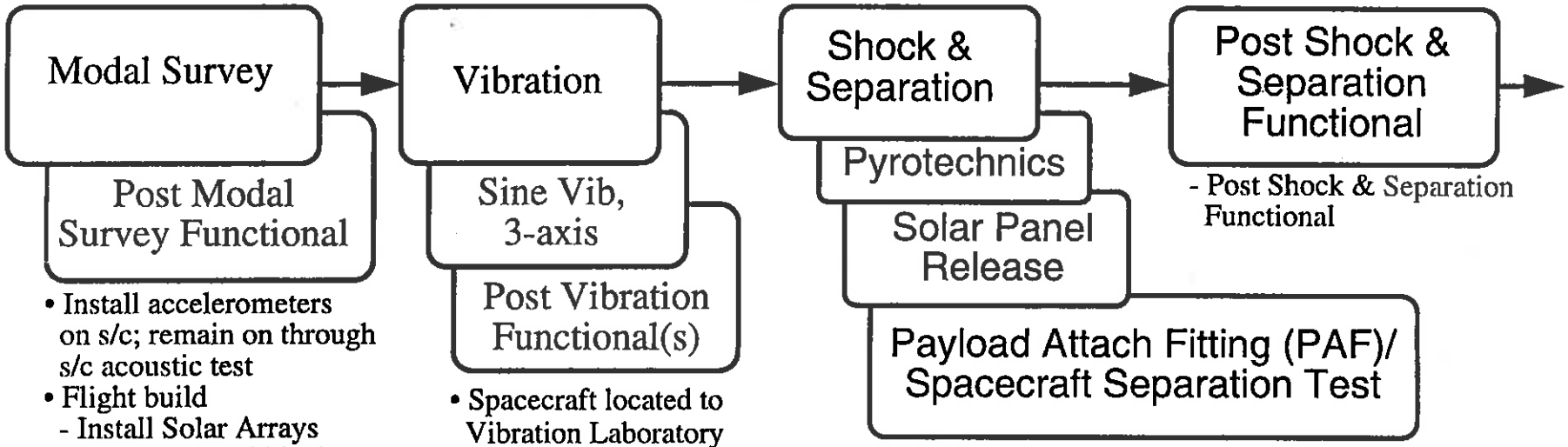
Spacecraft Environmental Test Flow



- Post Shock & Separation Functional

- Install accelerometers on s/c; remain on through s/c acoustic test
- Flight build
  - Install Solar Arrays
  - Install thermal blankets
- Perform Modal Survey **(s/c unpowered)**
- Post Modal Survey Functional Test

- Spacecraft located to Vibration Laboratory
- SEE Instrument GSE Vacuum Ion Pump (VIP) removed and SEE-EGS backfilled with GN_2
- SEE Instrument activate launch lock mechanism
- Spacecraft will be powered in the **launch mode** for each of the axis of vibration
- Post Vibration Axis Functional Test

- Tests verify s/c will survive all pyro related events
- Pyros and arming plug installed
- S/C will be powered in the **launch mode**
- Separation sequence performed
- Pyro deployment devices will be **fired twice**

(Note: S/C solar arrays and instrument covers will be secured during instrument pyro firings)

Spacecraft Environmental Test Flow

EMC Test

S/C EMC Test will consist of the following two (2) spacecraft configuration tests in accordance with TIMED EMC Control Plan (7363-9038):

- Launch Pad "Functional Test" Configuration
- S/C "Coast" (Plugs Out) Configuration

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Instrument Integration Flow

Instrument Pre-Ship Review

Instrument Pre-Ship Review:
- Mechanical Interfaces
  - Reporting weight
- Alignment Requirements
- Contamination Requirements
- Electrical Interfaces
  - Harness wiring review
  - Grounding & isolation checks
  - Commands & telemetry
  - Alarm limits
  - Final power budget
- GSE/GSS & GSE/S-C interfaces
- Software
- Procedures
  - Mechanical & electrical
- Hazardous procedures & related safety issues
- Instrument test summary
  - Including total burn-in hours
- Reliability
  - Problem reports and resolutions
  - Waivers
- Log of number of hours instrument was powered on during acceptance testing. (Goal of 250 hours prior to launch)
- Special Handling & Operational Requirements
- Simulator Requirements & Operations

Instrument Pre-Integration Readiness Meeting

- This meeting is to close the loop with the integration team on items covered in the Pre-Ship Review

Instrument Stand-Alone Functional Test

- Stand-alone instrument functional test using instrument GSE

Spacecraft Instrument Harness Verification

- Voltage distribution
- Ground verification
- Signal (1553 Bus) verification

Instrument Integration & Functional Test

- Mechanical installation
  - Weight & bonding
- Instrument intra-harness mating
- Continuity/isolation checks into instrument (w/flight intra-harness mated)
- Spacecraft harness mating
- Instrument initial power up
- Instrument functional test performed from TEST POC and using instrument GSE, if needed

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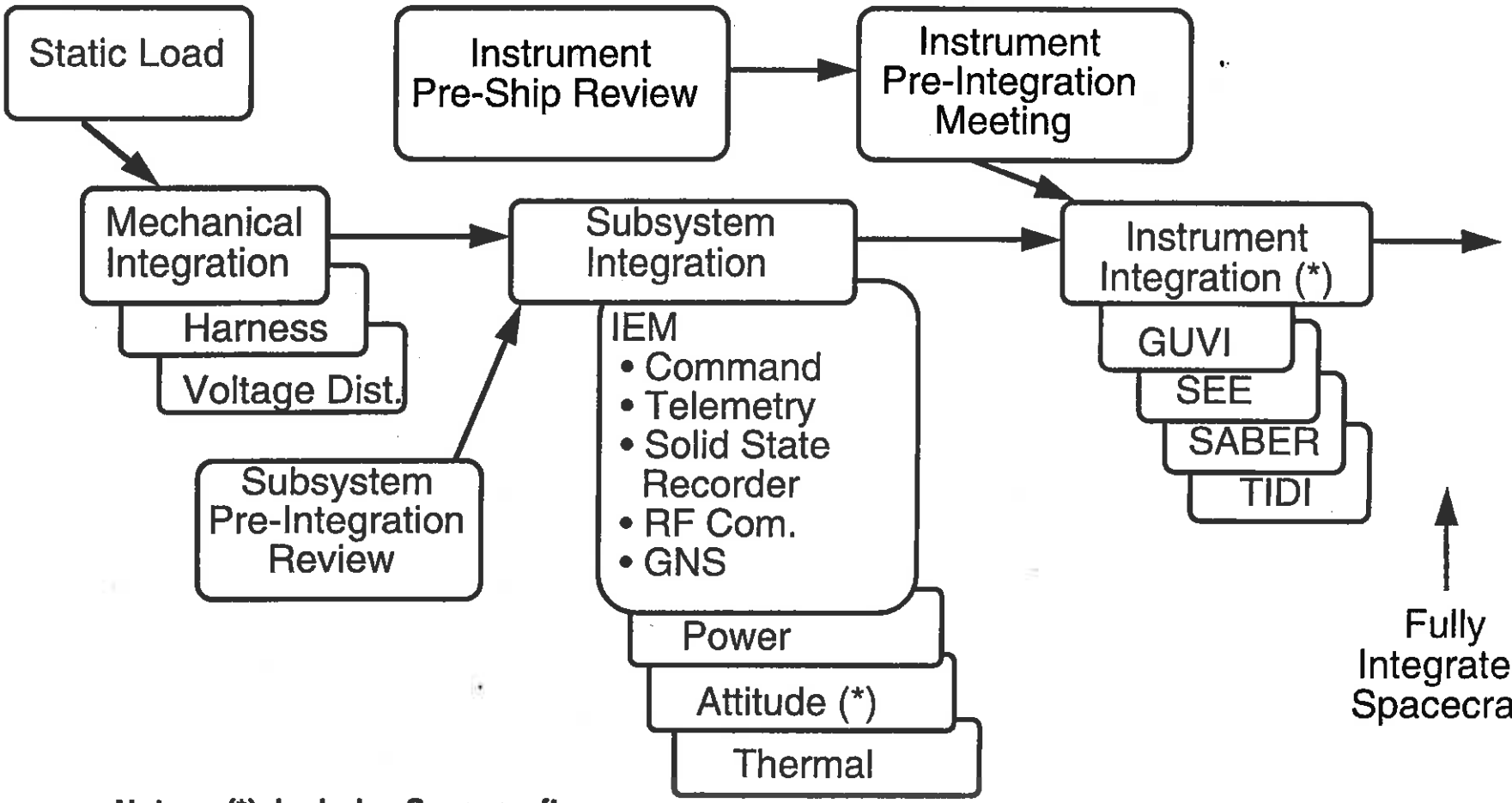
Spacecraft Integration

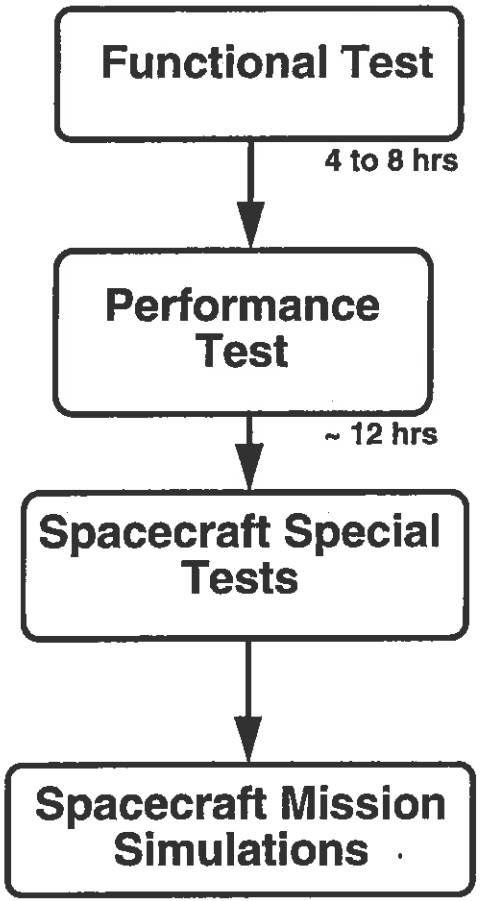


Notes: (*) Includes Spacecraft Alignment, as required

Functional Test:

- **Tests operation of every component on spacecraft**
- **Tests interfaces to other components**
- **Tests redundant components and cross-strapping**
- **Meant to be a "quick" test to verify spacecraft is working**
  - **Complete spacecraft functional test (including instrument functionals) will take approximately 4 to 8 hours**
- **Run routinely before and after a major environment test**

Spacecraft Electrical Tests



-- Verifies the spacecraft system operates properly
-- Nominal condition test which will not attempt to subject the spacecraft to a wide range of test conditions
-- Run routinely before and after a major environment test

-- Designed to verify performance specification parameters
-- Will test the spacecraft to specification extremes under a wide range of scenarios designed to simulate on-orbit conditions

-- Verifies the proper performance of a subsystem element or to collect data for the express purpose of evaluating performance
-- These tests will be run individually
-- Performed periodically to search for signs of functional degradation

-- These tests will be in essence, a ground-based "orbital shakedown
-- Will demonstrate conditions analogous to the most comprehensive conditions spacecraft will experience in orbit

Spacecraft Test Flow *(Cont.)*

During the S/W and H/W I/F verification testing, all phases of software will be exercised (e.g., autonomy functions, memory loads and dumps, alarm settings) with special emphasis on autonomy functions.
Software testing is an on-going activity and not a stand-alone test such as a hardware unit.

The Mission Operations personnel will utilize this opportunity for training and conduct of their procedures in preparation of spacecraft control and launch.

Prior to the initial baseline performance test, the flight battery will be installed.

Baseline Performance will consist of extensive testing of each subsystem and instrument. Included in the s/c initial performance test will be subsets of the following test segments:

- s/c functional test which tests the s/c in the primary, secondary and cross strap configurations;
- performance test which verifies system performance to specification values;
- mission operational scenarios (e.g., yaw maneuver, event driven operations);
- spacecraft special tests.

Optical alignments will take place after the baseline performance test. Optical alignments and mapping will take place during non-test periods.

A Pre-Environmental Review will follow the successful completion of the Baseline Performance test.

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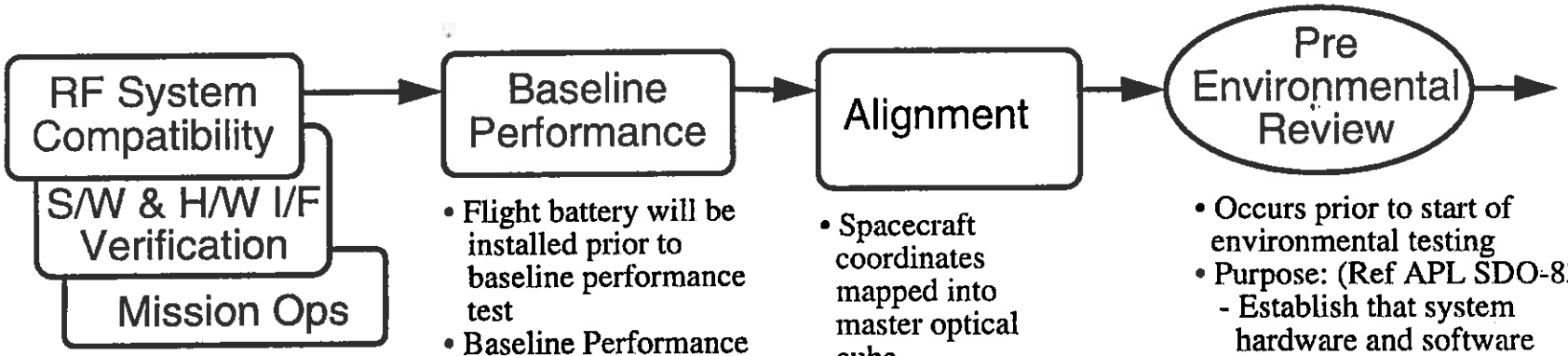
Spacecraft Test Flow



RF Compatibility
- Prime "APL" station compatibility
- Backup/contingency ground station compatibility

- Flight battery will be installed prior to baseline performance test
- Baseline Performance consists of
  - Functional Test
  - Performance Test
  - Mission Simulations
  - Special Tests

- Spacecraft coordinates mapped into master optical cube
- Instrument cubes/ boresights mapped into master cube
- Guidance and control devices mapped into spacecraft coordinates

- Occurs prior to start of environmental testing
- Purpose: (Ref APL SDO-8336)
  - Establish that system hardware and software are ready for test
  - Evaluate the plans and procedures for system level environmental testing and calibration
- Facility Review
- Transportation & Logistics

Fully Operational Spacecraft

Field Test Flow

The TIMED Spacecraft tare list will have the red tag items not removed from the spacecraft as well as the flight items not on the spacecraft.

The TIMED Spacecraft umbilical interface will be checked out and spacecraft aliveness checks performed prior to S/C "Abbreviated" Functional Testing.

Prior to performing any radiated RF spacecraft tests, VAFB Range Control will be notified and a clearance requested for the time in question.

Field Test Flow

Mate with Delta 2nd Stage & Electrical Interface Verification (SLC-2W) (T-10 Day)

- Boeing transports handling can (w/dual s/c assembly) to pad
- Boeing lifts handling can (w/ dual s/c assembly) to White Room
- Boeing performs mating operations
- Boeing removes handling can
- Begin TIMED S/C continuous purge and trickle charge from SLC-2W EEB
- TIMED S/C Electrical Interface Verification
  -- Baseband commanding
  -- Baseband telemetry
  -- RF link checkout, if required.
- TIMED S/C electrical aliveness test

TIMED S/C "Abbreviated" Pad Functional Test (SLC-2W) (T-9->T-8 Days)

- Perform TIMED S/C "Abbreviated" Pad Functional Test
  Note:
  Due to the **DPAF**, limited pad access to flight components will prohibit the performance of a full functional test
- Configure/verify instrument mechanisms requiring caging during launch have been completed.

Spacecraft & Launch Vehicle Integrated Tests (SLC-2W) (T-6 Day)

LV Stray Voltage Checkout
(Both S/Cs powered)

- LVFlight program verification
- Spacecrafts in launch mode (T-4 min)
- Stray voltage test
- Abort/Recycle Test
- Any combined test with the launch vehicle to demonstrate readiness will be supported by the spacecrafts

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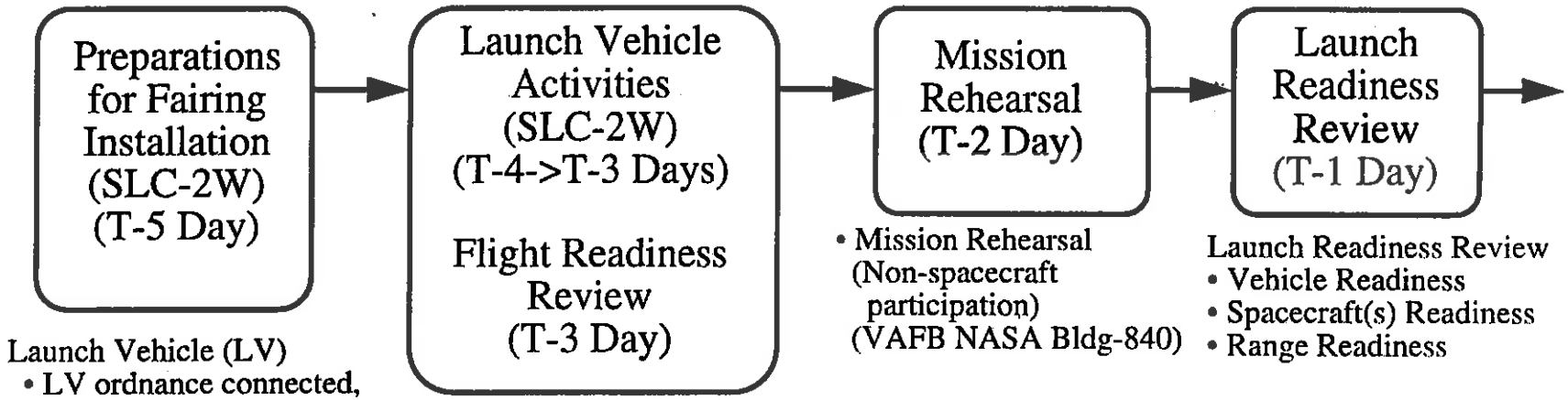
Field Test Flow



Launch Vehicle (LV)
- LV ordnance connected, limited pad access

Launch Vehicle
- Install L/V fairing (T-4 Day)
- L/V Propulsion Preps (T-3 Day)

Flight Readiness Review (T-3Day)

- Mission Rehearsal (Non-spacecraft participation) (VAFB NASA Bldg-840)

Launch Readiness Review
- Vehicle Readiness
- Spacecraft(s) Readiness
- Range Readiness

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Field Test Flow

TIMED S/C Final Operations (SLC-2W) (T-1 day)

- Install flight arming plug
- Final red tag removal

Launch (SLC-2W) (T-0 day)

- All TIMED S/C launch operations to be controlled from the APL-MOC, Laurel, Md.
- Power up s/c (~T-10 hours)
- Load and dump memories
- Configure to launch mode
- Terminal Count (T-4 minutes)
  - Internal (battery) power @ T-3.5 minutes
  - Disable baseband commanding/telemetry @ T-30 seconds

Post Launch Operations (L+1->L+5 Days)

- Mission Operations Director at APL will conduct mission
- System personnel in the field will support MOC personnel for ~2 days after launch
- Disconnect all GSE and blockhouse equipment
- Pack

Ship GSE to APL

- Ship all APL GSE items to APL MOC

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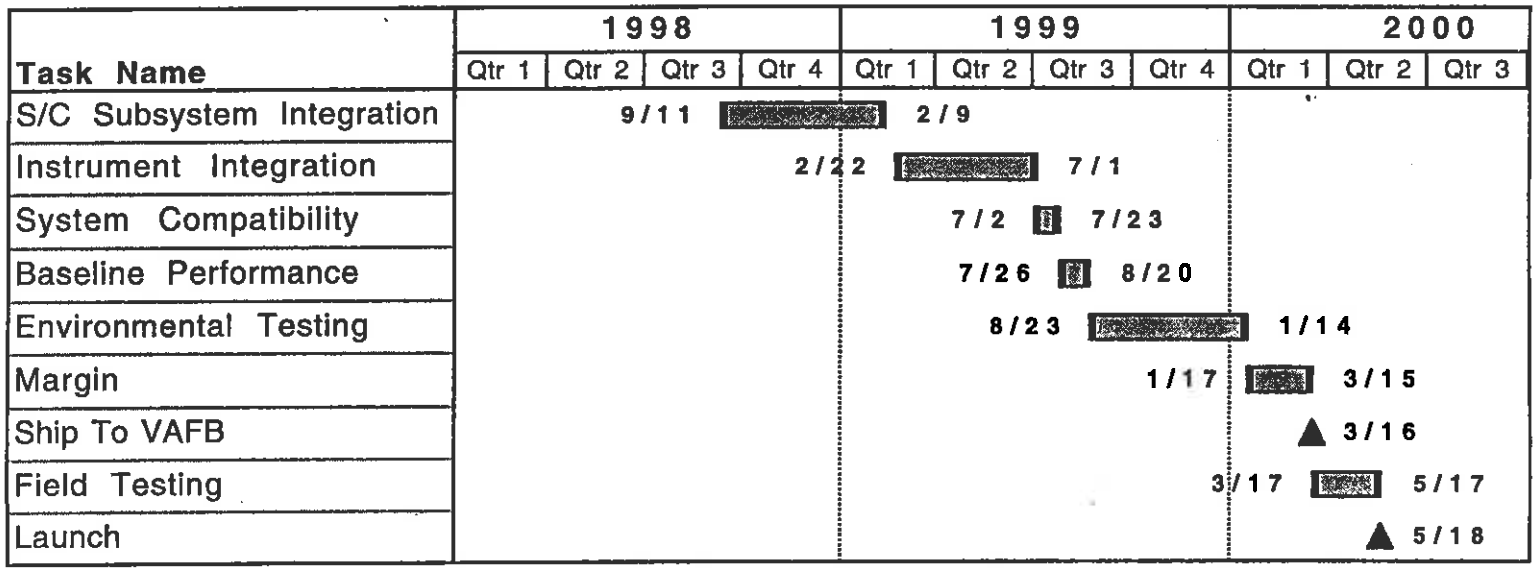
TIMED Integration & Test Schedule



Notes: 1.) The above schedule is based on one 8 hour shift/day and 5 days/week.
2.) Sufficient manpower has been allocated to support two extended shifts/day or three normal shifts/day. This additional manpower will be required to support various spacecraft environmental tests (e.g., S/C Thermal Vacuum)

Documentation

- Spacecraft I&T
- Environmental Testing
- Field Testing
- Range

Spacecraft I&T Required Documentation

- **Spacecraft Harness Wire List**
- **S/C Harness Checkout Procedure**

- **Ground Support Equipment (GSE) Drawings**
- **MOC/POCs Checkout Test Procedures**
- **GSE/S-C Umbilical Interface Checkout Test Procedure**

- **Spacecraft Integration Procedures**
  - **Subsystem Integration Procedures**
  - **Instrument Integration Procedures**

- **Flight Battery Installation, Conditioning & Maintenance Procedures**
- **Ordnance Stray Voltage/Bridge Wire Resistance and Arming Procedures**

- **Subsystem Performance/Functional Procedures**
- **Instruments Performance/Functional Procedures**
- **Spacecraft Performance/Functional/Special Tests Procedures**

Spacecraft I&T Required Documentation

- **System Compatiblity Tests**
  - **RF System Compatibility Procedures**
  - **Autonomy Rules Checkout Procedures**
  - **Spacecraft Contingency Checkout Procedures**
  - **Mission Operations Procedures**
- **S/C Alignment Procedure**
- **Mechanical Handling Procedure**

Spacecraft Environmental Testing Required Documentation

For Environmental Tests at APL

- **Modal Survey Procedure**
- **Spacecraft Vibration Procedure**
- **Shock & Separation Procedures**
- **Payload Attach Fitting (PAF)/Spacecraft Separation Test**
- **EMC Tests Procedure**
  - **Launch Pad Abbreviated Functional**
  - **S/C Coast Configuration**

For Environmental Tests at NASA-GSFC

- **NASA-GSFC Technical Interface Requirements Document (TIRDOC)**
- **Transportation Plan (APL to NASA-GSFC)**
- **Mechanical Handling Plan (for NASA-GSFC)**
- **Initial Operations Procedure**
  - **Field to MOC Data/Voice Communication Checkout Procedure**
- **Acoustic Procedure**
- **Thermal Vacuum Procedure**

Spacecraft Field Testing Required Documentation

- Launch Site Operations Test Plan (LSTP)
- Transportation Plan (NASA-GSFC to VAFB)
- Initial Operations Procedure
  - Field to MOC Data and Voice Communication Checkout Procedure
  - Initial Spacecraft Operations Procedure
    - -- RF Health Physics Check Procedure
- Mission Integration Readiness Procedure
- Mission Operations Readiness Demonstration (MORD) Procedure
- Integrated Launch Count Procedure
  - Abort/Recycle Contingency
- Solar Array Flood Light Test Procedure
- Ordnance Installation Procedures
- Power-On Stray Voltage & Arming Procedure
- GSE Pad Checkout Procedure
- S/C Abbreviated Functional Test
- Flight Readiness Review (FRR)
- Integrated Launch Count Procedure
  - Abort/Recycle Contingency

Range Documentation

Range Documentation

The Universal Documentation System (UDS) is used to formally document requesting agency program support requirements and support agency capabilities and commitments to support those requirements. The UDS provides for the three levels of user and support agency documentation.

PI (Program Introduction)

The PI is the initial planning document that officially introduces a program to the 30th Space Wing (30SW) at Vandenberg Air Force Base. It establishes the scope and support activity for a specific program..

- Prepared in UDS format by James L. Johnson, JHU/APL (with assistance from J. Demko/ NASA KSC VLS and J. Pimental/Space Mark, Inc.(SMI))
- Approved and submitted by NASA GSFC Payload Project Mgr., John J. Wolff to NASA KSC VLS Resident Mgr., Lawrence F. Kruse
- Approved and transmitted by NASA KSC VLS Resident Mgr. to Western Range 30SW/XPR

SC (Statement of Capability)

The SC is the formal response to the PI and is written by 30SW/XPR. When signed by the 30SW Commander, the SC is evidence that a program has been accepted by the 30SW. The PI and the SC compliment each other in establishing the scope of the program support activity, and together, form a basic agreement between the Western Range user and the 30SW as a guide for more detailed planning.

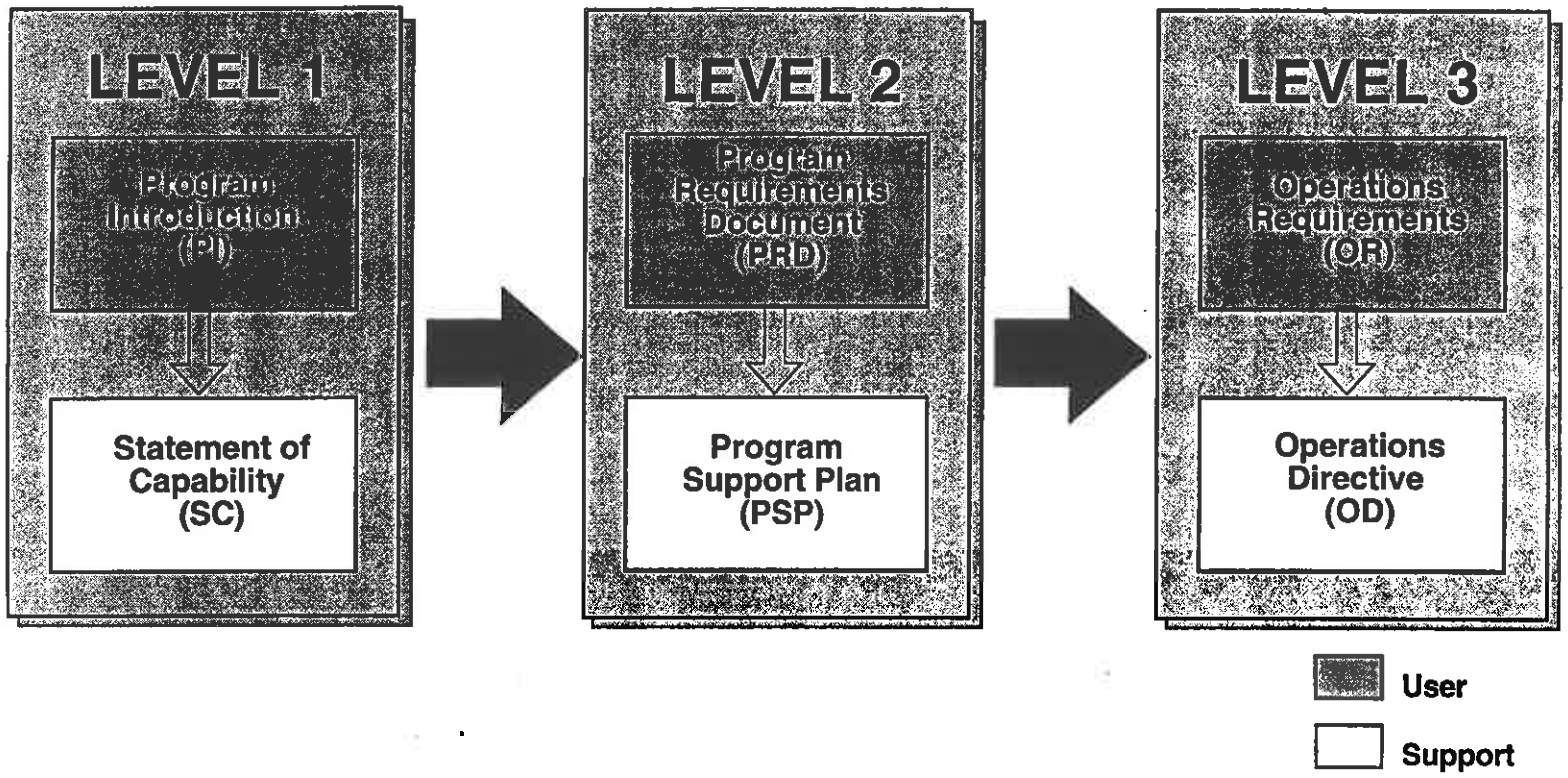
- 30SW/PR will publish PI and SC combined document.
- 30SW Commander will send a letter to John J. Wolff, NASA GSFC issuing the PI/SC.

PRD (Program Requirements Document)

The PRD is the official means for NASA to task the Western Range for mission support. The PRD identifies, in UDS format, the capabilities that the Western Range must have, or obtain, to support the prelaunch and launch operations for the program. The PRD should be submitted to the Western Range in sufficient time and detail to allow for planning and budgeting for any needed resources.

- The NASA GSFC Payload Project, and JHU/APL (with assistance from NASA KSC VLS and SMI) should begin preparation of the Payload PRD approximately 18 months prior to the TIMED launch date.
- The Payload PRD should be submitted by NASA GSFC Payload Project MGR., John J. Wolff to NASA KSC VLS Resident MGR., Lawrence F. Kruse for approval/transmittal to the 30RANS/DOUF Program Support Manager one year prior to the TIMED launch date.

Range Documentation



Note: James L. Johnson (JHU/APL) has been designated as the TIMED Range Coordinator and has generated this portion of the presentation.

Range Documentation (Continued)

PSP (Program Support Plan)
The PSP is the page-for-page response to the PRD and shows how the Western Range user's requirements outlined in the PRD will be met. The PSP response indicates those requirements that can be met from existing resources, those that can be met through developing new resources or through alternatives, and those that cannot be met by the Western Range. 30RANS/DOUF develops/publishes and distributes a combined PRD/PSP.

OR (Operations Requirements)
The OR document identifies, in UDS format, the support resources that are needed to support each specific test. The OR should not reflect any requirements not previously stated in the PRD. The OR test documentation is prepared by the JHU/APL and NASA GSFC Payload Project (with assistance from NASA KSC VLS and SMI), and submitted to the launch vehicle contractor. The launch vehicle contractor is responsible for preparing an Integrated OR (test requirements document) the Launch Vehicle and Payload prelaunch tests and launch countdown. The launch vehicle contractor will obtain approval by the NASA KSC Director of Unmanned Launch Operations and submit the Integrated OR to 30RANS/DOUF at least 60 days prior to the first test.

OD (Operations Directive)
30RANS/DOUF will publish and distribute the OD in response to the Range user's Operations Requirements. The OD details each Western Range and supporting Range organization's role, the configuration of Western Range and supporting range equipment, and the duties of the Western Range and support Range personnel involved in the operation. To schedule payload operational tests, the JHU/APL (with assistance from NASA KSC Vandenberg Launch Support (VLS) and Space Mark, Inc. (SMI)) will coordinate with Range Tasking (Tel no. 6-8825) by referring to the assigned OD test number.

Required TIMED Range Documentation

Document Title	Lead	Required NLT Date
Program Introduction (PI)	APL (GSFC 8/13/97)	Nov 1997
Request for Environmental Impact Analysis (Form 813)	APL (Approved 8/19/97)	Nov 1997
Statement of Capability (SC)	30 SW/XPR	Jan 1998
Program Requirements Document (PRD)	APL	Dec 1998
Program Support Plan (PSP)	30 RANS/DOUF	Mar 1999
Launch Site Support Plan	NASA/WLS	Apr 1999
Operations Requirement Document (OR)	Launch Vehicle Contractor	Jul 1999
Operations Directive	30 RANS/DOUF	Sep 1999
Missile System Prelaunch Safety Package (formerly ARAR)	APL	Nov 1999