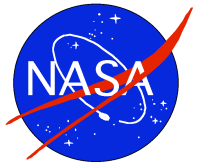
Section 6

Ground System Verification

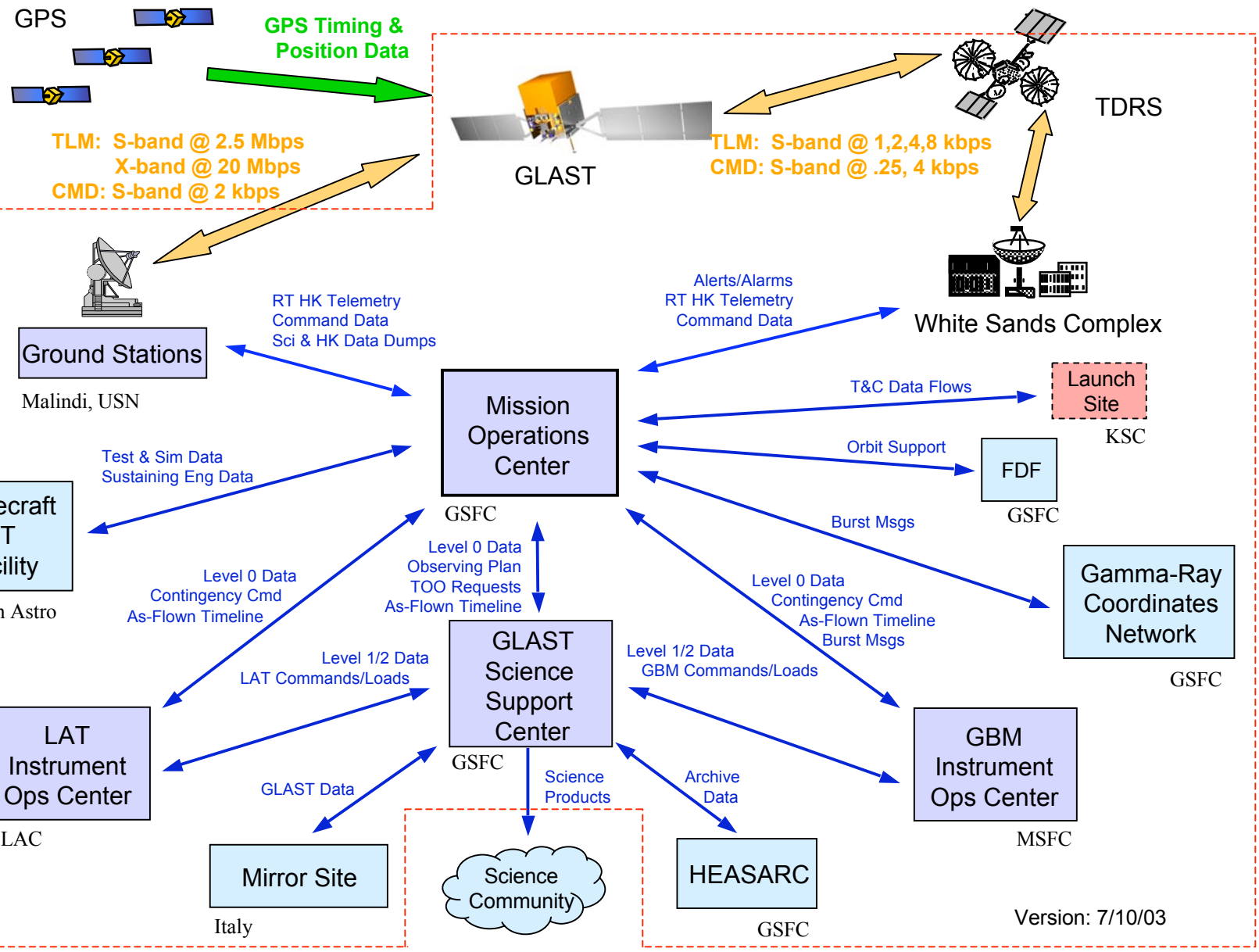
Ernest V. Canevari
Ground System Support Engineer

Outline

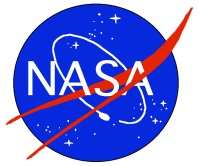


- ***Ground System Architecture***
- ***Test Roles and Responsibilities***
- ***Ground System Test Approach***
- ***Test Planning and Management***
- ***Requirements Verification Roll-Up***
- ***Simulators and Test Data***
- ***Verification Test Overview***
  - *Element Level Testing*
  - *RF Compatibility Testing*
  - *Ground System Readiness Testing*
  - *End To End Testing*
  - *Science Tool Verification*
- ***Discrepancy Management/Tracking***
- ***Schedule***

Ground System Architecture



Test Roles and Responsibilities

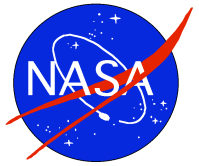


- ***Ground System and Operations Manager (GSOM) - Michael Rackley Code 581***
  - *Has overall responsibility for ensuring that the ground system requirements, interfaces, and design are developed and documented, and is ready to support GLAST launch by the launch freeze date*
  - *The individual elements have been implemented and that the elements individually and the ground system as a whole has been validated as meeting all critical requirements*
- ***Ground System Test Lead***
  - *Primary responsibility for administering the Ground System Test Program*
  - *Responsible for developing and maintaining the appropriate test program documentation, and chairing the Ground Readiness Test Team (GRTT) meetings*
  - *Coordinates the End To End Tests and controls the Ground System Test Plan*
  - *Maintains the GLAST Test Plan and the Test Verification Matrix*
  - *Schedules resources as necessary for individual tests*

Test Roles and Responsibilities

- ***Ground System Engineering Support***
  - *Responsible for assisting the GSOM in the technical management of the ground system development effort.*
  - *Responsible for chairing the GLAST Ground System Discrepancy Review Board (DRB) once ground system testing begins.*
  - *Ensures the Ground System is ready to meet test readiness objectives*
- ***Element Leads***
  - *All Ground System Element leads will be active participants in ensuring their element is capable of supporting the test objectives laid out by the Ground System Test Lead*
    - *This includes timely completion of element level testing, build capabilities and resource availability*

Ground System Test Approach



- ***The scope of the testing is limited to verifying the functionality, performance and interfaces of the Ground System as defined in the GSRD (Baseline 08/03)***
  - *GSRD covers Ground Communications, GN, SN, MOC, LAT and GBM IOCs, GSSC, HEASARC, GCN, Spacecraft I&T Facility, FDF and KSC*
  - *Test participation will include the above elements as necessary*
  - *Resources include spacecraft and simulators (PSS, CTS, MTS, HotBench,and SDMS)*
  - *Testing will include Element Level, RF compatibility, Ground Readiness Test, and End To End*
- ***A Ground System Test Plan (Draft 09/03) will describe the overall plan for ground system testing and the describes the tests demonstrating the ground system's readiness to support the GLAST mission***
  - *Identifies the configuration, and team members roles and responsibilities for implementation, as appropriate*
  - *Contains dependencies and objectives for each test*
  - *Specifies target dates for Configuration Management of products, reviews of test script, test readiness dates*

Test Planning and Management

- ***The Ground Readiness Test Team (GRTT) will be responsible for developing the detailed plans and scripts for the ground system tests and for analyzing results of each of the tests***
  - *The GRTT will be chaired by the Ground System Test lead*
  - *The GRTT will be include representatives of all elements of the Ground System*
- ***A Test Script will be generated for each test that will provide more detail than is documented in the high level Test Plan***
  - *For example, while the Test Plan will give the objectives for a given test, the Test Script would provide the specific step-by-step details for how the test will be conducted and would identify the products needed to conduct the test*
- ***Briefing Messages will be distributed to ensure that all test participants have the information needed to conduct the test***
  - *This is particularly important when institutional resources are needed, such as SN support*
- ***The GRTT will meet to discuss the results of the test, and a provide a Test Report that will be distributed to document the results***

Requirements Verification Roll-Up

- ***The Ground System Test Lead will generate and maintain a Ground System Requirements Verification Matrix***
  - *The Requirements Verification Matrix will be the primary vehicle to record specifically what will be tested (i.e. the test requirements), when it will be tested, and the status of each of the test requirements at any given time*
  - *The GRTT will play an integral part in reviewing the requirements matrix and keeping it up to date with actual test status and progress*
  - *Up-to-date versions of the Requirements Verification Matrix will be maintained on the GLAST Ground System Web site to ensure that the team has ready access to the information and the information being accessed is current*
- ***Sample Ground System Requirements Verification Matrix to be developed by Ground System Test Lead***

REQUIREMENT				PLANNED VERIFICATION				RESULTS				SIGNATURE
A	B	C	D	E	F	G	H	I	J	K	L	M

A: Source ID
B: Sub ID
C: Criticality
D: Description

E: Major System
F: System Test
G: Method
H: Test Planning Documentation ID

I: Test Run Name or #
J: Status
K: Test Result Documentation
L: Comment

M: Ground System Test Lead

Requirements Verification Roll-Up

- ***The GLAST Project Systems Manager will generate and maintain a complete system-level Project Test Verification Matrix***
  - *Project Test Verification Matrix will be used by the Project to track progress and status across all of the mission components, primarily the spacecraft, instruments, and ground system*
  - *The Project will be using the DOORs software package to maintain the Matrix*
  - *For the ground system, this Matrix will contain requirements from the GLAST Ground System Requirements Documents, which is the primary requirements document for the ground system*
    - *There will be linkage between the Project Test Verification Matrix and the Ground System Requirements Verification Matrix.*
  - *Ground System entries in the Project Test Verification Database will be updated based on actual progress and status achieved in the Ground System testing process*

Simulators and Test Data

- ***The GRTT has at its disposal several simulator tools that will be used in the execution of the Ground System Test Plan***

Simulator	Provider	Use	Schedule
Portable Spacecraft Simulator (PSS)	GSFC Code 584	Initial MOC testing, Ground system testing	August 2003
Command and Telemetry Simulator (CTS)	Spectrum	Initial MOC/spacecraft interface testing (1553 bus only)	January 2005
MOC Training Simulator (MTS)	**Spectrum and Instrument Teams**	FOT training, Ops simulations, Ops product development/test	September 2005
Spacecraft Hot Bench	Spectrum	For activities requiring spacecraft high fidelity simulator support (e.g., selected contingency simulations)	To Goddard Post-launch (but available starting at S/C I&T)
Software Development and Maintenance Simulator (SDMS)	Spectrum	Flight software maintenance	September 2005

- ***Instrument data that is gathered during the Data Challenges and subsequent instrument tests will be captured at the packet level and transferred into frame level using the PSS***
- ***Data will also be recorded during instrument, spacecraft and observatory I&T for use during GRT testing***

Verification Test Overview

- ***Ground system and mission operations readiness to be determined via series of ground system tests and operations tests/simulations***
  - *Element Level Testing*
    - *Verify functionality and performance of the individual elements that comprise the ground system*
    - *Demonstrate element-to-element interface compatibility*
  - *RF Compatibility Tests*
    - *Verify RF link between spacecraft and ground system (TDRSS & ground stations)*
  - *Ground Readiness Tests (GRT)*
    - *Verifies functionality of ground system elements and interfaces/data flows among the elements (the end-to-end system)*
    - *Demonstrates/proves that the ground system satisfies the requirements*
    - *GRTs will be designed to only use simulators and test data*
  - *End-to-End Tests (ETE)*
    - *Establishes ground system compatibility with the spacecraft and instruments*
    - *ETE Tests will be performed using the observatory*

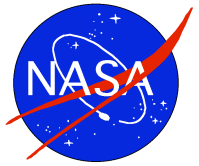
Element Level Testing

- ***The purpose of Element Level Testing is to verify functionality and performance of the individual elements that comprise the ground system and to demonstrate element-to-element interface compatibility***
- ***A structured, incremental approach is used for ground system testing, verification and readiness***
  - *Includes a modular build strategy for ground system development, where each build or module is integrated and tested*
  - *Build or module testability is determined during design and code walkthroughs. Module testing confirms satisfaction of design requirements*
  - *A system acceptance test plan will be developed by each element that documents the approach to testing each of the planned deliveries*
  - *The main drivers for the element-level testing are the element-level requirements documents and the ICDs*
  - *The element-level testing for each build will ensure that it is ready to support the more formal ground system tests that will follow after delivery*

RF Compatibility Testing

- ***RF Compatibility testing validates the ability of the spacecraft and ground system RF systems to communicate***
  - *Comprised of 4 tests (5 days in length) that verify all aspects of the RF interfaces and forward and return links*
  - *Tests will assess the spacecraft RF interface compatibility with the ground station and TDRS,*
  - *Measure the telemetry values at the ground station's receivers,*
  - *Verify the spacecraft command receiver operations and the ability of the spacecraft to perform ranging*
- ***Verification of the RF Suitcase will be conducted using the Hot Bench and/or Portable Spacecraft Simulator prior to testing with the spacecraft***
- ***All RF compatibility testing will be conducted while the spacecraft is in the spacecraft contractor facility (Gilbert, AZ)***
  - *MOC workstations (approx. 2) support at Spectrum*
  - *For TDRSS, CTV may also send data to GSFC MOC via TDRS/WSC*

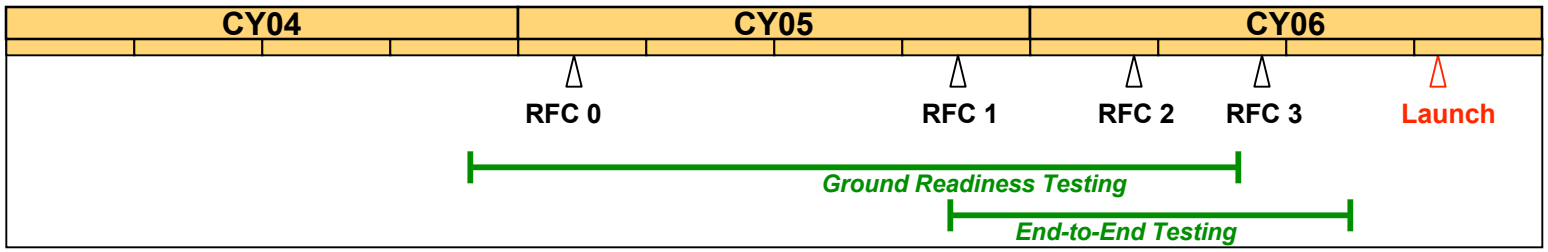
RF Compatibility Testing



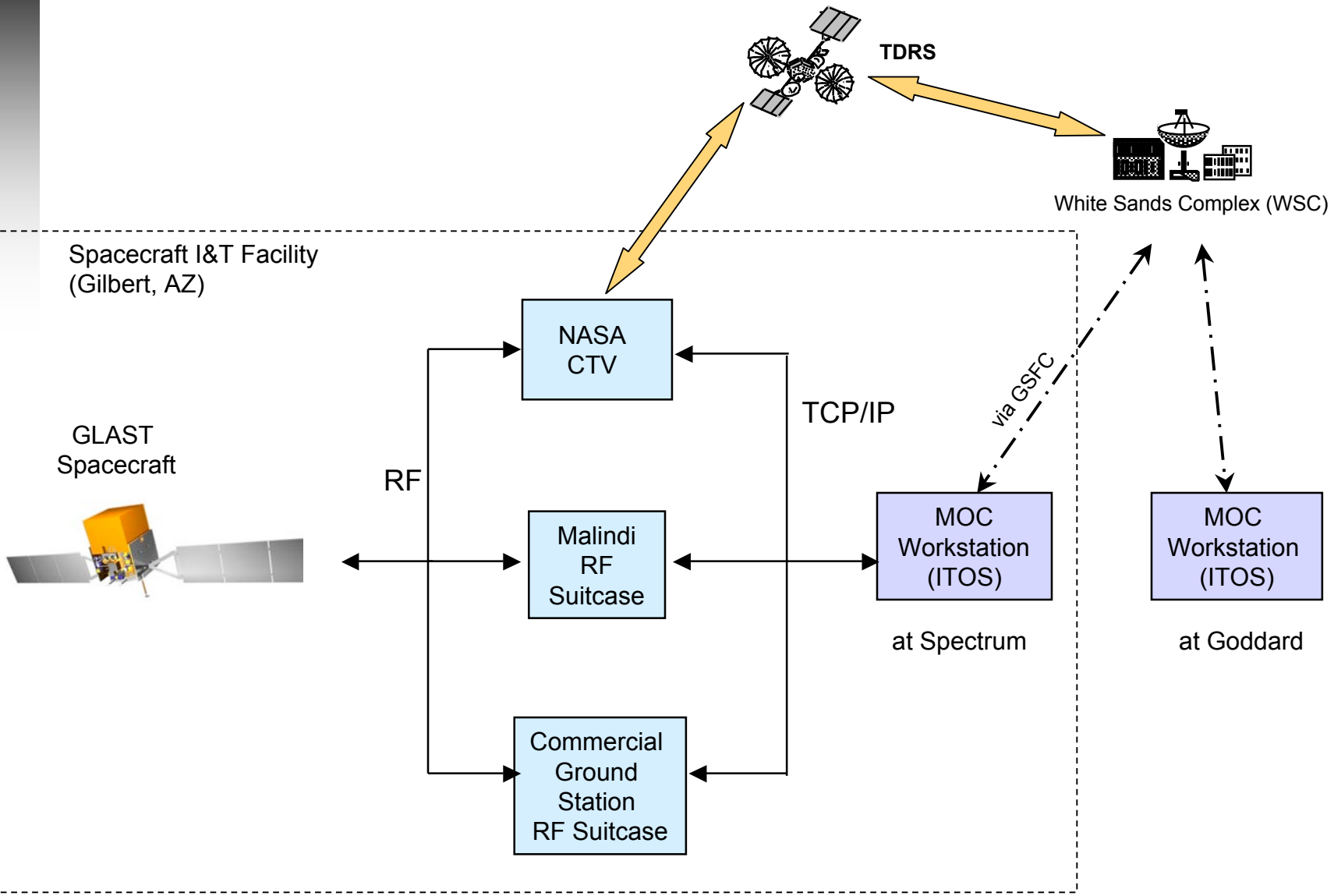
- ***Malindi RF Compatibility Testing***
  - *Malindi: ASI to provide RF Suitcase similar to Swift*
    - *CGS: Vendor provide an RF Suitcase*
  - *The RF Suitcase will receive data from the RF transponder on the spacecraft and process it in accordance with the ICD*
  - *The data will be transmitted to the MOC via the TCP/IP port on the back end of the RF Suitcase.*
- ***USN RF Compatibility Testing***
  - *USN will provide an RF suitcase that will simulate the Commercial Ground Stations*
  - *The RF Suitcase will receive data from the RF transponder on the spacecraft and process it in accordance with the signed ICD*
  - *The data will be transmitted to the MOC via the TCP/IP port on the back end of the RF Suitcase*

RF Compatibility Testing

- ***TDRSS: Compatibility Test Van (CTV) at Spectrum Astro***
  - *The Simulations Operations Center (SOC) at GSFC and the Compatibility Test Van (CTV) will be used to communicate with TDRS and the Space Network's (SN) Demand Access System (DAS), at the White Sands Complex (WSC), and forward data to the MOC*



RF Compatibility Testing Architecture



Ground Readiness Tests (GRTs)

- ***The purpose of the Ground Readiness Tests (GRTs) is to validate the ground system interfaces, data flows, performance and major functionality of the GLAST ground system using the observatory simulators***
- ***Ground Readiness Testing is a series of tests that involve two or more ground system elements whose purpose is to collectively validate the primary functionality of each element and the interfaces among the elements***
  - *This will be accomplished through a series of seven ground-system oriented tests using the simulators or recorded data (e.g. instrument frame level data)*
  - *The objective is to have all functionality tested by the first 5 tests and to use the subsequent 2 tests for regression testing*
  - *GRTs will serve as the prerequisite to the End-to-End Tests where appropriate*
  - *The mechanism to officially and formally demonstrate that the ground system meets it's requirements and is ready to support ops*

Ground Readiness Tests (GRTs)

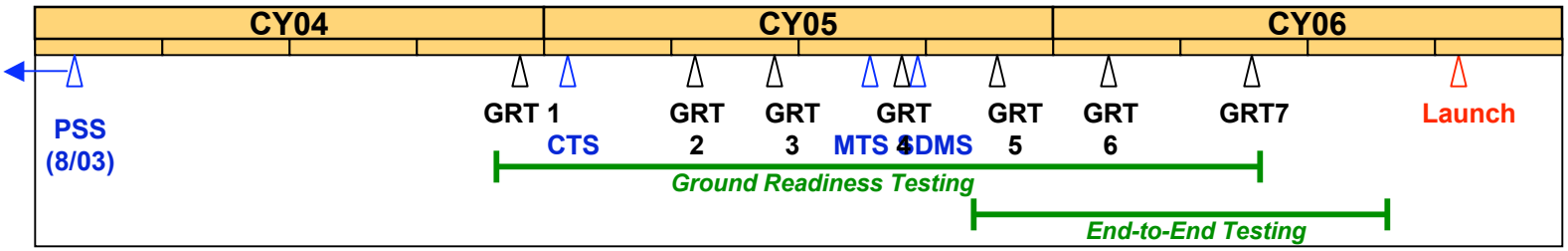
- ***The ground system element deliveries/releases will be tied to the GRTs in the Project schedule***
  - *GRTs are predecessors to ETE Tests and Sims*
- ***Comprised of a series of approximately 7 tests***
  - *GRT-1 (12/1/04)*
    - *Real-time (RT) T&C data flow between MOC and a S/C simulator and instrument data*
    - *Telemetry packets to GSSC and IOC's*
    - *RT packets to IOC's, Level-0 files to all*
    - *Instrument science data in packet/frame format*
    - *ITOS T&C data base that covers spacecraft and instruments*
  - *GRT-2 (4/1/05)*
    - *Similar GRT#1 T&C flows*
    - *Some basic planning & scheduling (P&S) activities*
    - *Plans from IOC's to GSSC*
    - *Plans/activities to MOC from GSSC*
    - *MOC builds and uplinks stored command loads to simulator*

Ground Readiness Tests (GRTs)

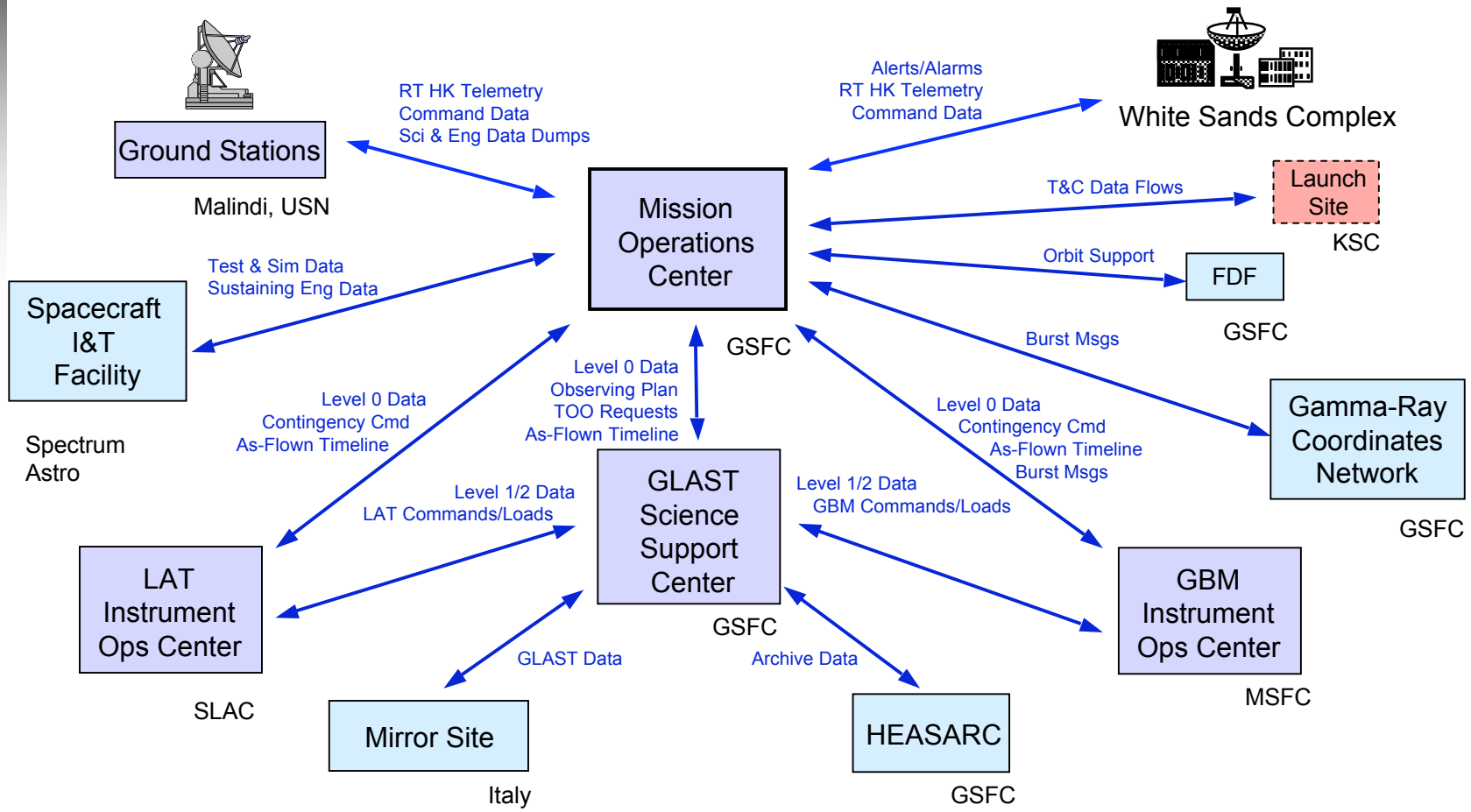
- *GRT-3 (6/15/05)*
  - *Burst Alert and Housekeeping Telemetry flows through TDRSS*
  - *Generated by simulator, get to TDRSS via SOC at Goddard*
  - *MOC forwards Burst Alert's to the Burst Alert Processors(BAPs) in the MOC, which forwards to the GCN*
  - *Commanding through TDRSS (to the simulator)*
- *GRT-4 (9/1/05)*
  - *Main focus is T&C data flows to/from the ground stations*
  - *Spacecraft and instrument data, housekeeping and science*
  - *MOC passes Real-Time packets to IOC's*
  - *MOC sends Level-0 data to IOC's and GSSC*
  - *IOC's build Level-1 and Level-2 products and send to GSSC*
  - *GSSC sends products to Italian Mirror Site*
- *GRT-5 (11/15/05)*
  - *Bring in more complex P&S among IOC's, GSSC and MOC*
  - *Bring in supporting spacecraft and instrument memory loads*

Ground Readiness Tests (GRTs)

- *GRT-6 (2/15/06)*
  - *Clean-up/regression testing*
- *GRT-7 (5/1/06)*
  - *Clean-up/regression testing*



Ground Readiness Test (GRT) Architecture

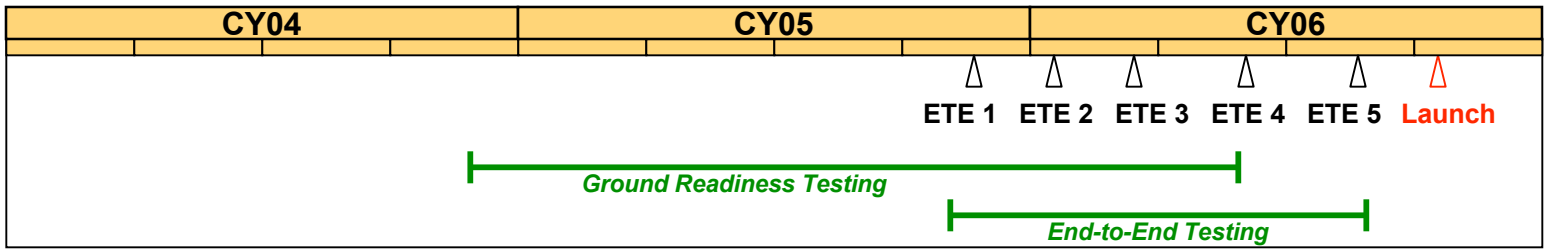


End to End Tests

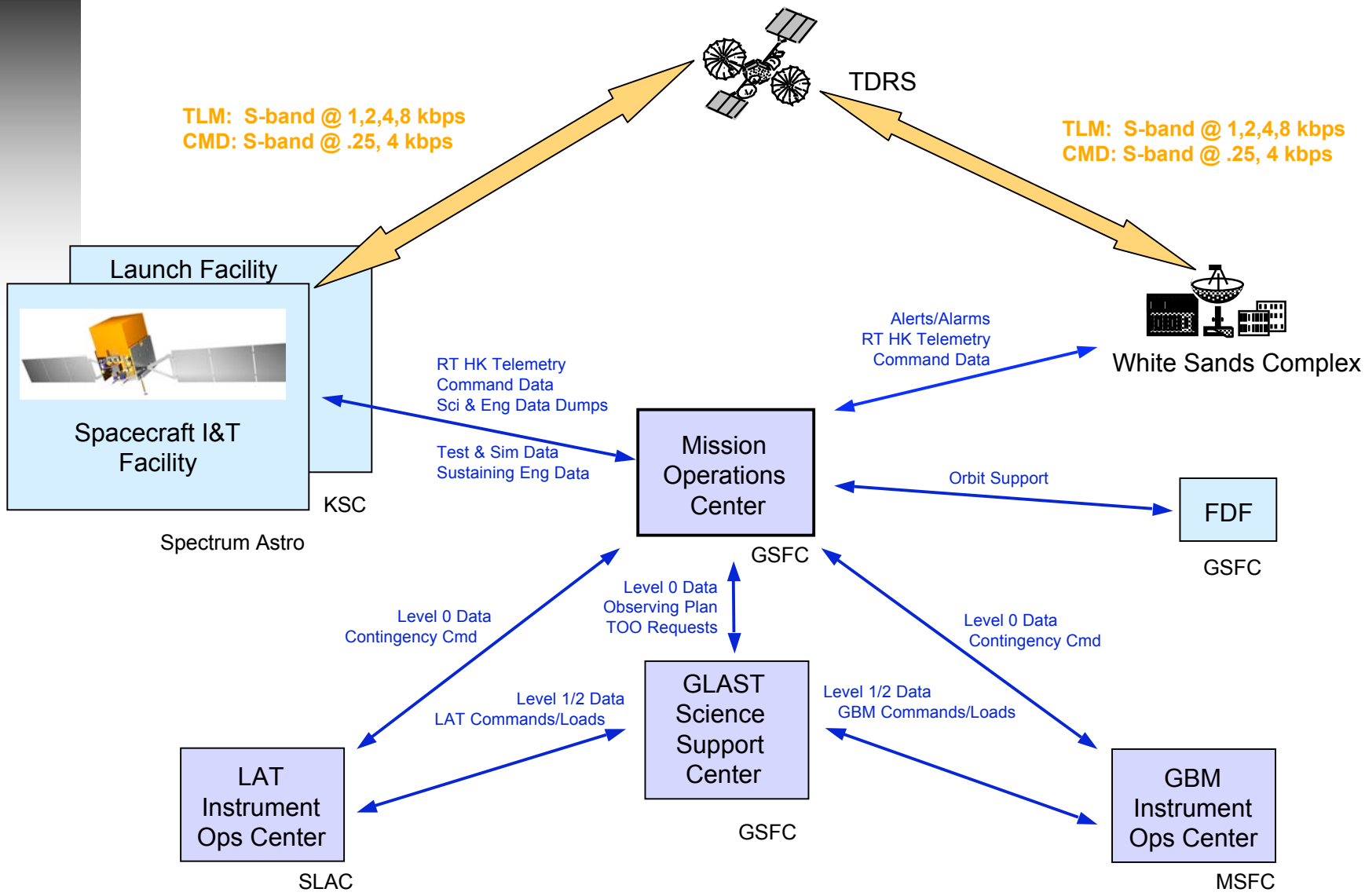
- ***The GLAST project will perform a series of 5 end-to-end tests (approximately 2 days in length each) to verify the compatibility between the MOC and the observatory***
  - *The End-to-End Test goals will be documented in the Ground System Test Plan (Draft 11/03)*
  - *The tests will validate data exchanges including: telemetry, memory dumps, Solid State Recorder (SSR) operations, commands, command loads, and memory loads*
  - *The primary interfaces are defined in the Spacecraft/MOC ICD*
  - *MOC workstations would be both at Spectrum facility & in GSFC MOC facility*
  - *As the system matures the end-to-end tests will become more operational in nature and include additional ground system elements*
    - *The preliminary End to End tests will be used to test basic interface compatibility between the Observatory and the Ground System*
    - *The subsequent tests will be tailored towards operational scenarios*

End to End Tests

- ***The Ground System Test Lead Coordinates the tests and provides NASA oversight***
  - *Spectrum leads testing in terms of determining what activities can and should be performed with the observatory*
    - *Spectrum is also responsible for maintaining observatory health and safety during testing and will provide test support through the Observatory Ops Lead*
    - *Examples: Deciding which PROCs should be run against the spacecraft, signing off on PROCs before they are used in the test*
  - *FOT responsible for planning, documenting, and executing (from the MOC) the test*
    - *FOT will also generate briefing and debriefing messages*
  - *Instrument teams are responsible for supporting their respective instruments during testing and will provide support through the IOC Leads*
    - *Example: IOTs will provide personnel at the Spectrum I&T Facility or the MOC as required to monitor instrument operations during ETE testing*



End to End Test Architecture



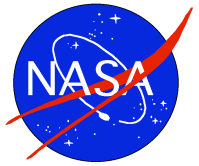
Science Tool Verification

- ***The LAT & GBM IOCs will be responsible for the validation of their respective science tools and products***
  - *Validation will be performed via a series of Data Challenges*
  - *Successive Peer Reviews and collaboration with GSSC will ensure products meet the science community needs*
- ***The GLAST User's Committee will conduct a series of independent peer reviews of the science tools and algorithms being used on the GLAST Project***
  - *The GLAST User's Committee will ensure that the design and functionality of the tools meet the science communities' needs*

Discrepancy Management/Tracking

- ***Discrepancy management refers to the process to be used to document, prioritize, track, and close out anomalies that are detected in the ground system***
  - *Anomalies may be detected during element development, element-level testing, ground system testing, or operations activities*
- ***Each element will manage it's own discrepancies internally***
  - *As presented previously by the Element Leads*
- ***At the Ground System level, discrepancies discovered during testing will be recorded and managed through the Discrepancy Management System***
  - *The Discrepancies will be categorized by element and test*
  - *The discrepancy management system will be based on the Spacecraft Emergency Response System (SERS) which is a SWIFT heritage system*
    - *This same system will be used for tracking element level discrepancies for the MOC*

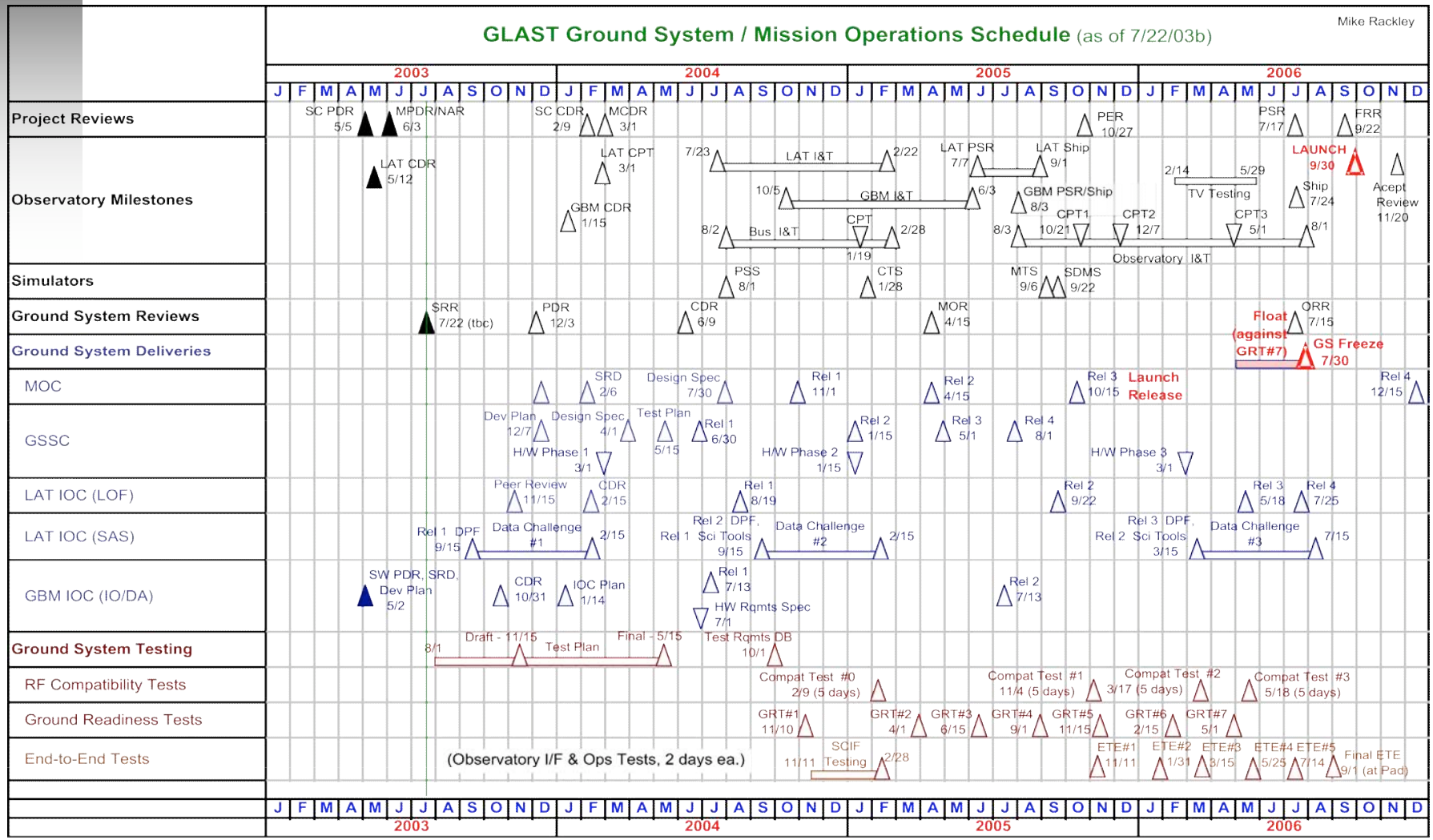
Discrepancy Management/Tracking



- ***The ground system Discrepancy Review Board (DRB) will disposition all DR's, allocating the proper severity based on the criticality of the associated functionality***
- ***Problems that are considered essential to supporting launch and early orbit activation will be categorized as "launch critical", and will thus receive the appropriate level of priority by the development team***
- ***The DRB will be chaired by the Ground System Manager, and will be made up of representatives from each of the ground system elements and appropriate operations personnel***
- ***The GRTT and DRB will work closely together, but essentially will serve two different purposes:***
  - *The GRTT will primarily plan and analyze tests*
  - *The DRB will evaluate and track individual system anomalies and associated repairs*

Schedule

- ***Preliminary Test Schedule in relationship to Project Milestones and Observatory Milestones***



Schedule

- ***Test Schedule has been coordinated with all elements build capabilities to ensure compatibility with test objectives***
  - *Reference to Element presentation for Build Contents*
  - *Table indicates which Builds are available for each test if required*
    - *Note: As of GRT 5, all Elements will use Launch Builds for testing*

Test	Builds/Release				
	MOC	LAT SAS	LAT LOF	GBM IOC	GSSC
GRT 1	1	2	1	1.1	1
GRT 2	1	2	1	1.2	2
GRT 3	2	3	1	1.3	2
GRT 4	2	3	1	2.1	3
ETE 1	2	3	1	2.2	3
GRT 5	3	3	2	2.2	4
ETE 2	3	3	2	2.2	4
GRT 6	3	3	2	2.2	4
ETE 3	3	3	2	2.2	4
GRT 7	3	3	2	2.2	4
ETE 4	3	3	2	2.2	4
ETE 5	3	3	2	2.2	4