You won your proposal! Now what?

Global Ecosystem Dynamic Investigation (GEDI) Example

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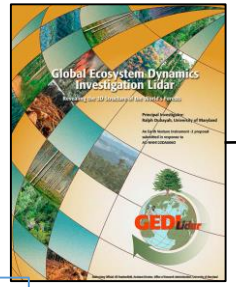
September 22, 2015

Phase-A Task & Time Frame

GEDI had approximately 7 months to mature a proposal to a cost-capped detailed 3 year development plan

Page limited report, Word-format, document created by half dozen engineers, scientist, project specialists (cost/scheduler) over several weeks period



29 weeks

Nearly fully staffed project team must create a 2 day detailed presentation to Independent Review Team including detailed requirements, design, development strategy with 3 year cost & schedule

Excellent detail given the limitation, but includes some "holes" and large error bars

Demonstrate build plan is feasible within defined cost/schedule & uncertainty is within budget contingency

Proposal Acceptance Announced

Kick-off Meeting w/ Mid-level Management & potential team members

Project Activities Start

Project System Requirements Review

KDP-B

June 2014

Sept 19th 2014

(Limited Support)

November 1st 2014

June 11th & 12th 2015

Time

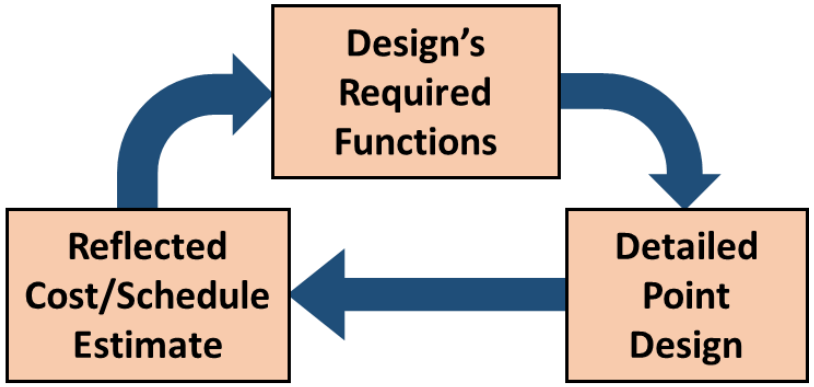
29 weeks

Proposal to System Requirements Review

<u>After winning, all these items now need immediate attention:</u>

[See Back-up for GEDI's "to do" tracking list.]

- Design Refinement & Definition:
  - Identify and start Long lead Procurements
  - Refine functional block diagram to remove holes and create a complete solution
  - Identify and complete Trades Studies
- Getting the team Organized
  - Identify team members and organize responsibilities/assignments
  - Identify documents & ICDs, owners & due dates
  - Organize meetings & reporting (daily, weekly, monthly)
- Developing the build Plan
  - Create development flow and identify number/fidelity of units to build
  - Identify & prioritize project's risks and plan to mitigate
  - Identify and develop detailed plan to get "collection of defined products" to flight instrument



The original winning proposal is controlled information (& typically cannot be distributed). You must gather the key information from the proposal as your Phase-B starting point

Long Lead Procurements & Design Maturity

Long Lead Procurements:

- Acquisition strategy for Project must be developed or considered first
  - Many possible avenues.
- For major procurements, the product being procured will have a fixed functionality and interface.
  - Other instrument elements being designed must accommodate the existing interfaces and be functionally compatible.
  - Hence procured elements need to be placed in design first
- Major procurements require time to meet all the typical processes and approvals

Design Maturation:

- Less mature designs have higher uncertainty in cost estimate, higher potential risk and most likely will have higher cost!
  - Cost/schedule margins should reflect design maturity
- GEDI's Beam Dithering Unit (BDU) was listed as TRL-5 in proposal
  - After further review, it was categorizes as a TRL-6 due to the fact that all elements have flown, just in different implementations
  - For <TRL-6, additional planning, reviews and activities is mandatory

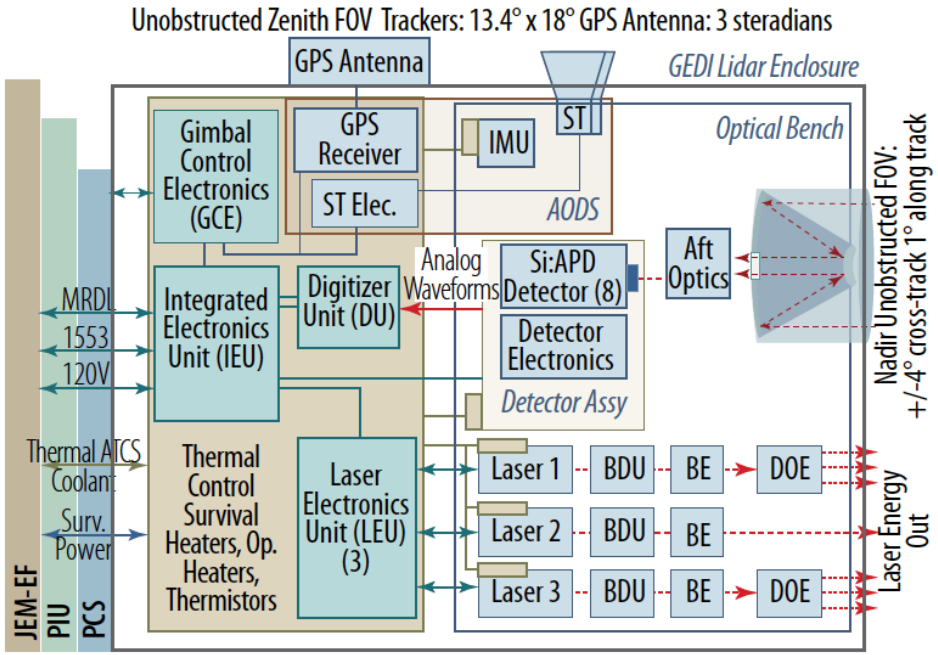
Subcontract	Contract Type	Est. Full Value ($M)	Est. FM Cost prior to KDP-C ($M)
Optical Telescope Assembly	FFP	>$2	>$2
Integrated Electronics Unit	FFP	>$3	~$0.5
Star Tracker / IMU	FFP	~$1	~$0.5
GPS	FFP	~$1	~$0.5
Wafer Build	FFP	~$0.5	~$0.5

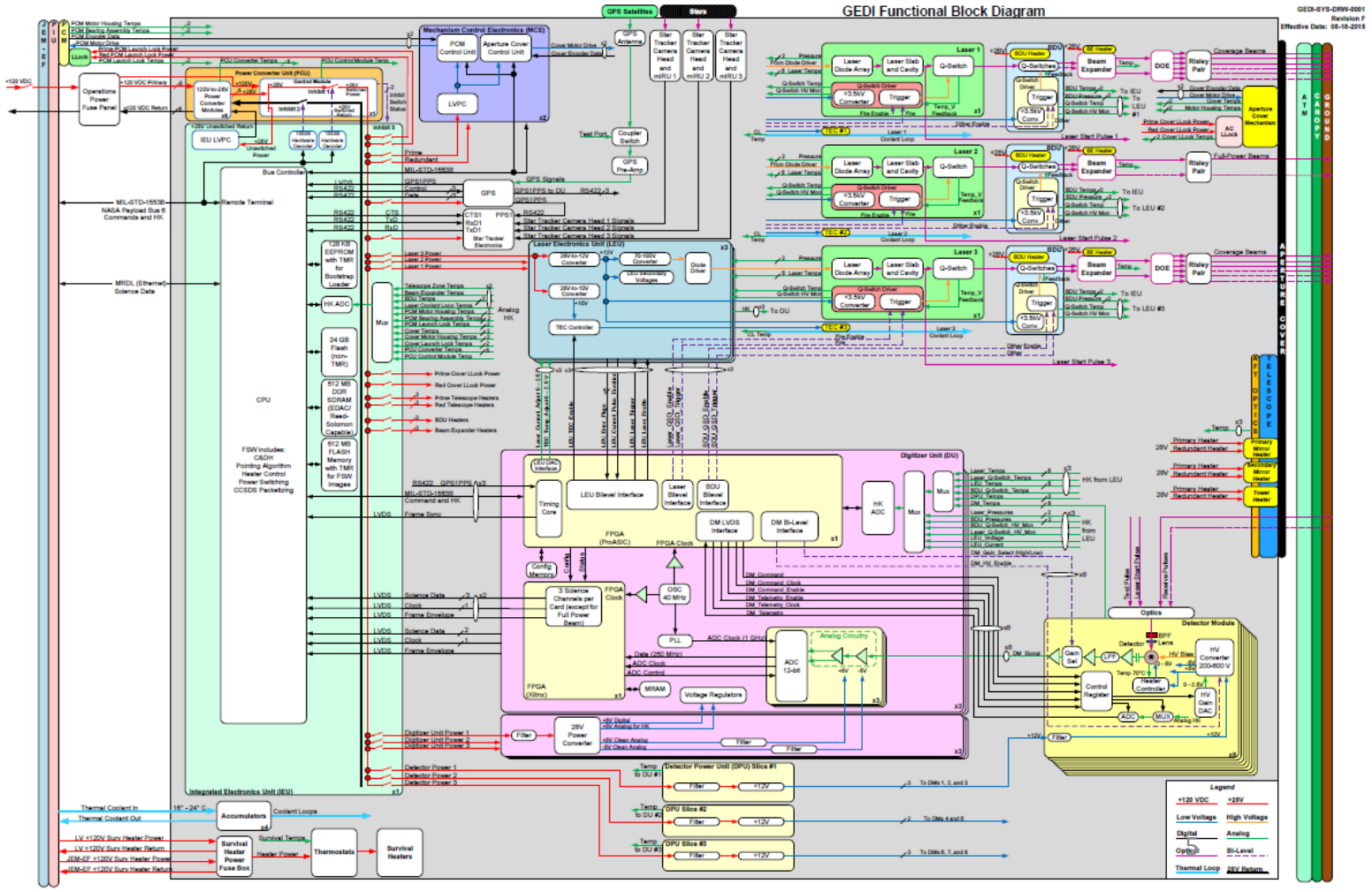
GEDI's Long Lead Procurements

Maturing the design…

System engineers capture the PDLs' component design concepts and combined them into an "integrated instrument" along with developing a "Concept of Operations"

- Iterative process to remove all holes, have a working design and get team concurrence





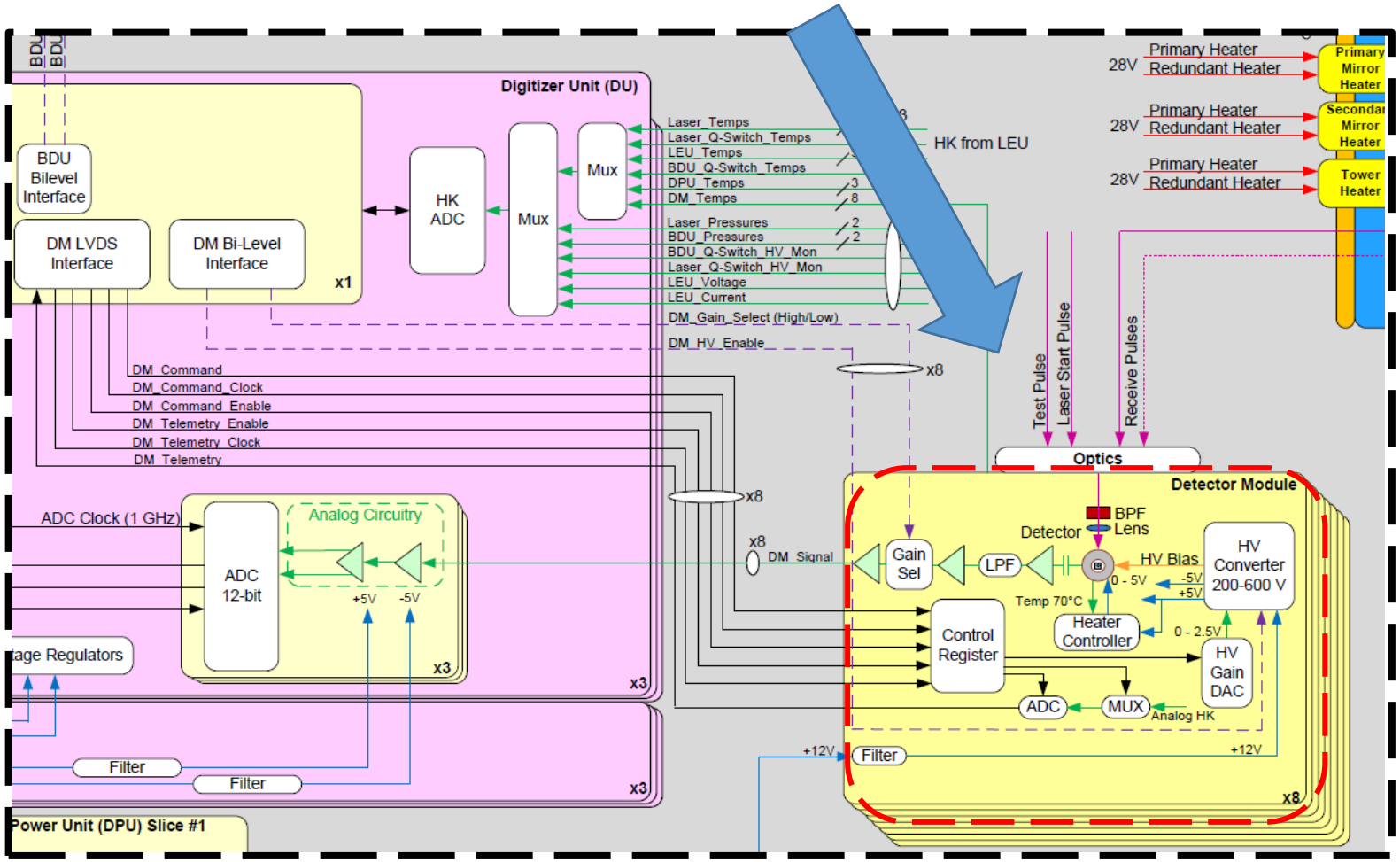
System Block Diagram is a extremely important team communication tool.

Detector Example

- At the Proposal stage: "*The core component of each detector assembly (DA) is a receiver module containing a Si:APD detector element, thermo electric controller [TEC], high voltage regulator, and trans-impedance preamplifier.*"
- The proposal was silent on
  - Functional range of the TEC
  - Required amplifier gain changing
  - Required detector gain stability
  - High Voltage command-ability

Through multiple team discussion, a complete system design solution was agreed to include:

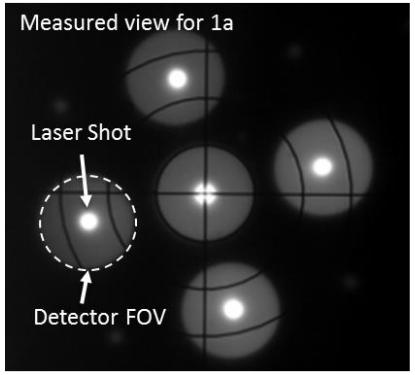
- The TEC (Heating and cooling) was replaced with a cold biased heater controller (gain setting & stability)
- A two stage Gain setting covered the necessary range. Including high voltage range control from 200V to 600V
- Finally, a high voltage Enable was added to address arcing safety



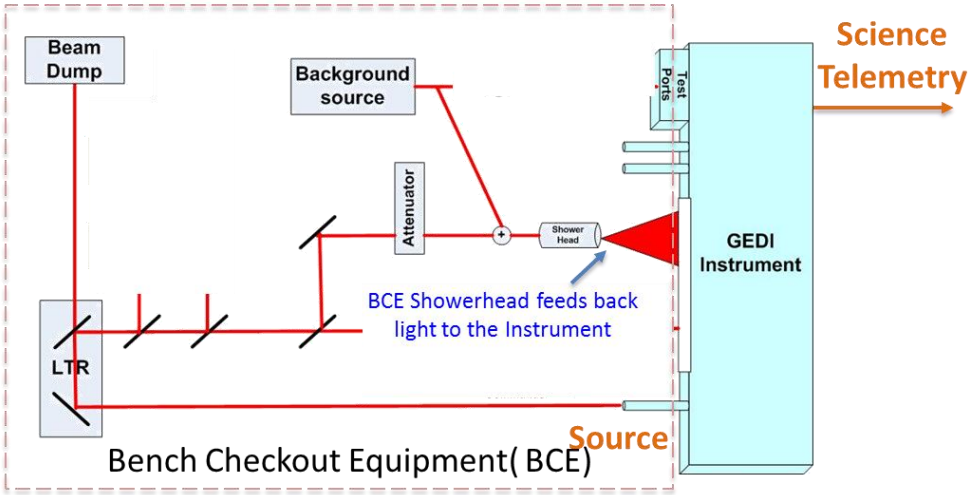
Requirements Capture

- Requirements captured in Excel, with a focus on what “Function” is needed and how well the hardware needs to perform that function (Performance)
  - Not intermixed with “good practices” and other instructional requirements
- Develop Instrument test plan on how to verify requirements (stimulus and measurement) plus identify equipment needed for the testing
  - Testing directly determines System engineering budget
- Where will your documents be stored/controlled? (TDMS for instruments)

ID	Requirement	Values	Type	Parent Requirements	Applicability	Verification Method
PRD-02-000	Receive 14 Laser Return Signals		F	PLRA-4.1.1b	Receiver Subsystem	T
PRD-02-010	Telescope Collecting Area without Obscuration	0.505 m^2	P	PLRA-4.1.1b	Receiver Telescope Assembly	I
PRD-02-016	Maintain Alignment of the 14 Receiver IFOVs with the 14 Laser Ground Tracks		F	PRD-02-000	GEDI Instrument	T
PRD-02-040	Bandpass Filter	0.7 nm ≤ bandpass ≤ 0.8 nm FWHM at 1064.3 nm	P	PRD-02-030	Detector Optical Assembly	T
PRD-02-075	Detector HV Bias Adjustment Range and Stability	200 - 600 VDC ±3 VDC	P	PRD-02-070	Detector Analog Electronics	T
PRD-02-090	Detector Temperature Range and Stability	70° C ± 1° C	P	PRD-02-085	Detector Analog Electronics	T
PRD-02-145	High-Pass Filter Cutoff Frequency	40 kHz	P	PRD-02-140	Detector Analog Electronics	T
PRD-02-170	Digitize Laser Start Pulses and Laser Return Signals		F	PRD-02-000	Digitizer Unit	T
PRD-02-175	Number of Bits	12 Bits	P	PRD-02-170	Digitizer Unit	T
PRD-02-180	Sample Rate	1 GSPS	P	PRD-02-170	Digitizer Unit	T
PRD-02-185	Linearity	±5% over detector optical dynamic range	P	PRD-02-170	Digitizer Unit	T
PRD-02-190	Pulse Waveform Ringing	< 1% peak-to-peak of 1/2 of full scale waveform peak	P	PRD-02-170	Digitizer Unit	T
PRD-02-235	Timestamp Accuracy	10 μsec referenced to the GPS 1-PPS signal	P	PRD-02-230	Digitizer Unit	T



LOLA Boresight Alignment Image



Trade Studies

- It's a thin grey line between trade studies and design refinements.
  - Trade study: A documented decision based on key parameter comparison to select a baseline design option from two (or more) options
  - Design Refinement: a decision to select a design option that is complete and compatible with the system design

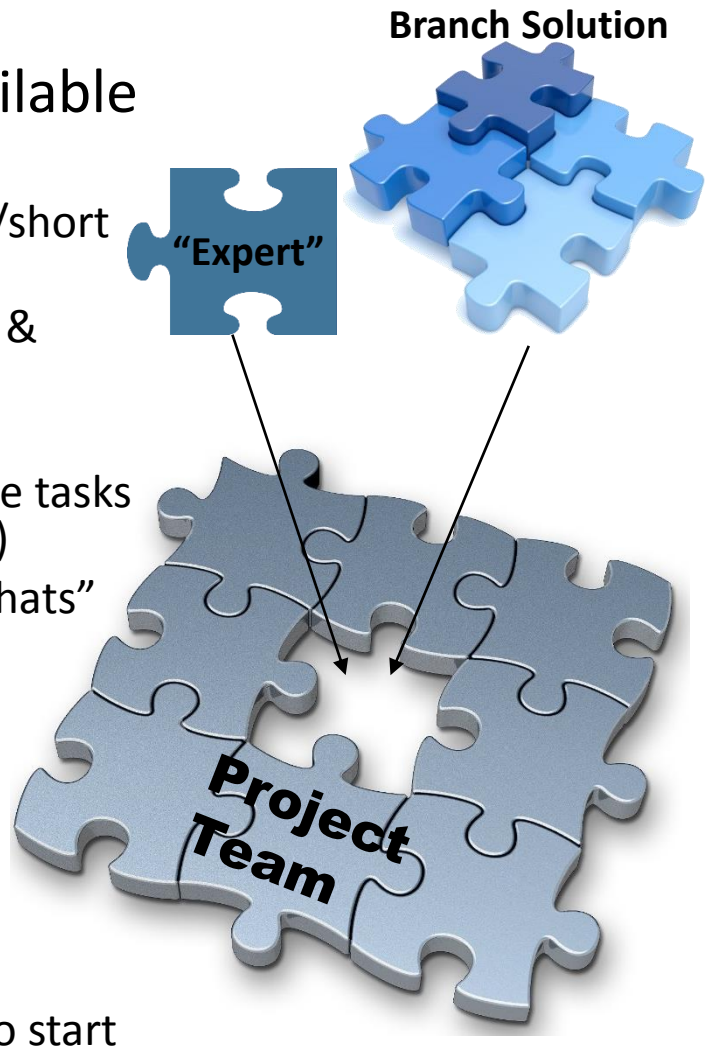
List of Design trades presented at GEDI SSR:

Trade Study	Report ID	Decision/Rationale
Telescope Size	GEDI-SYS-TRD-0005	0.8 m ATLAS copy; Saves $, reuse of models, interfaces, thermal control, GSE, increased area adds margin; Spare available
IMU vs. mIRU and number of Star Trackers	GEDI-PCS-TN-0002	3 star trackers with internal mIRU; saves $, simpler and fewer interfaces
Optical Bench Material: Al. vs. Composite	GEDI-MECH-TRD-0003	Composite Optical Bench; lower pointing error risk, reuse of ATLAS spare material, copy of telescope interface
GPS single vs. dual frequency	GEDI-PCS-TRD-0012	Dual Frequency; lower impact of multipath errors from ISS
Laser Thermal Control (TEC vs. Heaters)	GEDI-SYS-TRD-0006	TEC; lowers risk on laser control set-point due to JEM-EF fluid temperatures
IEU make-buy	GEDI-ELEC-TRD-0009	Out-of-House; lower cost, heritage FSW reuse on processor card
Receiver IFOV Design Trade	GEDI-OPT-TRD-0008	330 urad IFOV; increase in boresight margin

Trade Studies have significant project cost/schedule impacts and are formally documented

Team members, Organization & Responsibilities

- Rarely does a project's manpower needs perfectly align with available manpower
  - Each Branch will recommend a "complete solution" based on their branch's long/short term strategy, branch's area of expertise and perception of the Project's needs
  - Each team member brings specific skills to the project based on their experience & education
  - Every project is unique in the tasks to be completed and associated skills
  - The challenge is to identify all tasks, time sequence and a person to execute those tasks with minimal holes (tasks without owners) or overlaps (manpower without tasks)
  - Optimal teams are always a compromise with some personal wearing " multiple hats"



- Organize Team Co-location Space
  - Where do you need to co-locate your team?
  - What lab space is needed & how many team members?
  - Contact your space coordinator (Karla Kahler for instruments)
    - Need a draft list of positions & space (don't need names right away)
    - Meet with your space coordinator and the Directorate space coordinator to start negotiations.

Organize meetings & reporting

<u>Organize team Meetings:</u> (Purpose is to Development & Coordination design)

- Meetings should have a defined purpose and a logic decision flow
  - Aligned to the hardware products is the most logical
  - Aligned to Engineering Discipline (e.g., System engineering or Thermal)
  - Aligned to Critical interfaces (e.g., ISS working group meeting)
- Two types of meetings
  - Informational sharing: large number of participates but minimal detailed discussion
  - Resolution Meeting: minimal number of participates but significant detailed discussion
  - Be flexible & not too dogmatic, allow communication need to drive meetings

Team Down & In

<u>Progress Reporting Meetings:</u> (Purpose is to report progress and ask for help)

- Reporting follows "Fever Chart" format
  - Green, Yellow or Red Status based on cost/schedule performance and risks/issues
  - Categories include Cost, Schedule, Technical, (Facilities &/or Manpower)
  - Both PDL and Project Management have a opportunity to communicate
- Like a fine bourbon, " *Small portions leave an all around good feeling, too much is counter-productive!*"

Chain of Command Up & Out

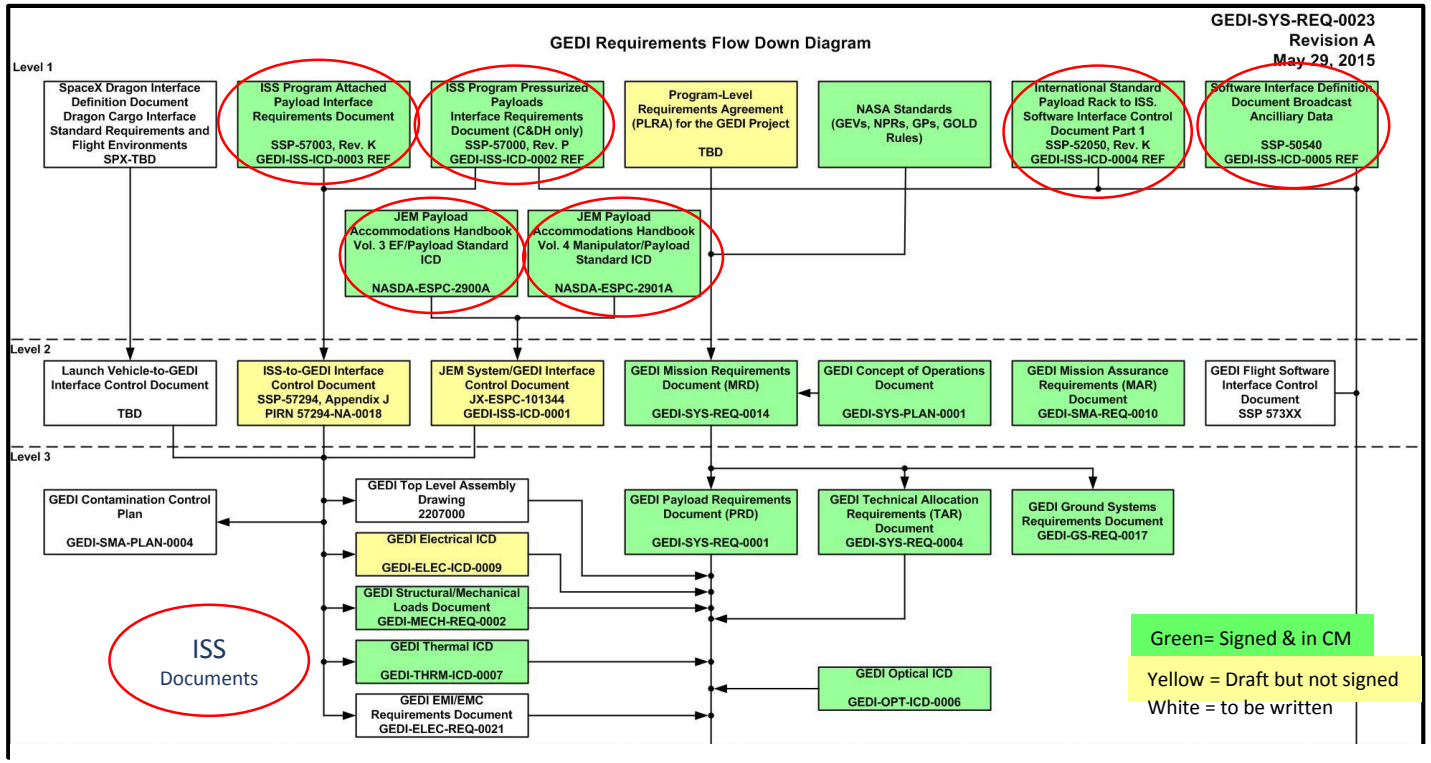
Need to develop a team drum-beat to get entire team moving in unison

Documentation and ICDs

Documentation is a **tool** for reducing miscommunication risk, but creating/maintaining them takes time, time is money!

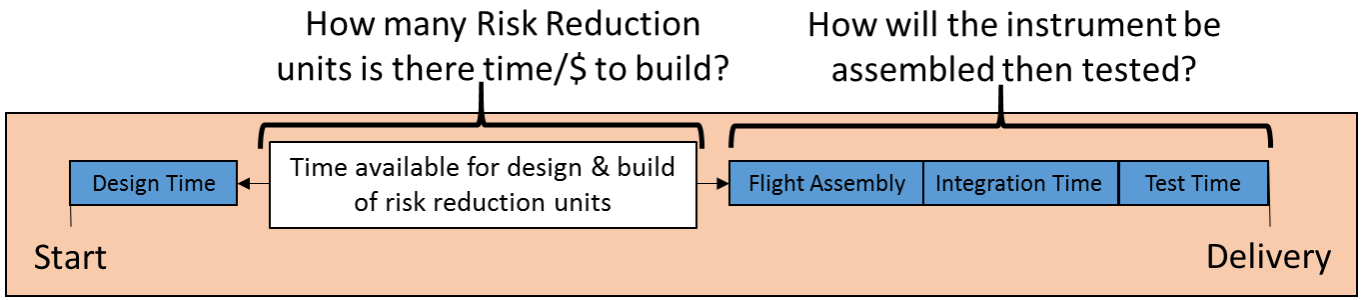
Layout a strategy (Project unique document tree) for complete but minimal set of Documents and ICDs

- Some documents are required by GPR-7123.1, (Operations Concept, requirements/verification, Failure Modes and Effects Analysis (FMEA))
- Some documents are required by the program (ISS process)
- Interface Control Documents are expected between major elements, depending on the risk some minors elements may not have an ICD
- Strategy must include who is writing the documents, approval/control process and due date
- Documents containing "shalls" must align to hardware assembly level where requirements can be verified.
  - Verifying a "2.5 level" requirement when no hardware exists at that level is difficult!



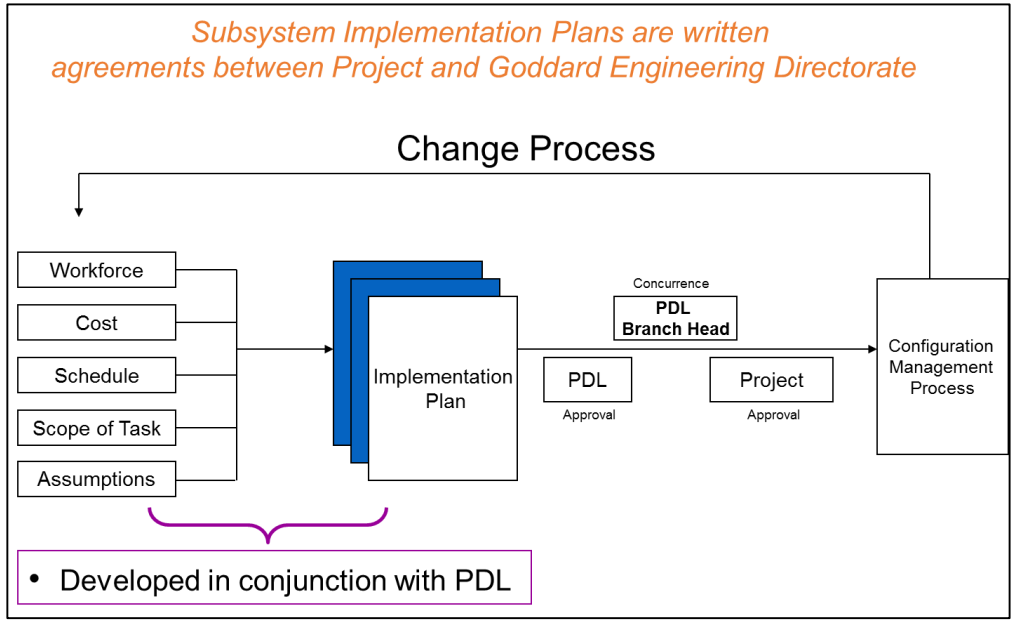
Reference point (Based on Atlas): for every ~200 requirements verified by test, you will need 1 verification engineer tracking documentation

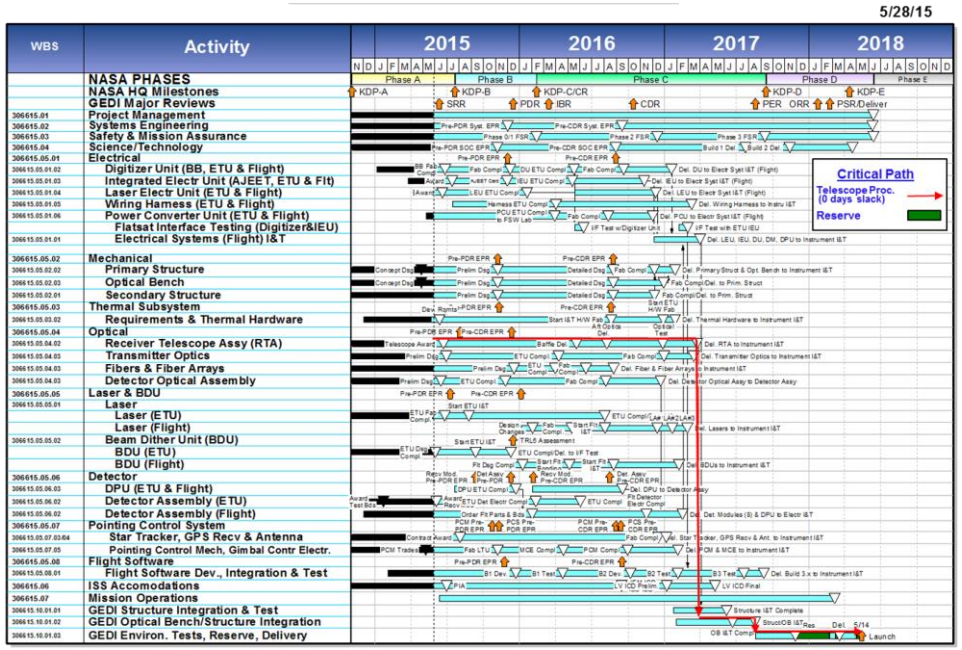
Risk Reduction Units



Develop Risk Reduction Unit Builds:

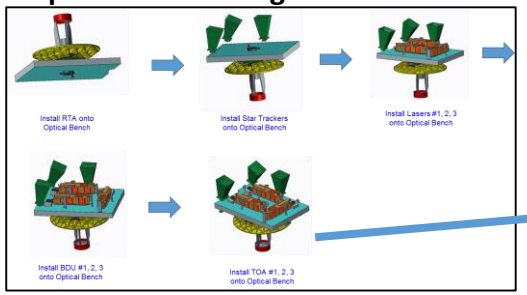
- Subsystem Implementation Plan is a risk based negotiation between Project and PDL
  - Detector front end and complex subsystems can typically justify risk reduction unit build
  - Mechanism or other limited life items will require X2 life time test demonstration on dedicated unit
  - Software GOLD Rule requires "*high fidelity software simulation*" & "*dedicated Engineering Test Unit for Flight software testing*"
- Final Decisions captured in Cost Basis of Estimate (BOE) & Schedule



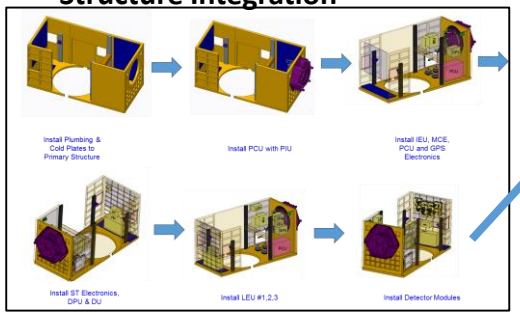


Development Flow

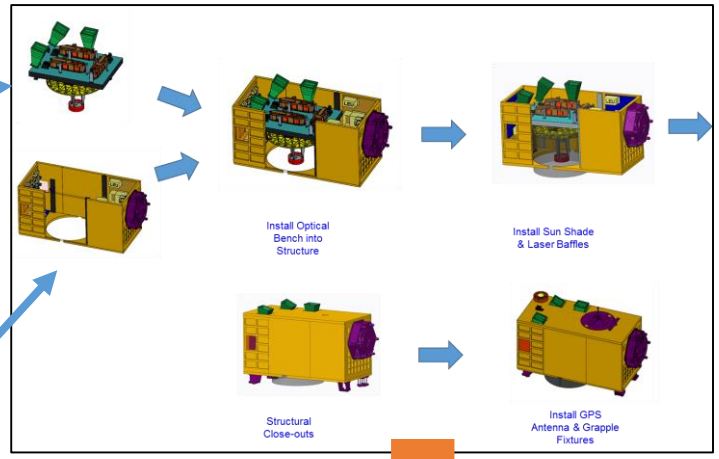
Optical Bench Integration



Structure Integration



GEDI Instrument Integration

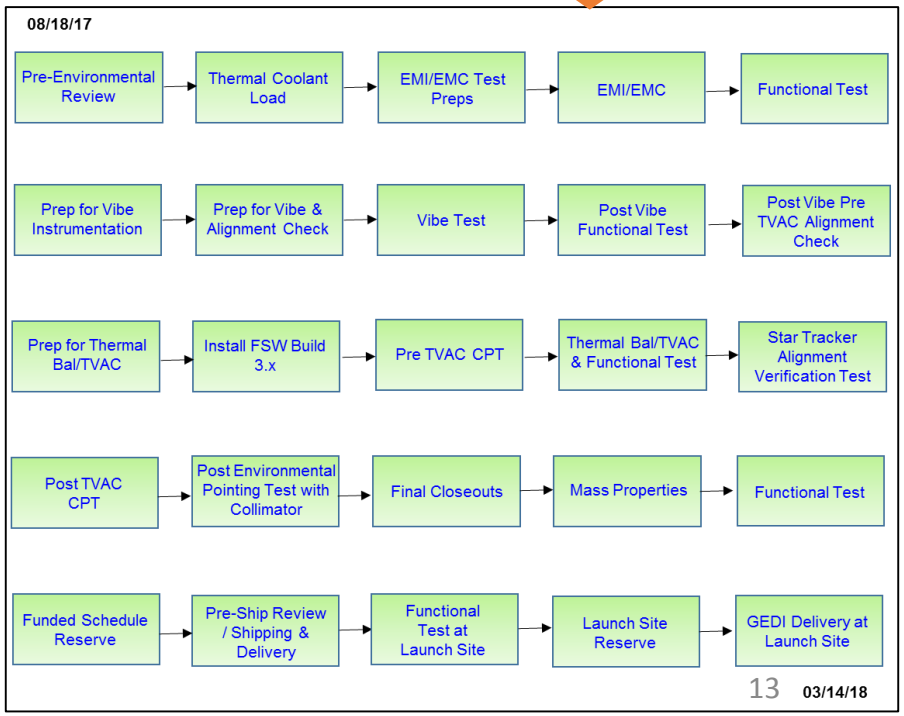


Develop integration & Test flow:

- Include detailed piece part assembly sequence
- Estimate environmental testing time, test equipment and functional testing time (based on requirements)
- Testing can be moved to higher/lower level assembly to balance risk & deliver dates
- I&T will need to development procedures & process flow development, typically practice on instrument Engineering Unit

Time View of Instrument:

- Developing the integration flow enables a different view of the necessary work than the Product Breakdown Schedule view or discipline engineering view.



Risk Board Activities

- Below the Risk Board activities, there **must** be some level of PDL-Leadership decision process
  - Can be a concerns process, Top 10 worries process or a “John Ruffa index card in the pocket” process
- Getting the decisions process churning is a critical step in evolving the design
  - A communication channel for PDLs to inform Project leadership in decisions needing attention
  - A communication channel for the Project to report to upper management.

Risk Management

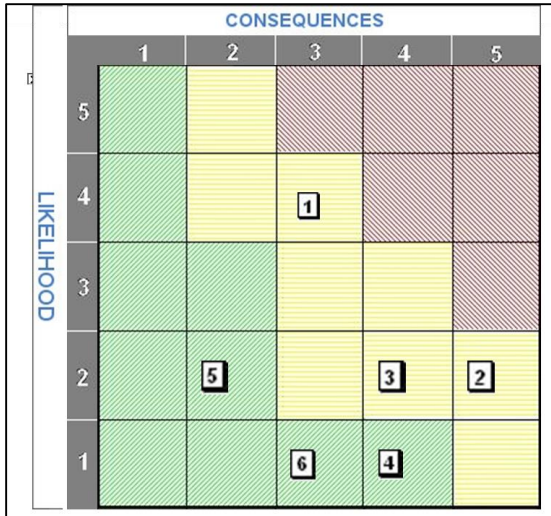
- Risk Board meets second week of every month to assess programmatic and technical issues and risks
- Regular Systems Engineering risk meetings collect concerns for vetting prior to the monthly Risk Board
- Risk Board consists of Principal Investigator, Instrument Project Manager (Chair), Payload Systems Engineer, Chief Safety and Mission Assurance Officer, Product Leads, Financial Manager
  - Schedule and cost threats assessed
    - Financial threats are weighted according to likelihood, 0% for L=1, 20% for L=2, 40% for L=3, 60% for L=4 (L=5 is no longer a risk, it would be an issue with a lien)
  - Mitigations identified with expected improvements in likelihood and consequence
  - Continuous risk management approach is followed, which includes identifying, analyzing, planning, tracking, controlling, documenting, and communicating risks
- Issue and risk management database is formally configuration managed within TDMS
- Consequence and Likelihood Assessment using GSFC Risk Matrix Standard Scale
- See Risk Management Plan GED-MGMT-PLAN-0010 for details

When

What

Who

How



Criticality	L x C Trend	Approach
HIGH	Decreasing (Improving)	M - Mitigate
MED	Increasing (Worsening)	W – Watch
LOW	Unchanged	A - Accept
	NEW New since last month	R - Research

Rank/ Trend	ID	Title	Approach
1 NEW	GEDI 00021	Laser Secondary Modes	Mitigate
2 ⇨	GEDI 00002	Direct Sun in Telescope Boresight and Transmitter Path	Mitigate
3 NEW	GEDI 00022	Launch Vehicle Environments Uncertainty	Mitigate
4 ⇨	GEDI 00004	Boresight Alignment	Mitigate
5 ⇨	GEDI 00006	ISS-Induced Downtime	Mitigate
6 ⇨	GEDI 00007	ISS Jitter	Mitigate

The Risk board is essential in making informed decisions.

Conclusion

Quote from SRR Independent System Review Boards' (SRB) post caucus out brief:

"*…the SRB was very impressed with the team's expertise across the board, and the impressive quality of the work we've done really honing in on what is important and they saw virtually no weaknesses*."

"*There was unanimous agreement that we had a great set of requirements, realistic solutions to implementation and are ready to move out to PDR.*"

Special Acknowledgement:
This presentation is based on the outstanding work of the GEDI leadership Team:

- Cheryl Salerno (ISE)
- Miles Smith (Deputy ISE)
- Jim Pontius (IPM)
- Keith Walyus (Deputy IPM)

Next Step is the KDP-B…

Back-up

Snap shot in time of the GEDI's "to do" tracking list

Actual List included person responsible

Expectations of Leads in Phase A	Due Date	Project Manager	Payload Systems Engineers	Instrument Scientist	Chief Safety & Mission Assurance Officer	Optical Systems PDL	Mechanisms/Optomechanical PDL	Mechanical Systems PDL	Electrical Systems Engineer	Electronics PDL	Digitizer PDL	Thermal Systems PDL	Laser PDL	Detector PDL	Pointing Control System PDL	FSW PDL	Contamination Control
Daily Actions																	
Be Available in Building 16 (Brick) During Core Hours		L	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Actively Participate in Capturing and Resolving Concerns			L	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Resolve PDL Concerns in a Timely Manner		x	L	x	x												

Weekly Actions
Actively Participate in Scheduled Meetings
Submit Written Weekly Report
Monthly Actions
Prepare and Present Status Report for Project Monthly Review
Submit Updated Technical Performance Measure Information to PSEs
Actively Participate in Monthly Risk Management Meetings (Risk Owners)
Develop Requirements and Specifications
Develop Baseline Instrument Functional and Performance Requirements
Develop Baseline Subsystem Functional and Performance Requirements
Develop Baseline Instrument Environmental Requirements
Develop Mission Assurance Requirements
Develop Telescope Assembly Specification
Develop Detector Specification
Develop Detector Electronics Specification
Develop Laser Specification
Develop Laser Electronics Unit (LEU) Specification
Develop Interfaces
Develop Initial Optical ICD
Develop Initial Electrical ICD
Develp Initial Mechanical Interface Control Drawings (MICD's)
Develop Initial Thermal ICD
Develop ISS Payload Integration Agreement
Develop Initial ISS-to-GEDI ICD
Develop Initial Launch Vehicle-to-GEDI ICD

Perform Trade Studies
Perform Structure Material Trades; Composite vs. Al Honeycomb vs. Machined
Perform IRU LN200S vs. SIRU vs. Alternates Trade Study
Perform Telescope Size Trade Study (0.7 baseline vs. 0.8 m /materials)
Perform GPS Viceroy vs. Alternate Dual Frequence Trade Study
Perform Electronics Packaging Trade Study & make/buy
Perform Mechanism Trade on Motor Selection, Drive Electronics Implementati
Perform Analyses
Perform Optical Throughput Analysis
Estimate or Measure Detector Responsivity and Dark Current
Update Link Analysis
Perform Initial Pointing Control and Knowledge Analysis
Perform Initial Pointing Jitter Analysis
Perform Selective Redundancy Analysis, Identify SPFs and Criticality
Peform Boresight Alignment Stability Analysis
Perform Sun Avoidance Analysis and Impacts on Optical/Detector
Hardware Risk Reduction
Develop BDU Prototype and Maturation
Develop Fiber Prototype (assuming we stay with larger size)
Q-Switch Trade for BDU (and laser) Implementation
Laser Slab: Beam Quality

Develop Documents
Develop Initial SEMP (includes Requirements Management Plan)
Develop Baseline Operations Concept Document
Develop Baseline Architecture Description Document
Develop Initial Verification and Validation Plan
Develop Integration Concept
Develop Acceptance and Transition Concept
Develop Technical Performance Measures (TPM) Budget and Reports
Develop Initial Phase A GOLD Rules Compliance Matrix
Develop Engineering Peer Review Plan
Develop FSW Development Plan
Develop Systems Safety Program Plan
Develop Laser Safety Procedures
Develop PAIP
Establish Parts, Materials, Radiation, Safety, QA, Reliability Program
Develop Project Management Plan
Develop Subsystem Implementation Plans (SIPs)
Develop Configuration Management Plan
Develop Risk Management Plan and Process
Develop and Submit the Terms of Reference (ToR)
Develop Integrated Master Schedule
Develop Budget
Conduct Reviews
Conduct GEDI Internal Kickoff
Telecom for ECOSTRESS Kickoff with JSC (TBR)
Conduct Laser Peer Review before Diode and Slab Procurements
Conduct Telescope Assembly Peer Review before Procurement
Conduct Detector Peer Review before Procurement
Conduct GEDI Kickoff with JSC
Conduct Systems Engineering Peer Review
Conduct SRR Dry Runs
Conduct SRR