Laser Range Finder for Space Applications

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Problem Statement

Design, build, and test an opto-mechanical structure to facilitate a laser rangefinder (LRF) device and operations on-orbit, employing DFM (design for manufacturing) practices

Deliverables

- Assembly Procedures, with justifications for reliability
- CAD Design
- Physical Prototype

Background and Impact

- Millennium Space Systems creates reliable, low-cost satellite products for NASA, National Security Space, and commercial customers
- Laser Range Finders (LRFs) are used by satellites for location services and rendezvous operations, but translating them into space have proved challenging
- LRF modules adapted to space environments would make laser time transfer more widely available, improve space domain awareness, and greatly increase rendezvous capabilities
- By designing this LRF for space, a novel and unique assembly process is also required, which will set a standard for future laser modules

Mechanical Design

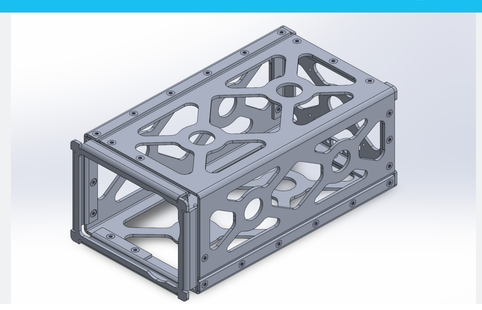
Design Approach:

- Internal Configuration
- Frame Design
- Validation and Prototyping
- Assembly Plan

Constraints:

- Maximum 3 day assembly time
- 1U size limit
- 2kg weight limit

Frame Design



Optical Design

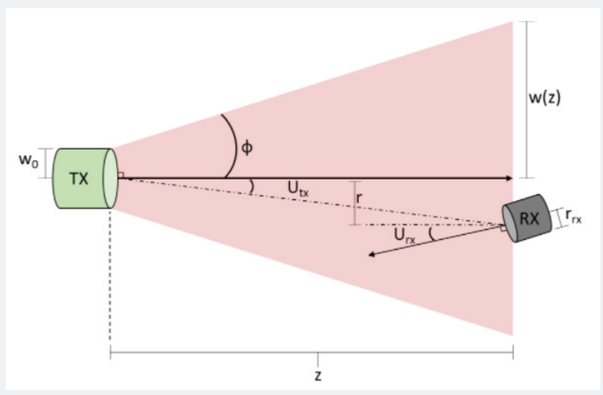
Design Approach:

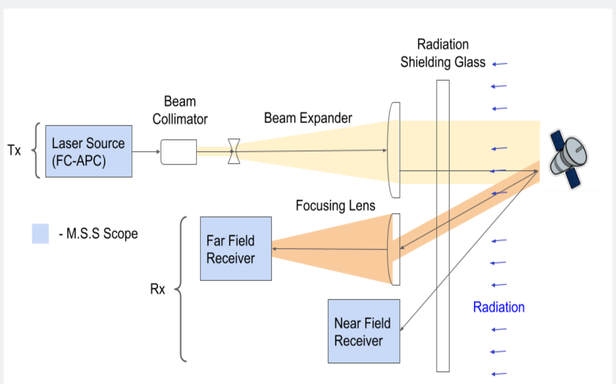
- Model system parameters using an optical link budget
- Create optical system design
- Optical system testing

1. Collimation
2. Beam power
3. Beam width

Objectives:

Detect 1m, 2m, 5m objects at 500 km (Stretch Goal: 1000km)



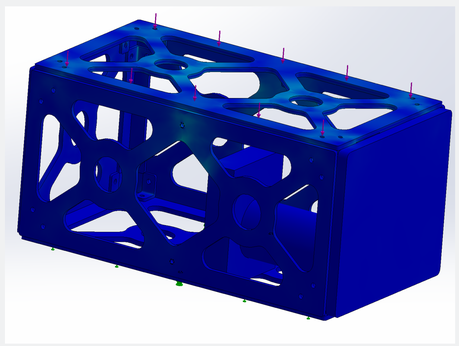


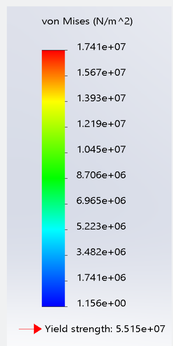
Structure Validation

- Static Loading
- Vibration Loading

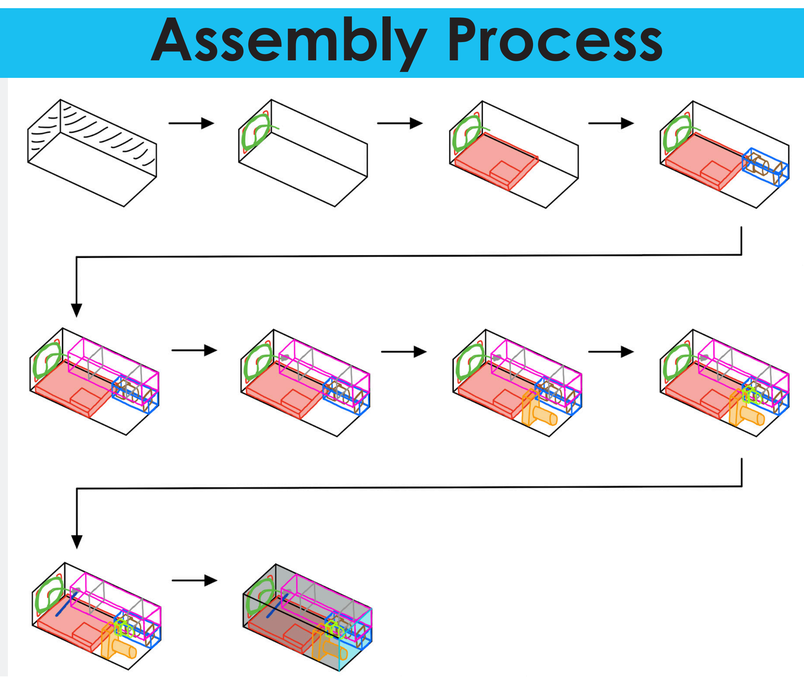
Additional Physical Properties:

- Venting/Outgassing
- Thermals
- Surviving Radiation

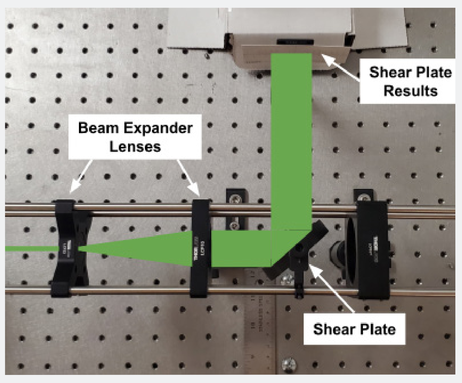




Assembly Process



Collimation Testing



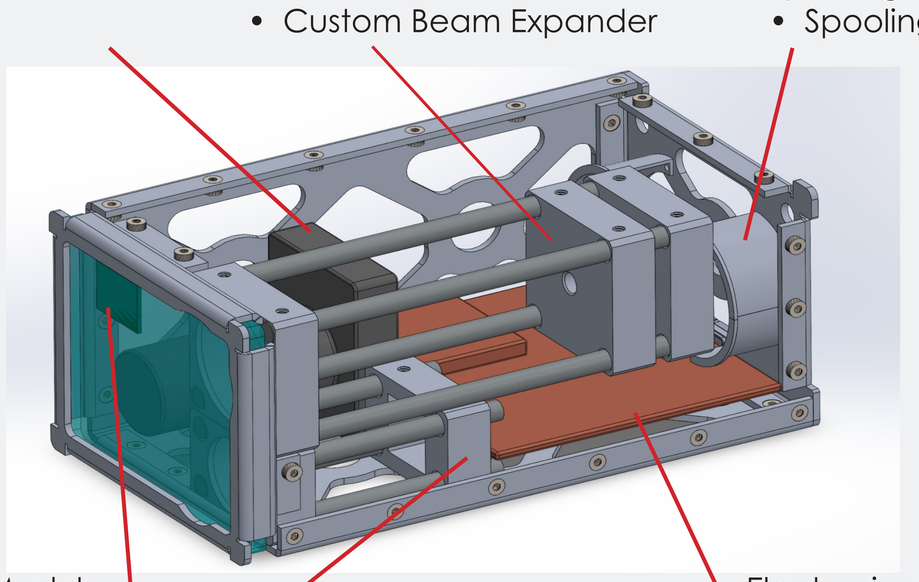
- Useful for characterizing beam and diagnosing any inconsistencies present in alignment

Final Assembly

Situational Awareness Camera

Transmit Module
- Custom Beam Expander

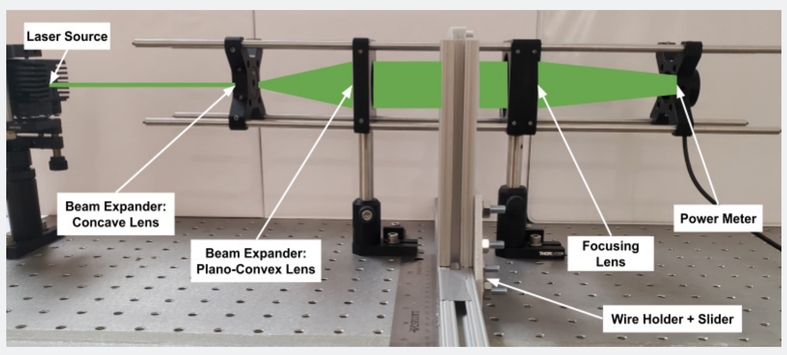
Spooling
- Spooling Brackets



Receiver Modules
- Near Field Sensor
- Far Field Optical Cage

Electronics
- Laser Pump/Driver
- Timer/Controller

Beam Power & Width Testing



Beam power: Checks efficiency of optical system to validate minimum receive distance

Beam width: Validates that transmitted beam is properly expanded

Future Work

- Look into how the optical systems will survive space and launch
- Recommend more intensive testing and simulation of the payload under the full profile of launch vibration and shock, undergoing thermal qualification via bake test, and then proceeding to build flight-qualified modules
- Further test and iterate on the assembly process

Acknowledgements

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