Lessons Learned: TES and SIM Laser Metrology Systems

Cheryl Asbury
Jet Propulsion Laboratory

Outline

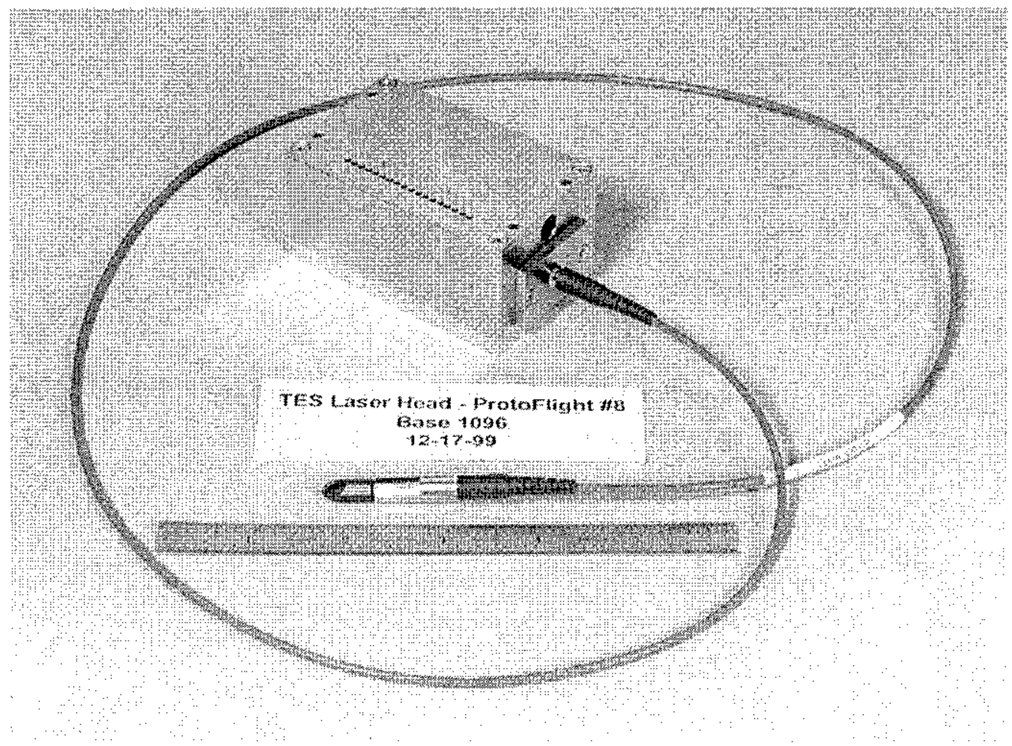
- TES mission and laser description
  - Challenges
  - Lessons learned
- SIM mission and laser description
  - Challenges
  - Application of lessons learned on TES
  - Lessons learned

TES Mission

- Over a period of five years, the Tropospheric Emission Spectrometer (TES) will gather data describing the global distribution of tropospheric ozone and other gas molecules that will be used to create a three-dimensional model depicting tropospheric chemistry.
- Laser requirements
  - Single frequency
  - 1064nm
  - 25mW (5 mW at End-of-Life)
  - Laser used as reference wavelength for the spectrometer, providing a fringe clock

TES Laser

- Ruggedized and space-qualified version of commercial laser built by Lightwave Electronics
- Laser flight electronics built by JPL



Key Challenges: TES Laser

- Lightwave had no experience with flight hardware, but they were only game in town
- Pump diode laser lifetime
- Mechanical stability of optical components to preserve output fiber coupling efficiency
- Verification of materials and process changes that were necessary to space-qualify laser
  - To improve thermal stability
  - To reduce outgassing

What Worked: TES

Collaborative, team atmosphere between JPL and Lightwave, the contractor

- Allowed JPL to:
  - Fully utilize Lightwave expertise to avoid mistakes due to incomplete knowledge
  - Be an educated customer
  - Identify failure modes early
  - Investigate physics of failure early

What Worked: TES

Early accelerated lifetesting of pump laser diodes

- Enabled:
  - Year-long test that provided almost 150,000 device hours
  - Determination of expected diode lifetime with high confidence (different from vendor estimate)
  - Project Mgmt to make educated decisions

What Worked: TES

Multiple early builds of Pre-Engineering Model prototypes

- Allowed:
  - Early identification of root causes of failures
  - Early determination of physics of failure
  - Non-accelerated laser lifetest data (8+ years) to inform trade-off decisions as early as PDR
  - Proving ground for new materials and processes

What didn't work well: TES

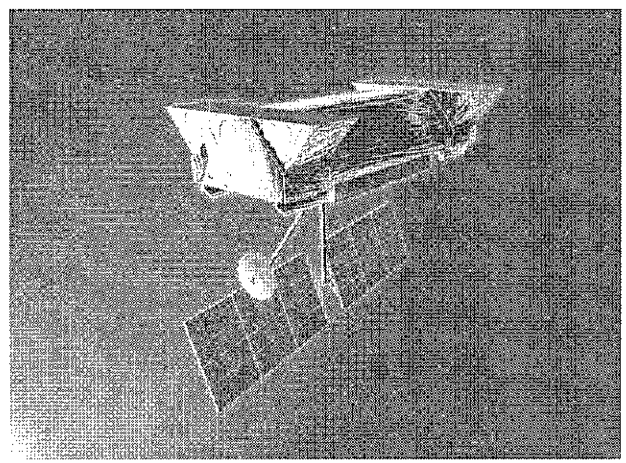
- Firm, fixed-price contract with Lightwave
  - Had to be modified a couple of times
  - Lightwave ended up losing money on the effort, which spoiled their interest in further space hardware work

What didn't work well: TES

- Integration of instrument components with fiber optic cable(s) attached
  - 2 cables were kinked during installation into the instrument (most flight techs not yet familiar with fiber optic cables)
  - If at all possible, design for installation of fiber optic cables after components are in place

SIM Mission

- Will enable astrometry with unprecedented accuracy in order to search for planetary companions to nearby stars, by detecting the astrometric 'wobble' relative to nearby reference stars.



How SIM is using laser

- Using laser to measure truss deformations so that they can be subtracted out, reducing error and allowing higher accuracy
- Laser Requirements:
  - Single mode with stable single frequency
  - Significant power (on the order of 0.5W) since it must be divided into 19 gauges
  - Wavelength > 1.2 microns

SIM Laser vs. TES Laser

- Lower gain at SIM wavelength, leading to lower maximum output power
- SIM needs higher power than TES
- 5.5-year laser life for SIM vs. 2.5-year laser life for TES

Key Challenges: SIM Laser

- Eliminating optical misalignment over the life of the mission
- Producing adequate laser output power
- Enabling redundancy of pump diodes
- Receiving the requirements necessary to avoid over-engineering
- Laser funding not consistent

What has worked: SIM

Early collaboration with other projects

- Enabled early prototypes to be built
- Cultivated current and future laser customers that could provide funding
- Provided visibility to both laser problems and solutions

What has worked: SIM

Built flight-like prototypes very early

- Used to prove that laser-welded packaging solves misalignment problems
- Allows focus on increasing output power and improving pump diode life and reliability

What hasn't worked: SIM

Discontinuous laser funding

- Lost momentum on laser development, so having to re-learn processes now
- Lost opportunities to cost-share with other projects that have similar pump diode concerns

What hasn't worked: SIM

Convoluted Work Breakdown Structure with industry partner

- Led to:
  - Poor lines of communication
  - Contradictory or incorrect requirements
  - Confusion about which organization was responsible for what deliverables, and which organization pays for them

Summary

- Prototyping is very important
  - The earlier the better
  - Allows for early identification of root causes
- Trust vendors and learn from them, but also independently become an educated customer so you can teach them about what you need
- Laser development costs money!
  - Funding needs to be consistent
  - Collaboration between projects can take the pressure off individual projects and protect against funding inconsistency, but each project needs to contribute