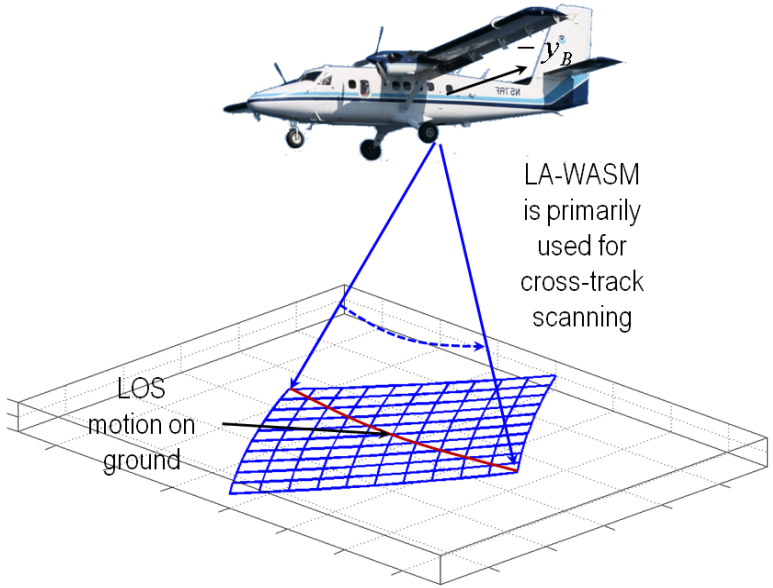


REMI - Reduced Envelope Multi-Spectral Imager for Sustained Land Imaging

Dennis Nicks, PI

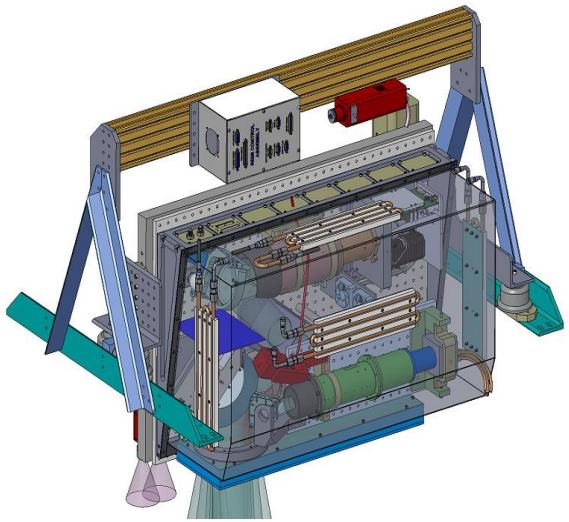
James Howell, PM

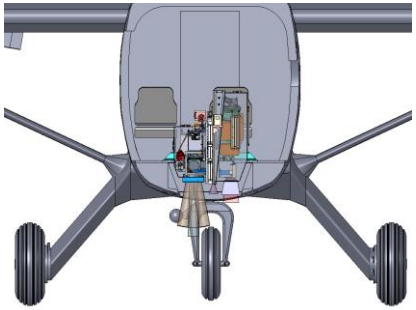
Earth Science Technology Forum

June 2018

Reduced Envelope Multispectral Imager (REMI)

- Airborne, multispectral VIS-SWIR demonstrator for **S**ustainable **L**and **I**maging
- In fabrication phase through September 2018
- Flight tests: Fall 2018, Spring 2019
- The REMI architecture meets SLI req's with an instrument that is much smaller than OLI by using a precision 2-axis mechanism to stabilize the scene during image acquisition.
- Features of the REMI architecture:
  - Single, reflective aperture that can also support the thermal infrared channels for full SLI spectral coverage
  - Mechanism and associated electronic control with space-flight heritage from TEMPO and GEMS
  - Much simpler focal plane than OLI and OLI-2 with associated lower costs and risks for acquisition and integration and test





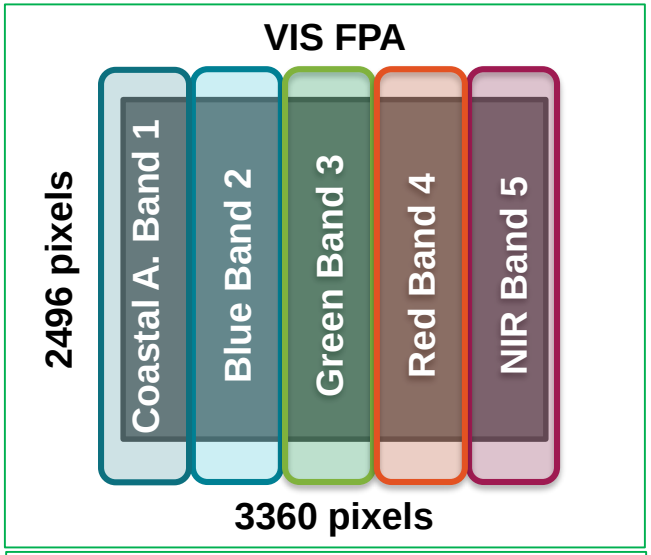
All VSWIR Spectral Bands Demonstrated

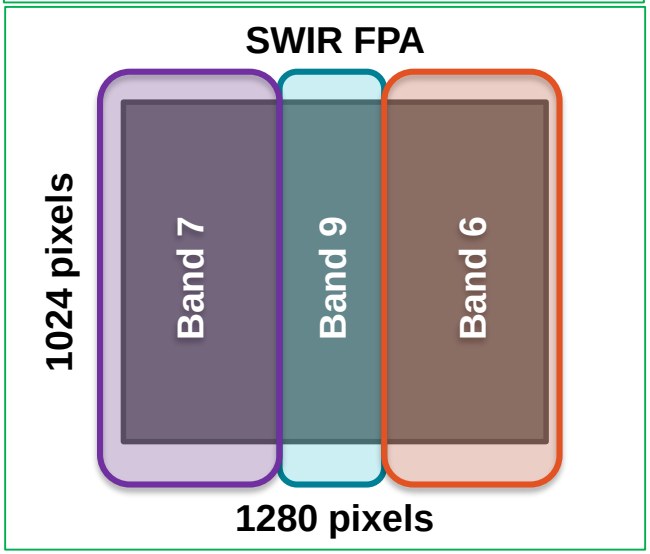
Full VSWIR optical solution for SLI-T demo

- Proposal: 4 visible bands and 2 SWIR bands
  - Demonstrate step-stare approach
  - Multiple optical paths with single aperture
- Baseline: Enable all 5 visible bands, the Cirrus band and both SWIR bands

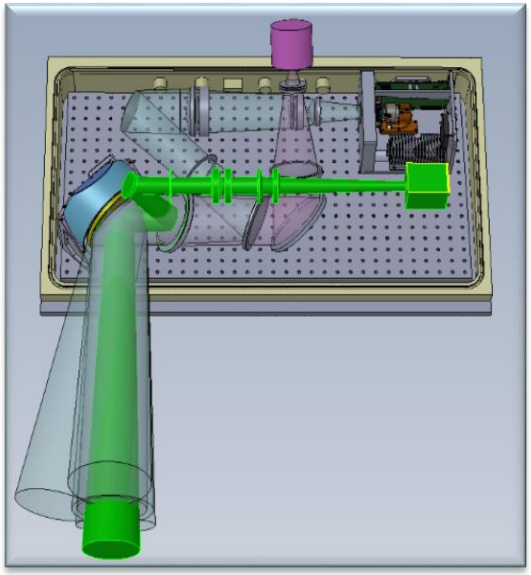
TABLE A.2 SLI-T REFERENCE MISSION SPECTRAL IMAGE PERFORMANCE REQUIREMENTS

Band #	Band Name	Band #	Center Wavelength (nm)	Center Wavelength Tolerance (nm)	Minimum Lower Band Edge (nm)	Maximum Upper Band Edge (nm)
1	Coastal Aerosol	1	448	2	443	453
2	Blue	2	482	5	450	515
3	Green	3	562	5	525	600
4	Red	4	655	5	630	680
5	NIR	5	865	5	845	885
6	SWIR 1	6	1610	10	1560	1660
7	SWIR 2	7	2200	10	2100	2300
8	Panchromatic	N/A	590	10	500	680
9	Cirrus	9	1375	5	1360	1390
10	Thermal 1	N/A	10800	200	10300	11300
11	Thermal 2	N/A	12000	200	11500	12000

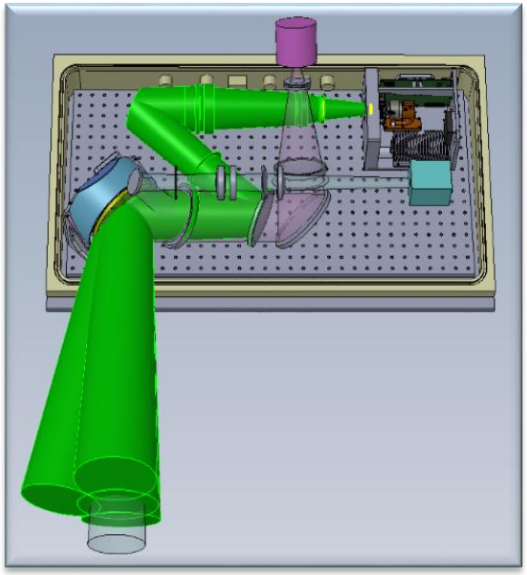




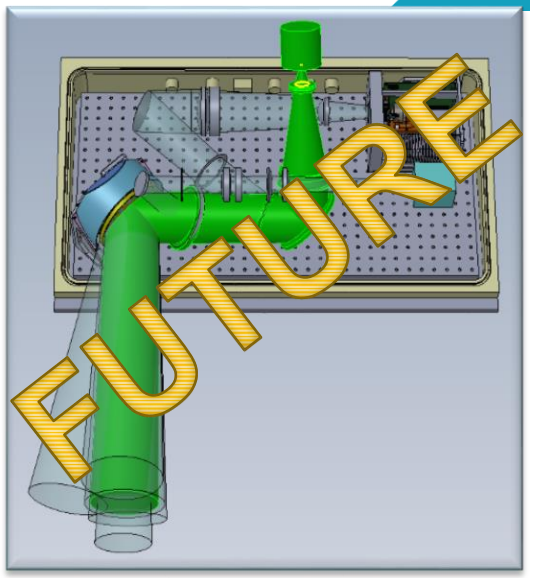
Instrument Design Accommodates VNIR to TIR



VNIR Optical Path



SWIR Optical Path



TIR Optical Path

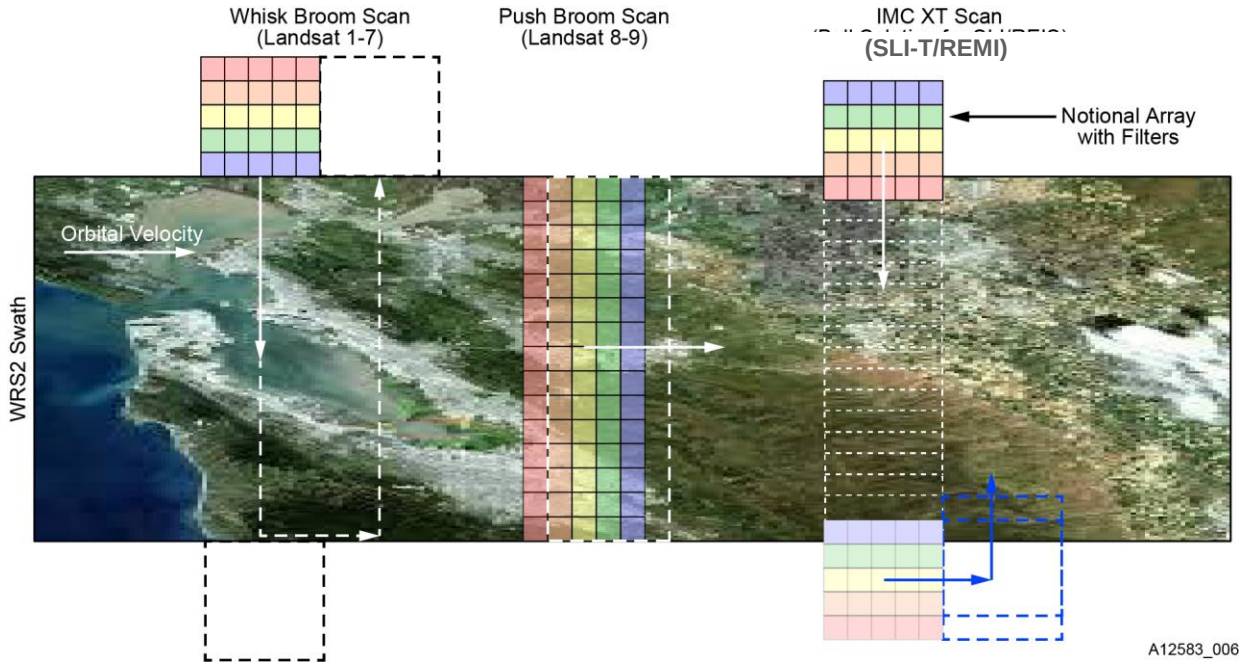
- The VNIR and SWIR channels are within scope of the REMI program
- Instrument design can accommodate and additional TIR channel
  - Compatible with the current optical design
  - Some modifications to instrument base plate and housing would be required

Image Motion Control Enables Smaller Aperture

- In optical instruments, SWaP scales with aperture
- SLI funded REIS (NASA SLI) identified that the driving requirement for aperture size was relative edge response (RER)
  - RER performance is a function of
    - Motion blur
    - Optics blur
    - Detector footprint
    - Platform jitter
- REMI utilizes active image motion control to
  - Reduce motion blur and platform jitter that offset the impacts to smaller aperture
  - Enable smaller aperture / instrument footprint while meeting SLI imaging requirements

Scan Approach Opens the Design Space

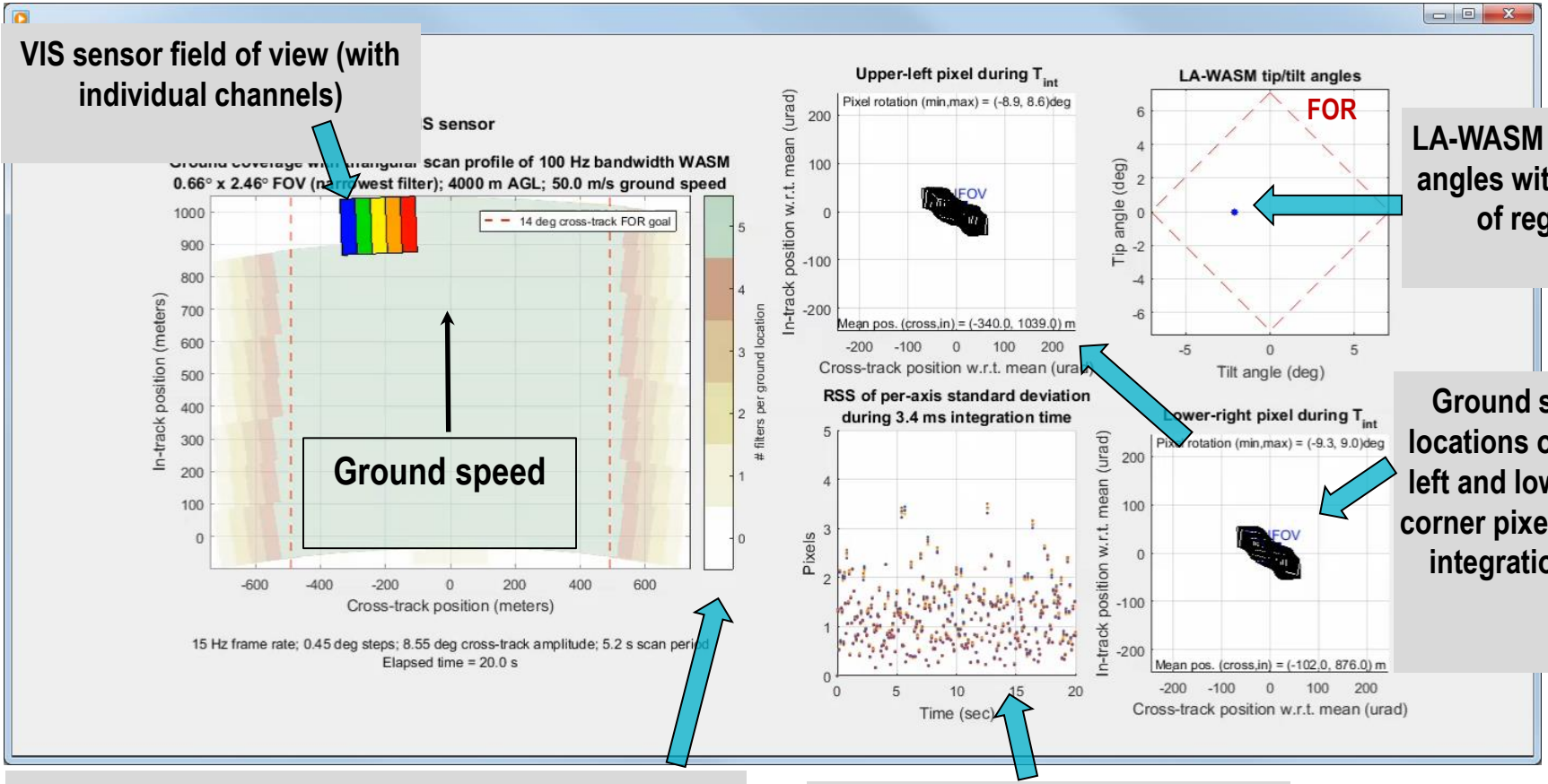
- **Whisk Broom: LandSat 1-7**
- **Push Broom: LandSat 8 & 9**
- **Step-Stare with Image Motion Correction: SLI-T/REMI**



Comparison of three different scan methodologies: Whisk Broom, Push Broom, and Step-Stare.

Scan Modeling (Airborne System)

(OLI equivalent VIS IFOV = 42 urad)



LA-WASM pointing angles within field of regard

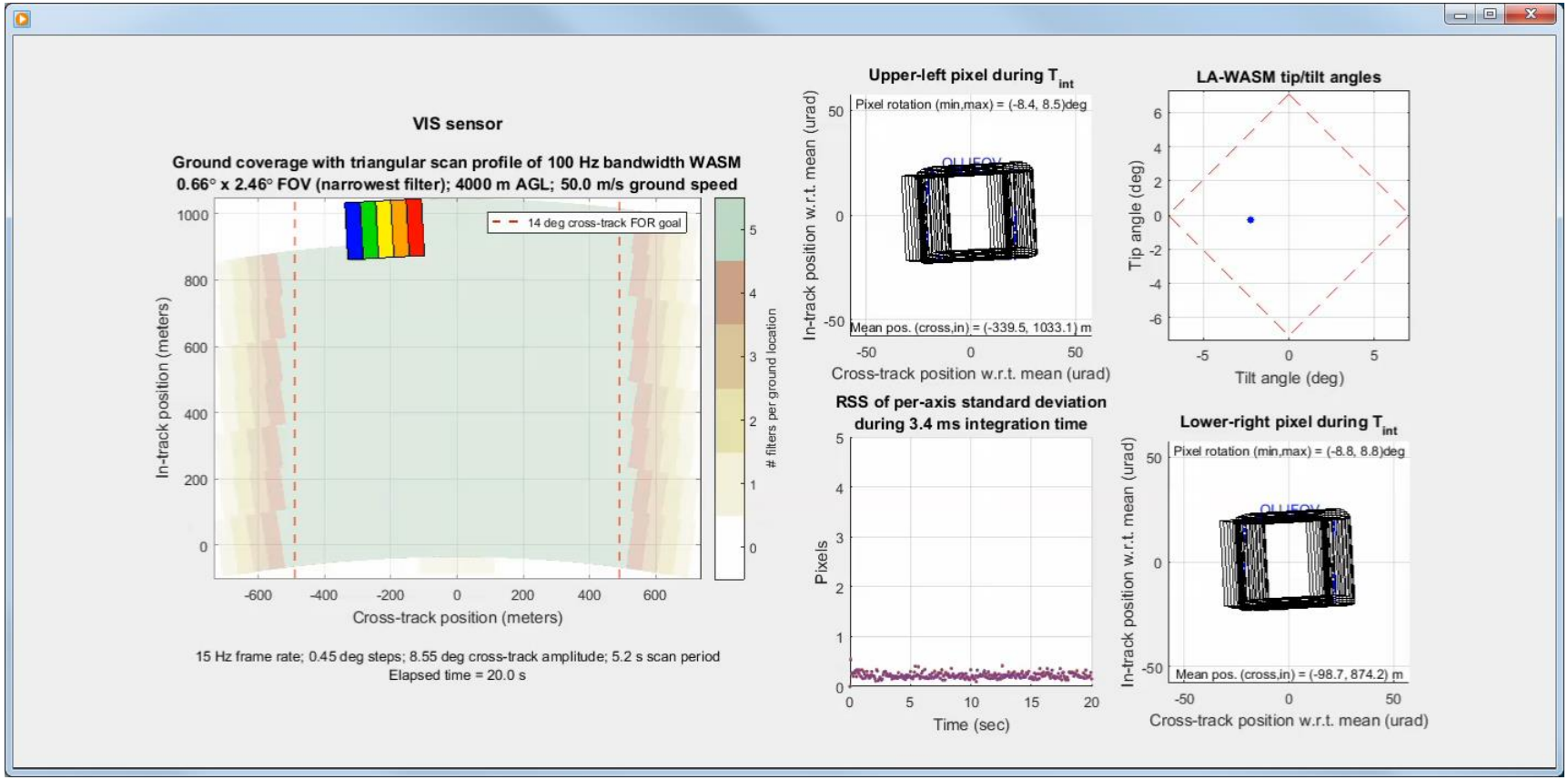
Ground sample locations of upper-left and lower-right corner pixels during integration time

Ground coverage plot (color indicates # of VIS channels that sampled point on ground)

RMS motion of corner pixels during integration time

Scan Modeling (On-Orbit Case)

(OLI equivalent VIS IFOV = 42 urad)

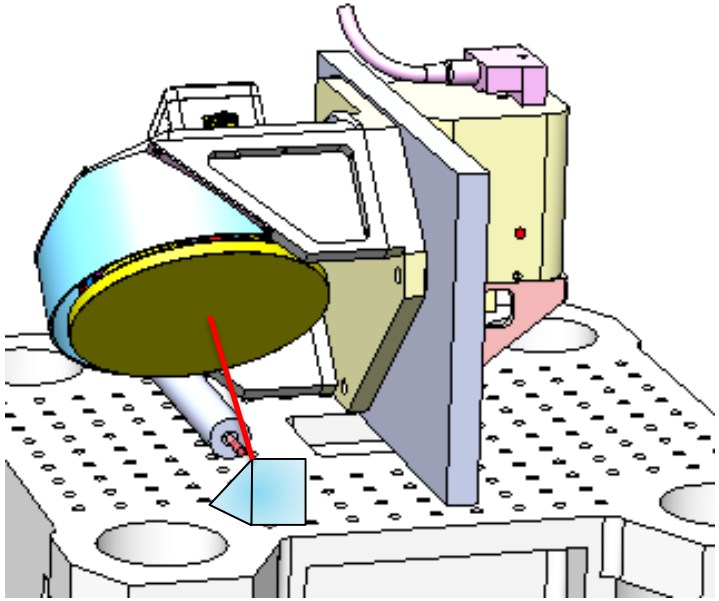


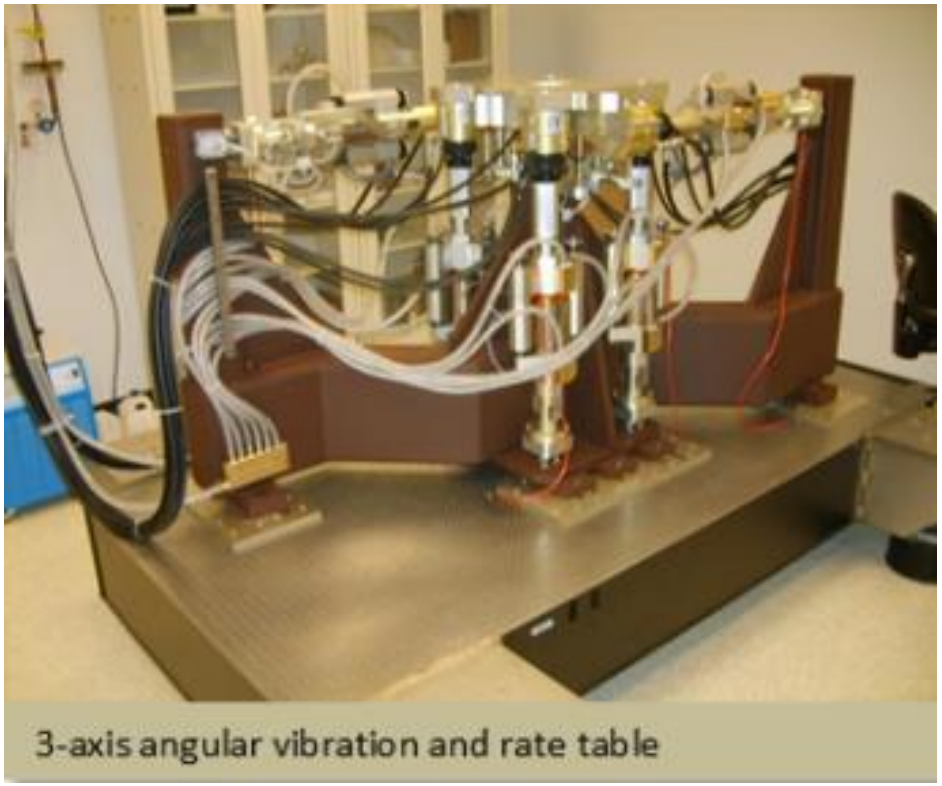
Aircraft is the more challenging environment

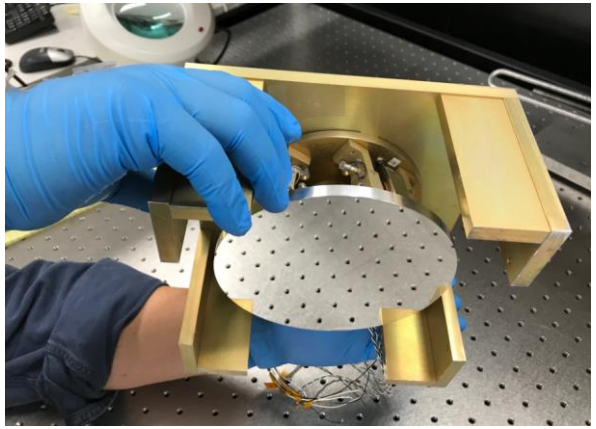
REMI Program Status

- REMI design and all drawings are complete
  - Parts are on order and are planned to arrive when needed
- First stage lens bonding completed
- Second stage lens bonding in process
  - SWIR optics currently on laser alignment station
  - VNIR optics staged for second stage lens bonding
- WASM manufacturing complete
  - In final calibration
  - Preparing for rate table testing
- Flight mechanical housing complete
  - Mounting plate complete as is instrument cover and thermal interface and plumbing
- REMI control electronics box complete
- Preparing for system integration later this summer

Rate table testing planned for July 2018

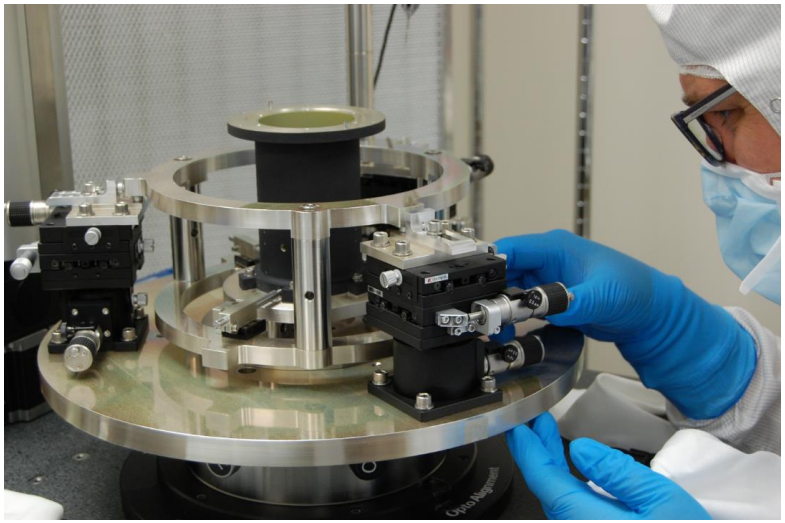


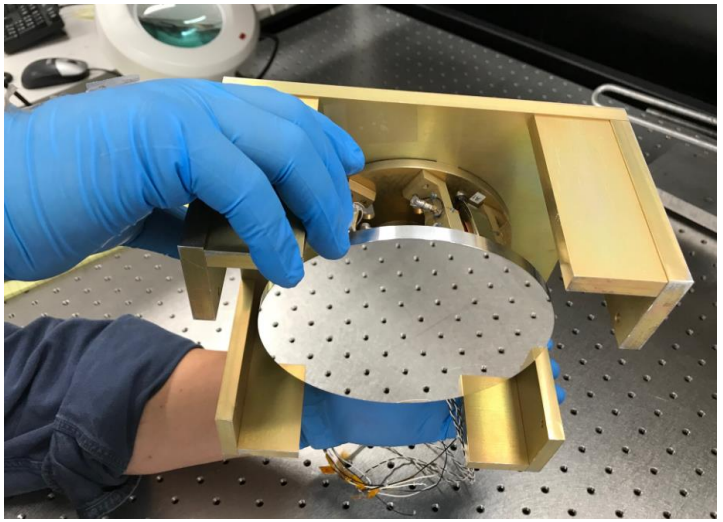


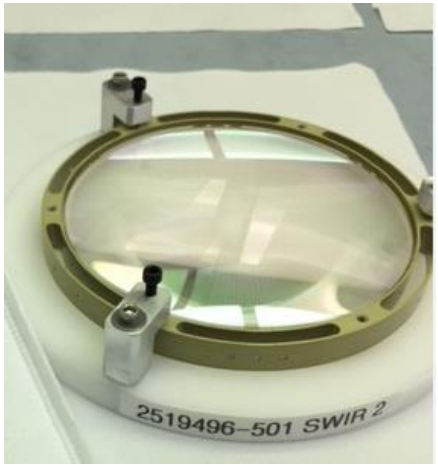


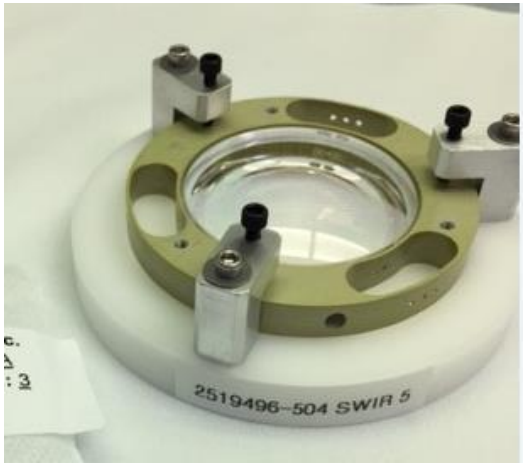
Test will verify scan mirror performance for both spacecraft and Twin Otter disturbance environments

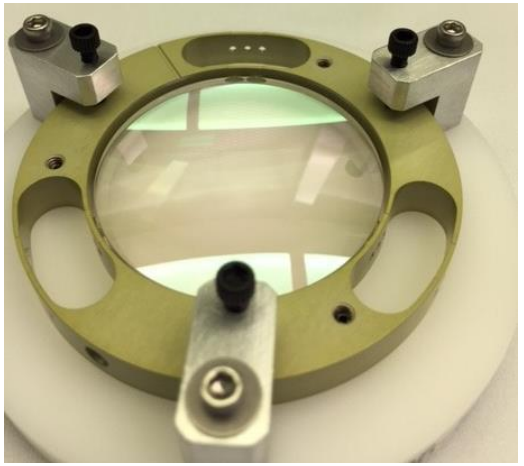
Optical alignment in process



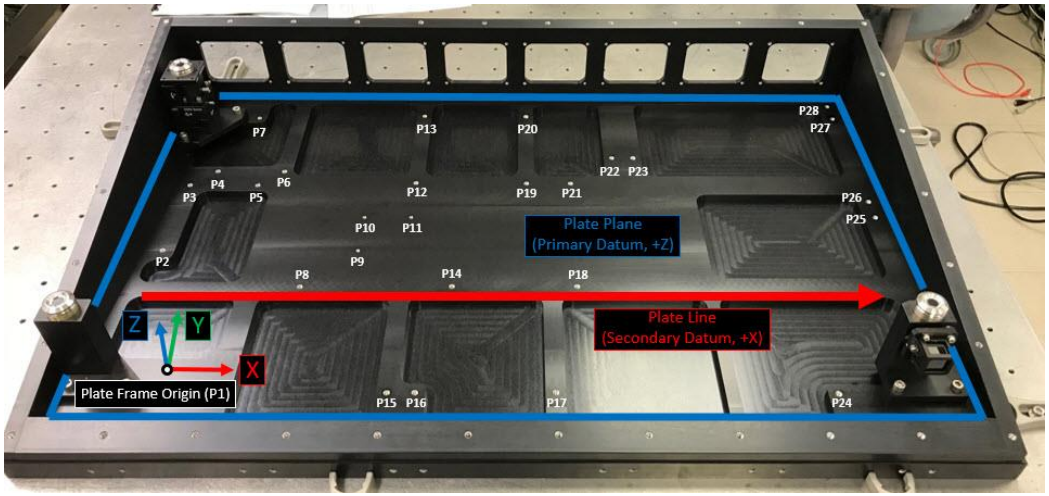








Flight Mechanical Housing and Control Assembly Complete



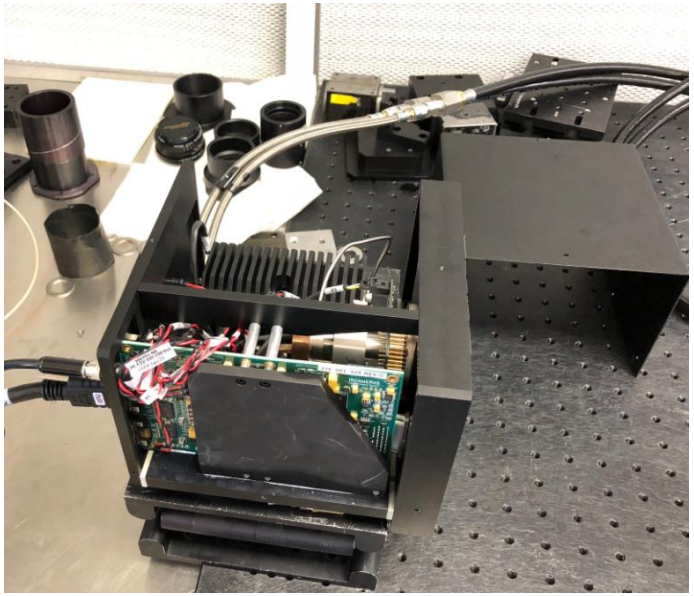
Flight mechanical baseplate

Control Assy

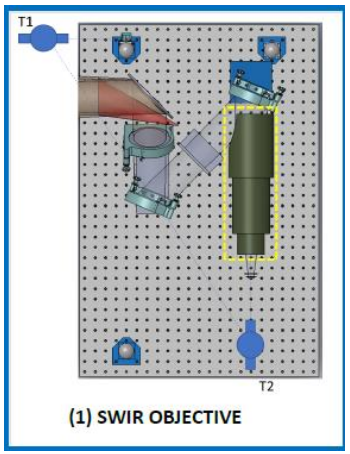
Housing and thermal subsystem

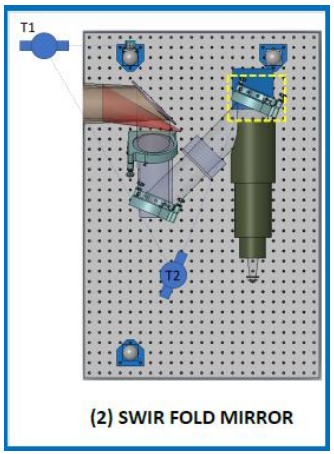
SWIR Camera Thermal Testing

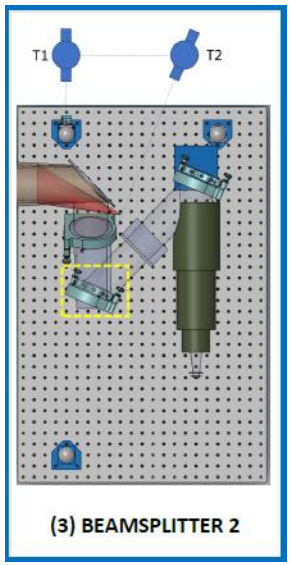
- The SWIR camera was tested using the REMI thermal system to predict performance in flight configuration
  - Verified that the radiometric accuracy of the flight system will be limited by the shot noise of the detector

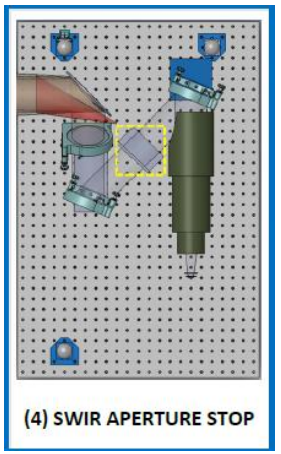


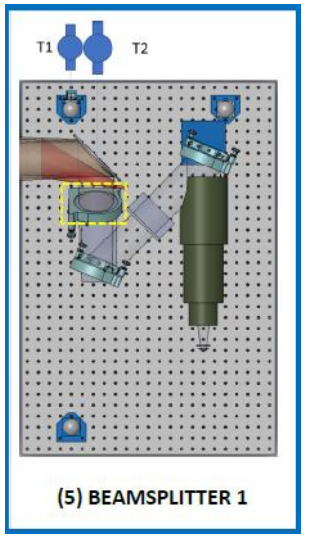
System level Integration and Optical alignment

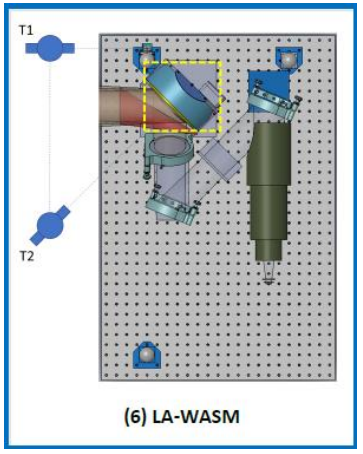


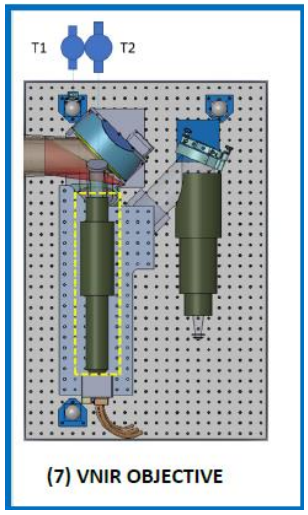


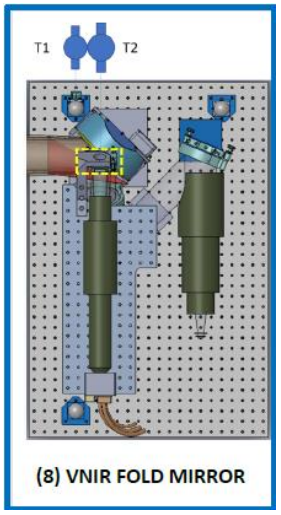


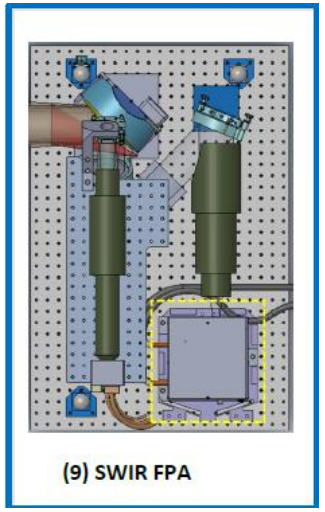




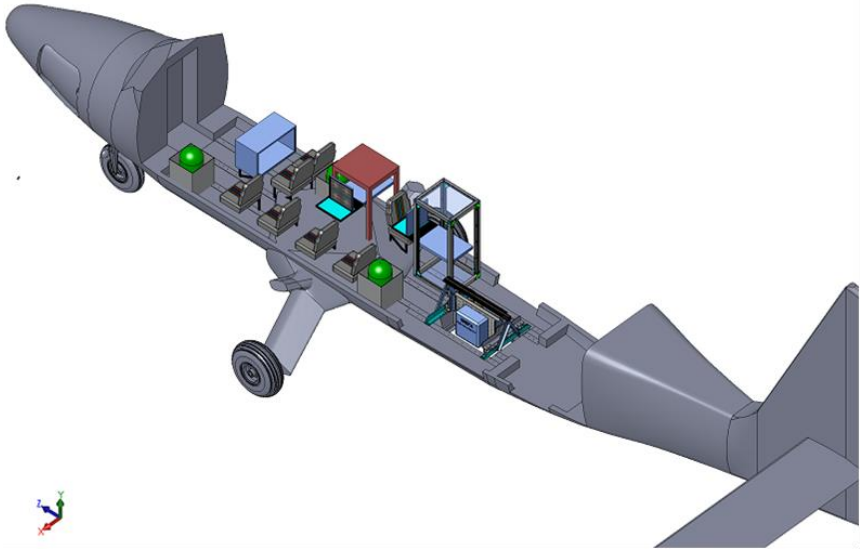


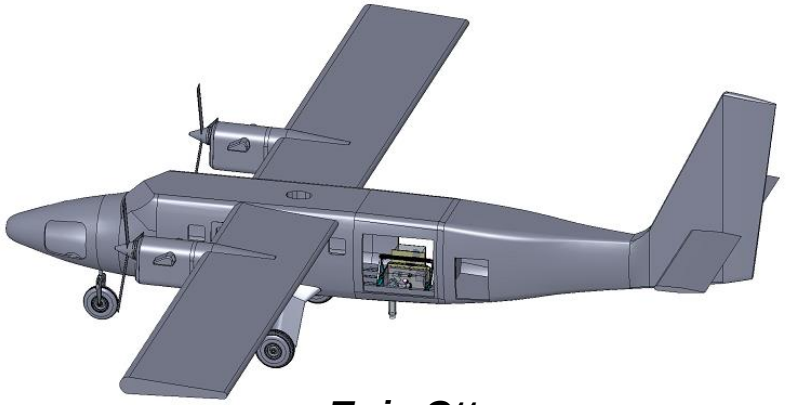






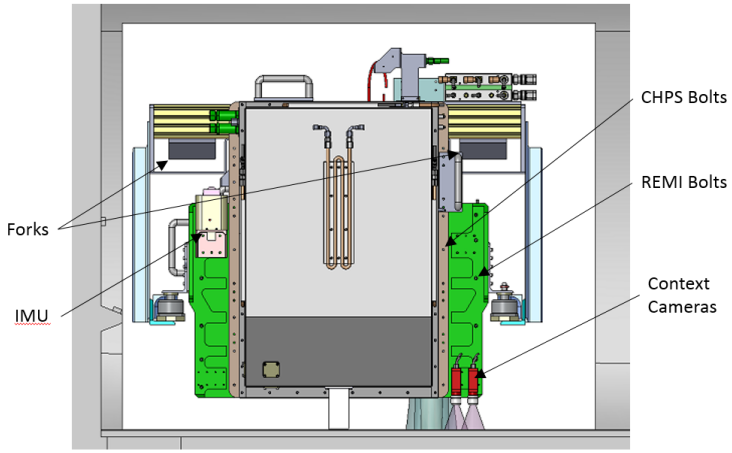
Twin Otter Integration Configuration Complete

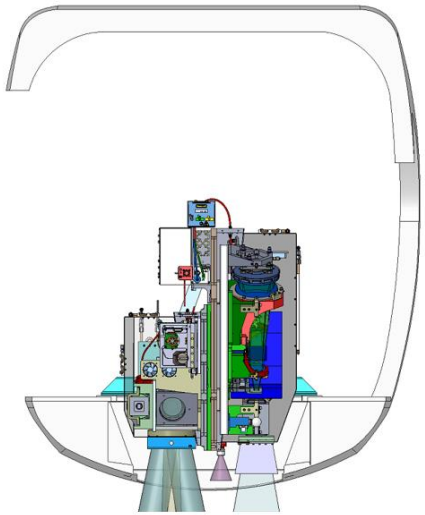




Twin Otter

Attachment to Mount

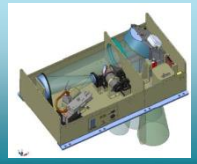




Flight Plans

2018Q3
Lab Testing
Rate Table

2018Q3
System
Integration



2018Q3/4
Engineering
Flight

2019Q2/3
Science
Flights

REMI SLI-Tech Project validated the measurement concept through aircraft testing and rate table testing with expected spacecraft motion.

- Eng. Flights ensure proper interfacing and functionality while airborne
- Science Flights used to acquire data of specific interest to the science community

Summary

- REMI utilizes a high performance scan mirror to achieve Landsat requirements with significant reduction in SWaP
  - Reduces image smear typical of Landsat instruments
  - Enables smaller aperture
  - Enables use of simple detector types
  - Key scan mirror technology has been space qualified on the GEMS and TEMPO programs
- REMI is currently in integration and test
- Engineering flights planned for Fall 2018, followed by science flights in 2019.

Acknowledgements

- Funding from ESTO/SLI-T, Contract No. NNX16AP63G
- Ball Team:
  - Dennis Nicks, PI
  - Jim Howell, PM
  - Bob Slusher, AI&T
  - Pauk Kaptchen, AI&T
  - Betsy Farris, Systems Engineering
  - Tom Kampe, Optical Engineering
  - Emily Mrkvicka, Optical Engineering
  - Bob Warden, Mechanical
  - Kyle Solander, Electronics
  - Jonathan Fox, Software
  - Homero Gutierrez, Scan Mechanism Controls
  - Lyle Ruppert, L1B Data Processing
  - Bill Good, Aircraft Ops

THANK YOU!