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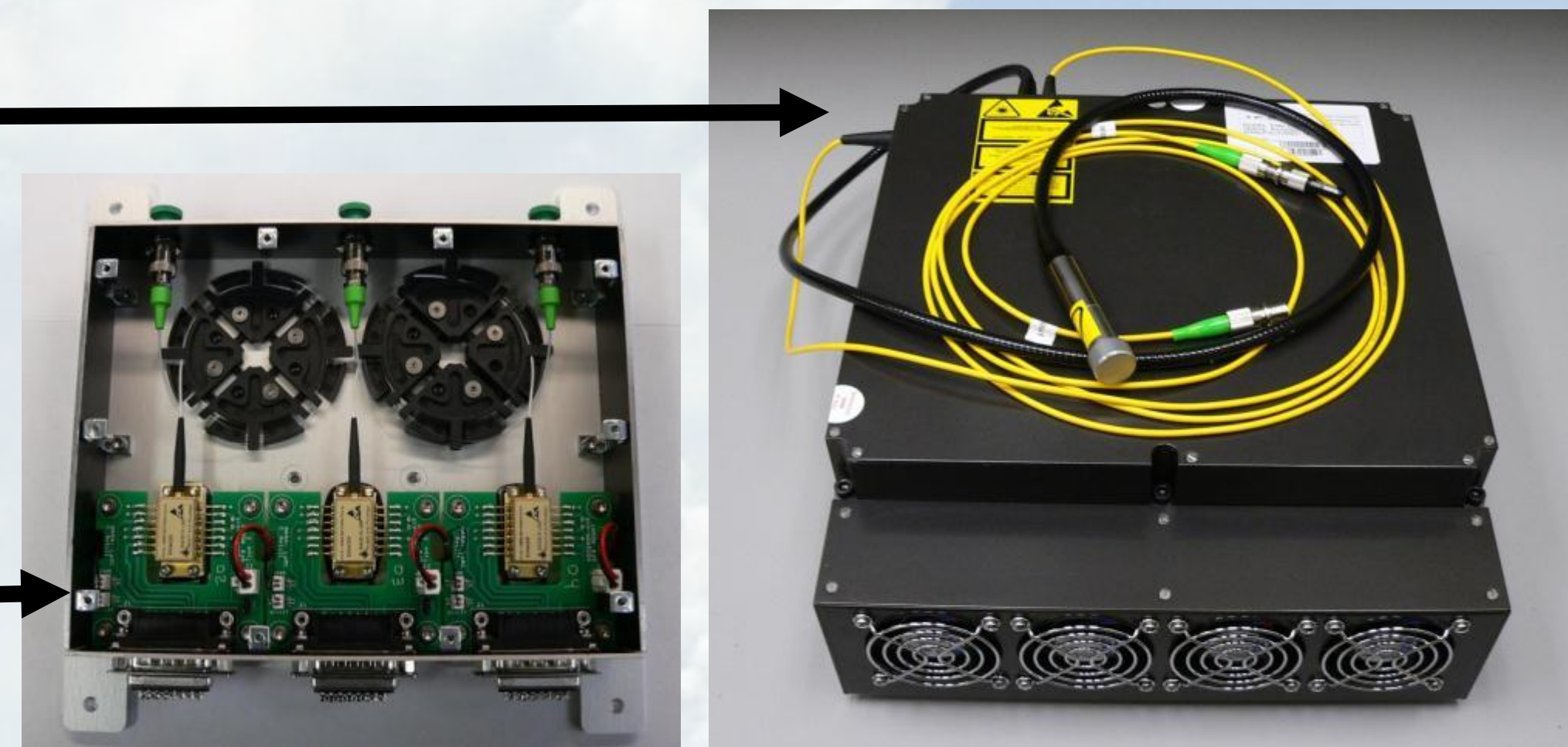
Background

The ASCENDS CarbonHawk Experiment Simulator (ACES) is a NASA Langley Research Center project funded by NASA's Earth Science Technology Office (ESTO) Instrument Incubator Program (IIP). ACES seeks to advance technologies critical to measuring atmospheric column carbon dioxide (CO₂) mixing ratios in support of the NASA Active Sensing of CO₂ Emissions over Nights, Days, and Seasons (ASCENDS) mission. The technologies being advanced are: (1) multiple transmitter and telescope-aperture operations, (2) high-efficiency laser transmitters, (3) a high bandwidth detector and transimpedance amplifier (TIA), and (4) advanced algorithms for cloud and aerosol discrimination. The instrument architecture is being developed for ACES to operate on a high-altitude aircraft, and it will be directly scalable to meet the ASCENDS mission requirements. The above technologies are critical for developing an airborne simulator and spaceborne instrument with lower platform consumption of size, mass, and power, and with improved performance. ACES technologies will be initially tested on the NASA DC-8 and Hu-25 aircraft and are designed to eventually operate on board the NASA Global Hawk Unmanned Aerial Vehicle (UAV).

Laser Transmitter

The laser transmitter development includes fabrication of high-efficiency fiber seed laser electronics, modulators, and amplifiers for sensing of CO₂ at 1.57 micron. The transmitter utilizes Master Oscillator Power Amplifier (MOPA) technology meant to resonantly probe the atmosphere using an Integrated-Path Differential Absorption Lidar (IPDA) approach. The combination of multiple transmitters will be demonstrated in ACES. Compact, low noise, stable, narrow-linewidth seed sources (EM4) are being used. Wavelengths near 1.26 microns are not readily available from commercial off-the-shelf (COTS) lasers, and thus laser technology is being advanced by Exelis in this area to demonstrate the performance necessary for a space payload.

- CO₂ transmitter:**
- 3 - 10 W COTS EDFAs (IPG)
 - Custom seed laser control and wavelength locking circuits
 - Multiple beams combined in far-field
 - Temperature-stabilized seed lasers locked to CO₂ absorption line



- O₂ transmitter:**
- Flight-tested laser absorption spectrometer being provided by Exelis
 - Custom fiber amplifier with 2 beams (on- and off-line) near 1.26 micron
 - 5 W total optical output power

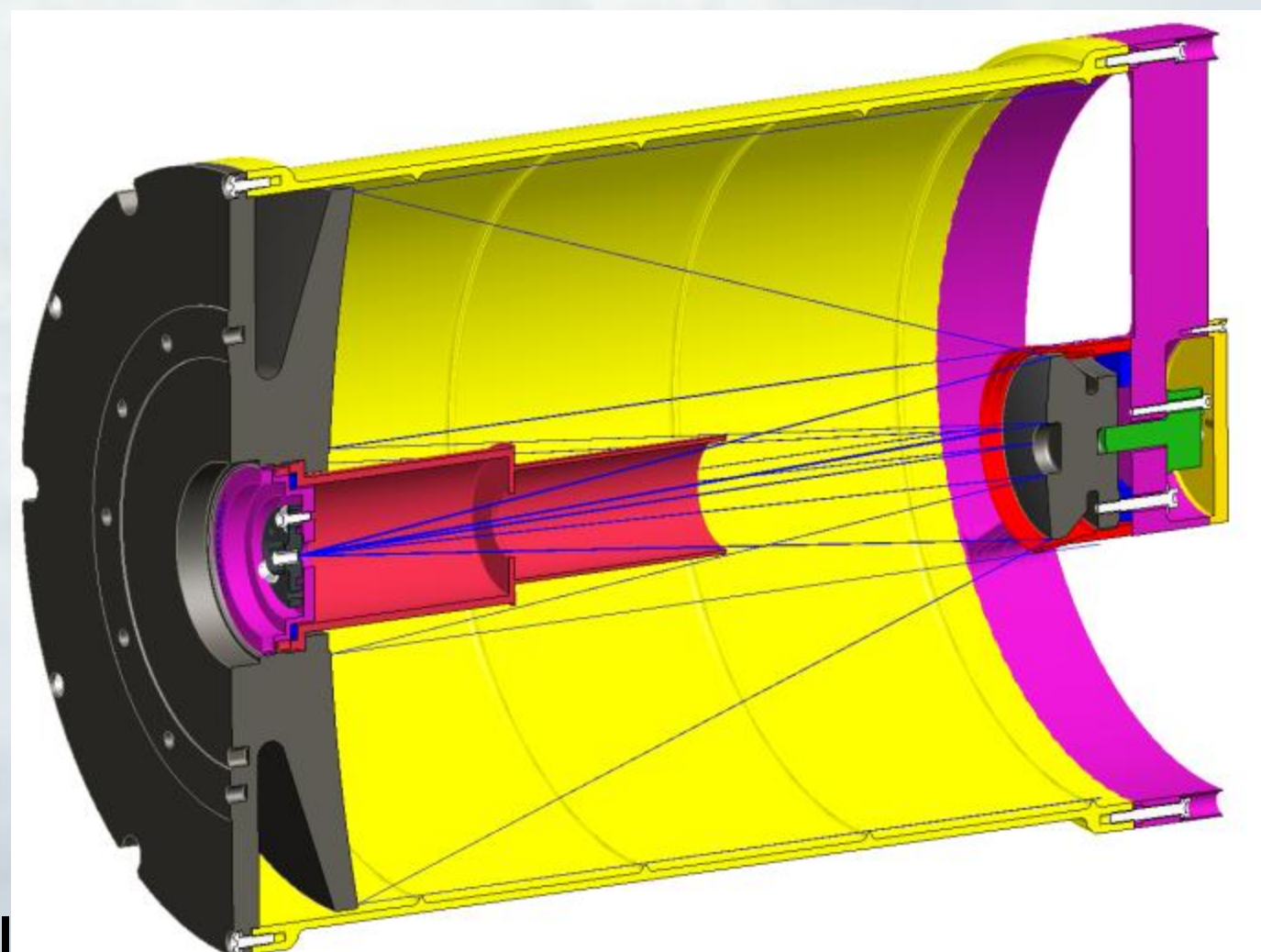
Multi-aperture Receiver

The telescope development consists of a three-telescope design built for the constraints of the Global Hawk aircraft. This task addresses the ability of multiple smaller telescopes to provide equal or greater collection efficiency compared with a single larger telescope with a reduced impact on launch mass and cost.

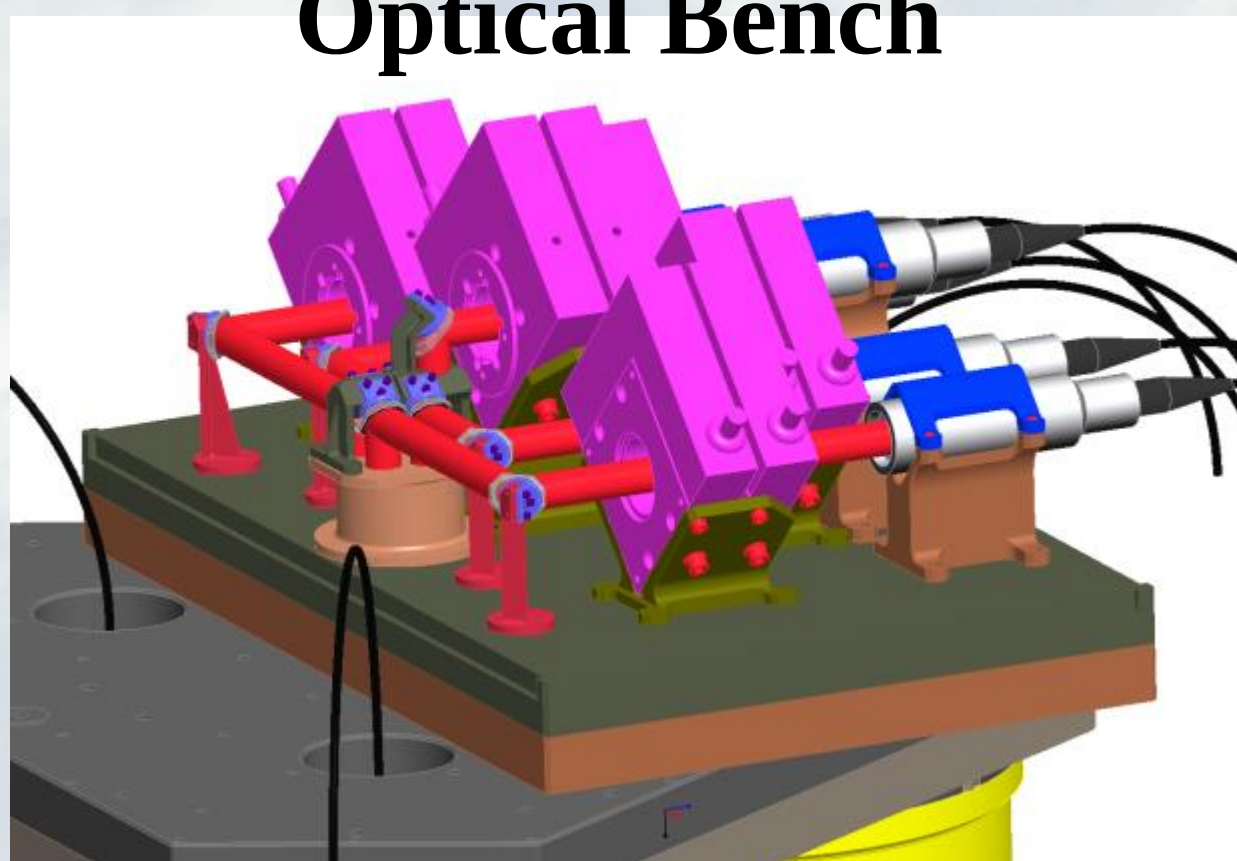
Three 7-inch telescopes designed and built by Welch Mechanical Designs (WMD):

- Fiber-coupled transmit collimator mounts and beam steering coupled to telescope array optical bench
- Optical signal output fiber-coupled to aft optics and detector subsystem
- Telescopes and ACES hardware housed in Global Hawk-compatible environmental enclosure

Telescope Side View



Transmit Collimators and Optical Bench

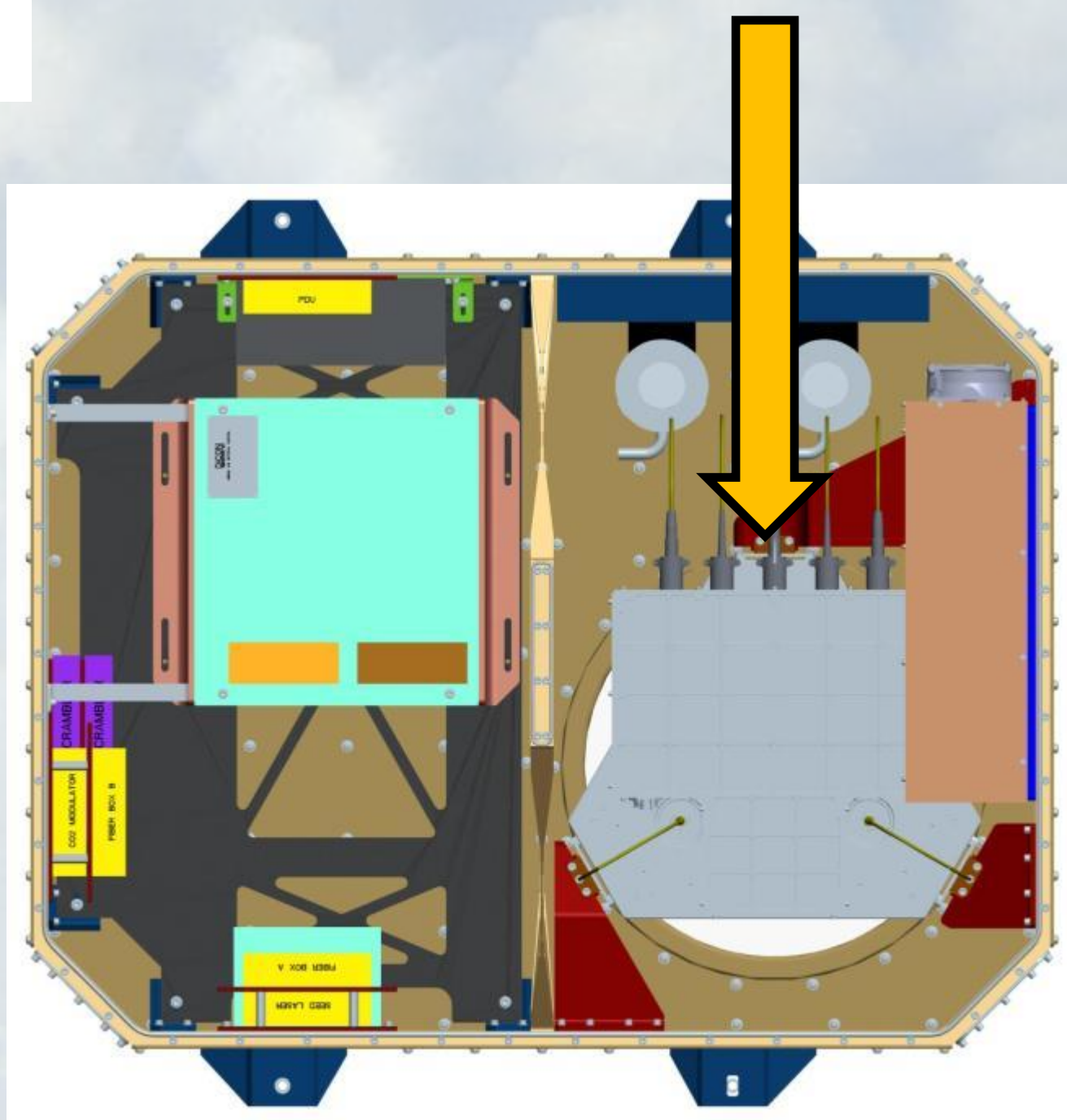


Science Detector Subsystem

Seed lasers and modulation electronics

IPG Fiber Amplifiers (3)

Telescopes (3)



Enclosure Top View

Window portal

Enclosure Bottom View

High-bandwidth Detector

The ACES detector effort has improved the existing detector subsystem by increasing its bandwidth from 500 KHz to 4.7 MHz, reducing its overall mass from 18 lbs to <10 lbs, and stretching the duration of autonomous, service-free operation periods from 4 hrs to >24 hrs.

The technology advancement permits:

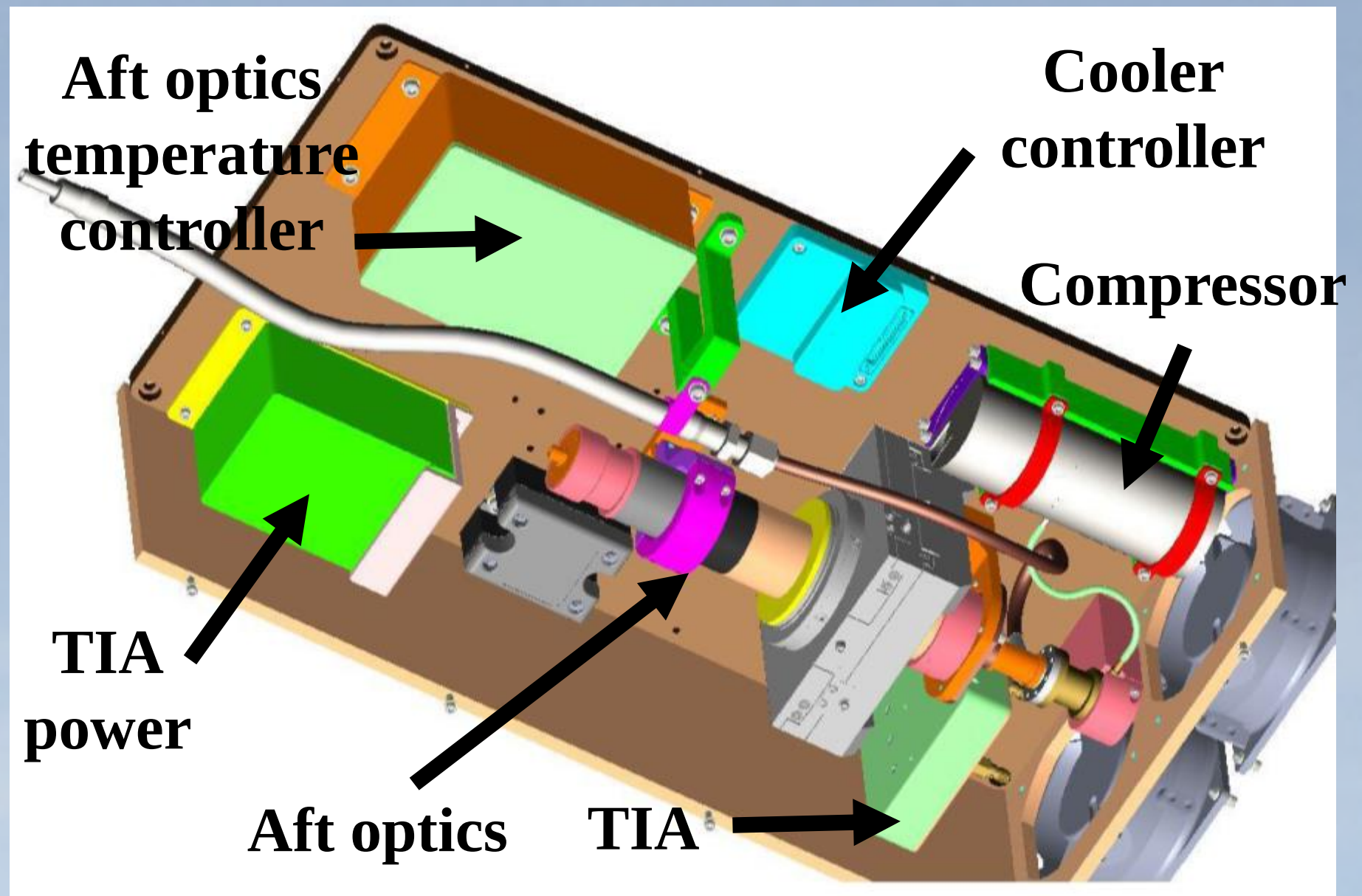
- higher laser modulation rates, allowing greater flexibility for implementing advanced retrieval algorithms as well as improving range resolution and error reduction
- long flights on a high-altitude UAV

Detector characterization and design and build of the TIA and aft optics performed by Exelis:

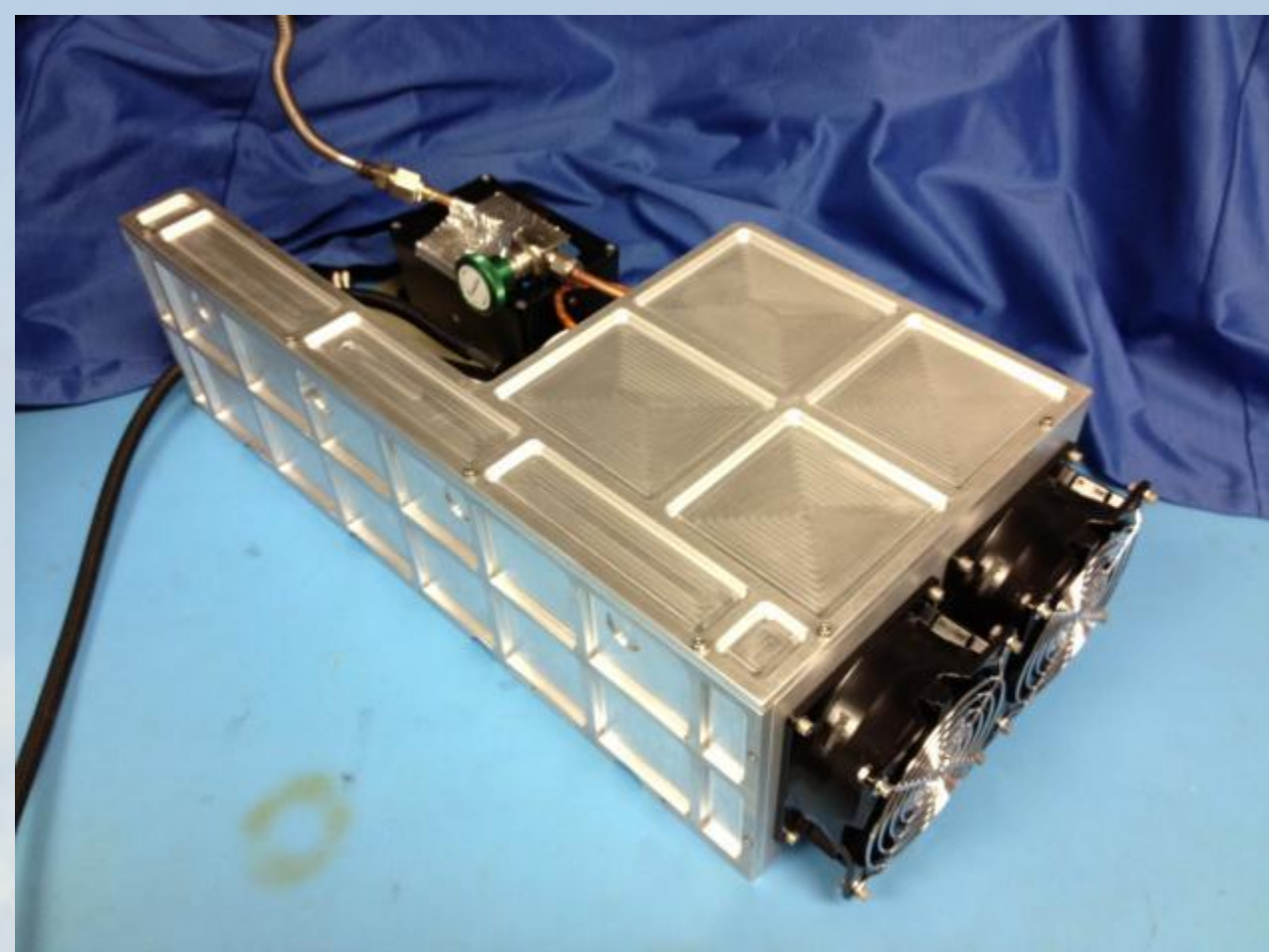
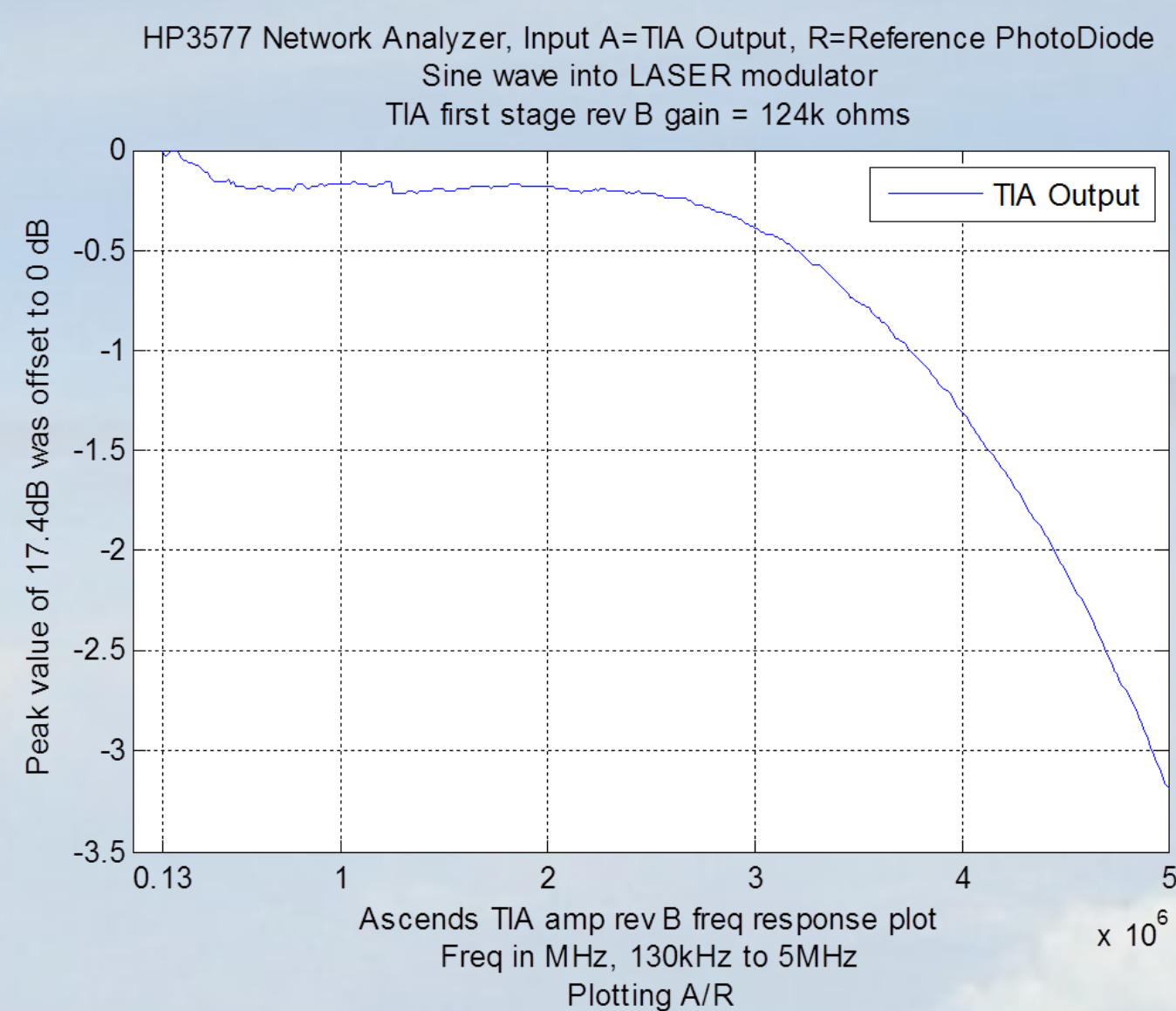
- Detector (DRS Imaging and Targeting Solutions) is HgCdTe array with 59 diodes
- Array integrated into tactical dewar (IRcameras, LLC) with operational range between ~60 – 100 K
- Temp stability: +/- 0.25 K (1 hour), +/-1.0 K (24 hours)
- Detector array interfaces with custom TIA
- Detector subsystem flight-tested on NASA DC-8 aircraft

Mechanical design and manufacture for detector subsystem complete:

- Aft optics couples light from telescope fiber bundle to detector array



Frequency response of detector subsystem is ~5 MHz, limited by custom TIA



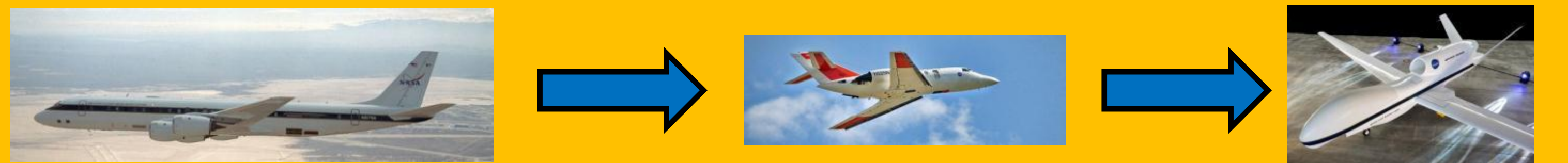
Advanced Algorithms

The cloud/aerosol discrimination work features development by NASA Langley Research Center and Exelis of new algorithms for the avoidance of bias errors in the retrieval of column CO₂ induced by the presence of thin clouds. Coupled with the advanced detector performance, this effort seeks to significantly mitigate thin cloud effects on the retrieval. [See Presentations A23H-04 and A23H-06 on Tuesday, Dec. 10 \(2:40 PM, 3010 Moscone W.\) for more information!](#)

Atmospheric and Environmental Research, Inc. (AER) has implementing an updated line-by-line radiative transfer model (LBLRTM) using spectroscopic parameters from recent research. The updates have been evaluated using TCCON spectra. The LBLRTM, along with radiosondes, model analysis fields, and nominal CO₂ profiles, are being used to assess the impact of uncertainties in atmospheric state variables on differential absorption of CO₂ and O₂.

The University of Oklahoma is evaluating the improvement in understanding of global CO₂ sources and sinks using simulated ASCENDS measurement retrievals.

Summary



The ACES project is advancing key technologies in support of the ASCENDS satellite mission. These technologies are viewed as critical towards developing an airborne simulator and eventual spaceborne instrument with lower size, mass, and power consumption, and improved performance. The ACES detector subsystem was successfully tested during multiple flights on the NASA DC-8 aircraft in February-March, 2013. The full ACES instrument will be tested during multiple test flights on the NASA Hu-25 aircraft in March, 2014, with the eventual goal of flights on board the NASA Global Hawk UAV.

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