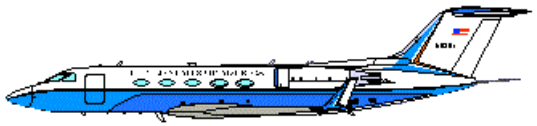


UAVSAR System Overview

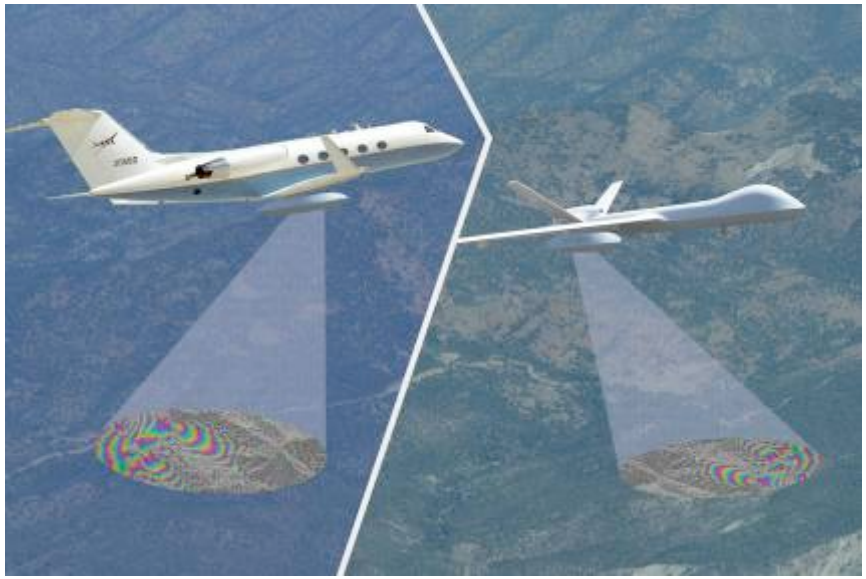
10/25/07

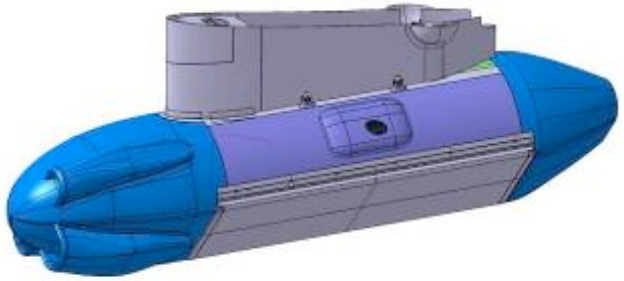
JPL

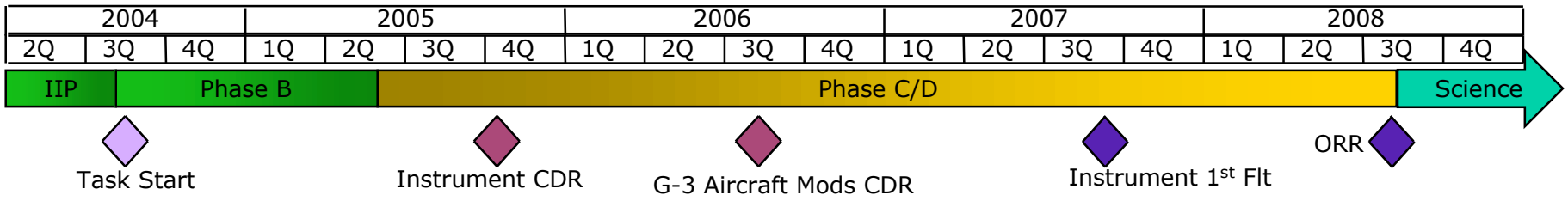
NASA

G-3 UAVSAR Program

- Mission Objective
  - Provide new capability for solid earth science
    - Perform airborne repeat pass radar imaging
    - Interferometrically map deforming surfaces
- Organization
  - Program Office: Earth Science Technology Office
  - Instrument Dev. Lead: Jet Propulsion Laboratory
  - Platform Dev. Lead: Dryden Flight Research Center
- Description
  - Pod mounted instrument (L-Band Synthetic Aperture Radar)
  - 24 element array
  - < 10 m tube flight path using JPL real-time DGPS and Dryden Platform Precision Autopilot
  - Capable of being flown on Gulfstream G-3 or UAS







Project Background

- The UAVSAR project began as an Instrument Incubator Program (IIP) out of the NASA ESTO Program Office.
- After a year of study JPL presented to NASA an instrument concept that could be accommodated on the desired class of platforms, that would meet the original IIP science and instrument objectives and could be expanded to meet future airborne radar science needs.
- The UAVSAR project is a four year program consisting of a 3 year phase in which the radar system is designed and fabricated, the platform is modified, radar is installed on the aircraft and an initial flight testing program is begun.
- The last year of the program is designed
  - to collect repeat pass data
  - to improve system robustness and
  - to validate that the scientific objectives of the sensor are being met

Project Objectives

- The primary objectives of the UAVSAR Project are to:
  - develop an aircraft precision navigation system that will allow the radar (SAR) to be repeatedly flown along a given flight path
  - develop a miniaturized polarimetric L-band synthetic aperture radar (SAR) for use on an unmanned aerial vehicle (UAV) or minimally piloted vehicle
  - develop the associated processing algorithms for repeat-pass differential interferometric measurements (see next slide)
  - conduct measurements of geophysical interest, particularly changes of rapidly deforming surfaces such as volcanoes or earthquakes

- The system has been designed to support a wide range of science investigations including cryospheric studies, vegetation mapping and land use classification, archeological research, soil moisture mapping, geology and cold land processes.

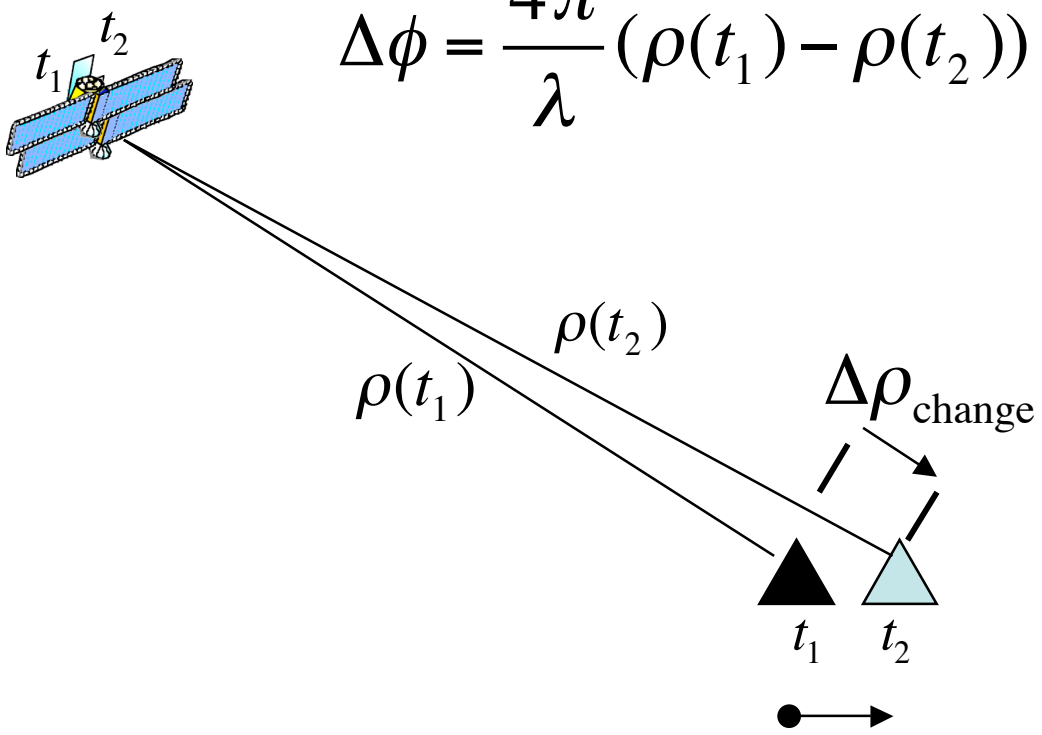
SAR Instrument Design

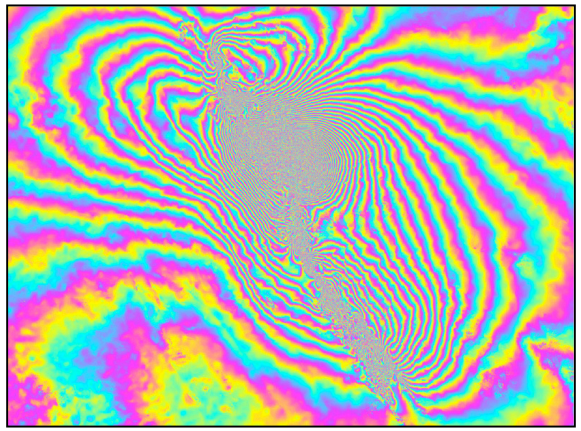
- The UAVSAR radar is designed from the beginning as a miniaturized polarimetric L-band radar for repeat-pass and single-pass interferometry with options for along-track interferometry and additional frequencies of operation.
  - The radar will be initially deployed on the NASA Gulfstream III aircraft with the potential to be ported to other aircraft such as the Predator or Global Hawk UAVs.
- Requirements for a robust repeat pass capability are:
  - It is necessary that on repeat observations the aircraft fly within a specified distance of its previous flight trajectory.
    - UAVSAR has a science-derived requirement for flight track repeatability of 10 m, hence NASA Dryden has modified the NASA Gulfstream III to include a Precision Autopilot capability to control aircraft position.
  - It is also essential that the antenna look directions are identical within a fraction of the beam width.
    - UAVSAR thus employs an electronically steered flush mounted antenna that is pointed in the desired direction based on real-time attitude angle measurements.
- Other technological factors that also influenced the design:
  - The design should be modular, compact, light-weight, and adaptable to the NASA Gulfstream III as well other airborne platforms including UAVs.
  - The design should also be flexible so that this radar platform can serve as a testbed to demonstrate new radar technology and techniques.

Deformation Interferometry

When two observations are made from the same location in space but at different times, the interferometric phase is proportional to any change in the range of a surface feature directly.

$$\Delta\phi = \frac{4\pi}{\lambda}(\rho(t_1) - \rho(t_2)) = \frac{4\pi}{\lambda}\Delta\rho_{\text{change}}$$

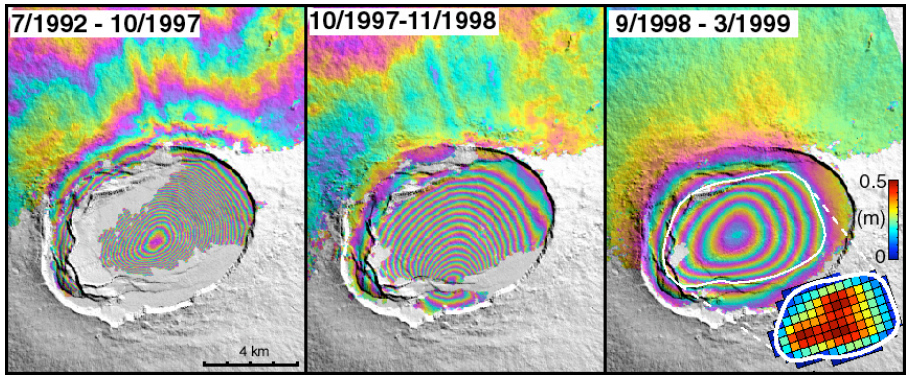




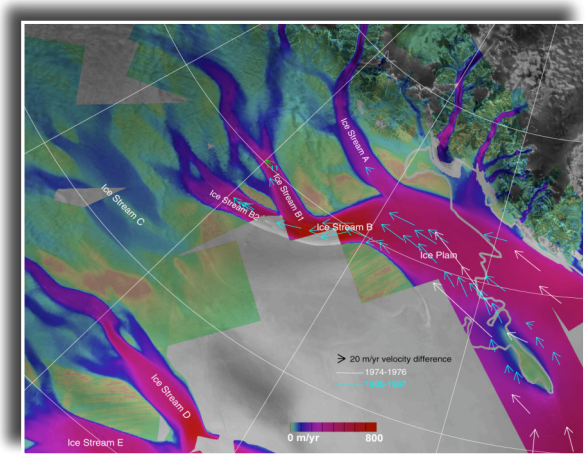
Surface Deformation of the 1999 Hector Mine Earthquake

The Role of Airborne SAR

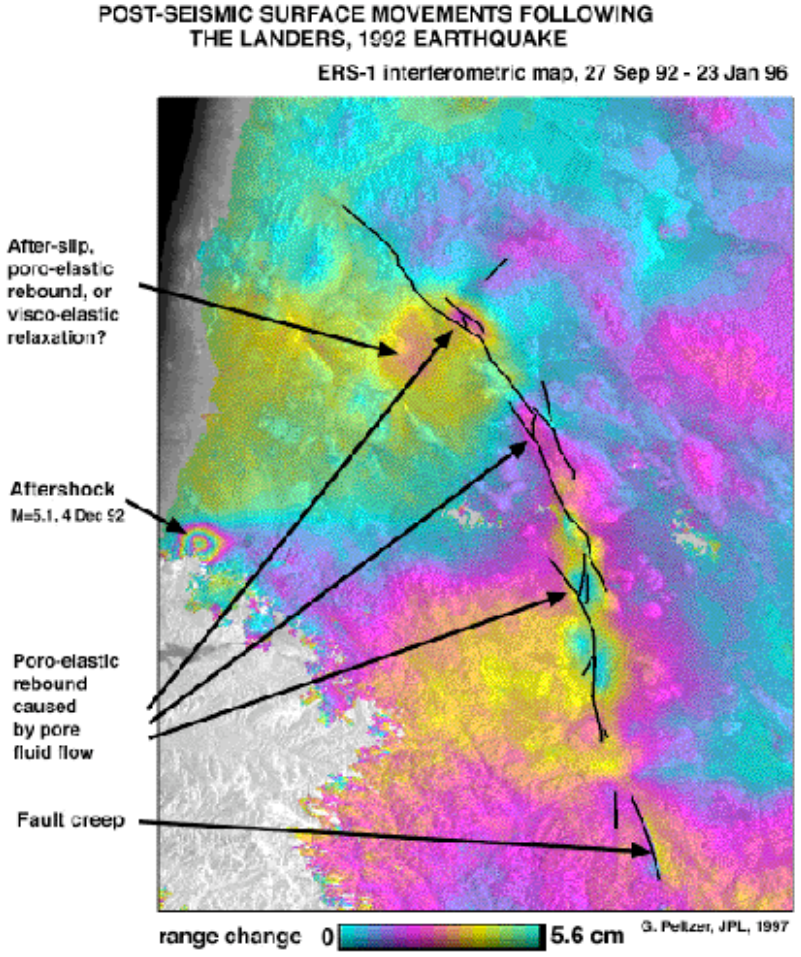
Airborne SAR can contribute to local measurements of rapidly evolving surfaces



Evolution of volcanic magma chambers



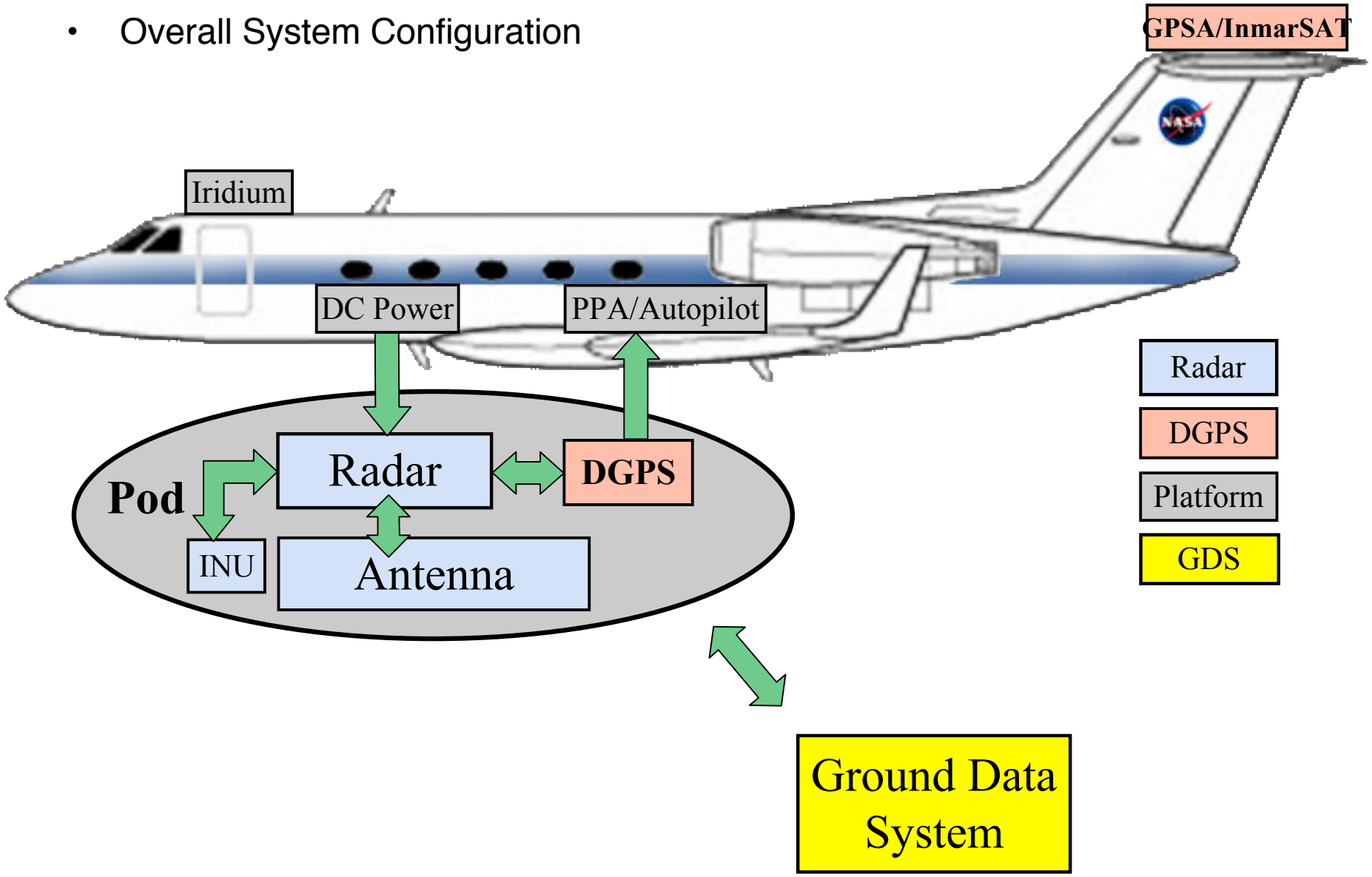
Rapid evolution of ice



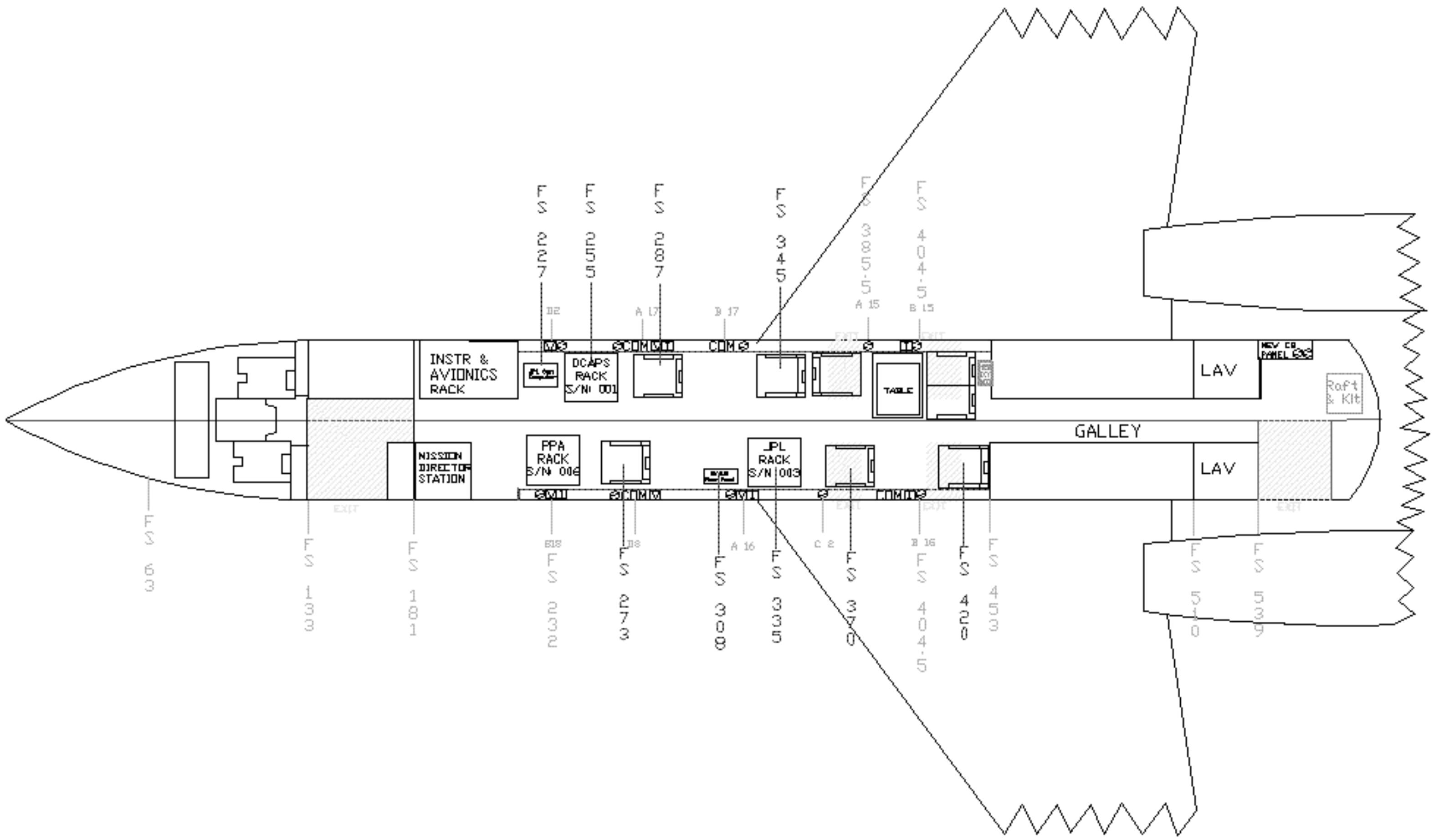
Post/Inter-seismic deformation

High Level Architecture

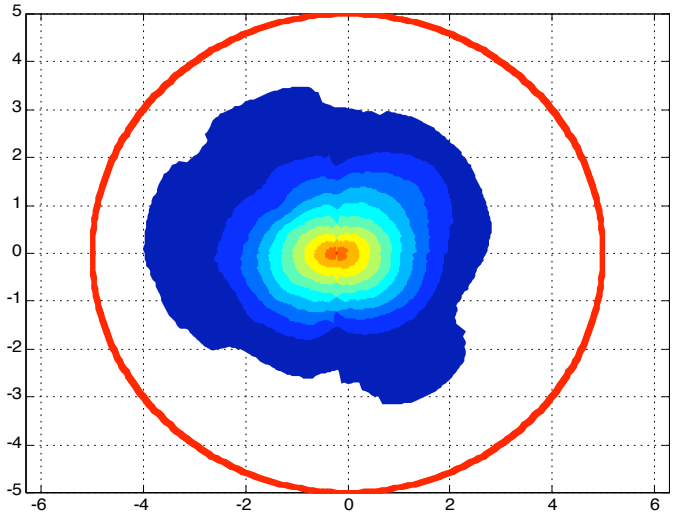
- Overall System Configuration



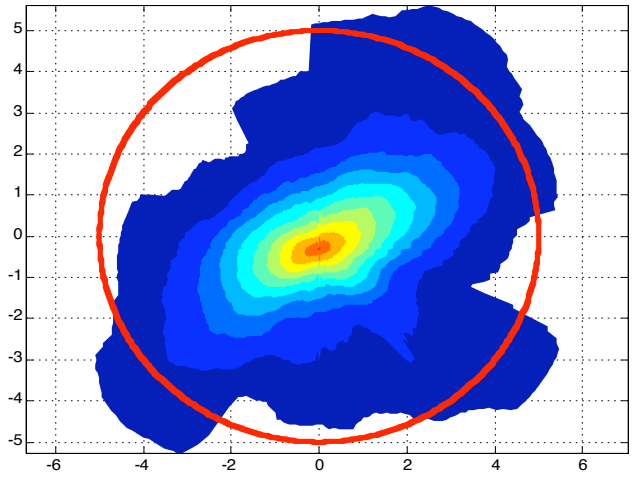
Aircraft Cabin Configuration



Platform Precision Autopilot Performance



- Performance Meets Specifications
  - > 90% of time within 10m tube
  - Pitch rate < .45 deg./s
  - Roll rate < 1.0 deg./s
  - Yaw rate < .45 deg/s

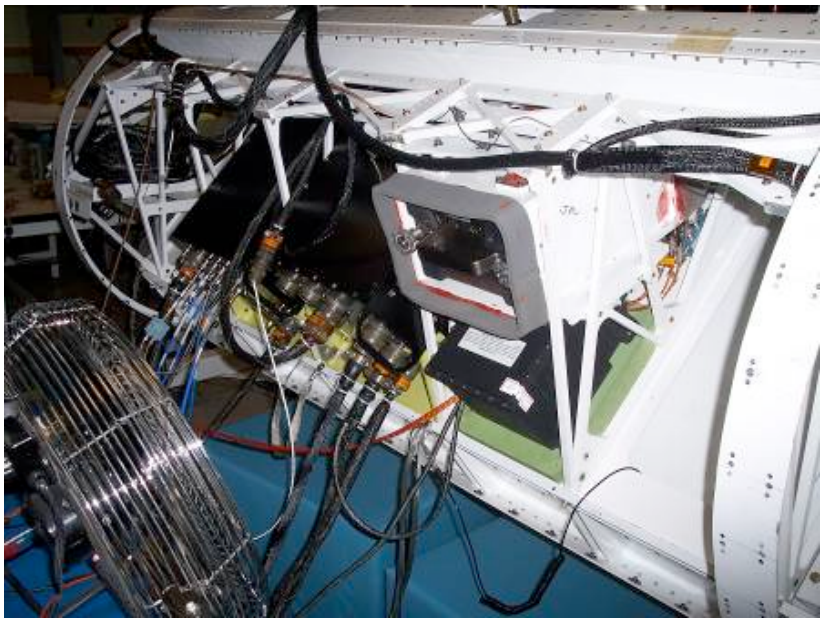


- Performance varies with airspeed
  - Degradation at lower Mach Numbers
  - On back-side of power curve
  - Still within spec
  - Working continues to improve Low-speed performance

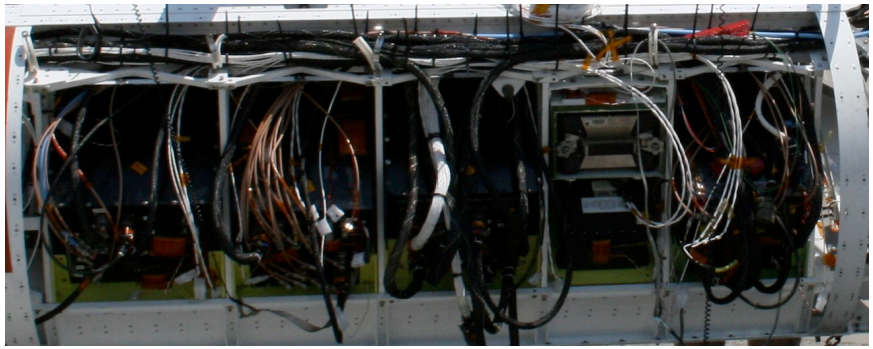
Key Radar Instrument Parameters

Parameter	Value
Frequency	L-Band 1217.5 to 1297.5 MHz
Bandwidth	80/100 MHz Chirp/Noise
Resolution	2.0 m Range, 0.8 m Azimuth
Polarization	Full Quad-Polarization
ADC Bits	1 to 12 bit selectable BFPQ, 180Mhz
Waveform	Nominal Chirp/Arbitrary Waveform
Antenna Aperture	0.5 m range/1.5 azimuth (electrical)
Azimuth Steering	Greater than ±20° (±45° goal)
Transmitter Power	> 2.7 kW
Polarization Isolation	<-20 dB (<-30 dB goal)

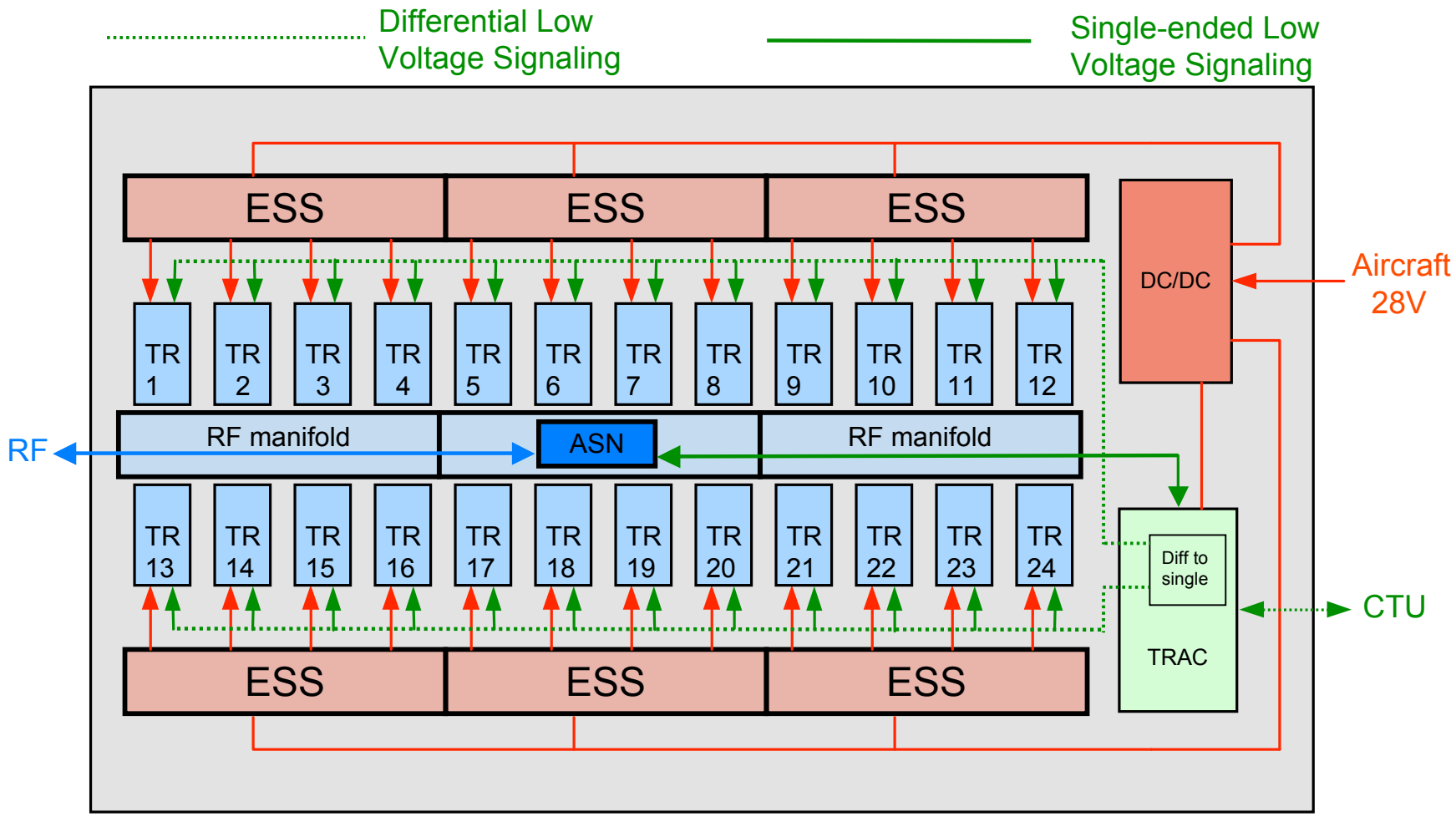
UAVSAR & Pod



DGPS RF PDU JBOD EGI Digital

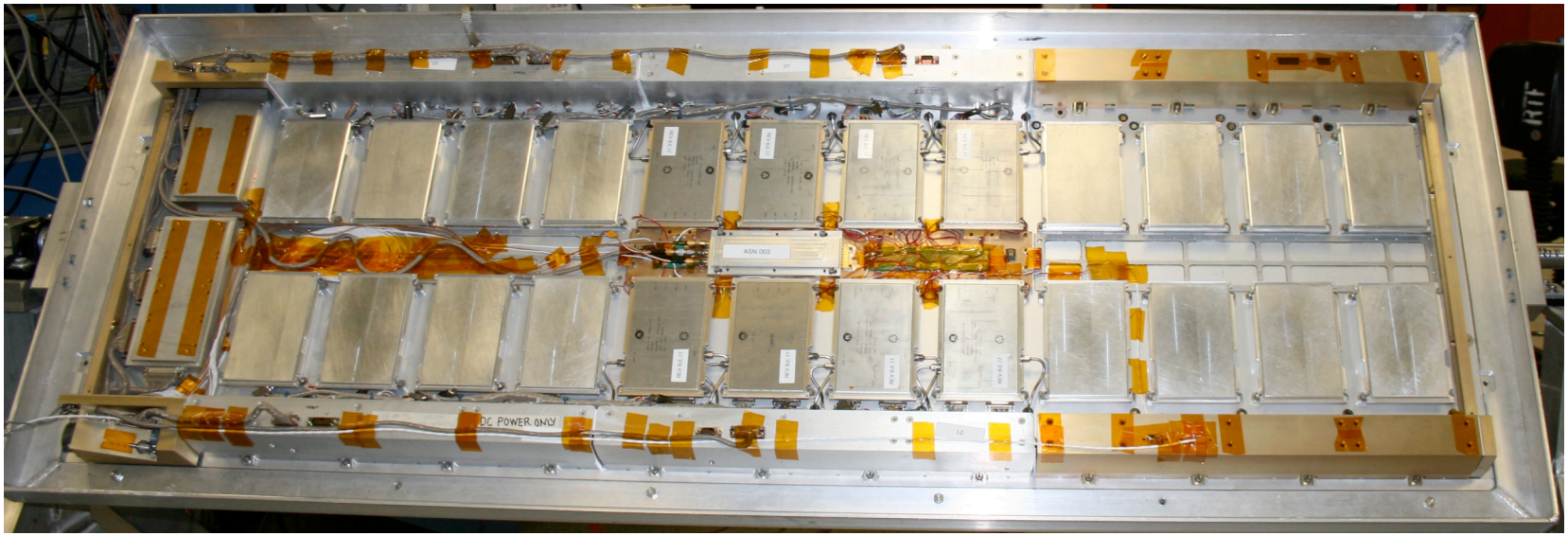


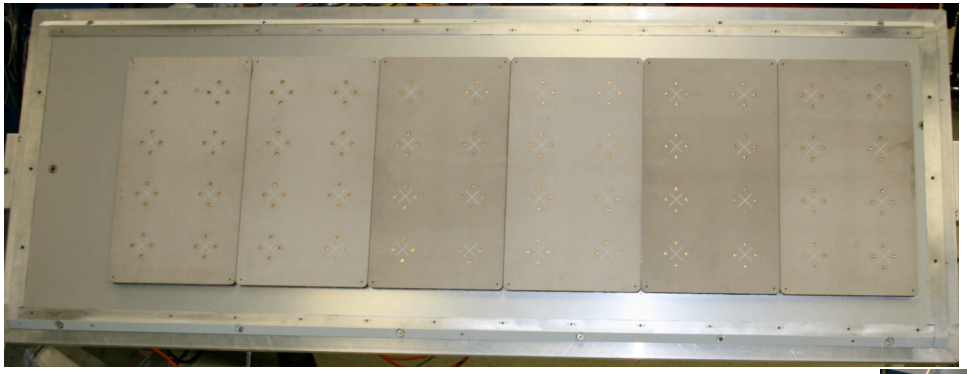
Antenna Overview



- **24 T/R Modules**
- **3 RF Manifold Boards ASN**
- **6 power only ESSs**

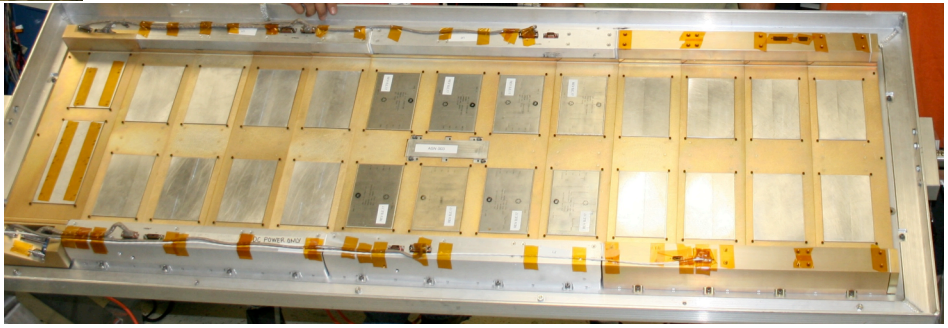
UAVSAR Active Array Antenna





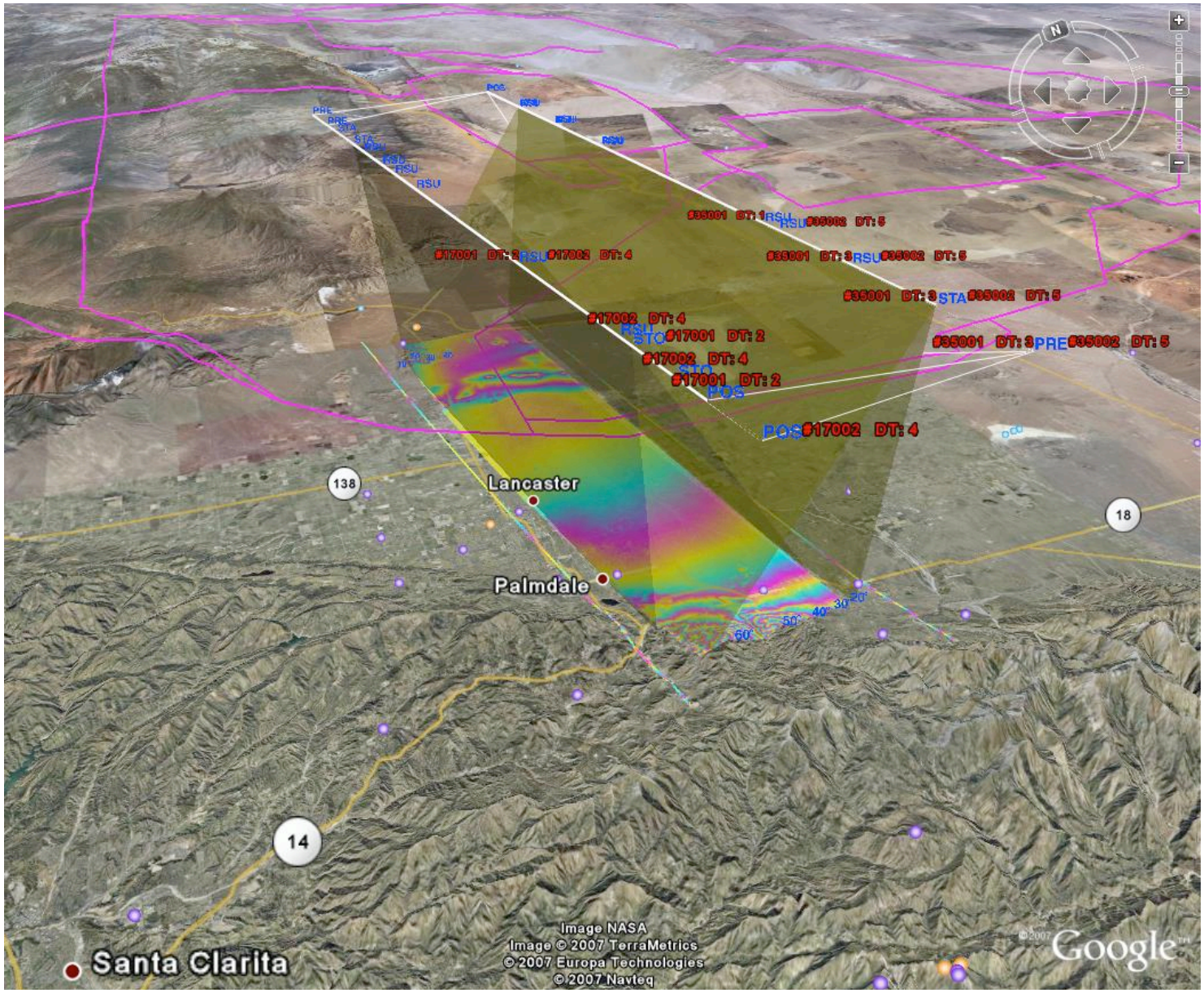
Radiating Elements

Covers in Place

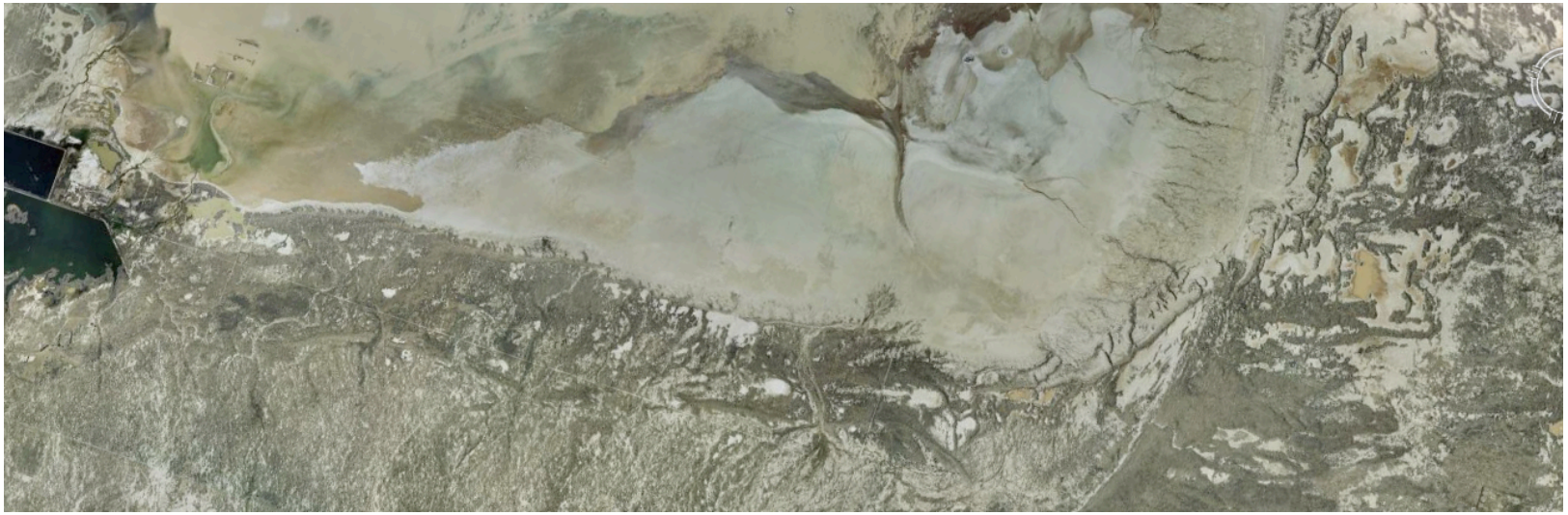


Radar Eng & Cal Checkout Profile

Radar Eng & Cal Checkout Profile



UAVSAR LHH Image of Rosamond Lake Bed

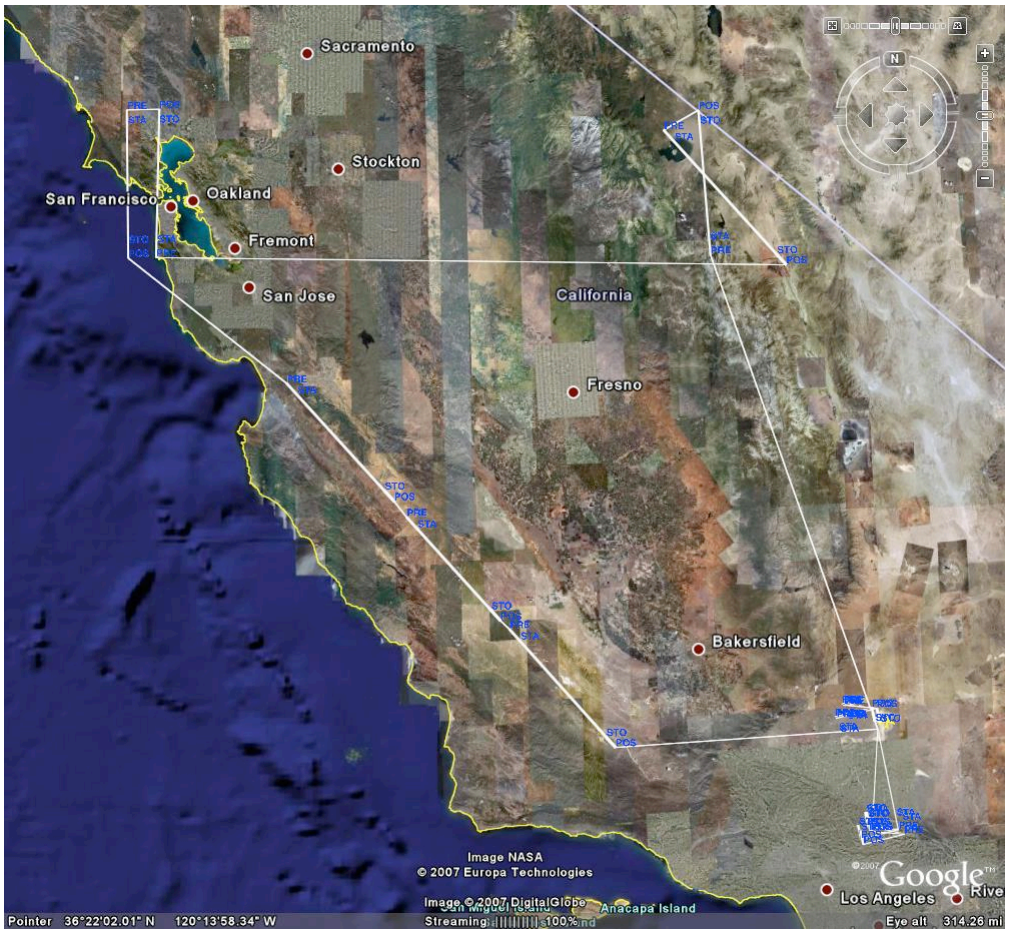


Google Earth Image of Rosamond Lake Bed

LHH – L-Band Horizontal Transmit, Horizontal Receive

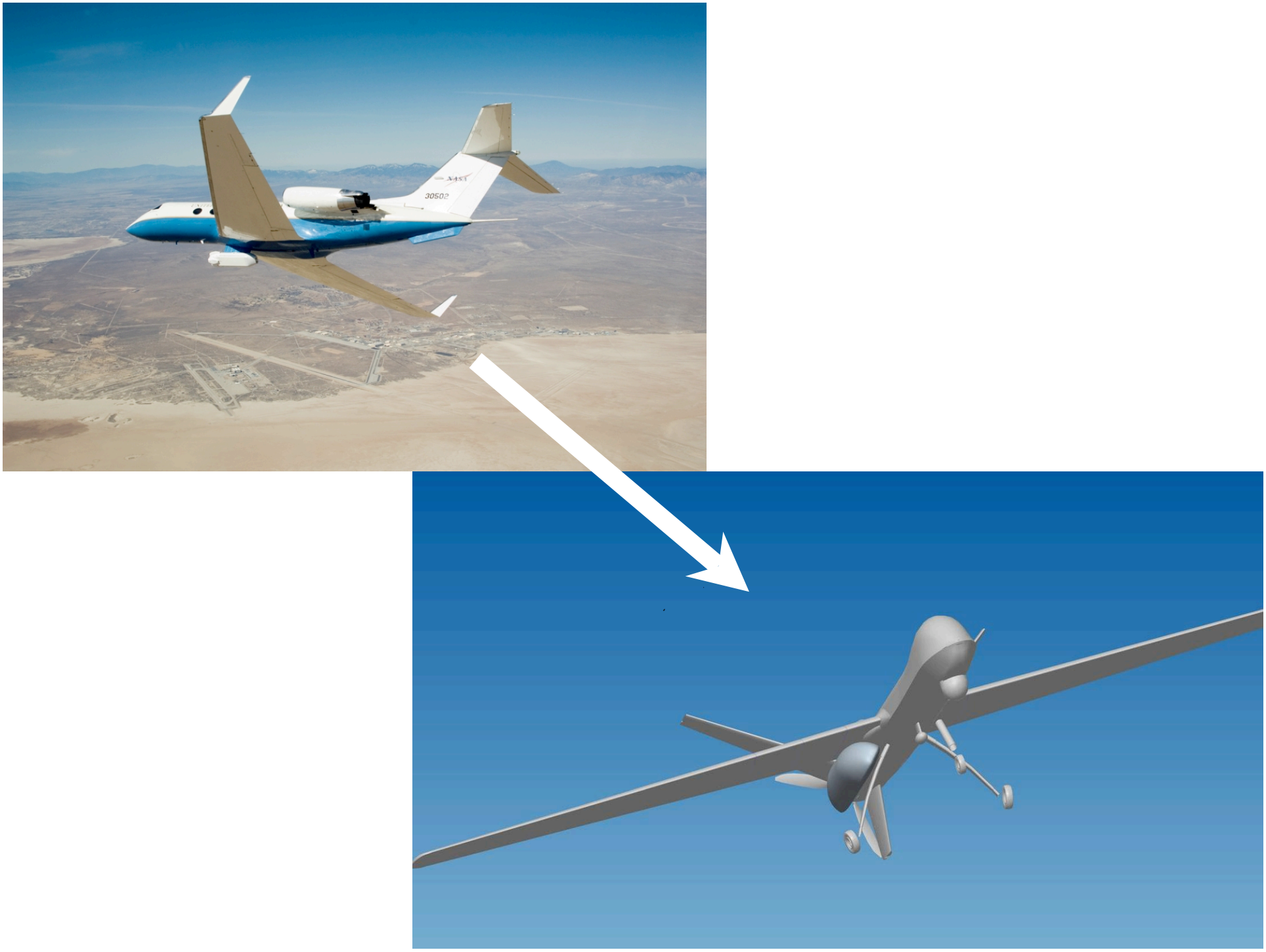
UAVSAR Scenic Flight Path

- **Lake bed images are boring**
- **Topologically varied**
  - **Will include vegetation**
- **Will use polarization**
  - **False color images**



UAVSAR Science Targets

1. **Santa Rosa**
   - 35 mm/yr across San Andreas fault
2. **Creeping section San Andreas fault**
   - And San Simeon earthquake postseismic
3. **Eastern California shear zone and San Andreas fault**
   - 10 and 20 mm/yr respectively
4. **Transverse Ranges**
   - Los Angeles and Ventura basin: 7 mm/yr
5. **Mammoth Lakes**
   - 20 mm/yr
6. **Southern San Andreas system**
   20–35 mm/yr
7. **Three Sisters Volcanoes**
   Up to 48 mm/yr
8. **Yellowstone Hotspot**
   Inflation events up to 50 mm/yr


NASA
30502