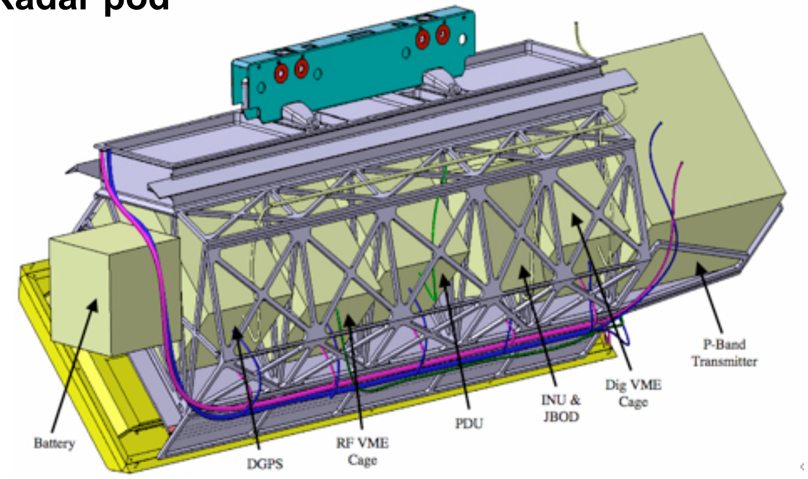
UAVSAR Overview

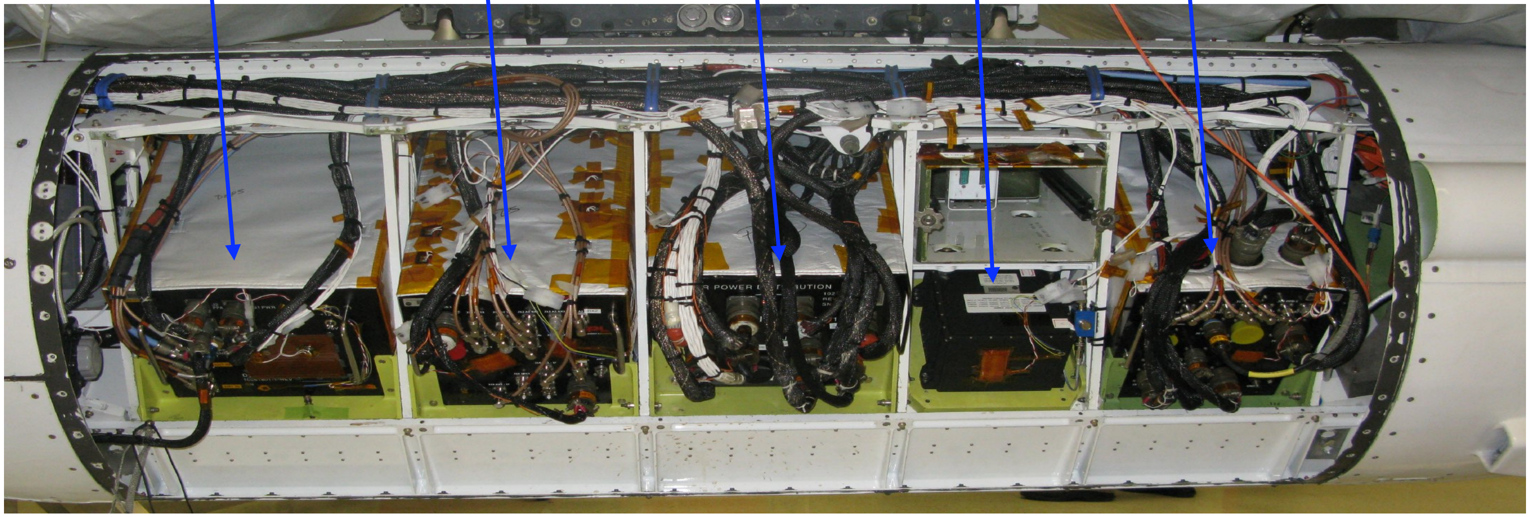
- UAVSAR was developed under NASA ESTO funding beginning in 2004.
- UAVSAR is an L-band fully polarimetric SAR (POLSAR) employing an electronically scanned antenna that has been designed to support a wide range of science investigations.
  - Science investigations supported by UAVSAR include solid earth, cryospheric studies, vegetation mapping and land use classification, archeological research, soil moisture mapping, geology and cold land processes.
- To support science applications requiring repeat pass observations (RPI) such as solid earth and vegetation applications, the UAVSAR design incorporates:
  - A precision autopilot developed by NASA Dryden that allows the platform to fly repeat trajectories that are mostly within a 5 m tube.
  - Electronic pointing of the antenna based on attitude angle changes measured by the INU to compensate for attitude angle changes during and between repeat tracks.
- Two identical L-band radar systems (pods) have been built and flight tested.
- **We are porting 2 radar pods to the Global Hawk UAV to enable high precision topographic map generation and single pass polarimetric interferometry for vegetation structure measurements**.

Current UAVSAR Configuration

Radar pod



DGPS RF PDU EGI Digital Subsystem



Key Radar Parameters

Parameter	Value
Frequency	L-Band 1217.5 to 1297.5 MHz
Bandwidth	80 MHz
Intrinsic Resolution	1.8 m Slant Range, 0.8 m Azimuth
Polarization	Full Quad-Polarization
Nominal Altitude (G-III)	12,500 m (41,000 ft)
Nominal Ground Speed (G-III)	215 m/s
Nominal Spatial Posting	6 m
Nominal Range Swath	22 km (POLSAR), 18 km (RPI)
Look Angle Range	25° - 65°
Noise Equivalent s°	< -50 dB

UAVSAR Instrument Pods

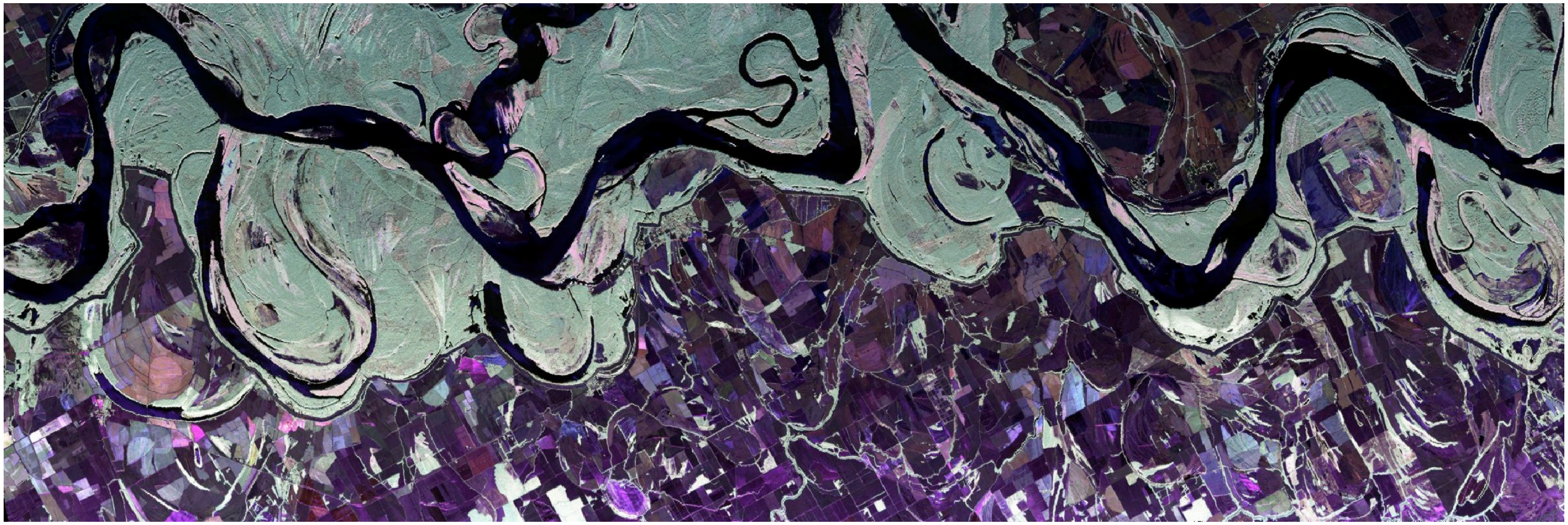
Operational L-band pod

Pod in experimental Ka-band configuration (includes a new passive Ka-band antenna)

2009 UAVSAR Highlights

Jet Propulsion Laboratory

- Science data flights began in February 2009 onboard the NASA Gulfstream-III aircraft
  - Completed ~375 flight hours in FY09 and, to date, about half of the 400 planned flight hours for FY10
  - About half of NASA Airborne Science requested flight hours are for UAVSAR
- Major accomplishments included:
  - Successful completion of the IPY campaign to Greenland, and deployments to the East Coast, Alaska, Hawaii, and Central America
  - Successful modification of UAVSAR for Ka-band single-pass interferometric SAR for demonstration flights, including data acquisition over ice sheets and glaciers in Greenland
  - Rolled out the production polarimetric processor that allows users to search for processed data via a web-based map interface and download data from Alaska Satellite Facility



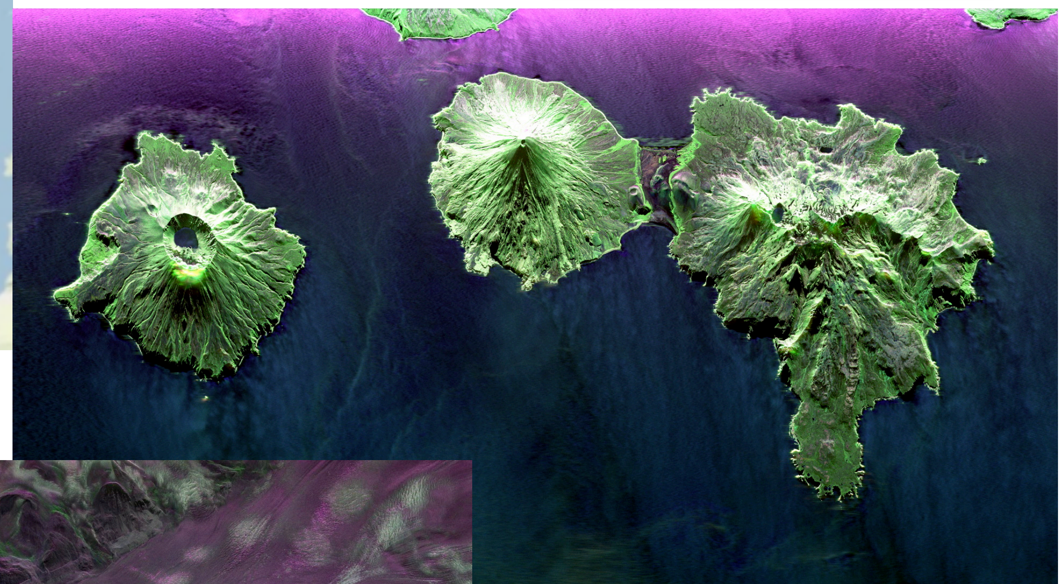
3-color polarization overlay of Mississippi River for levee studies

ESTO
Earth Science Technology Office

2009 UAVSAR Data Acquisitions

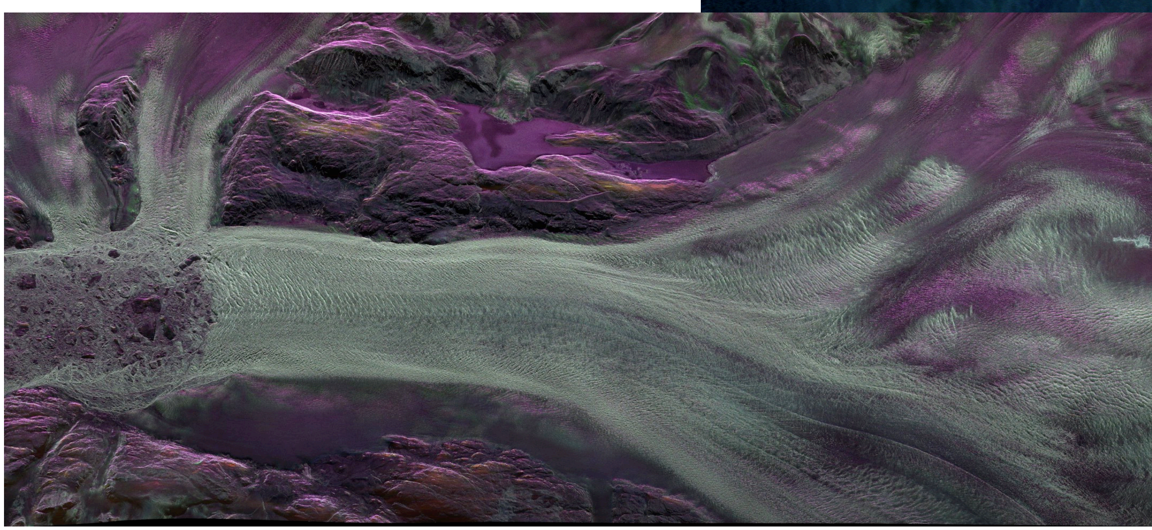
Major Campaigns
- Calibration
- San Andreas Fault
- Greenland/Iceland
- East Coast Terrestrial Ecology

Other Data Collections
- Aleutian Islands
- Gulf Coast
- Yellowstone National Park
- Sacramento Delta
- Ka-band testing

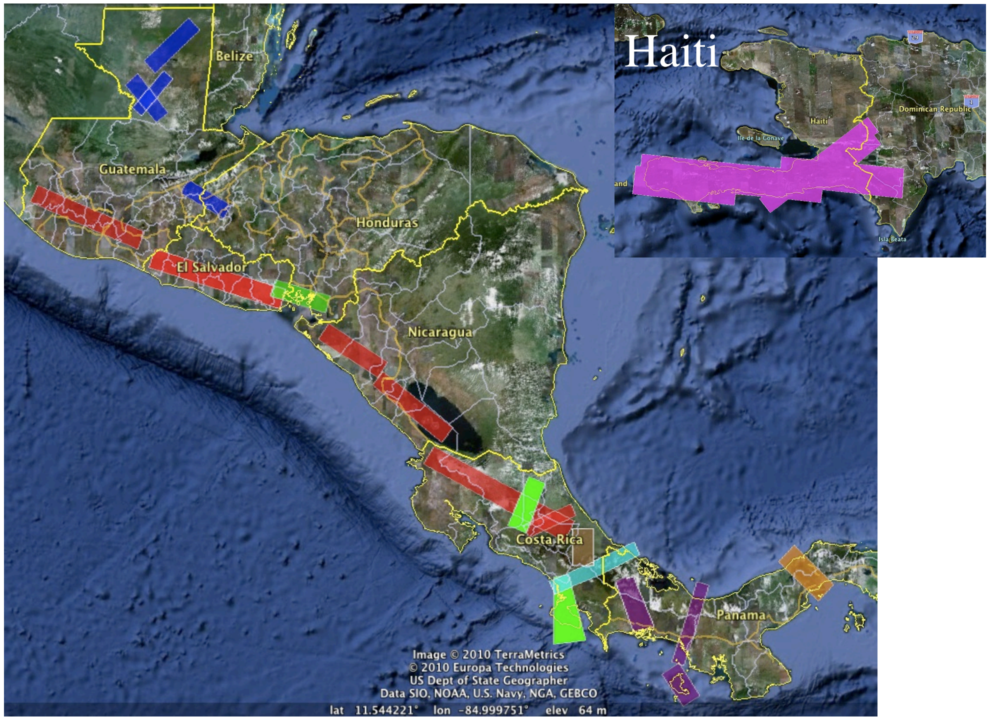


3-color polarization overlay of the Aleutian volcanoes

3-color polarization overlay of Kangerlugssuaq Glacier in Greenland



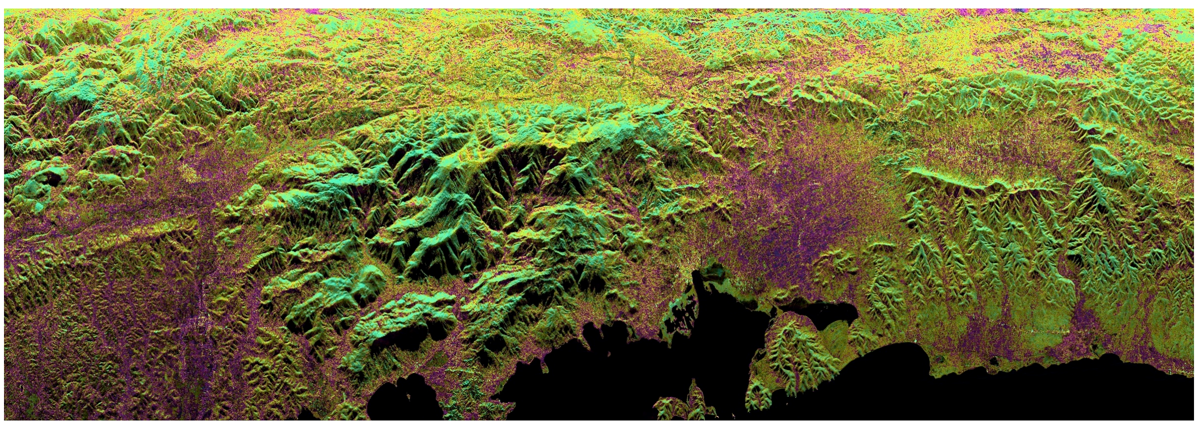
2010 UAVSAR Central America Campaign



- Volcano surface deformation
- Tropical forest structure
- Archaeology
- Haiti seismic study
- Multi-baseline forest gradient
- Forest height and biomass
- Vegetation classification
- Search lost aircraft

Total: 92 flights hours, 153 science data lines

Group photo with the US Ambassador, Anne Andrew, after our briefing to her and the Costa Rica Ministers of Science & Technology and Security



Coherence image of Haiti's Enriquillo-Plantain Garden Fault – purple indicates low coherence, which may be due to mudslide, water runoff, or vegetation change

Jan. 25 – Feb. 15, 2010

Earth Science Technology Office

Artist's Rendering of UAVSAR on Global Hawk

Two L-band pods are mounted under the wing fix points of the Global Hawk

UAVSAR Port To Global Hawk

- Global Hawk application with two UAVSAR pods would enable
  - high precision topographic map generation
  - single pass polarimetric interferometry for vegetation structure measurements
- Global Hawk endurance of nearly a day would enable long loiter time over dynamic targets such as volcanoes and earthquake prone regions for pre-event signature studies or post-event scientific and hazard management activities
- Global Hawk range on the order of 8000 nm could enable data collection of distant areas of interest (e.g. Greenland, Aleutians, Antarctica) without complicated campaign deployments
- Global Hawk would be an ideal platform for performing mapping and regional science using the UAVSAR

Key Radar Parameters

Parameter	Value
Frequency	L-Band 1217.5 to 1297.5 MHz
Polarization	Full Quad-Polarization
Resolution	1.67 m Range, 0.8 m Azimuth
Range Swath	22 km (13.2 miles)
Look Angle	25º - 65º
Antenna Baseline	**5.6 m**
Platform	**Global Hawk**
Nominal Altitude	**13.7 km (45,000 ft)**
Nominal Ground Speed	**180 m/s (330 knots)**
Nominal Flight Duration	**22 hours**
Nominal Flight Range	**14,500 km (7800 nm)**

Overview of Task Objectives

Three organizations are participating in the UAVSAR-GH development:

1. JPL will –
   - Develop electrical interfaces between the existing UAVSAR pods and the airframe
   - Modify radar control and timing to remote control the radar and synchronize the two radar pods
   - Develop ground data processing software to handle the polarimetric Single Pass interferometric (SPI) data
   - Participate in flight and ground testing, and perform data analysis
2. Northrop Grumman will –
   - Assess aerodynamics, flutter, and flight control system for dual-pod and altitude-hold operation
   - Perform all mechanical and electrical integration of the radar with the GH
   - Conduct ground vibration tests, weight and balance with/without the pods
3. DFRC will -
   - Manage the platform modification activities, integration of the mechanical and electrical systems
   - Perform ground and flight tests
   - Perform independent engineering analysis, and conduct the Flight Safety Review

AV-6 Maiden Flight at Dryden

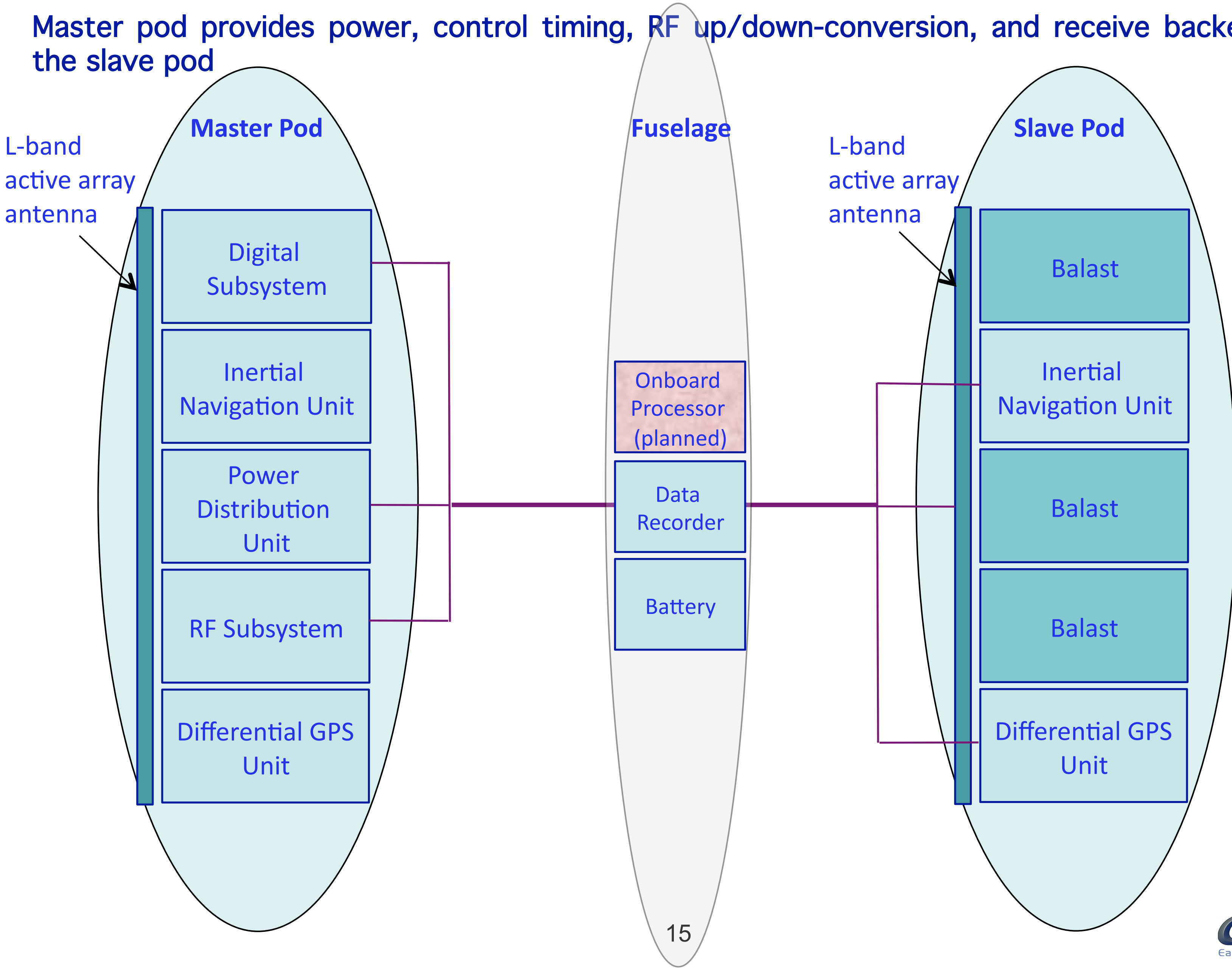
Earth Science Technology Office

Picture of Global Hawk Platform

Instrument Bays in the Fuselage

Functional Block Diagram of UAVSAR-GH

Master pod provides power, control timing, RF up/down-conversion, and receive backend for the slave pod

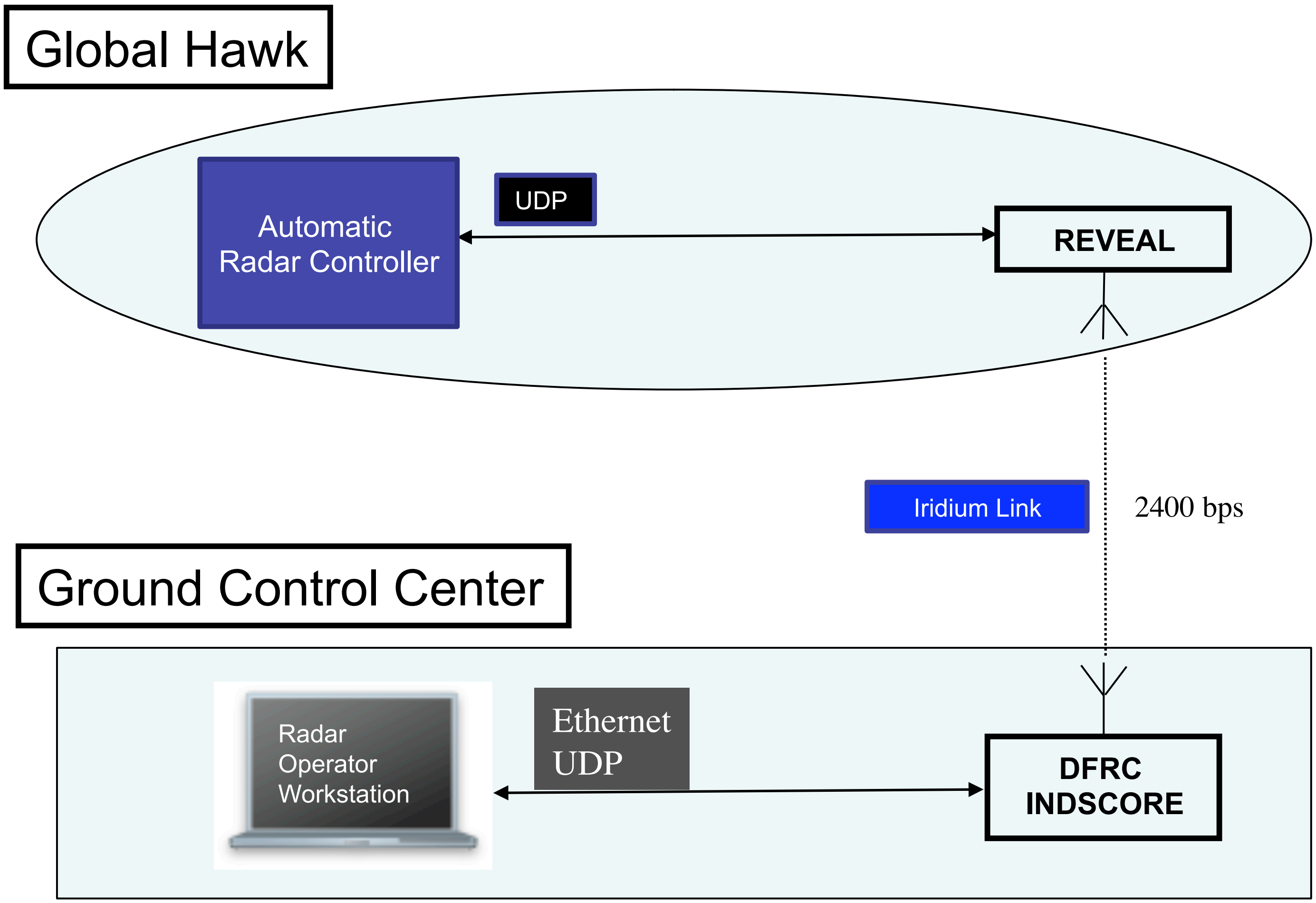


Mass and Power Estimates

Parameter	Value
Per pod weight estimate	765 lb
Power estimate	4500 W

- The weight of both pods are matched to within 10 pounds by using ballast in the slave pod

Remote Operation with REVEAL



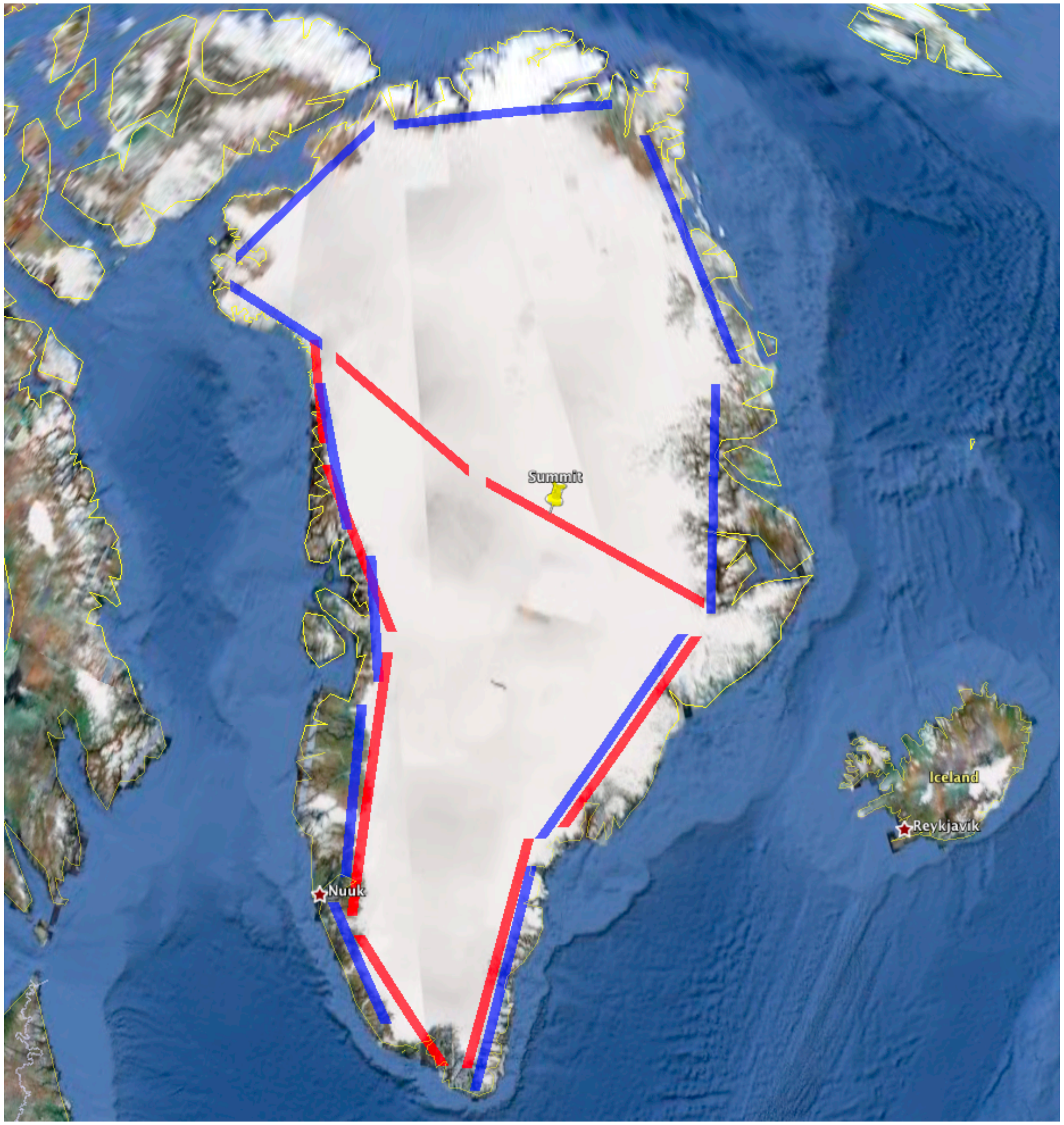
REVEAL is a 4-channel Iridium satellite phone link

Operational Concept

- The first application of the Global Hawk version of UAVSAR will be the collection and processing single pass polarimetric-interferometric data for DEM generation and vegetation structure estimation
- The basic steps in the operational flow for UAVSAR are as follows:
  - Generate a flight planning file that contains the flight lines to be flown, and a waypoint file. These will be provided to the GH Project for implementation in the normal GH Mission Planning and NGC 6DOF verification process.
  - Load flight plan information via the ROW (Radar Operator Workstation) to the ARC (Automatic Radar Controller)
  - Load a disk to collect data during flight
  - Fly to selected sites and fly desired flight lines
  - Monitor via the GH Payload C2 System engineering data to insure proper instrument operation
  - Return platform to base of operations and recover data disk and complete orderly shutdown of radar
  - Transfer data to JPL for processing and analysis

Example Flight Plan for Global Hawk

Jet Propulsion Laboratory



- A typical Global Hawk flight can last ~22 hours
- One single flight from Wallops Island will provide ~16 hours of data acquisition in Greenland
- This will allow us to image the glaciers along the entire coastline (blue flight lines) and half the coastline in an offset flight path (red flight lines)

ESTO
Earth Science Technology Office

Current Implementation Status

- **UAVSAR-GH is funded by American Recovery and Reinvestment Act**
  - JPL's task plan was approved and funded in August 2009
  - Northrop Grumman's subcontract was approved in mid-March 2010
  - Initial test flights are planned for September 2011
- **Held kickoff meeting on May 21, 2010**
- **JPL has completed the following tasks:**
  - ☑ System requirements document
  - ☑ Preliminary thermal analysis of pod electronics
  - ☑ Redesigned and built new Automatic Waveform Generator boards to support 4-receive channel radar operation
  - ☑ Modified Automatic Radar Controller software to control dual antennas and 4 receive channels
  - ☑ Modified Control and Timing Unit and antenna control FPGA firmware to support dual antennas and 4 receive channels
  - ☑ Conducted initial lab testing of instrument modifications
  - ☑ Delivered one pod in the master radar configuration to Dryden for inertia swing to determine a baseline weight and center of gravity for the pod
  - ☑ Procured long lead items such as the ruggedized data storage device and a dual-channel L-band receiver

Current Implementation Status (cont.)

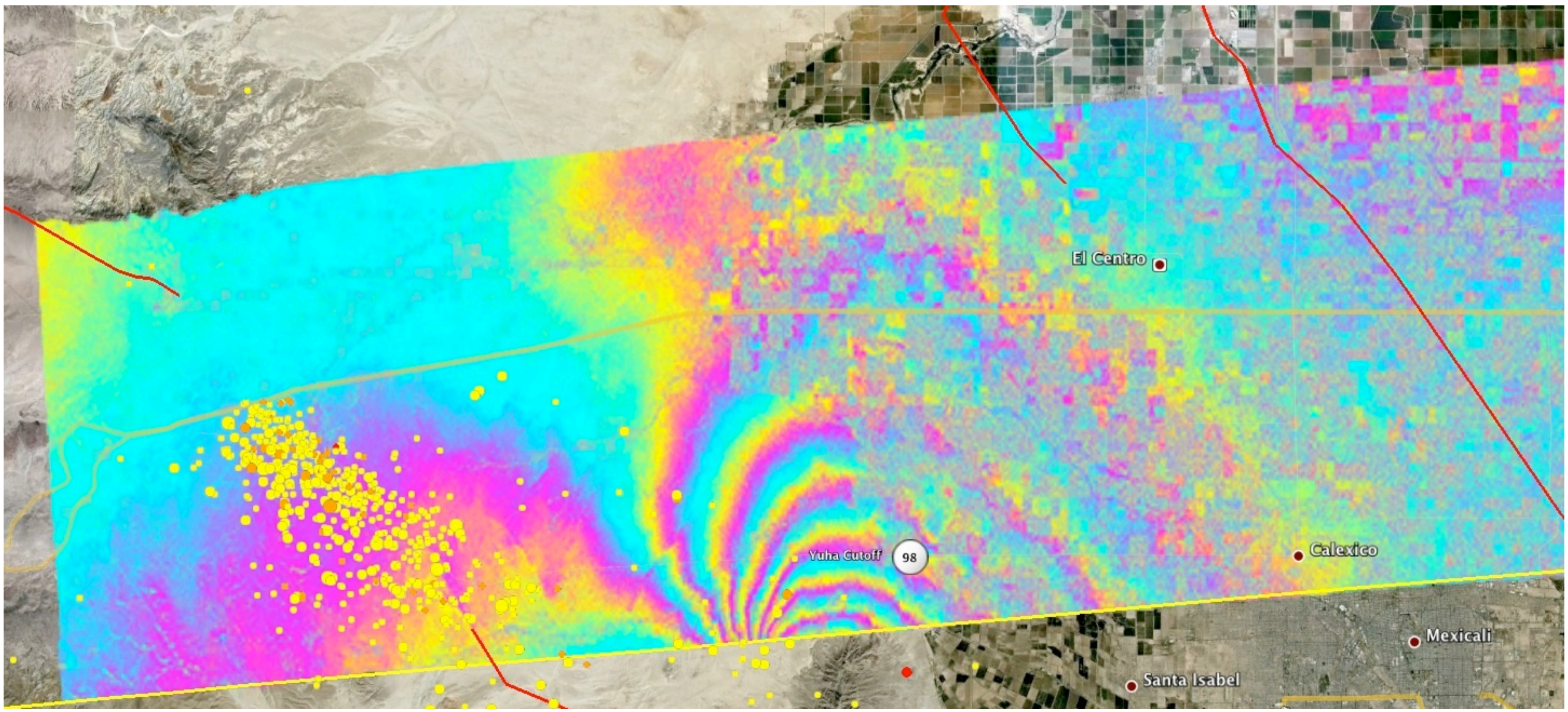
- **Dryden/NGC have completed the following tasks:**
  - ☑ Inertia swing to determine a baseline weight and center of gravity for the pod
  - ☑ Completed wind tunnel test; data analysis in work
  - ☑ Completed SAR pod faring interface structural layout; drawings in work
  - ☑ Flutter modeling complete; data analysis in work
  - ☑ Completed air inlet (in the nose cone) drag reduction study – no modification is warranted
  - – Began harness routing between pods and the fuselage
  - – Conducted initial ground clearance measurements

Key Implementation Challenges

- The weight of each pod (~765 lb) is near the limit of what GH can handle
  - Northrop Grumman is performing aerodynamic analysis to determine aircraft stability
  - Northrop Grumman is performing ground clearance measurements using aircraft with dummy weights on the wing fix points
- Routing of electrical harnesses from one pod to the other through the wings can be challenging due to space availability in the wings
- UAVSAR pod availability
  - UAVSAR with G-III program is heavily subscribed with science campaigns, leaving us with one pod to work with for much of the time
  - A third pod was procured to serve as the slave pod. However, the procurement was 4 months late, leading to the projected late delivery of the pod (December 1)
- Global Hawk platform availability

Future Applications

- With implementation of precision platform auto-pilot (currently not funded), will be able to support repeat-pass interferometry for
  - Rapid response of natural hazards such as earthquake, volcano eruption, and post-fire debris flow
  - Coherent and incoherent (amplitude) change detection



First earthquake deformation captured by the UAVSAR using data acquired on October 21, 2009 and April 13, 2010. (yellow dots are activities based on GPS measurements)