NASA Global Hawk Overview

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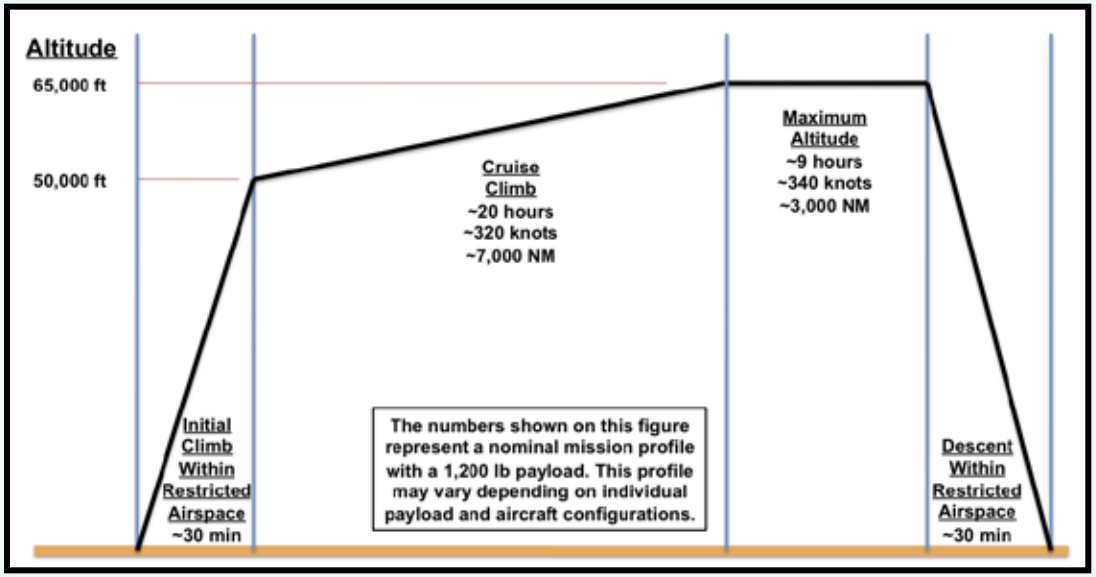
Edwards Air Force Base and NASA Dryden Flight Research Center

NASA Dryden Aircraft Fleet

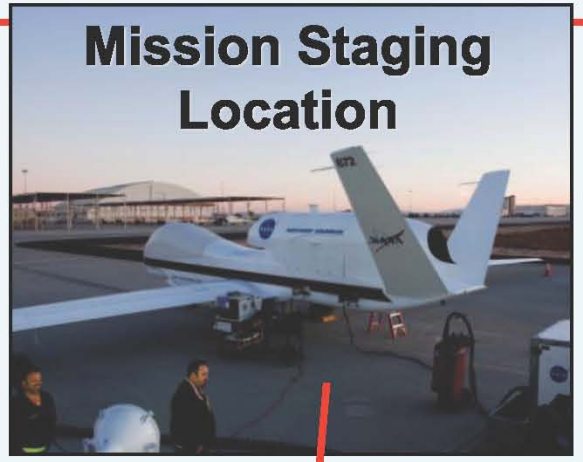
NASA Global Hawk System

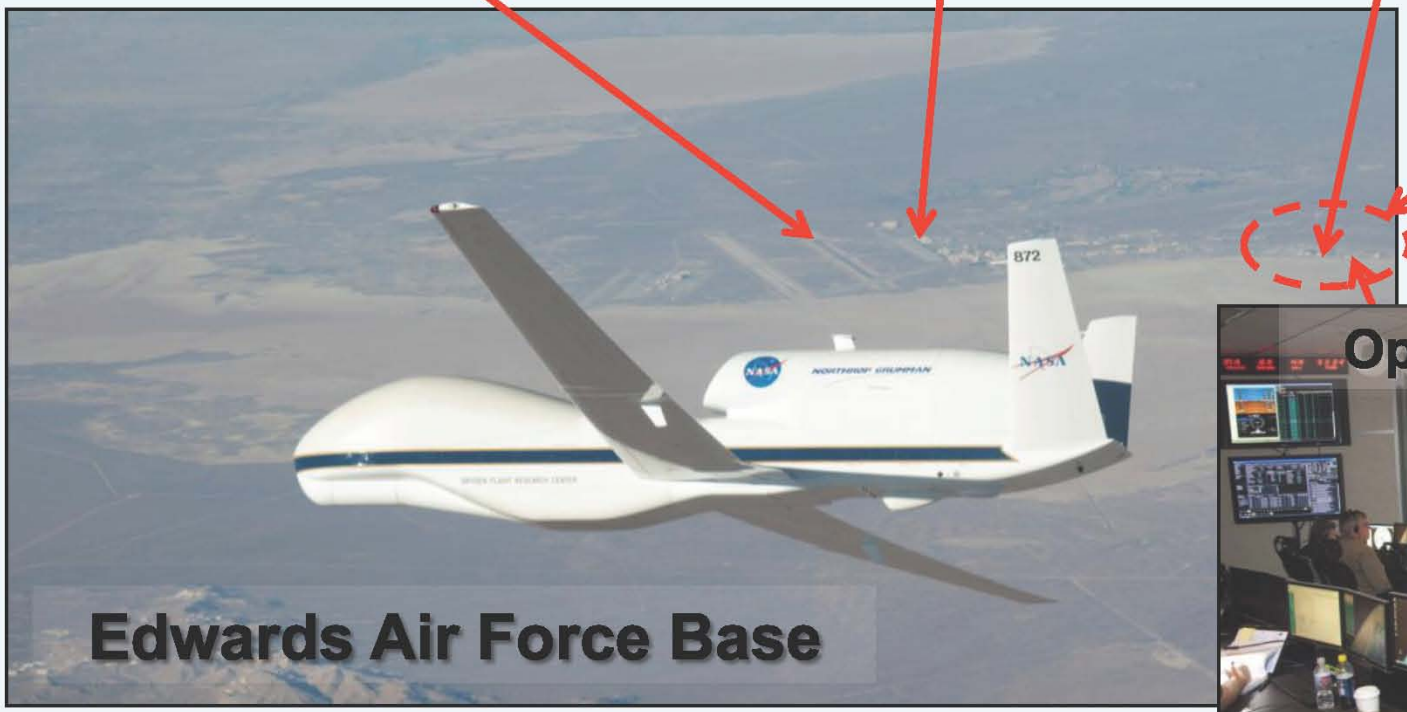
- **Two USAF Pre-Production Global Hawk aircraft were transferred to NASA in September 2007. (A third aircraft arrived in January 2010)**
- **A combined NASA/Northrop Grumman team is maintaining, modifying, and operating the UAS through a 5-year partnership. (2008-2013)**

Endurance	> 30 hours
Range	>10,000 nmi
Service Ceiling	65,000 ft
Airspeed (55K+ ft)	335 KTAS
Payload	1,000-1,500 lb
Take-off Weight	26,750 lb
Length	44 ft
Wingspan	116 ft



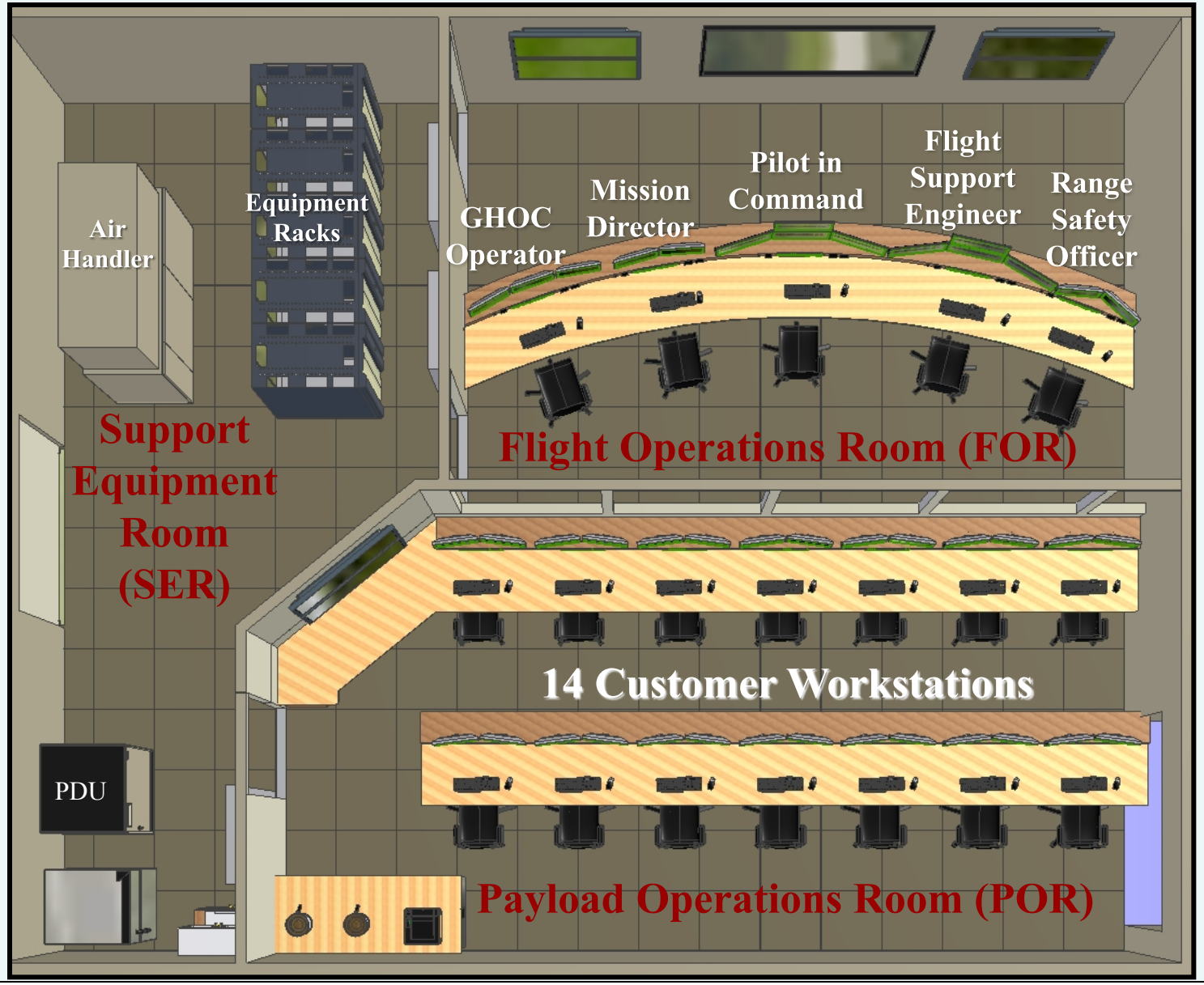
NASA Global Hawk Operations Overview





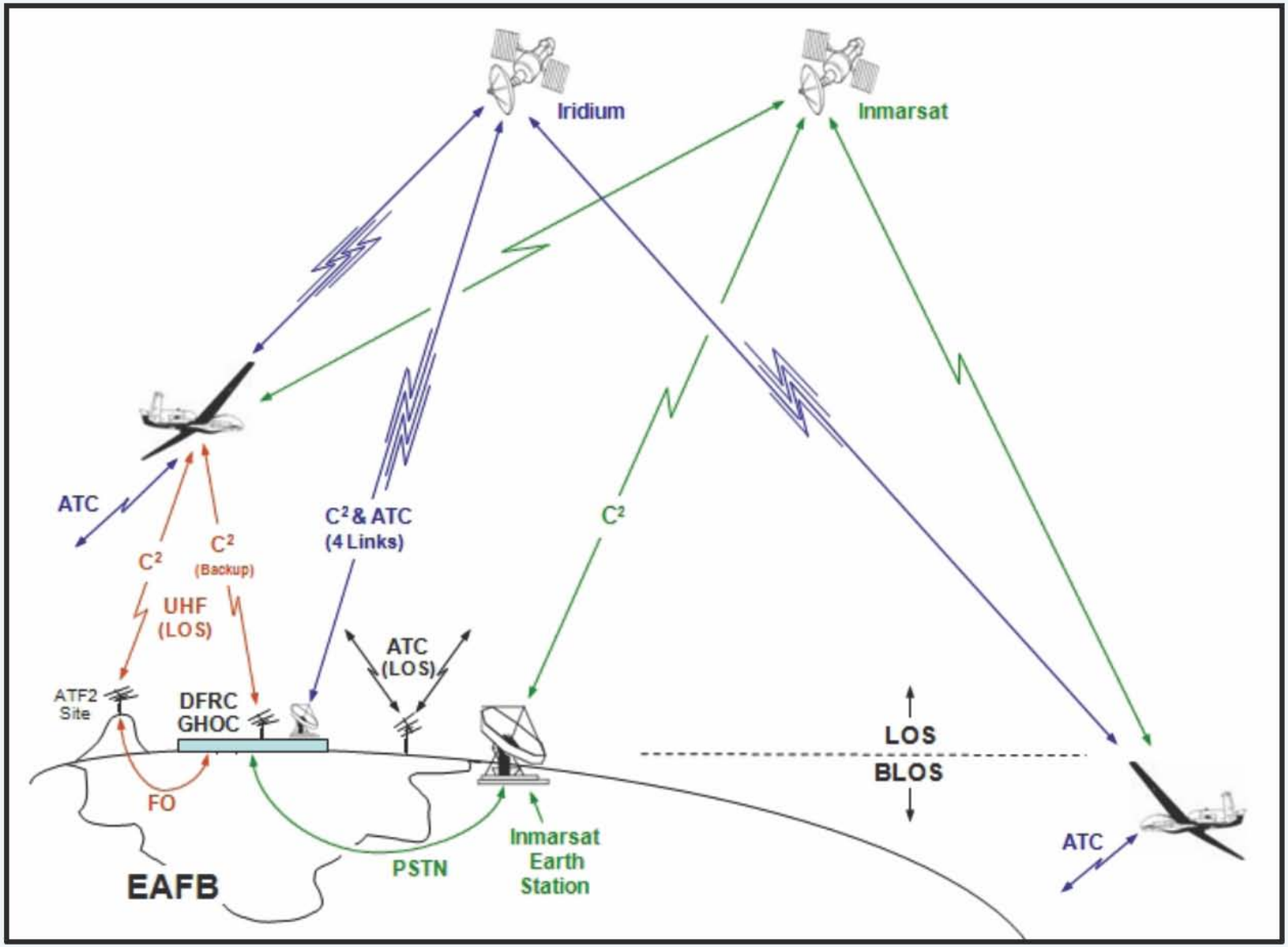
NASA Dryden Flight Research Center

Global Hawk Operations Center (GHOC)

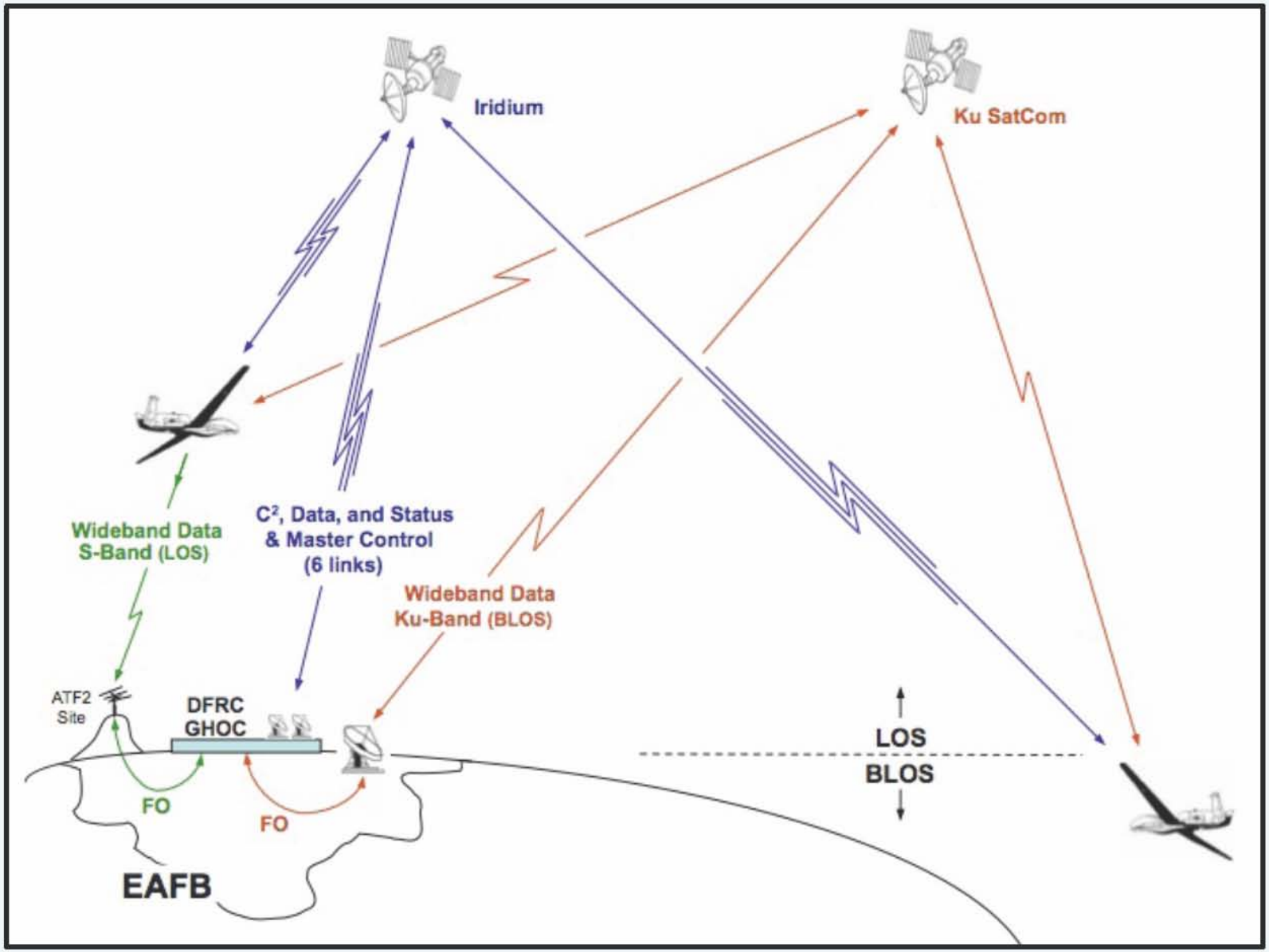


Global Hawk Operations Center (GHOC)

Flight Control and Air Traffic Control Communications Architecture



Payload Communications Architecture



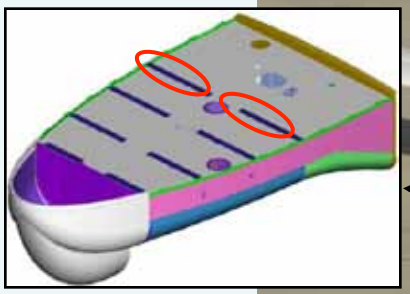
Payload Integration Process

- Site visit at customer's location; initial discussion of payload details and operational concept.
- Receipt of payload solid model(s) and design/ integration data from customer.
- Integration engineering (at DFRC and/or NGC).
- Avionics harness manufacture at DFRC.
- Fabrication and fit-check of payload mounting structure.
- Initial mechanical integration on aircraft.
- IT assigned configuration of instrument.
- Electrical integration on payload test bench.
- Final integration on aircraft.
- GHOC payload instrumentation setup.

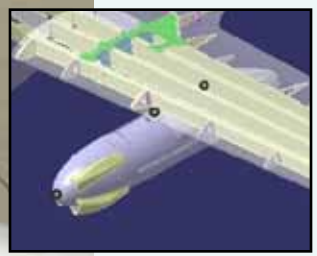
Payload Integration and Accommodations

Experiment Interface Panel & Ethernet Switch

Payload Integration Software T&E

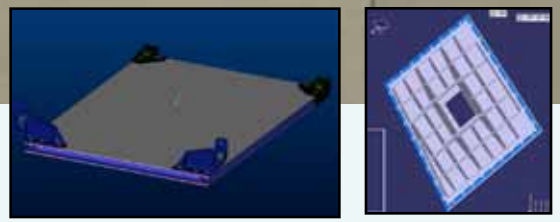


Mounting Rails

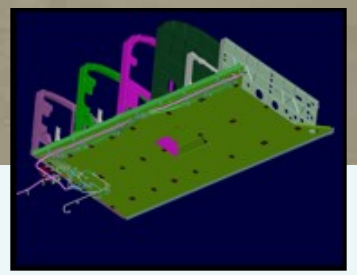


Wing Pods (future capability)

Bay Under the Nose



Pallets and Hatches



Mounting Hard Points

NASA Global Hawk Missions During First Year of Flight Operations

	TN871 (AV-1)		TN872 (AV-6)		
Date	Flight Number	Duration, hr	Flight Number	Duration, hr	Flight Objective
10/23/09			0044	4.0	Return to flight for AV-6, Functional Check flight
10/29/09			0045	2.8	Completion of Functional Check Flight objectives
11/4/09			0046	1.4	Pilot Proficiency
11/9/09			0047	0.9	Pilot Proficiency
11/9/09			0048	1.2	Pilot Proficiency
3/3/10			0049	2.6	Checkout flight for Payload Support System
3/5/10			0050	9.2	Checkout flight for Payload Support System
3/11/10			0051	10.3	Checkout flight for Payload Support System
4/2/10			0052	6.3	GloPac Instrument check-out flight in the range
4/7/10			0053	14.1	GloPac Science Flight #1
4/13-14/10			0054	24.4	GloPac Science Flight #2
4/23-24/10			0055	28.6	GloPac Science Flight #3
4/30/10			0056	9.3	GloPac Science Flight #4
5/27/10	0068	4.1			Return to flight for AV-1, Functional Check flight
6/15/10	0069	0.7			Pilot Proficiency
6/15/10	0070	0.8			Pilot Proficiency
6/22/10	0071	0.8			Pilot Proficiency
6/22/10	0072	1.0			Pilot Proficiency
6/29/10	0073	4.3			Pilot Proficiency
8/15/10			0057	6.1	GRIP Instrument check-out flight in the range
8/24/10			0058	2.5	Dropsonde test flight
8/28/10			0059	15.3	GRIP Science Flight #1
9/1-2/2010			0060	24.2	GRIP Science Flight #2
9/12-13/2010			0061	24.3	GRIP Science Flight #3
9/16-17/2010			0062	25.2	GRIP Science Flight #4
9/23-24/2010			0063	25.1	GRIP Science Flight #5
10/13/10	0074	1.0			Pilot Proficiency
10/13/10	0075	1.7			Pilot Proficiency
10/21/10	0076	0.8			Pilot Proficiency
Totals	9 flights	15.2	20 flights	237.8	

First Year of Operations	29 Flights	253 hours

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Flights Outside the EAFB Airspace During the First Year

Flight Summary

- 9 Flights
- 190.5 Total Hours
- ~64,000 nmi

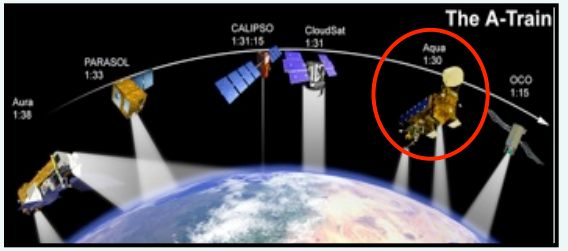
Certificates of Authorization

- Pacific-Alaska-Arctic
- Western Atlantic-Caribbean-Gulf of Mexico

First Global Hawk Science Mission (March-April 2010)

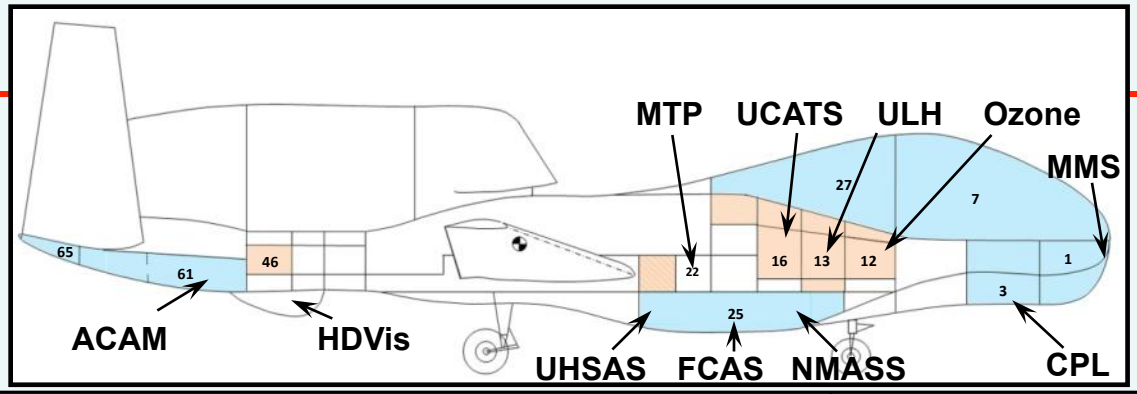
GloPac Objectives

- First demonstration of the Global Hawk unmanned aircraft system (UAS) for NASA and NOAA Earth science research and applications.
  - Development of science-operation protocols & procedures.
  - Long duration Pacific Ocean and Arctic flights.
- Exploration of trace gases, aerosols, and dynamics of remote upper troposphere and lower stratosphere regions.
  - Aura satellite instrument validation.
  - Sample Arctic vortex fragments, and aerosol plumes.



- Risk reduction for future Global Hawk missions.
  - Hurricane and severe storm missions.
  - Earth Venture (EV-1) proposed missions.

GloPac Instrument Overview

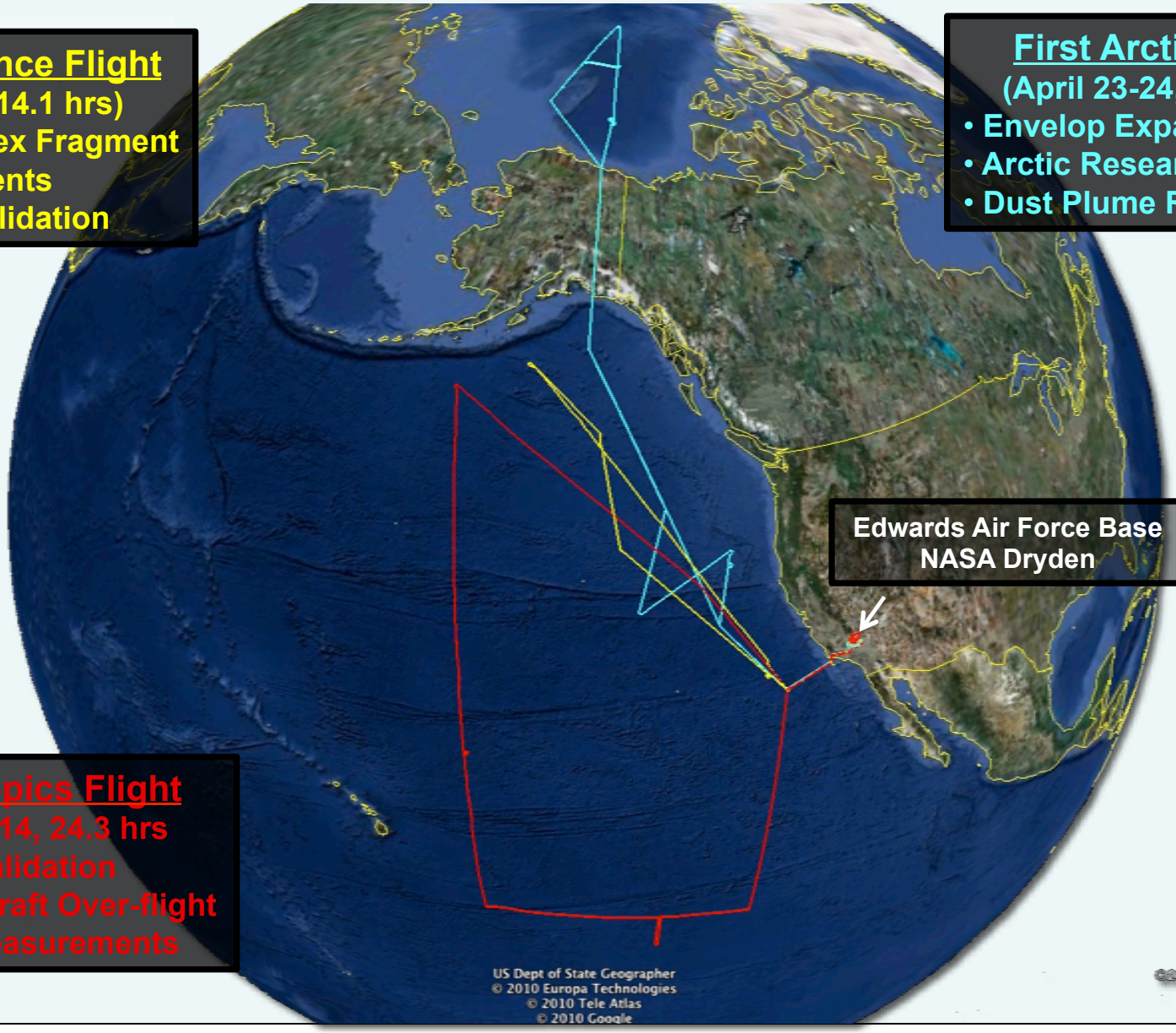


ACAM	Airborne Compact Atmospheric Mapper (GSFC)	Cross-track scanning spectrographs of NO2, O3, & aerosols.
CPL	Cloud Physics LIDAR (GSFC)	Backscatter LIDAR for hi-res profiling of clouds & aerosols.
FCAS	Focused Cavity Aerosol Spectrometer (U. of Denver)	Aerosol size and concentration measurements.
MMS	Meteorological Measurement System (ARC)	Science quality aircraft state variable measurements.
MTP	Microwave Temperature Profiler (JPL)	Passive microwave radiometer meas. of O2 thermal emissions.
HDVis	HiDef Video System (ARC)	Time-lapse nadir color digital imagery with georeferencing.
NMASS	Nuclei-mode Aerosol Size Spectrometer (U. of Denver)	Aerosol size and concentration measurements.
Ozone	UAS Ozone (NOAA)	Dual-beam UV photometer for accurate O3 measurements.
UCATS	UAS Chromatograph for Atmospheric Trace Species (NOAA)	Dual gas chromatographs for N2O, SF6, H2, CO, & CH4 meas.
UHSAS	Ultra-High Sensitivity Aerosol Spectrometer (Droplet Measurement Technologies)	Ultra-high sensitivity aerosol spectrometer.
ULH	UAS Laser Hygrometer (JPL)	In-situ hi-accuracy atmospheric water vapor measurements.

Global Hawk Pacific 2010 (GloPac)

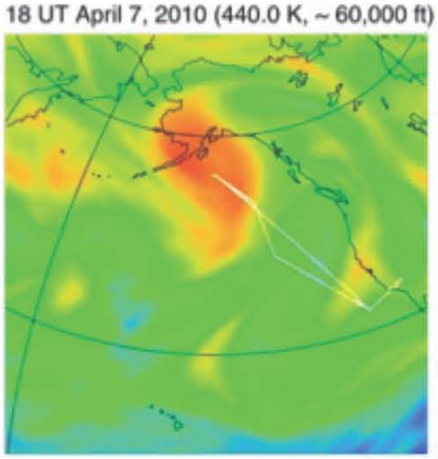
First Science Flight
(April 7, 14.1 hrs)
- Arctic Vortex Fragment Measurements
- Satellite Validation

First Arctic Flight
(April 23-24, 28.6 hrs)
- Envelop Expansion
- Arctic Research
- Dust Plume Rendezvous

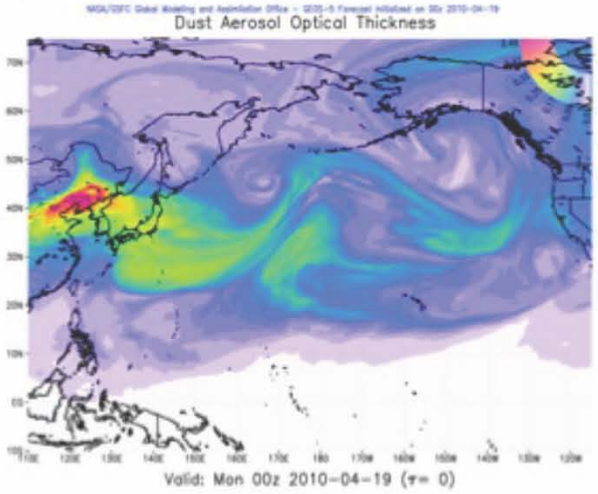


First Tropics Flight
April 13-14, 24.3 hrs
- Satellite Validation
- NCAR Aircraft Over-flight
- Tropics Measurements

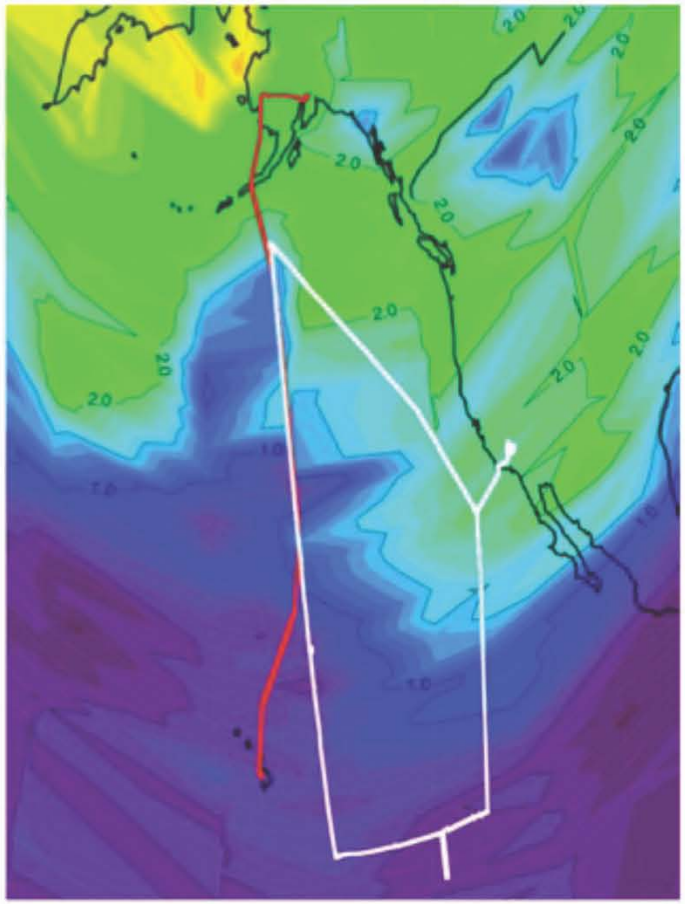
GloPac 2010 Science Highlights



Intercept an Arctic vortex fragment that broke off on about March 28



Sample Asian dust from the Gobi Desert

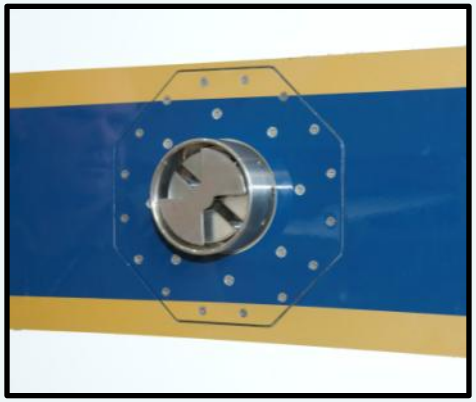


Rendezvous with the NSF GV aircraft and underfly the Aura satellite.

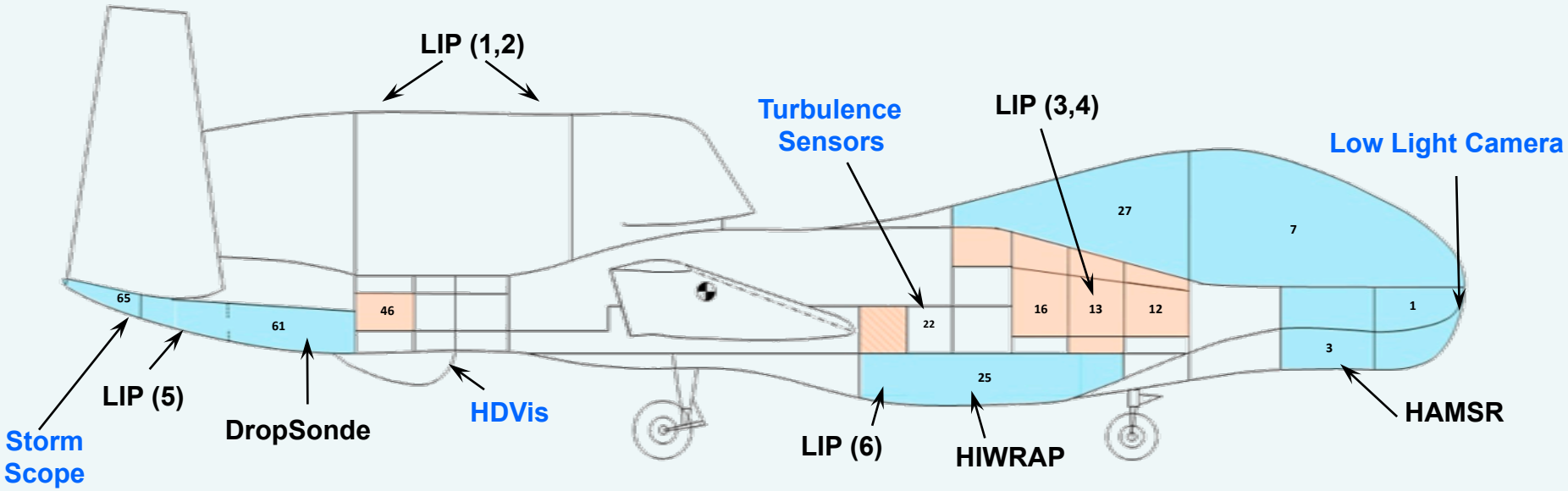
Second Global Hawk Science Mission (August-September 2010)

GRIP Goals

- Demonstration of Global Hawk Capabilities for Severe Storm Research
- Multi-agency, Multi-aircraft Research Campaign
- Improve Intensification Forecast Models
- Integration of New Global Hawk Payloads and New Aircraft Systems



GRIP Instrumentation



HIWRAP - **High Altitude Imaging Wind and Rain Profiler**

DropSonde - **NOAA DropSonde System**

HAMSR - **High Altitude MMIC Sounding Radiometer**

LIP - **Lightning Instrument Package**

2 Cameras - **HDVis and Low Light for Pilot Situational Awareness**

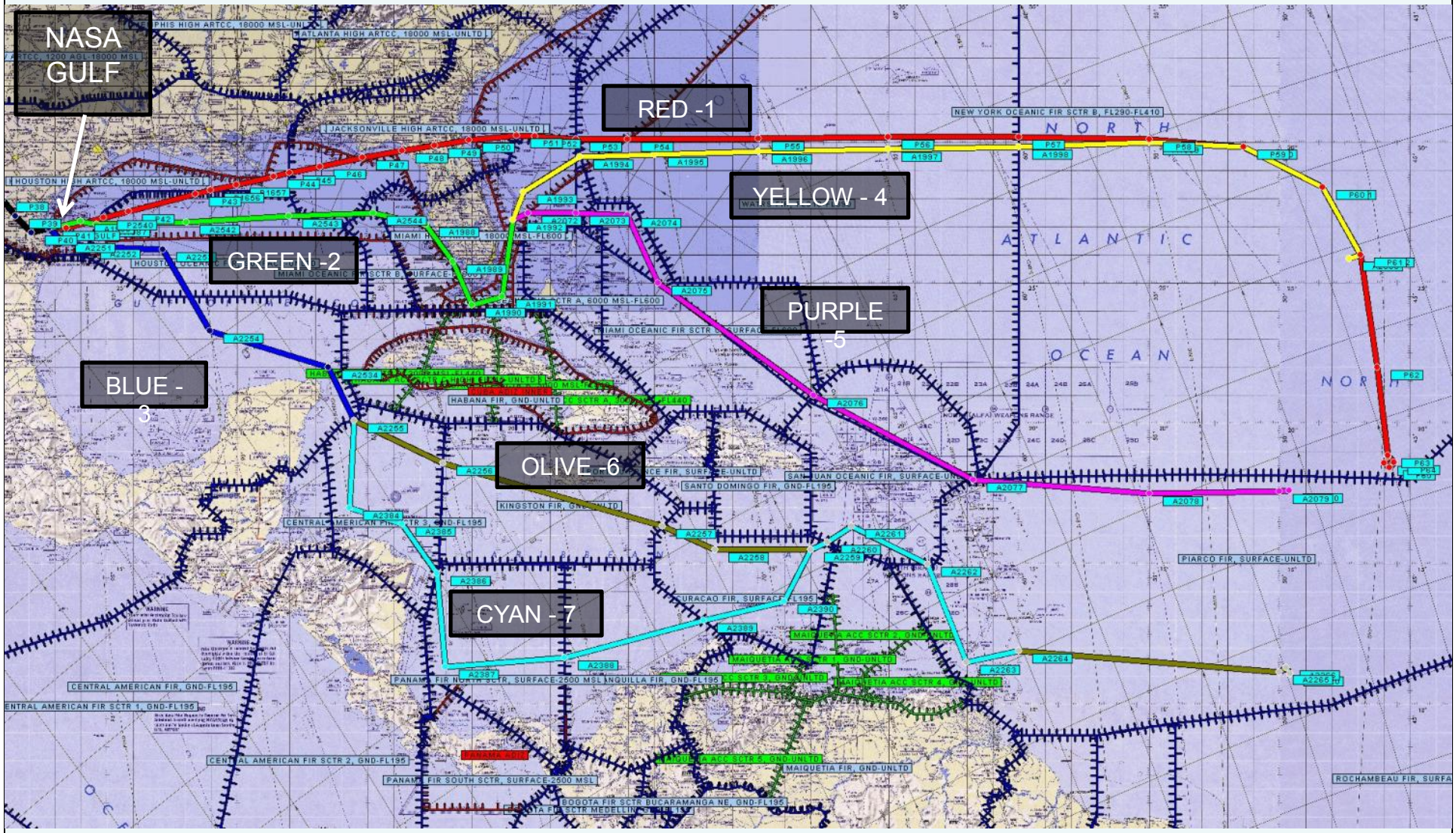
Storm Scope - **Lightning Detection Display in the GHOC**

Accelerometers - **Real-time Turbulence Time-history Display in the GHOC**

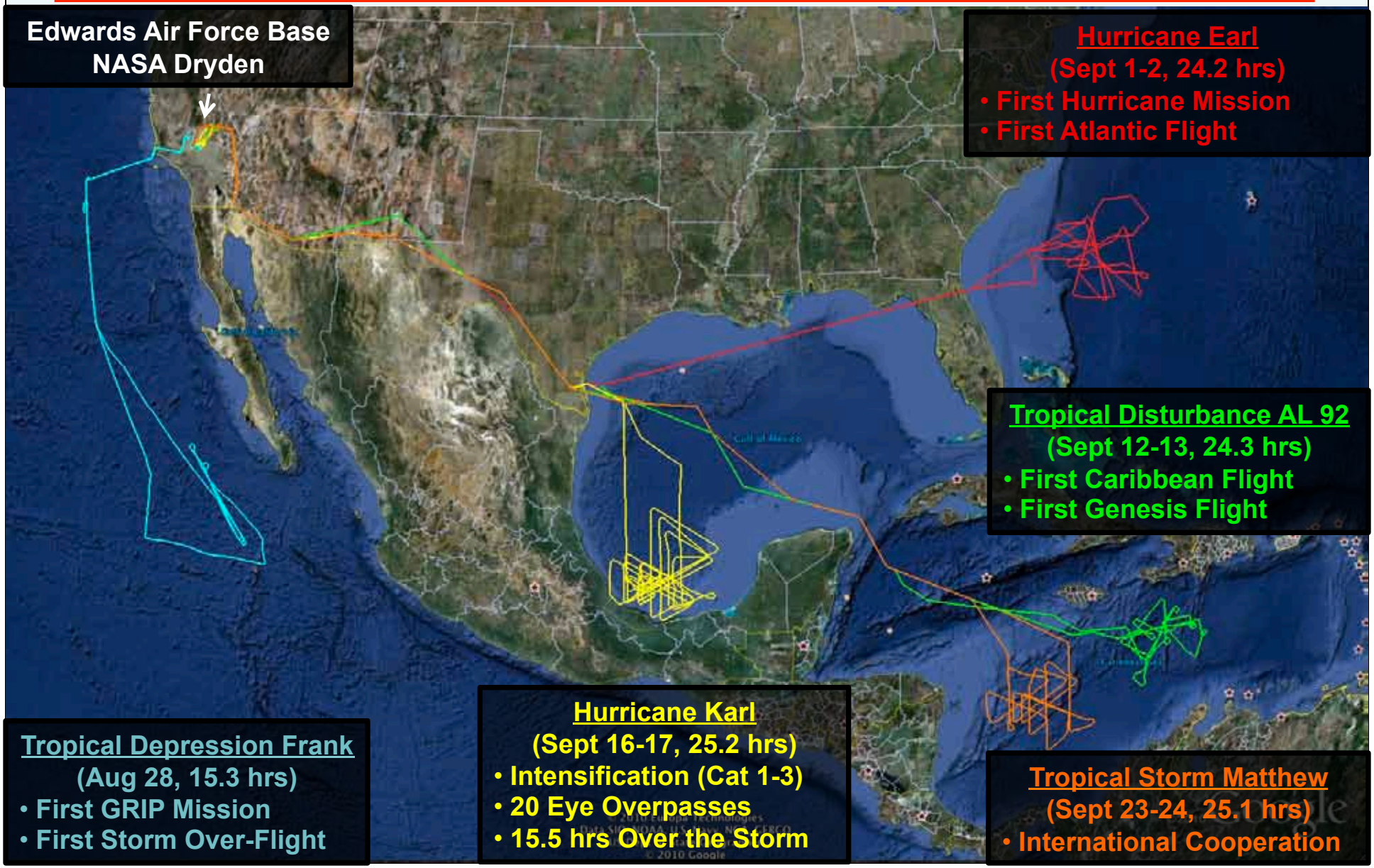
GRIP Challenges

- Flight Environment
  - No Global Hawk flight data over tropical storms
  - Limited flight envelope & FOM restrictions
    - No flight in moderate or severe turbulence
    - No flight within 25nm of lightening
- Aircraft
  - Limited hazardous weather detection systems
    - Integrated storm scope, 2 cameras, & vibration sensor
  - Additional aerodynamic drag of larger radome
  - Staffing surge for multiple long duration flights
    - Multi-shift operations
    - Edwards closed field operations

GRIP Mission Plan Routes



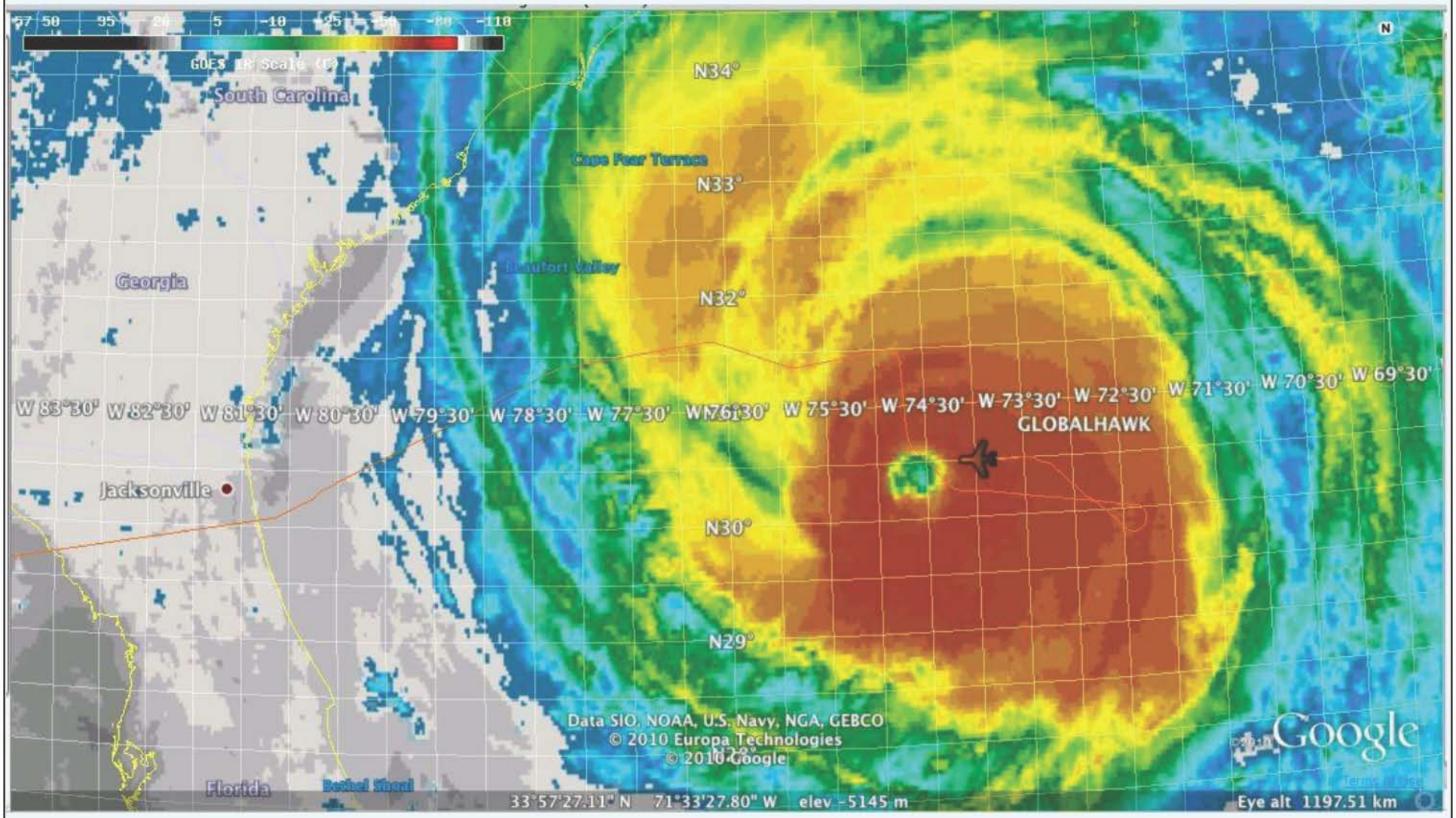
Genesis and Rapid Intensification Processes (GRIP) 2010 Global Hawk Flights



Tropical Depression Frank - Aug 28

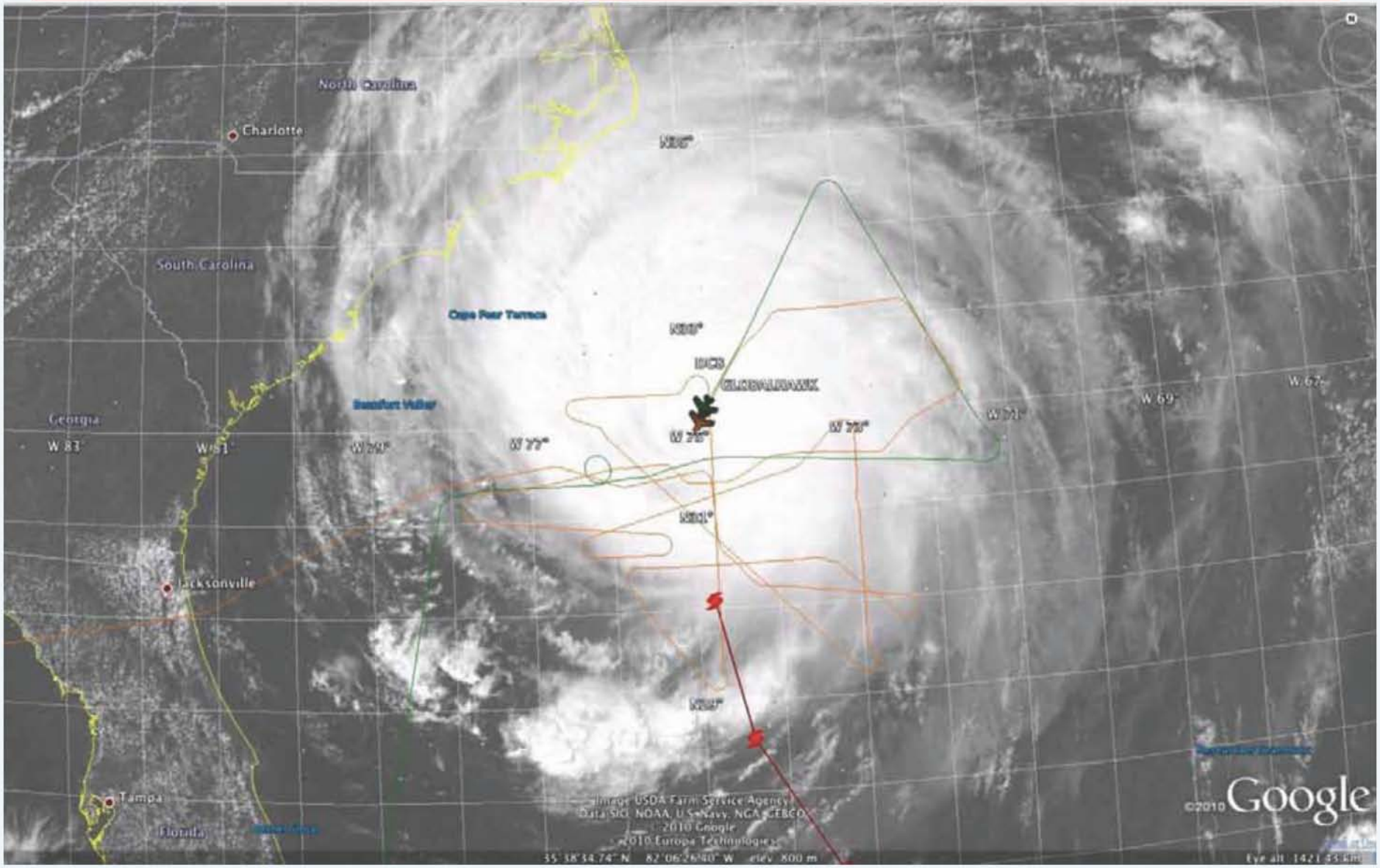
Hurricane Earl, Sept 2010

First Global Hawk Pass over the Eye of a Hurricane

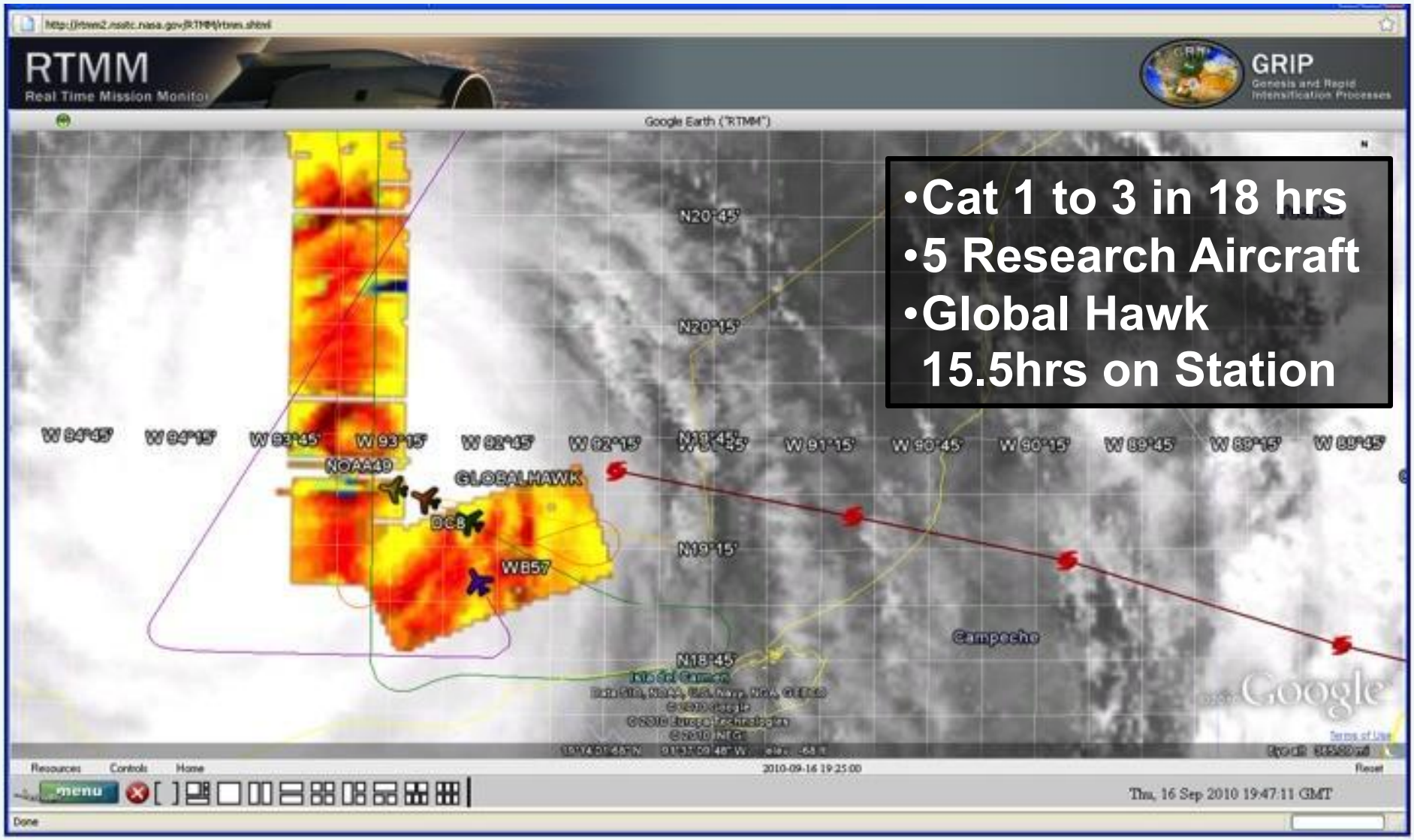


Hurricane Earl, Sept 2010

Global Hawk Over the Eye and DC-8 Passing Through Eye

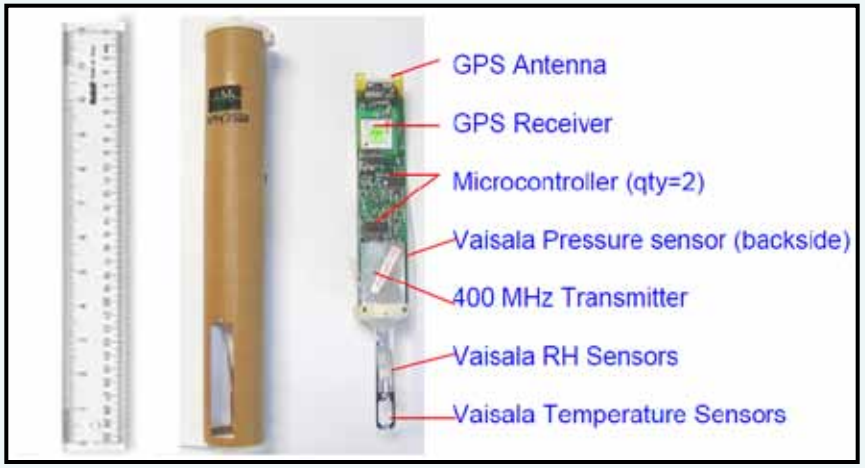


Hurricane Karl



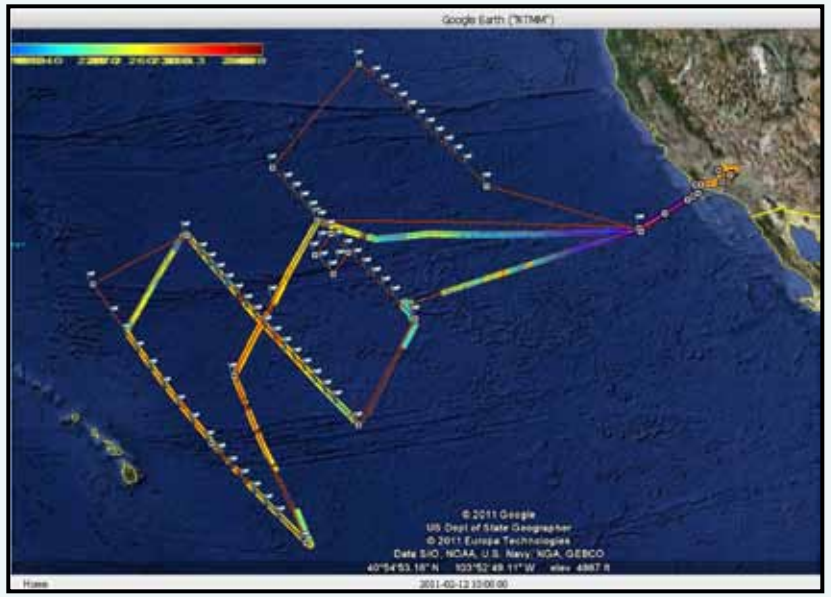
Winter Storms Pacific and Atmospheric Rivers (WISPAR), Feb-March 2011

Vibration Testing on Airborne Vertical Atmospheric Profiling System (AVAPS)



Sonde Description

Test Flight in EAFB Range

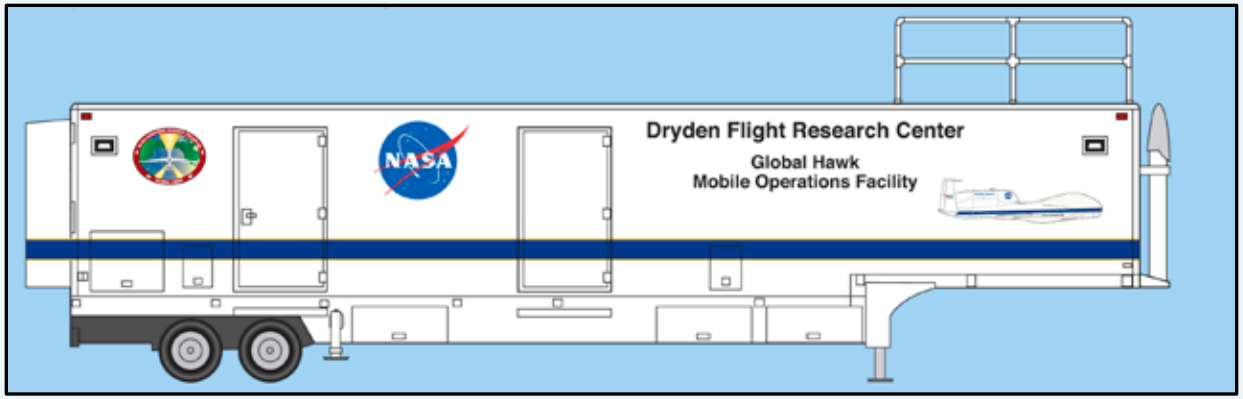


First AVAPS Operational Flight

Upcoming Projects

Capability Developments for Deployments

All Three Systems will be on-line by September 2011

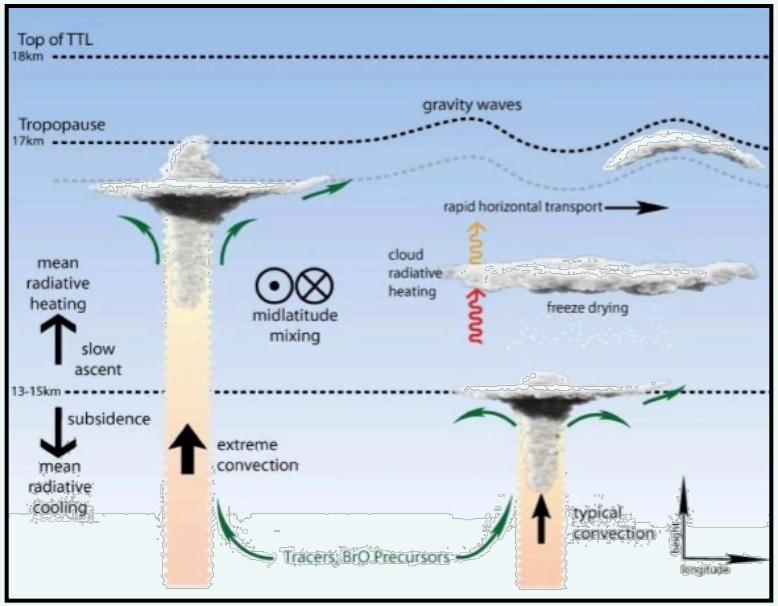


Aircraft Command and Control Facility

Ku Portable Ground Station

A Payload Operations Facility, with extendable sides and accommodations for 14 Scientists, is in development

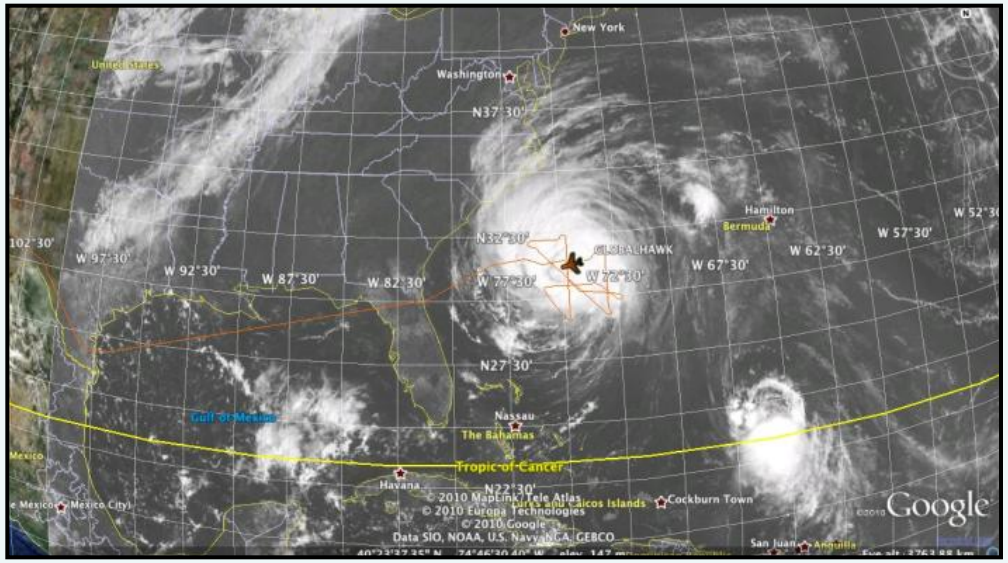
Future Missions



ATTREX (2012-2014)

Airborne Tropical TRopopause Experiment

(Base of Operations either Hawaii, Guam, or Australia)



HS3 (2012-2014)

Hurricane and Severe Storm Sentinel

(Base of Operations on the East Coast)

UAVSAR

Reconfigurable polarimetric L-band SAR designed for repeat pass deformation measurements.

Global Hawk Project Team

Project Management, Pilots, Aircraft Mechanics, Avionics Technicians, Operations Engineers, Software Developers, Quality Assurance, Logistics, Public Affairs, Flight Test Engineers, Crew Chiefs, Configuration Management, Systems Engineers, System Safety, Range Safety, Ground Control Station Developers, Communications Engineers

Project Summary

- NASA Global Hawk is operational and supporting Earth science research.
- 29 Flights were conducted during the first year of operations, with a total of 253 flight hours.
- Three major science campaigns have been conducted with all objectives met.
- Two new science campaigns are in the planning stage.

Operations Summary

- Airspace Challenges
  - ATC system is challenged by HALE UAS
    - Limitation of number of UAS in one ARTCC
      - Increase tempo and number of UAS
      - Deconfliction between organizations
    - Most ATC personnel have little UAS technical understanding
    - Flight plans
  - COA process
    - Regional UAPO extremely helpful
    - Not knowing what the COA will stipulate until issued
    - Emergency landing/divert in non-positive controlled airspace
    - Renewal / extension processing
  - ICAO Airspace
    - International operations and state aircraft
    - RVSM and RPN certification issues

Operations Summary (continued)

- Technical Challenges
  - Need for predictability with autonomous systems
    - C-1 Altitude cannot be pre-selected with Global Hawk
    - New squawk code for UAS lost link, 7400
    - Machine / Human Interface
      - GCS designed by engineers sometimes with little pilot input
      - Pilots must become experts on non-intuitive logic of UAS
  - New system requirements
    - ADSB
    - TCAS
  - System reliability and pilot proficiency to level of manned aircraft
    - Communications
    - Training
    - Experience