

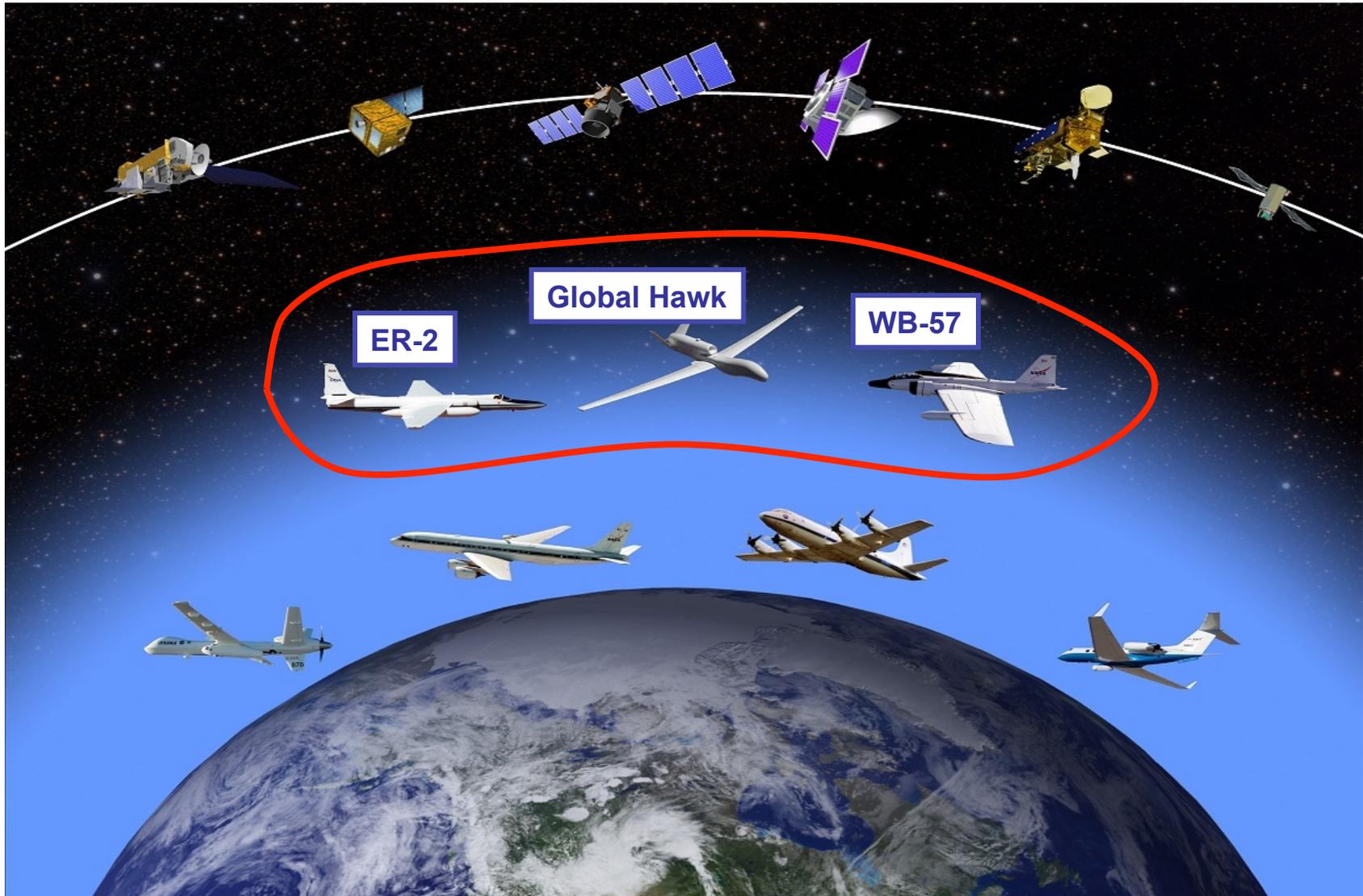


NASA Airborne Science Program





NASA Stratospheric Platforms





Performance Summary



			
	ER-2	WB-57	Global Hawk
Altitude	>70,000 ft >21 km	65,000 ft 20 km	65,000 ft 20 km
Payload	2,900 lb 1,300 kg	8,800 lb 4,000 kg	1,500 lb 700 kg
Duration	>10 hours	6.5 hours	30 hours
Range	>4,000 nm >7,400 km	2,500 nm 4,600 km	>10,000 nm > 18,500 km
Airspeed	410 kts	410 kts	335 kts

Note: performance parameters are sensitive to payload distribution and atmospheric conditions



Manned Platforms



WB-57

*Based at Ellington Field, Texas / NASA JSC
2 aircraft available for science missions
Dual crew*



*Variant of the Canberra, B-57 airframe developed
for Air Force weather reconnaissance*

*Recent upgrades have increased gross weight
and added new payload accommodations*

- **Multiple pressurized and unpressurized compartments**
- **115 VAC and 28 VDC experimenter power**
- **Common payload infrastructure**

- **Science mission operations since the 1970's**
- **World-wide deployment experience**

*Based at Palmdale California / NASA DFRC
2 aircraft available for science missions
Single crew*

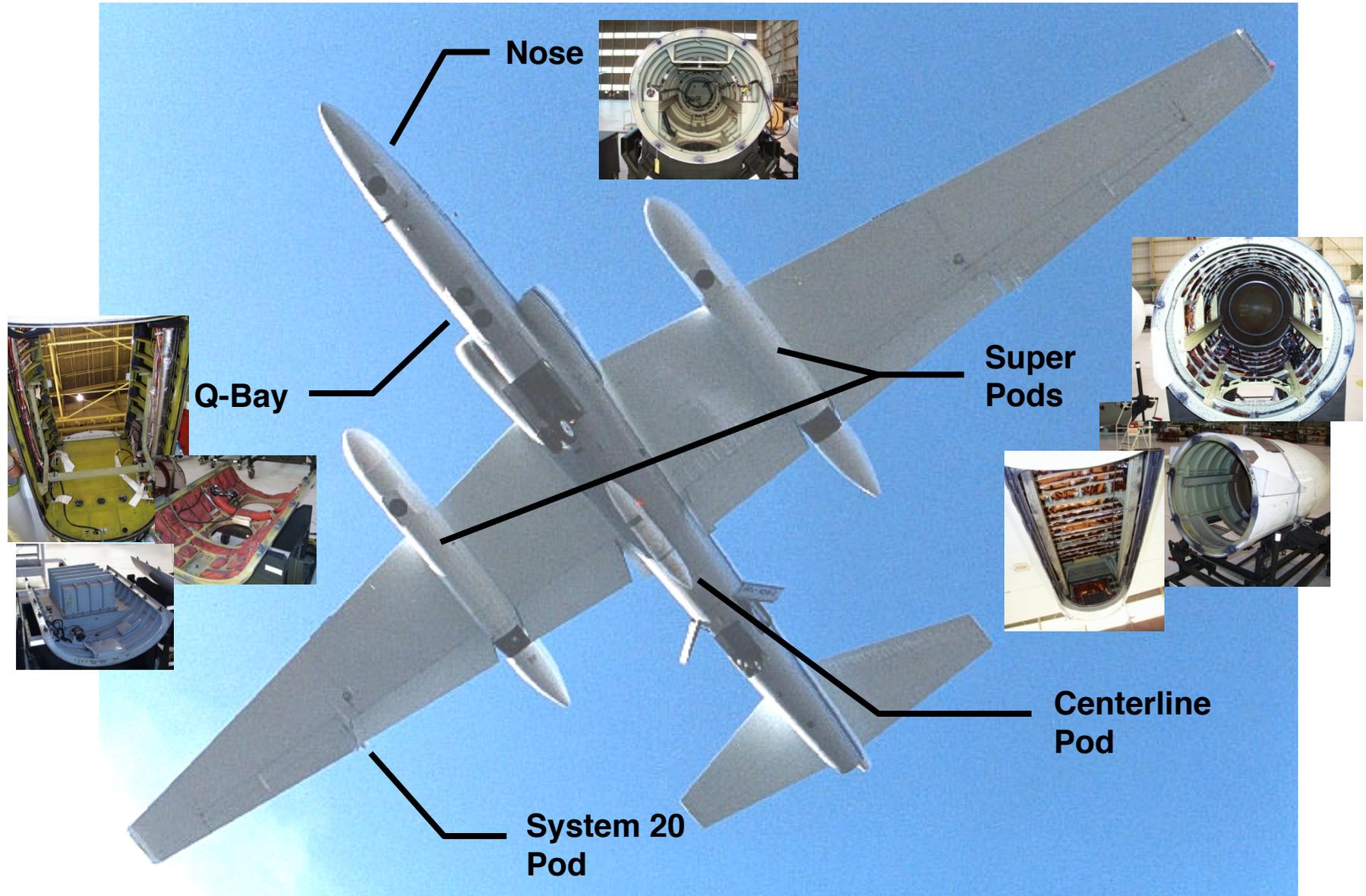


ER-2

*Air Force U-2 derivative
Over 100 science instruments integrated*

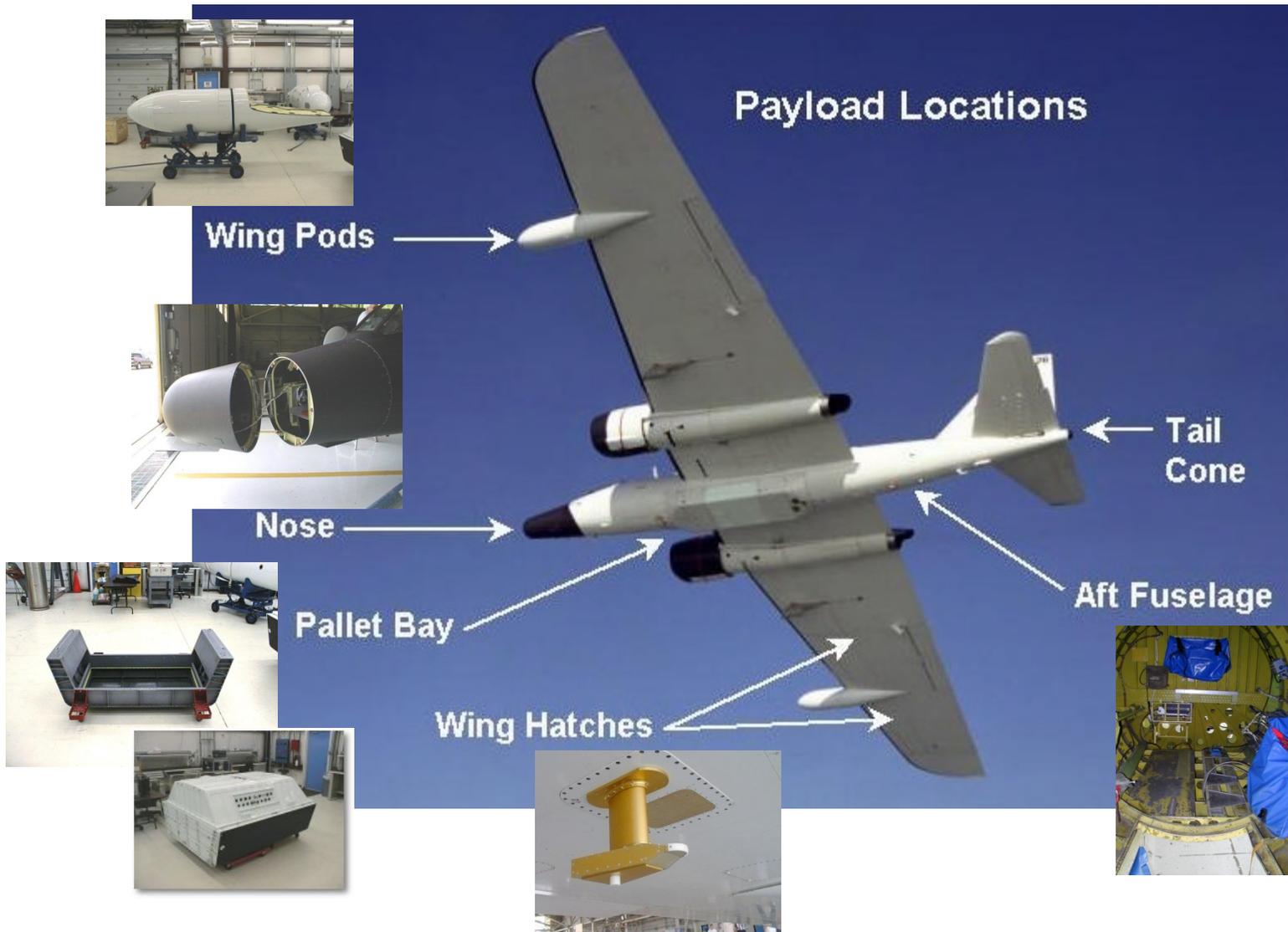


ER-2 Payload Accommodations





WB-57 Payload Accommodations





Global Hawk



- **Highly reliable Unmanned Aircraft System (UAS)**
 - Multiply redundant system design
 - Military experience with Global Hawk now exceeds 40,000 flight hours and 12 years of operation
- **NASA owns three, Advanced Concept Technology Demonstrator (ACTD) aircraft**
- **Aircraft are based at the Dryden Flight Research Center on Edwards Air Force Base**
- **Configuration and performance similar to standard 'Block 10'**
- **First NASA flight – Oct. 23, 2009**



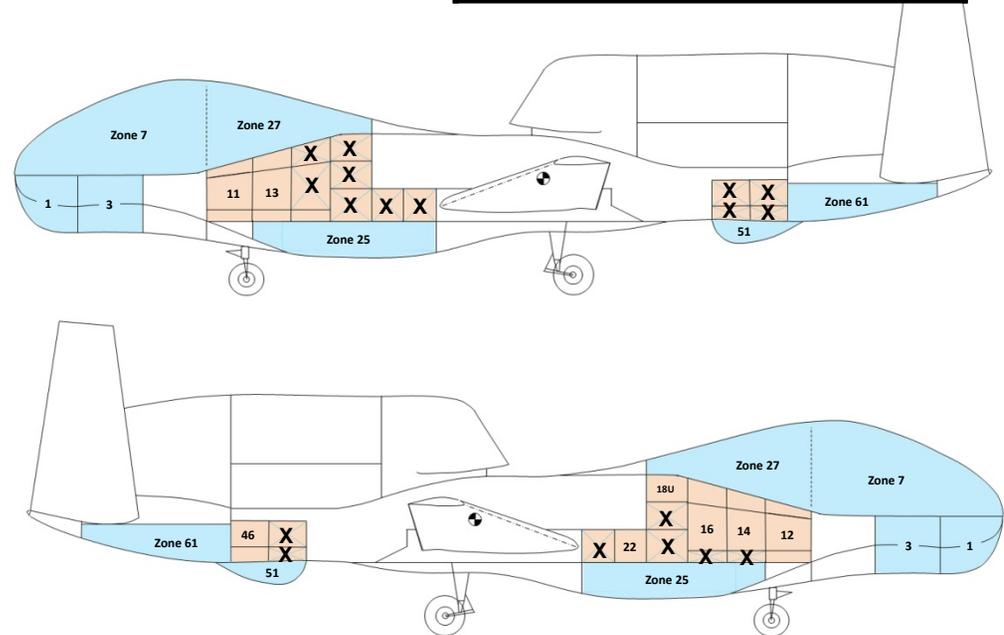


Global Hawk Payload Accommodations



- Total payload weight ~ 680 kg (1,500 lbs)
- Multiple compartments
 - Standardized power and command/control interface (EIP's)
 - Some ECS controlled
 - Pressure alt < 8.2 km
 - 0 < Temp < 55° C
 - No condensation
 - Some w/19" rack mounting
- Integration
 - Conducted by NASA / Northrop Grumman team
 - Pre-flight simulations
 - full mission duration
 - extreme environments
 - full functional check-out

Power for Experiments	
DC	2.0 KVA
AC	8.8 KW
Additional 7.5 KVA DC can be derived from AC power	



Legend:

ECS controlled, pressurized compartments: 

Non-ECS controlled, unpressurized compartments: 

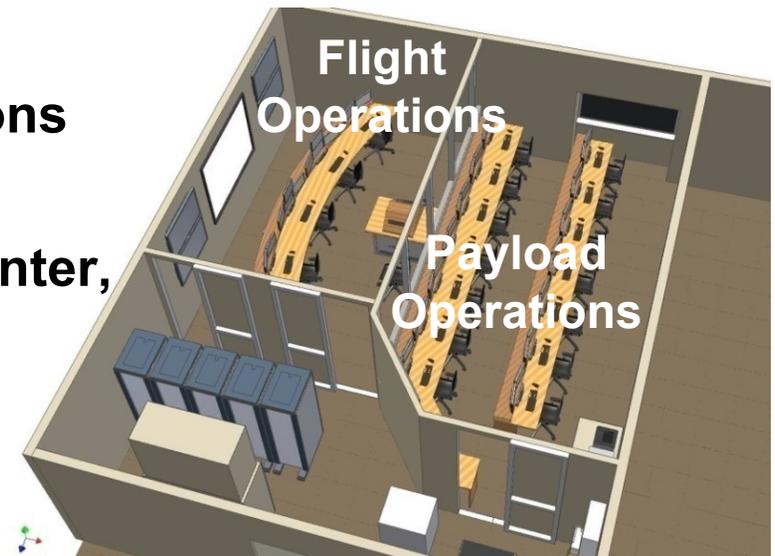
Compartment space unavailable to payloads: 



Global Hawk Operations Center (GHOC)



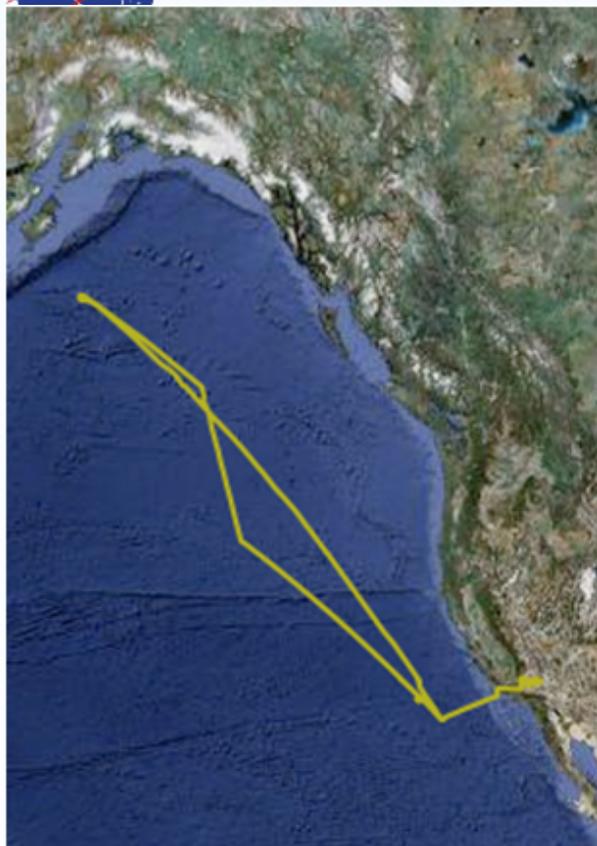
- **Unique to NASA Global Hawk operations**
- **Located at Dryden Flight Research Center, Edwards AFB, CA**



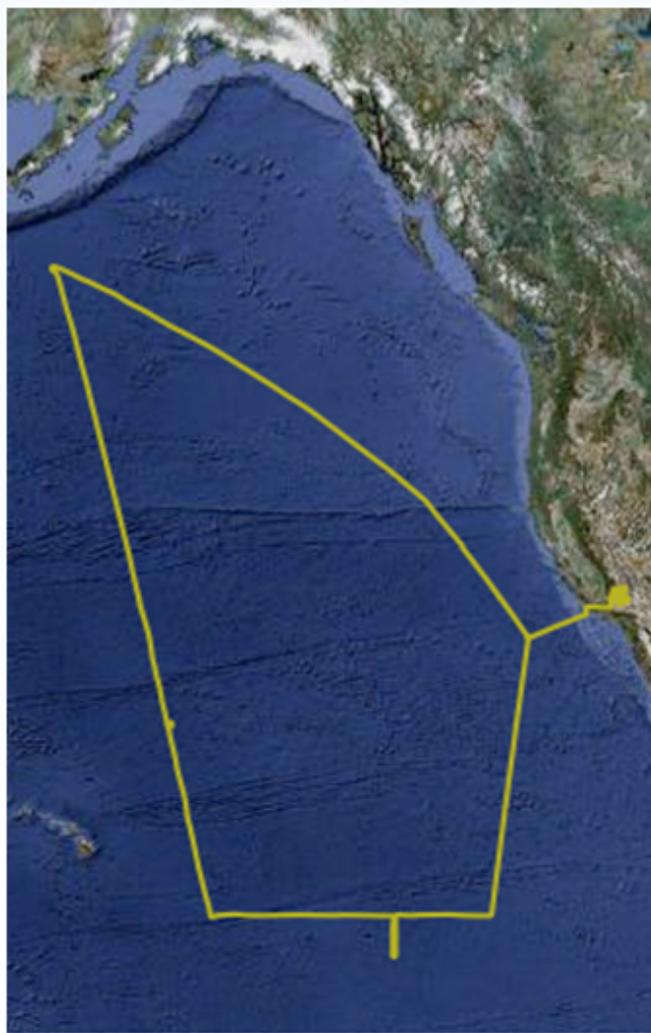
- **Designed to enhance scientist's participation during flight**
 - Situational awareness
 - Controlled access to flight crews
 - Science collaboration
- **Researchers have limited command and control access to their instruments**



GloPac – Global Hawk Pacific



April 7th
14.1 hrs, 4600nm, 61200 ft



April 13th
24.3 hrs, 8000nm, 62300 ft



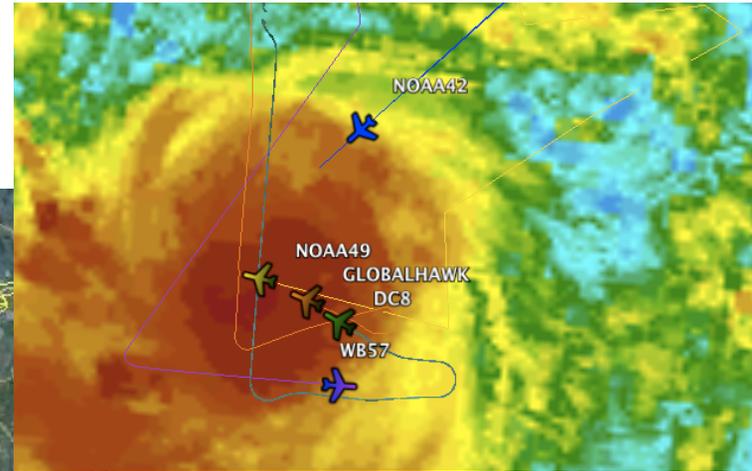
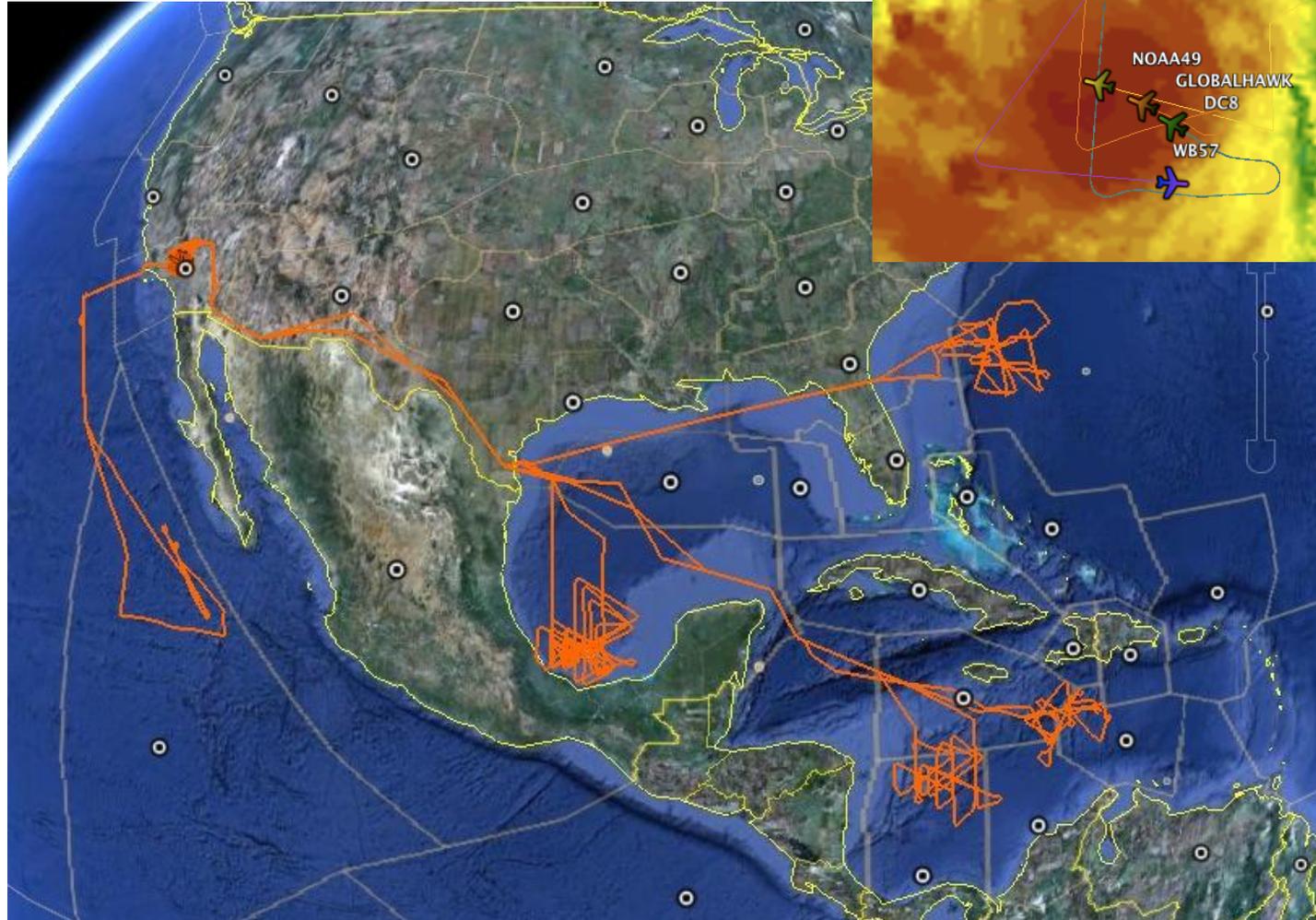
April 23rd
28.6 hrs, 9700nm, 65200 ft

(April 2: Range flight, 6.3 hrs)
(April 30: Equatorial flight attempt, 9.3 hrs) GloPac Total: 82.6 hrs



GRIP

Genesis and Rapid Intensification Processes





Opportunities for International Missions



- **Collaborative science opportunities announced through NASA ROSES**
- **Availability**
 - Commitments generally developed 12 to 18 months before deployment
 - ER-2 and WB-57 have schedule opportunities, contact project managers for discussion of interests
 - Global Hawk is heavily committed over next three years
- **Reimbursable missions for ER-2 or WB-57**
 - **Rate structure**
 - User fee (fuel included), per hour, per week
 - Mission peculiar costs
 - Travel, logistics, instrument integration, satellite communications



for more information



	ER-2	WB-57	Global Hawk
Program web-Site	http://www.nasa.gov/centers/dryden/aircraft/ER-2/index.html	http://jsc-aircraft-ops.jsc.nasa.gov/wb57/index.html	http://www.nasa.gov/centers/dryden/aircraft/GlobalHawk/index.html
Experimenter's Handbook	http://www.nasa.gov/centers/dryden/pdf/189893main_ER-2_handbook_02.pdf	http://jsc-aircraft-ops.jsc.nasa.gov/wb57/docs/33890BasicPCN1-03-18-02.pdf	



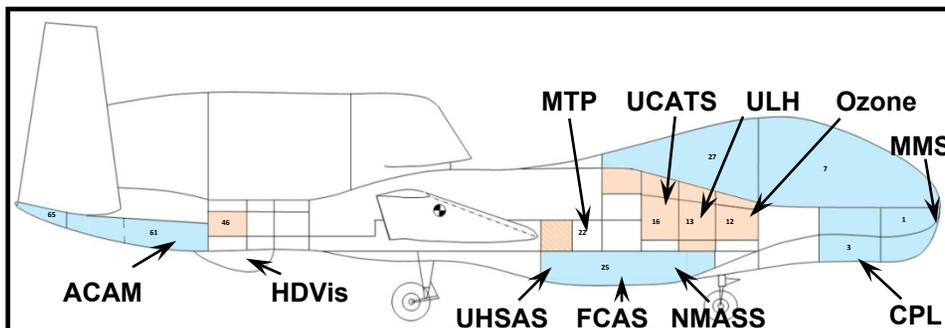
Back-Up Charts



First Science Mission



Global Hawk Pacific (GLOPAC)



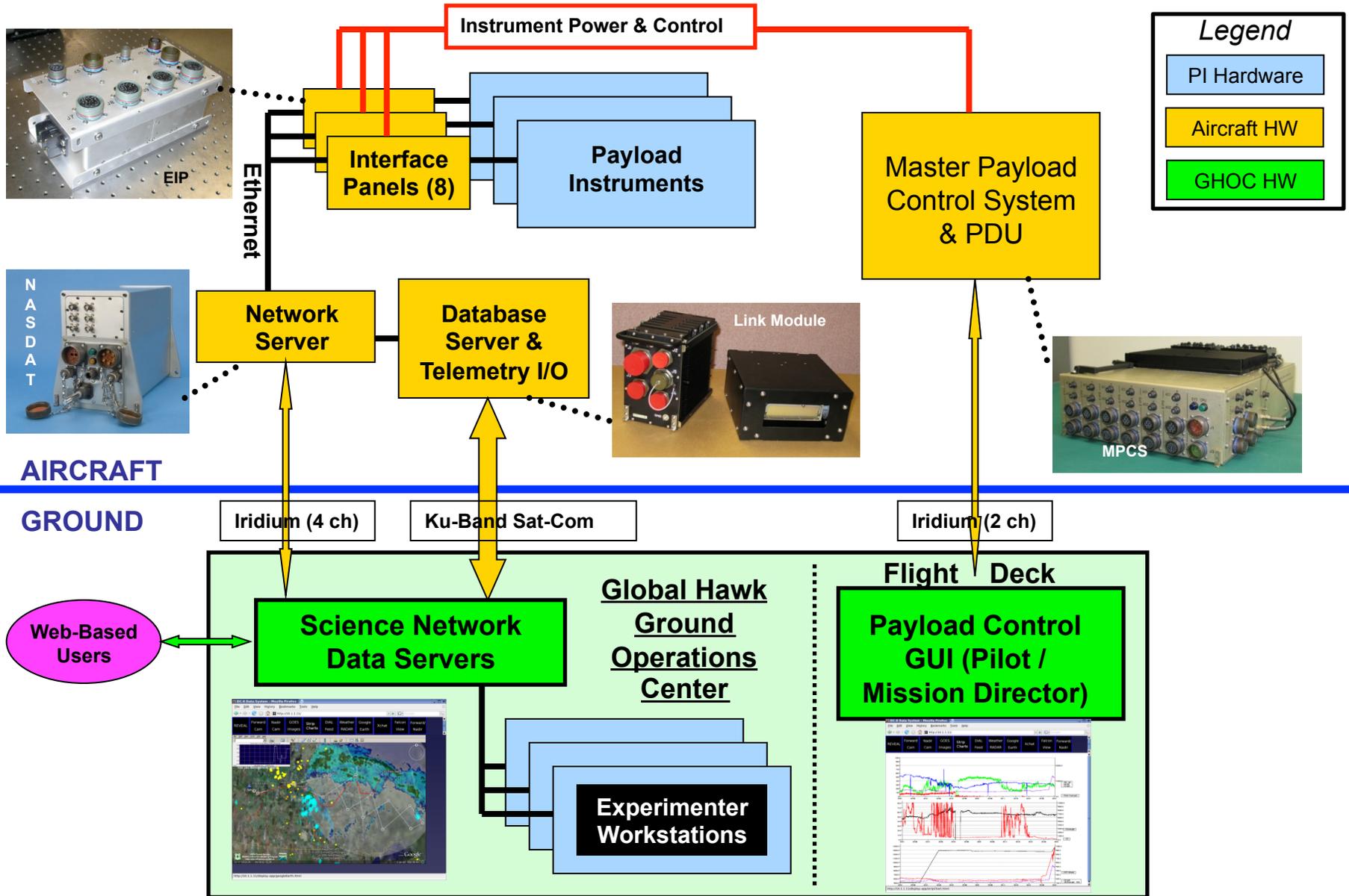
ACAM	Airborne Compact Atmospheric Mapper (GSFC)	Cross-track scanning spectrographs of NO ₂ , O ₃ , & aerosols.
CPL	Cloud Physics LIDAR (GSFC)	Backscatter LIDAR for hi-res profiling of clouds & aerosols.
FCAS	Focused Cavity Aerosol Spectrometer (U. of Denver)	Aerosol size and concentration measurements.
MMS	Meteorological Measurement System (ARC)	Science quality aircraft state variable measurements.
MTP	Microwave Temperature Profiler (JPL)	Passive microwave radiometer meas. of O ₂ 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 O ₃ measurements.
UCATS	UAS Chromatograph for Atmospheric Trace Species (NOAA)	Dual gas chromatographs for N ₂ O, SF ₆ , H ₂ , CO, & CH ₄ 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.

Objectives

- First demonstration of the Global Hawk unmanned aircraft system (UAS) for NASA and NOAA Earth science research and applications.
- Validation of instruments on-board the Aura satellite.
- Exploration of trace gases, aerosols, and dynamics of remote upper Troposphere / lower Stratosphere regions.
- Sample polar vortex fragments (IPY) and atmospheric rivers.
- Risk reduction for future missions that will study hurricanes and atmospheric rivers.



Real-Time Payload Communications & Control Systems



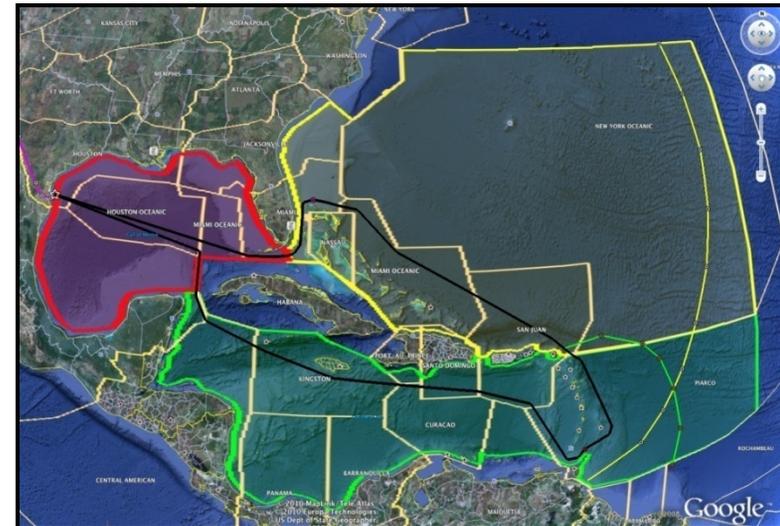


Global Hawk - PreGRIP



Risk reduction for Global Hawk participation in Genesis and Rapid Intensification Process (GRIP)

- **2 Flights operated from GHOC**
 - Edwards range
 - Gulf, demonstrate COA
- **July**
- **Partial payload integration**
 - Drop sondes
 - HiWRAP
 - HAMSRS
 - LIP
- **Demonstrate:**
 - Access to Gulf of Mexico and Caribbean
 - Methodology and sensors for operation near hazardous weather
 - stormscope
 - forward video both daylight and IR





Global Hawk – Future Capabilities



- **Mobile Operations Facility**
 - Allows deployed operations
 - Antarctic missions based in Chile or Australia
 - Eastern U.S. basing for greater coverage of Atlantic and Greenland
 - Supports terminal operations only, science team will support missions from the Dryden GHOC

- **Instrument integrations in progress**
 - UAVSAR (synthetic aperture radar)
 - Dual wing pylons for aero symmetry and mass balance
 - Bi-static interferometry option
 - Lidars for atmospheric profiling and topographic mapping

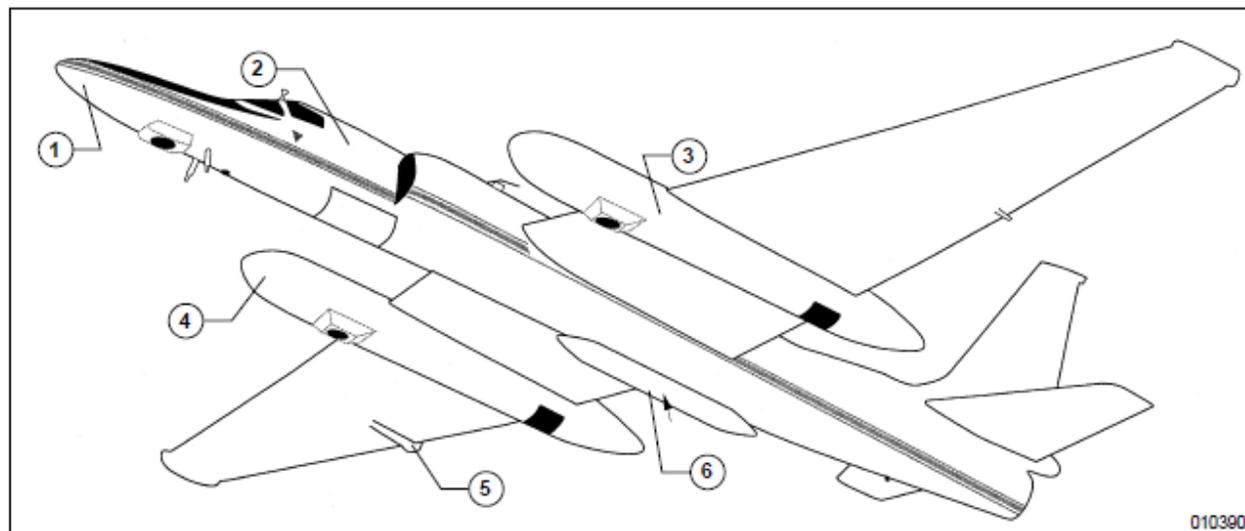




ER-2 Payload Accommodations



Area	ft ³	m ³	lb	kg	Electrical Company	
					VAC (3 ϕ)	VDC
1. Nose	47.8	1.35	605	294	50A at 115/208	2kW at 28
2. Equipment Bay (Q-Bay)	64.6	1.83	1,300	590	100A at 115/208	4kW at 28
3. Left wing pod	86.0	2.43	650	294	50A at 115/208	2.2kW at 28
4. Right wing pod	86.0	2.43	650	294	50A at 115/208	2.2kW at 28
5. System 20 pod	.74	.02	45	20.4	30A at 115/208	840W at 28
6. Centerline pod	14.0	.40	350	159	30A at 115/208	840W at 28



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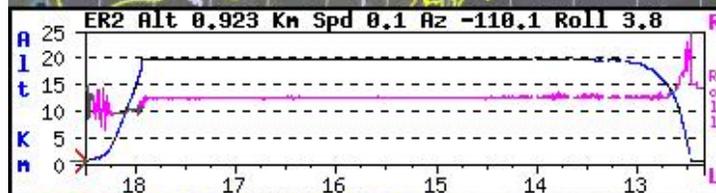


Mission Support

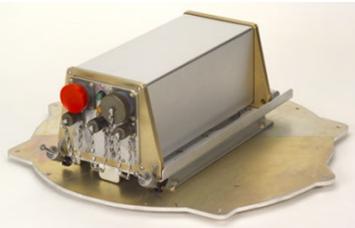


ER-2 and WB-57 both have long history with world-wide deployment capabilities

ER-2 flight track on 19 July 2007



On-board Hardware provides continuous aircraft data and limited monitoring and control of science instruments



Interactive Visualization

enables informed decision making during flight

- Integrates satellite, airborne and surface data sets
- Displays model and forecast parameter fields
- Tracks airborne vehicle state information

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2007-07-19 17:45:00



DC-8 Flying Laboratory

Large Capacity, Range and Endurance



Capabilities

- Ceiling 42,000 ft.
- Duration 12 hours
- Range > 5,400 nautical miles
- Payload 30,000 lbs

Mission Support Features

- Shirtsleeve environment for up to 30 researchers
- worldwide deployment experience
- Extensive modifications to support in-situ and remote sensing instruments
 - zenith and nadir viewports
 - wing pylons
 - modified power systems
 - 19 inch rack mounting





Gulfstream III

UAV Synthetic Aperture Radar (UAVSAR)



Capabilities

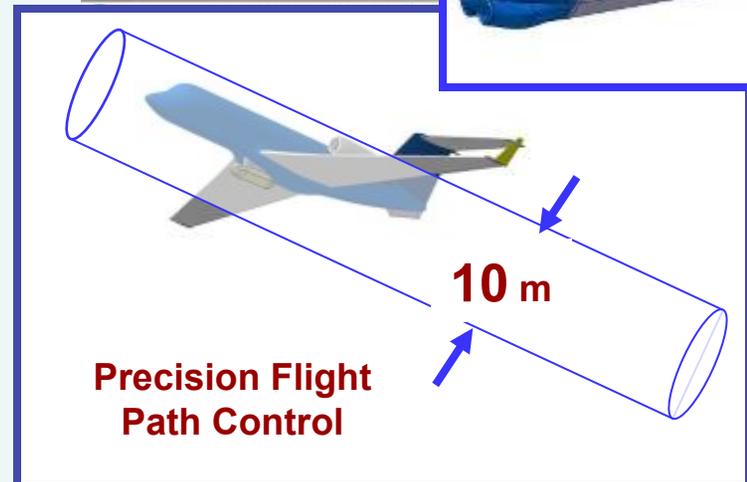
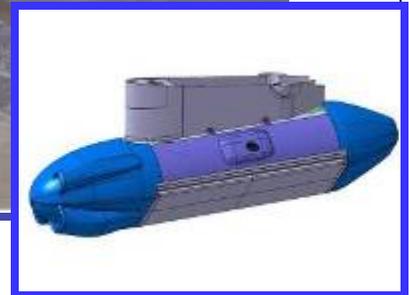
- Ceiling 45,000 ft.
- Duration 6 hours
- Range > 3,400 nautical miles
- Payload 2,610 lbs

Mission Support Features

- Center-line pod/pylon supports UAVSAR instrument
- Precision flight path capability
- Shirtsleeve environment instrument support
- World-wide deployment capability

UAVSAR

- Repeat-pass interferometry
- Ka- and L-band capability (separate pods)
- Designed for UAV operation – possible integration to Global Hawk





Ikhana (Predator B)

Medium Altitude, Very Long Endurance



Capabilities

- Duration > 24 hours
- Ceiling > 40,000 ft
- Payload 2,000 lbs, 750 lbs in wing pod
- Range 3,500 nautical miles

Mission Support Features

- Highly reliable UAS
- Deployment ready
 - Mobile ground station
 - High bandwidth science data link
 - Transport by land/sea/air
 - Ku Satcom for over the horizon missions
- External experiment pod with payload tray for parallel mission processing
- Internal payload compartments
- Experimenter network and data system
- Airborne Research Test System





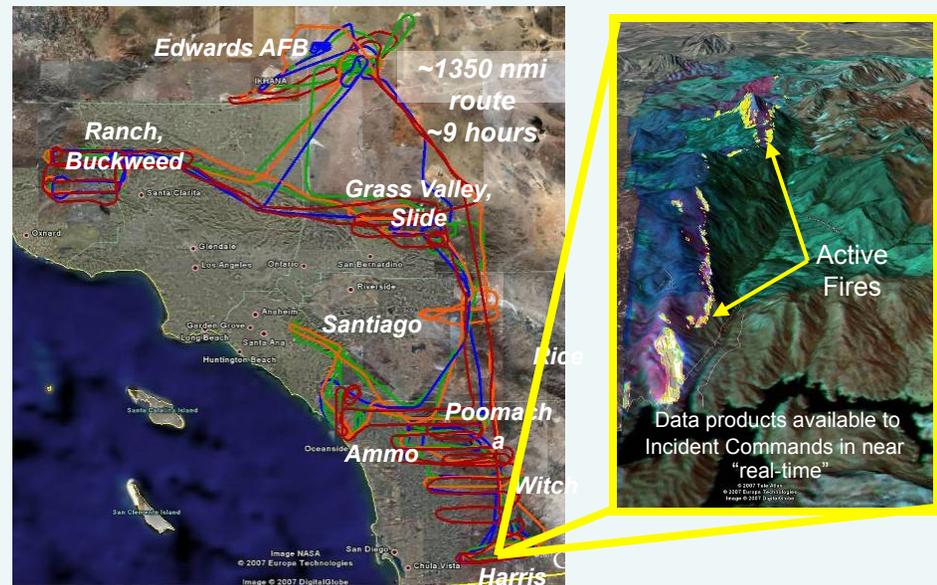
WRAP

– Recent Campaigns – Wildfire Research and Applications Partnership



**Long Range, Duration Flights
Over the Western States**

Flight operations with the Ikhana have demonstrated unprecedented UAS capability for data collection in the civil air space



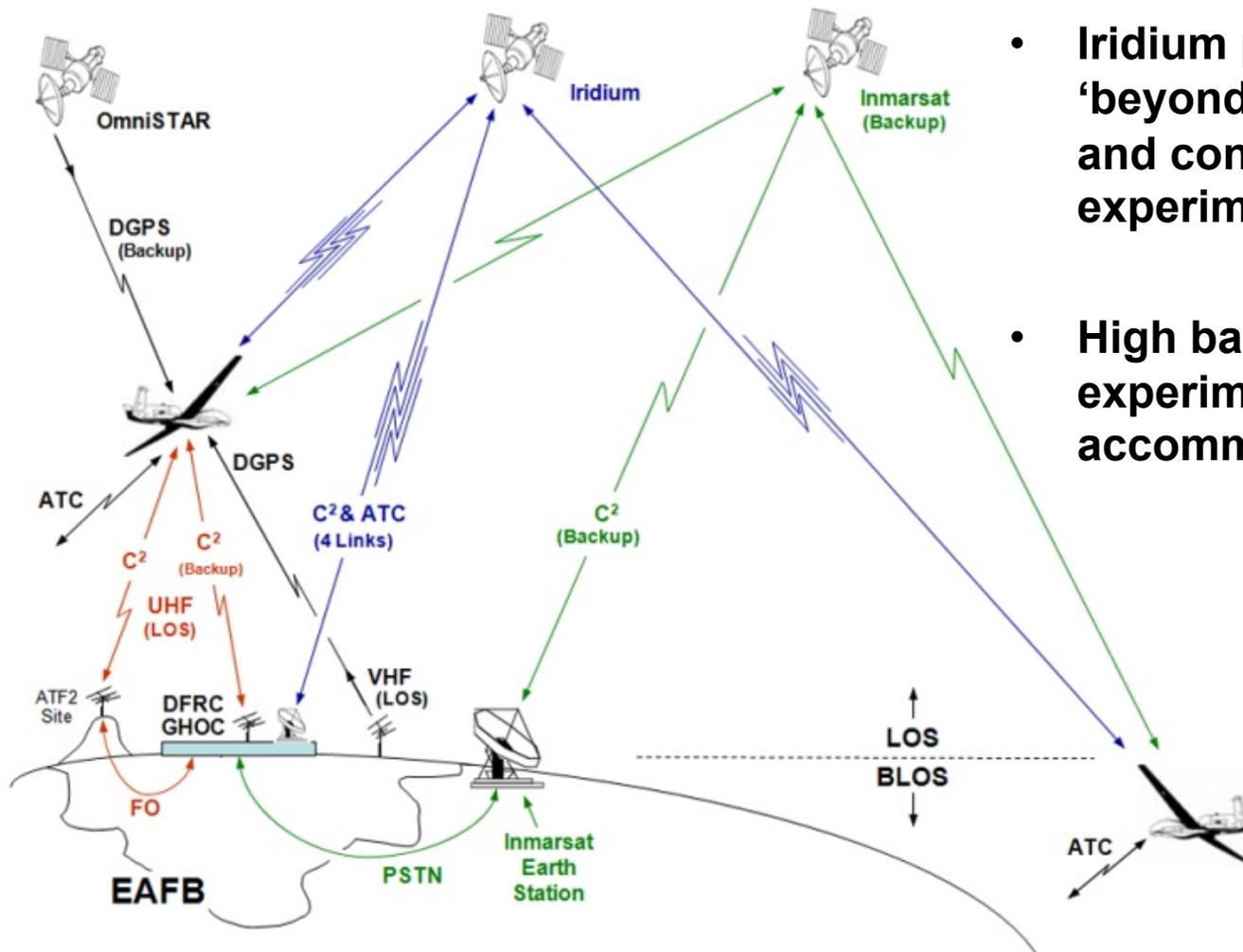
**Emergency Response Missions
into Congested Airspace**



Communications

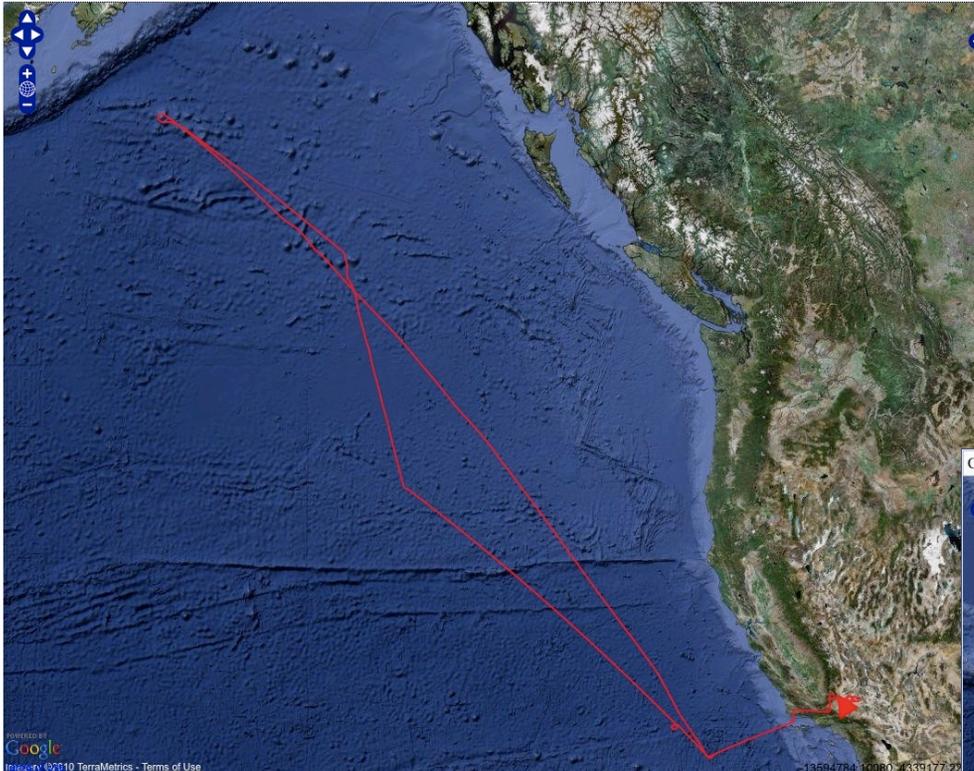


- Separate links for aircraft and payload communications
- Iridium provide primary 'beyond line of sight' command and control for aircraft and experimenters
- High bandwidth links for experimenters can be accommodated as required



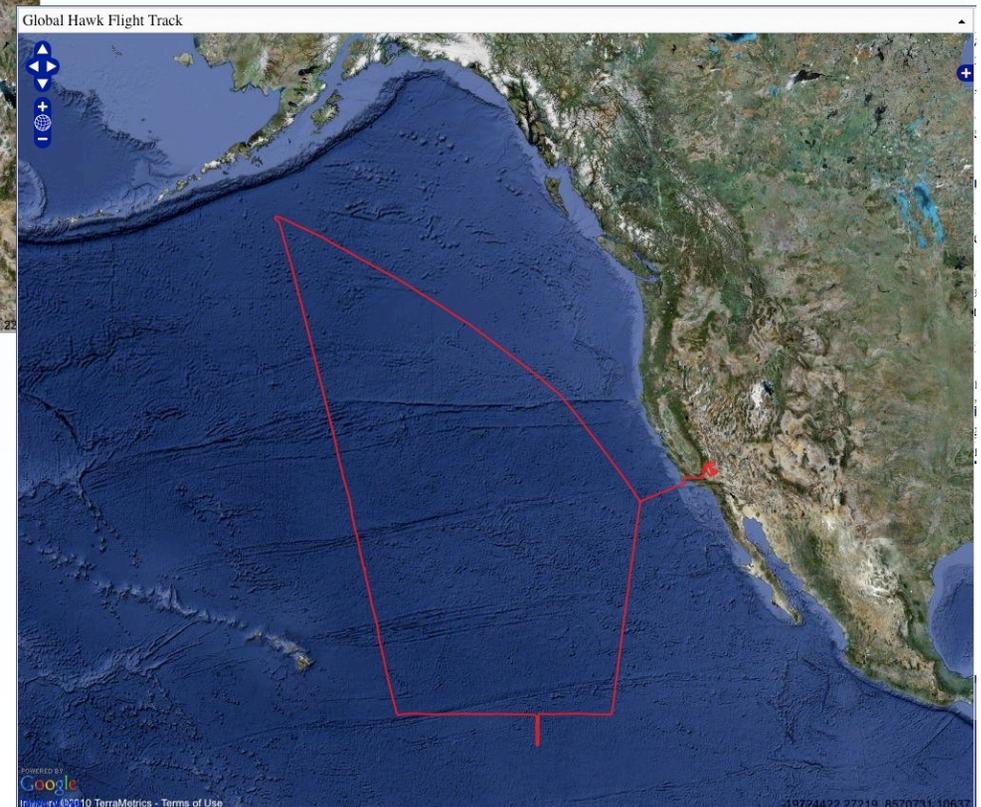


GloPac – Global Hawk Pacific



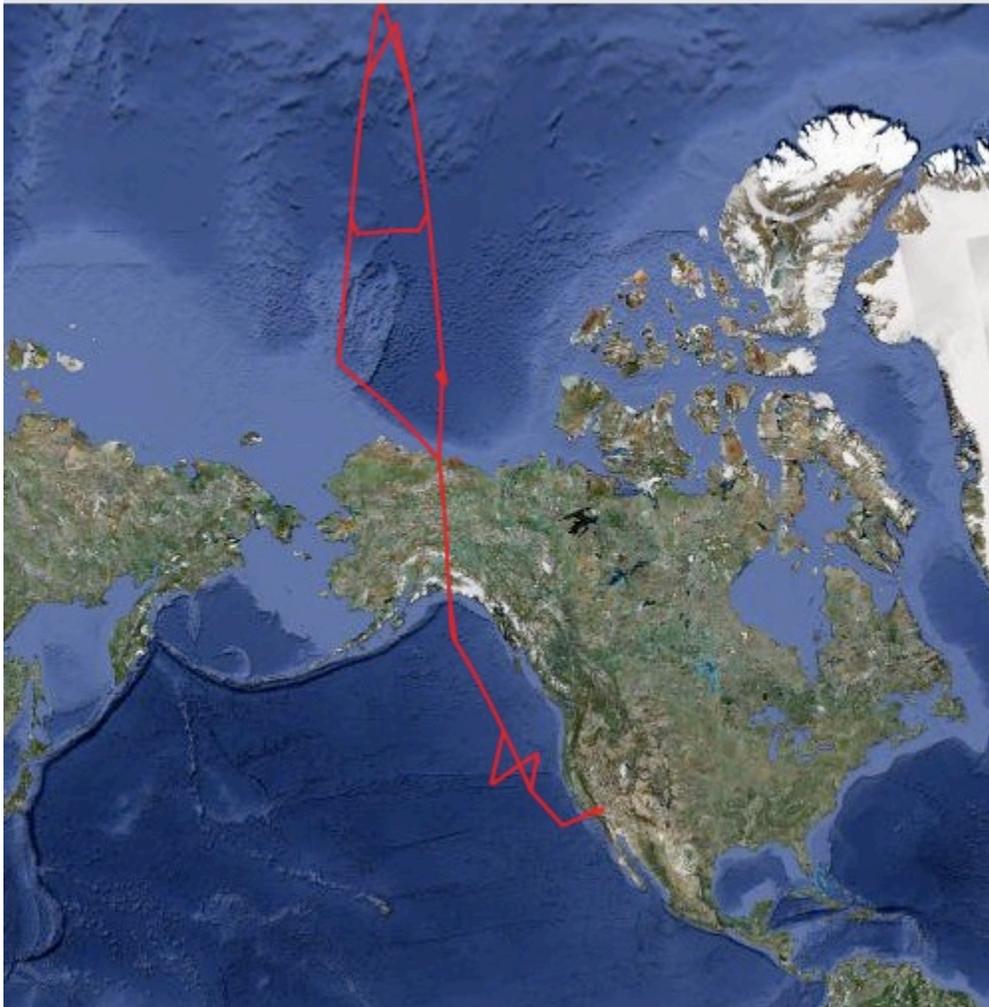
- **First Global Hawk science flight**
 - **Apr 7**
 - **14.1 hrs**
 - **Sampled polar vortex**
 - **Fulfilled last IPY goal**
 - **Satellite underpass**

- **Second Global Hawk science flight**
 - **Apr 13-14**
 - **24.3 hrs**
 - **A-train satellite underpass**
 - **2 vertical profiles to 43K'**
 - **Dipped to 12 degrees N**





GloPac – Global Hawk Pacific



- **First Global Hawk Arctic flight**
 - **Apr 23-24**
 - **28.6 hrs**
 - **Reached 85 deg North (new Global Hawk record)**
 - **Reached 65k ft altitude**
 - **Sampled Arctic air**
 - **Investigated Asian dust plume**
 - **Satellite underpass**