Planning for Success – An Operational Test Program for Unmanned Observing Strategies

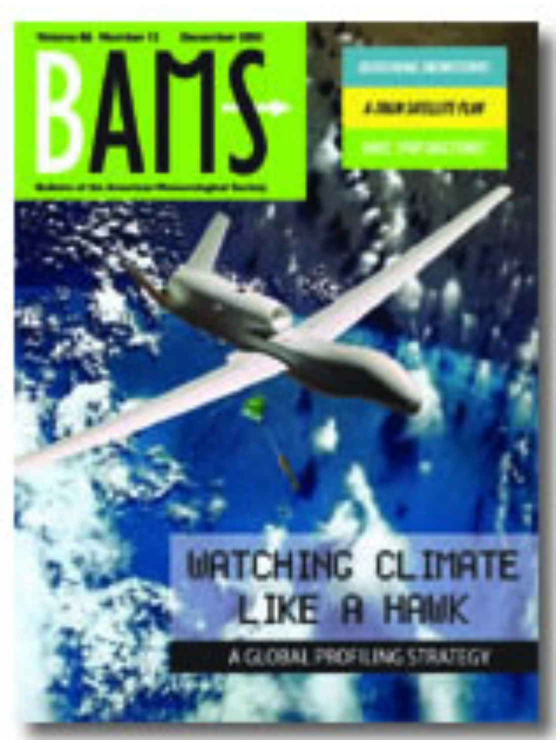
Robbie Hood, Director

NOAA Unmanned Aircraft Systems (UAS) Program

1 May 2012

Overview

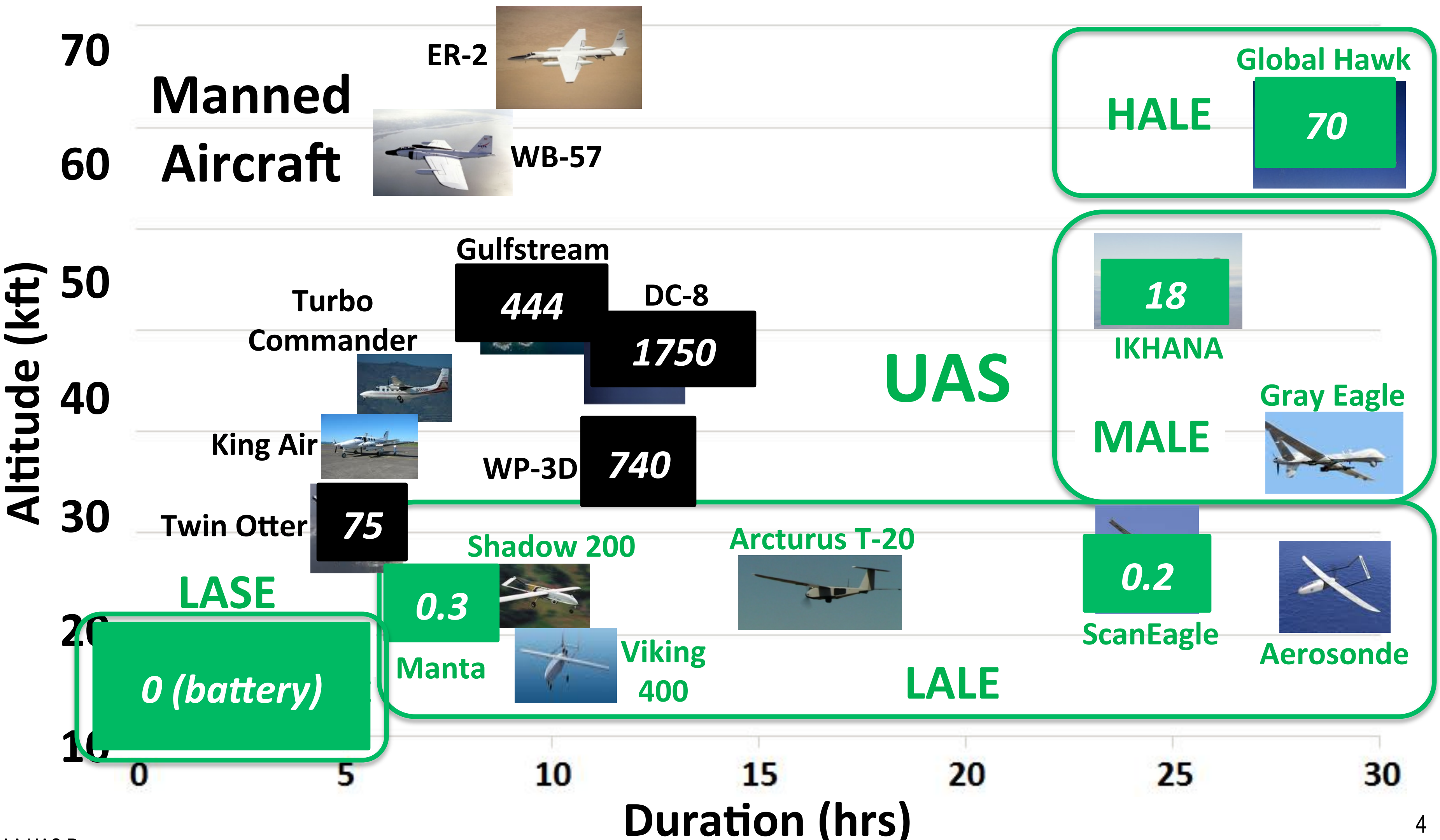
Initial Vision



- **Landmark article by Dr. Alexander MacDonald published in 2005 *Bulletin of American Meteorology Society (BAMS)***
  - **Global Profiling System with UAS and ocean buoys to improve weather and climate prediction**
  - **Long range, long endurance over hard-to-reach ocean areas**
  - **High altitude UAS releasing dropsondes for vertical profiles of meteorological data**
  - **Aircraft profiling to sample *in situ* atmospheric chemistry and air quality**
  - **Real-time data delivery for forecast input**
  - **Operationally feasible by 2015**

NOAA and NASA Manned and Unmanned Flight Capabilities

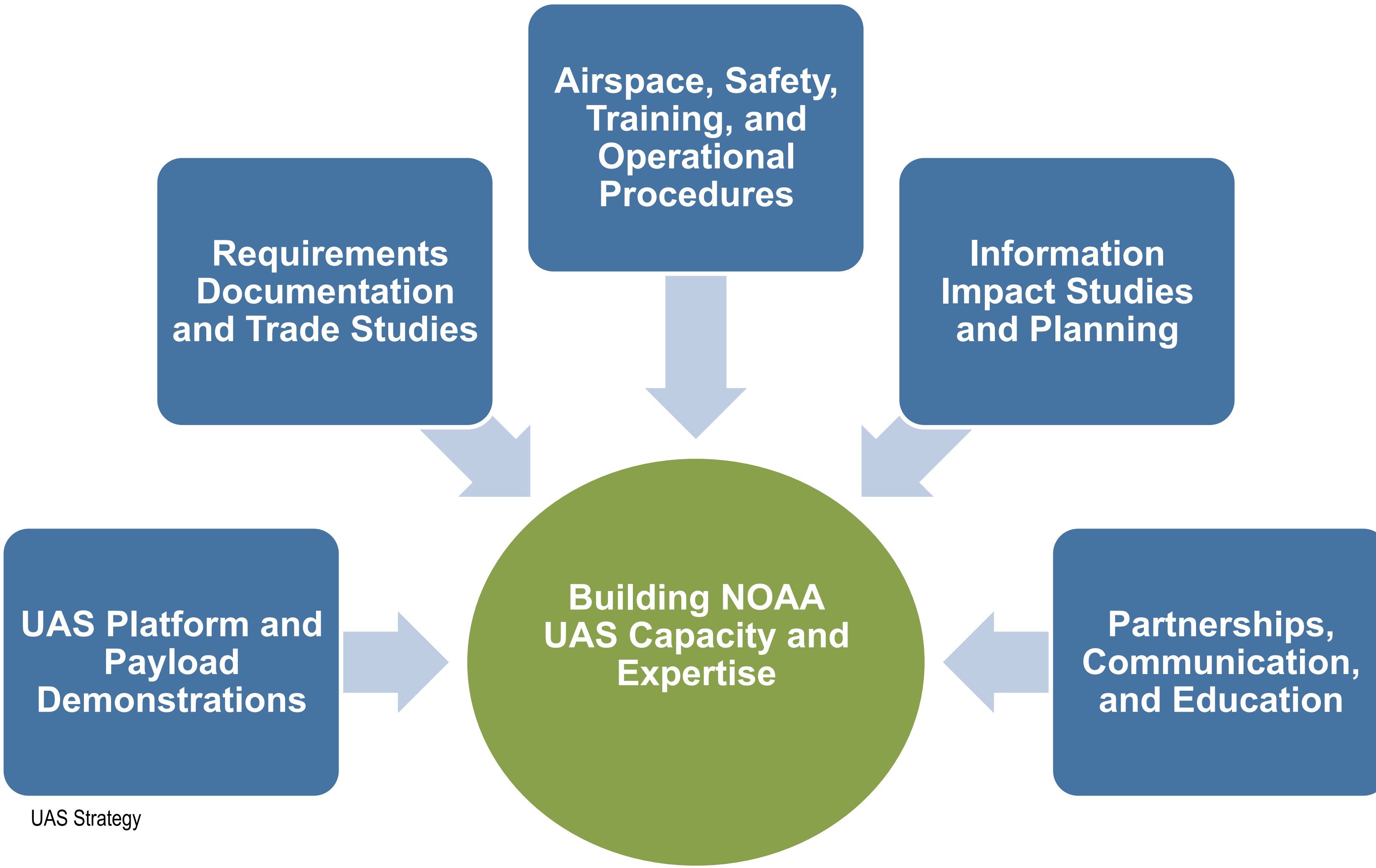
Fuel consumption (gph) for nominal mission



NOAA UAS Strategic Vision and Goals

- ***Vision***
  - UAS will revolutionize NOAA observing strategies by 2015
  - comparable to the introduction of satellite and radar assets decades earlier
- ***Goals***
  - Goal 1: Increase UAS observing capacity
  - Goal 2: Develop high science-return UAS missions
    - *High impact weather monitoring,*
    - *Polar monitoring*
    - *Marine monitoring*
  - Goal 3: Transition cost-effective, operationally feasible UAS solutions into routine operations

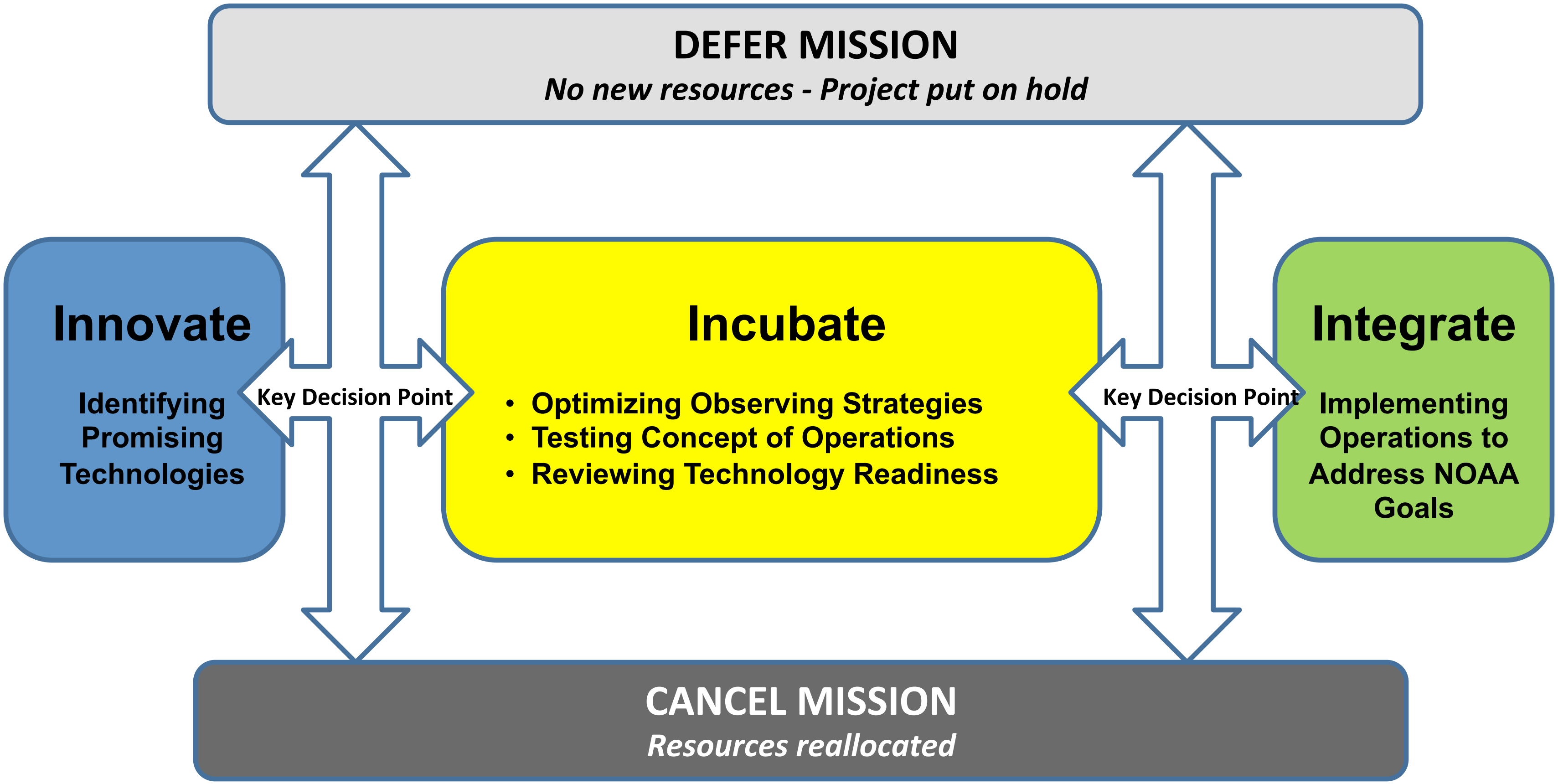
Tools for Building UAS Capacity



Metrics for UAS Technology Assessment

Technology Readiness Level	Description
TRL 1	Basic or fundamental research
TRL 2	Technology concept and/or application
TRL 3	Proof-of-concept
TRL 4	Concept validated in laboratory
TRL 5	Concept validated in relevant environment
TRL 6	Prototype demonstration in relevant environment
TRL 7	Prototype demonstration in operational environment
TRL 8	System demonstration in an operational environment
TRL 9	System totally operational

NOAA Unmanned Transition Process



Relevant Accomplishments

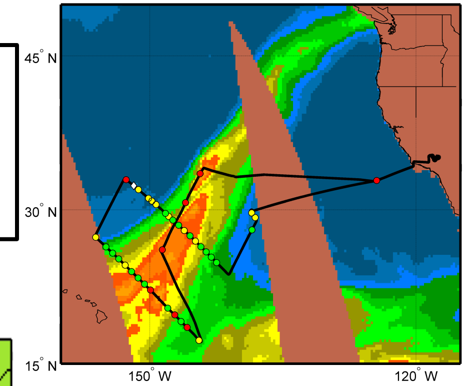
Completed Science Campaigns

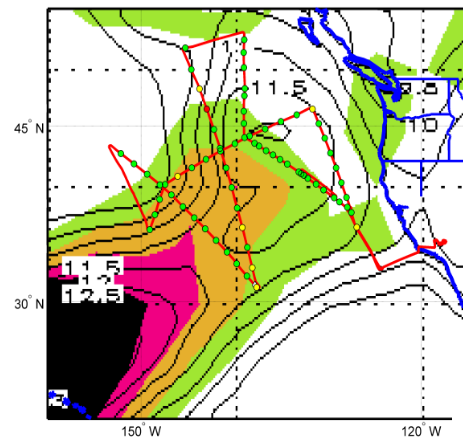
- Global Hawk Pacific (March-April 2010)
  - 11 instruments
  - 4 science missions, 76 hours
  - First Global Hawk Science Mission
  - Flights spanned 12 to 85 deg N Latitudes
- Genesis and Rapid Intensification Processes (August-September 2010)
  - 4 Instruments
  - 5 science missions, 114 hours total
  - First Global Hawk severe storm over flight
- Winter Storm Pacific and Atmospheric Rivers (February-March 2011)
  - 2 Instruments
  - 3 science missions, 70 hours total
  - First operational dropsonde deployment from a UAV

Winter Storm and Pacific Atmospheric Rivers (WISPAR) Experiment

- Demonstration of the scientific application of the Global Hawk dropsonde system for NOAA operational and research objectives
- 3 science flights targeted:
  - Atmospheric Rivers
  - Winter Storms Reconnaissance
  - Arctic Weather
- February-March 2011
- Just under 70 hours flown
- 177 total dropsondes deployed
- Additional measurements from HAMSR

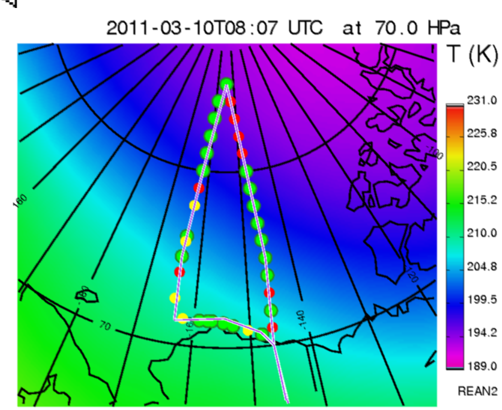
Atm. Rivers
11-12 Feb
37 sondes



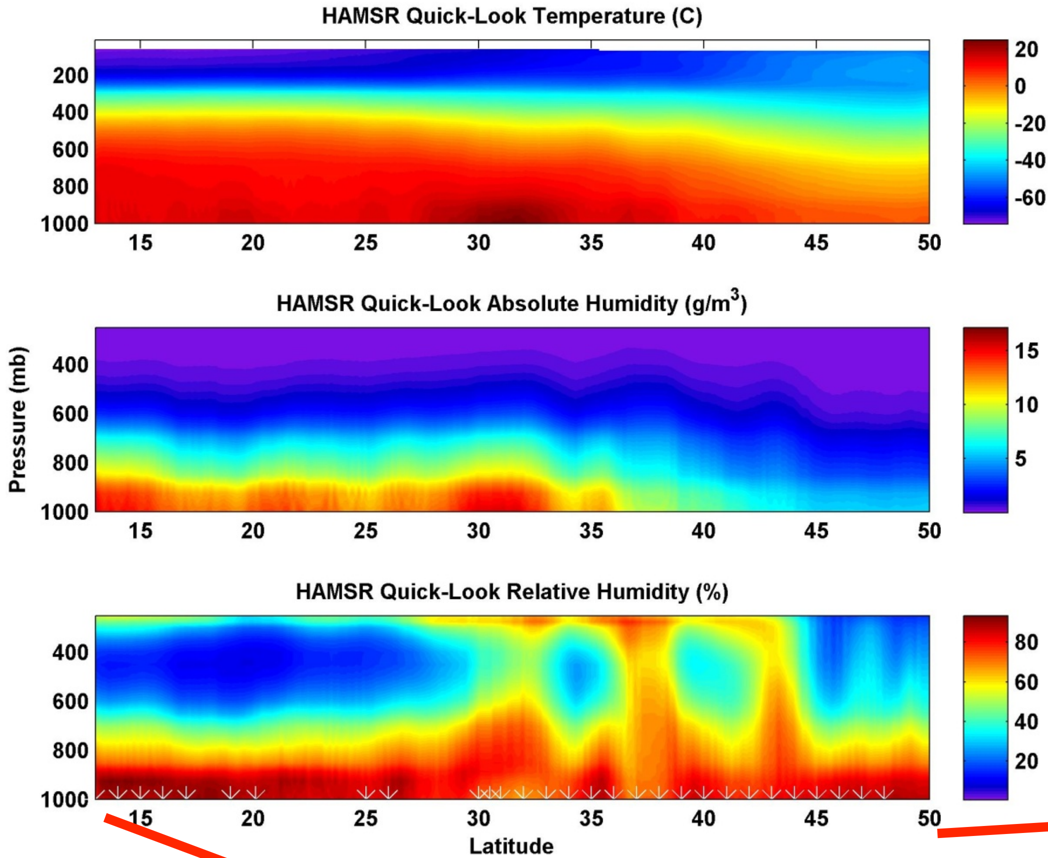


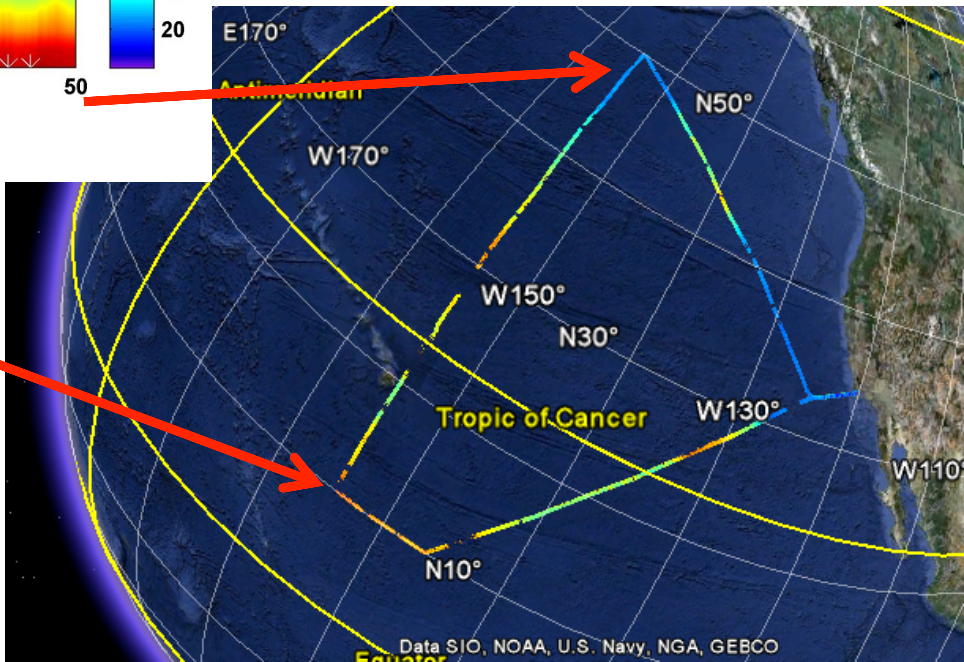
Winter Storms
3-4 March
70 sondes

Arctic Weather
9-10 March
70 sondes
35 N of AK



HAMSR Cross Sections

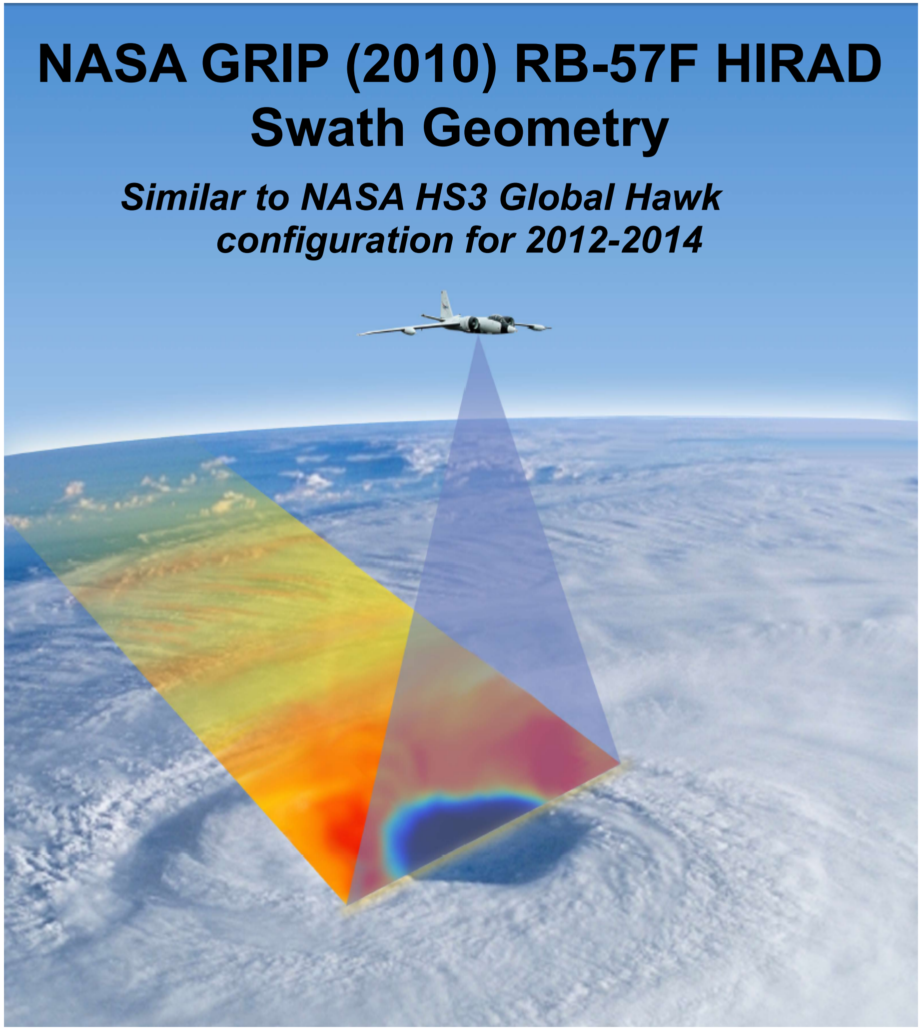




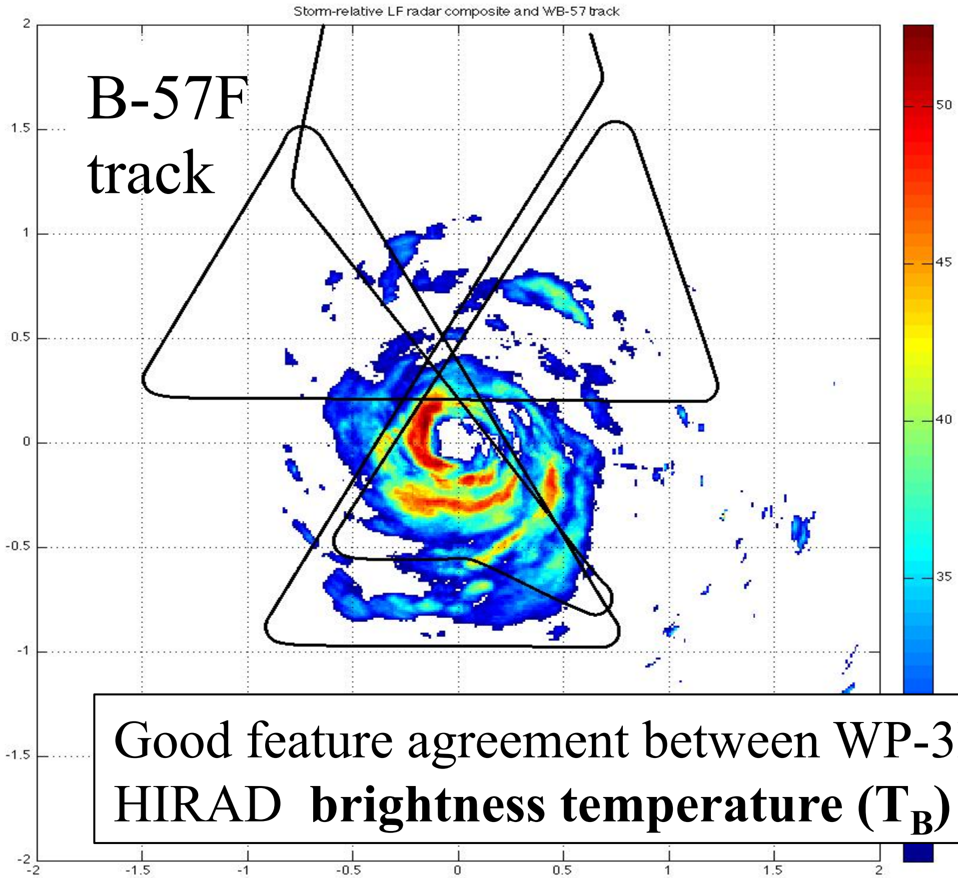
- HAMSR quick-look profiles shown for N-S leg of flight path of 9/8 flight
- White arrows indicate dropsonde locations

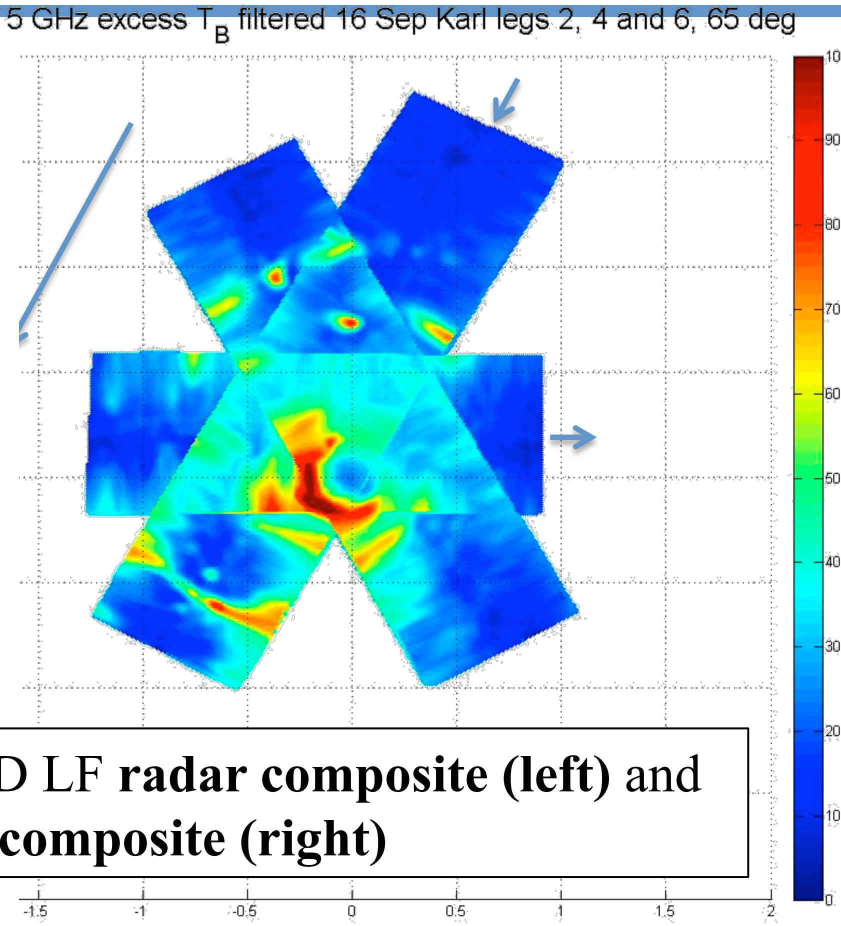
Hurricane Imaging Radiometer (HIRAD)

- **A passive microwave radiometer (C-band, 4 frequencies), similar to SFMR: Measures emissivity and retrieves hurricane surface wind speeds and rain rates over a wide-swath:**
  - **Swath Width ~ 80 km**
  - **Resolution ~ 1- 5 km**
  - **Wind speed ~10 – 85 m/s**
  - **Rain rate ~ 5 – 100 mm/hr**
- **Key Feature: Near-instantaneous mapping of entire inner-core hurricane surface wind field and rain structure.**
- **Operational advantages: Surface wind and rain swath will complement SFMR and airborne Doppler radar mapping of inner-core structure for improved short-term advisories and numerical model simulations.**



P3 radar reflectivity (left)
HIRAD Tb 5 GHz (right)





Good feature agreement between WP-3D LF **radar composite (left)** and HIRAD **brightness temperature (T_B) composite (right)**

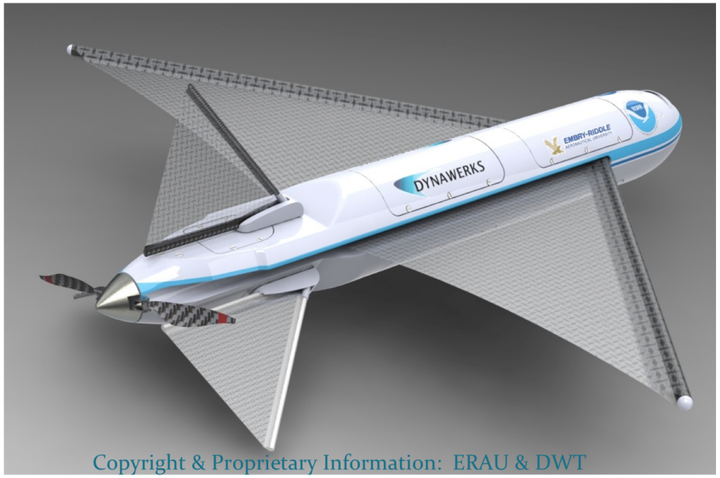
P3 radar center crossings

WB-57 HIRAD center crossings at 19:16:49, 19:52:37, 20:33:44

Guided Dropsondes

GALE UAS

Partnership with NOAA, Embry-Riddle U., and Dynawerks



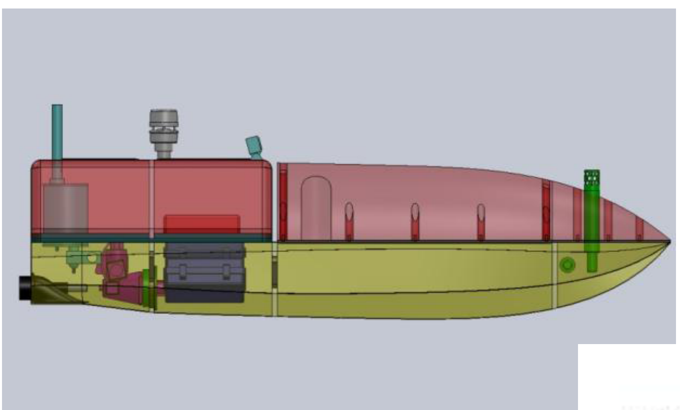
Performance Attribute	Estimated Performance
Mission Weight	8.0 lb
Cruise Speed	42 kts
Dash Speed	110 kts
Stall Speed	22 kts
Mission Endurance	60 minutes

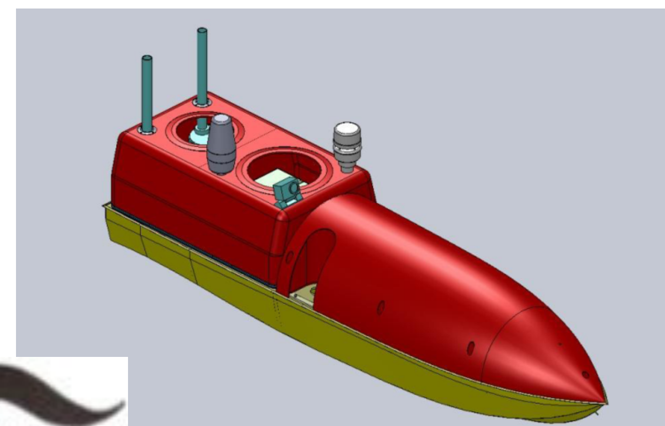
Effort lead by
Jose Cione, AOML-HRD
and
Nancy Ash,
OMAO-AOC

Unmanned Surface Vehicles

Emergency Integrated Life Saving Lanyard (EMILY)

- Developed through Phase 3 Navy SBIR
- 65 inch Unmanned Surface Vehicle (USV)
- Testing this summer with barometric pressure, air and sea surface temperature, salinity, wind speed and direction, humidity , camera, and satellite communication payload





HYDRONALIX

Next Steps

Increasing Technology Readiness

Proven

- Dropsondes vertical profiles (NSF/NOAA)
- Passive microwave temperature and water vapor images and vertical profiles (NASA)
- Upper tropospheric /stratospheric water vapor (NASA/ NOAA)

Maturing

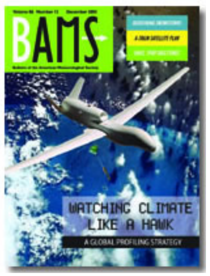
- Ocean surface wind speed and precipitation images (NASA/NOAA)
- Dual-polarized Doppler radar vertical profiles of wind and precipitation including ocean surface (NASA)
- Lidar vertical profiles of wind in clear air (NASA)
- Water vapor soundings (NASA/Wisconsin)
- Cloud physics lidar observations (NASA)

Emerging

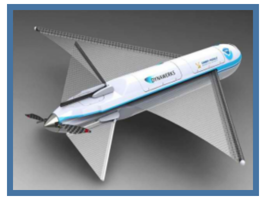
- Lightweight, lower cost UAS dropsondes (Navy)
- Aircraft-launched unmanned air and water vehicles (DOD/NASA/NOAA)
- Ship-launched unmanned surface water vehicles (DOD/ NOAA)

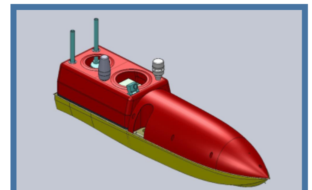
Roadmap for Transition of Unmanned Observations

Vision of Global Profiling System



Operational Test Program for Unmanned Observing Strategies





2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

Operational Test Program for Unmanned Observing Strategies

GENERAL CONCEPT: **Shared testing and evaluation of platforms, payloads, and observing strategies including targeted observation schemes, data assimilation techniques and information management plans**

VISION : **Accelerate accurate warnings and forecasts for hazardous weather and disasters by minutes, hours, and days**

MISSION: **Prompt operational transition of innovative unmanned observing strategies maximized for measureable societal benefit, scientific return, cost-effectiveness, and operational efficiencies**

PERIOD OF PERFORMANCE: **2014- 2020**

Operational Test Program Goals

- Improve 3-7 day weather forecast of high impact oceanic events with targeted unmanned observing strategies

- Improve delivery of real-time information needed for warn-on-forecast of rapidly developing weather

- Develop interagency rapid response observing fleet to provide critical situational awareness information needed during high impact events and disasters

- Improve understanding and prediction of climate change linkages to high impact weather events using consistent weekly or monthly unmanned observations

Potential Benefits To Interagency Partners

- ***NASA*** **– test program focused on faster transition of new observing, modeling, and information technologies into near-term aircraft applications as a stepping stone to future satellite applications**
- ***NOAA*** **– evaluate emerging observing strategies against operational requirements, cost and operational feasibility**
- ***US Pacific Command*** **- demonstrate and evaluate global observing capabilities needed for weather forecasting and real-time decision-making in data void regions**
- ***NSF*** **- increase research community access to large infrastructure unmanned systems**
- ***CROSSCUTTING*** **– provide cost-effective, gap-filling options for decreasing coverage of the Pacific by space borne platforms during the next 10 years**

Contact Information

UAS Web Site: http://uas.noaa.gov/

Questions should be directed to: noaa.uas@noaa.gov

Phil Kenul - NOAA UAS Program Senior Technical Advisor (philip.m.kenul@noaa.gov)

Robbie Hood - NOAA UAS Program Director (robbie.hood@noaa.gov)

Background Slides

Strategic Priorities

NOAA Next Generation Strategic Plan

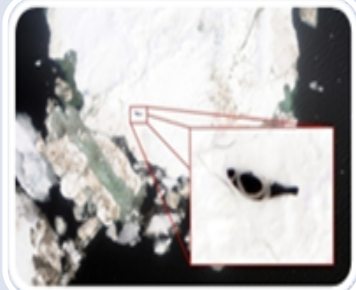
- *Success indicated by enhanced horizontal coverage, time, and vertical profile of the Earth*

National Ocean Policy

- *Call for the use of unmanned vehicles to gather data on the health and productivity of the ocean, our coasts, and the Great Lakes*

NOAA NWS Strategic Plan

- *Future focus on maintaining continuous situational awareness, interpreting information and providing decision for high-impact events*



NOAA Arctic Plan

- *Improved observations to better forecast sea ice, understand climate and ecosystem changes, and improve weather and water warnings*