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# **NOAA's Marine and Arctic Monitoring UAS strategies**

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# NOAA sUAS



## Overview

- NOAA UAS Program – A Brief History
- sUAS for Marine Resource Monitoring, Arctic and Emergency Operations
- Successes and Challenges
- Looking Forward
- Questions



# NOAA Requirements for UAS



Missions that are :

- Dirty
- Dull
- Dangerous (Threat assessments)
- **Denied** or Impossible to get to and/or impossible to use a manned aircraft (Low ceilings, etc.):
  - **Remote**
  - **Unique mission requirements:**
    - Smaller and quieter UAS don't disturb animals as much as a manned aircraft would
    - **Stealth** provides advantages for surveillance and enforcement
    - **Persistence**
    - **Better data resolution**
    - **Can be quickly deployed and positioned**

# NOAA and UAS



- Altair at Channel Islands
- Global Hawk



# NASA Global Hawk Operations Center



# NOAA / NASA Altair Test Flight Crew



# NOAA and UAS



- NASA Ikhana
- ScanEagle
- Manta





# NOAA sUAS history



- NOAA tests various systems including **ScanEagle** in 2007 and 2009 and acquires two **multi-copters** in 2010 and two **Puma** UAS in 2011
- Development of protocols and procedures
- Missions:
  - Living Marine Resource Surveys
  - Habitat Mapping and Characterization
  - Enforcement
  - Emergency Response
  - Marine Debris
  - USCG Arctic Support



# Scan Eagle on test deployment in Puget Sound 2007



# Scan Eagle recovery at sea



# Multi-copters



Md4-1000

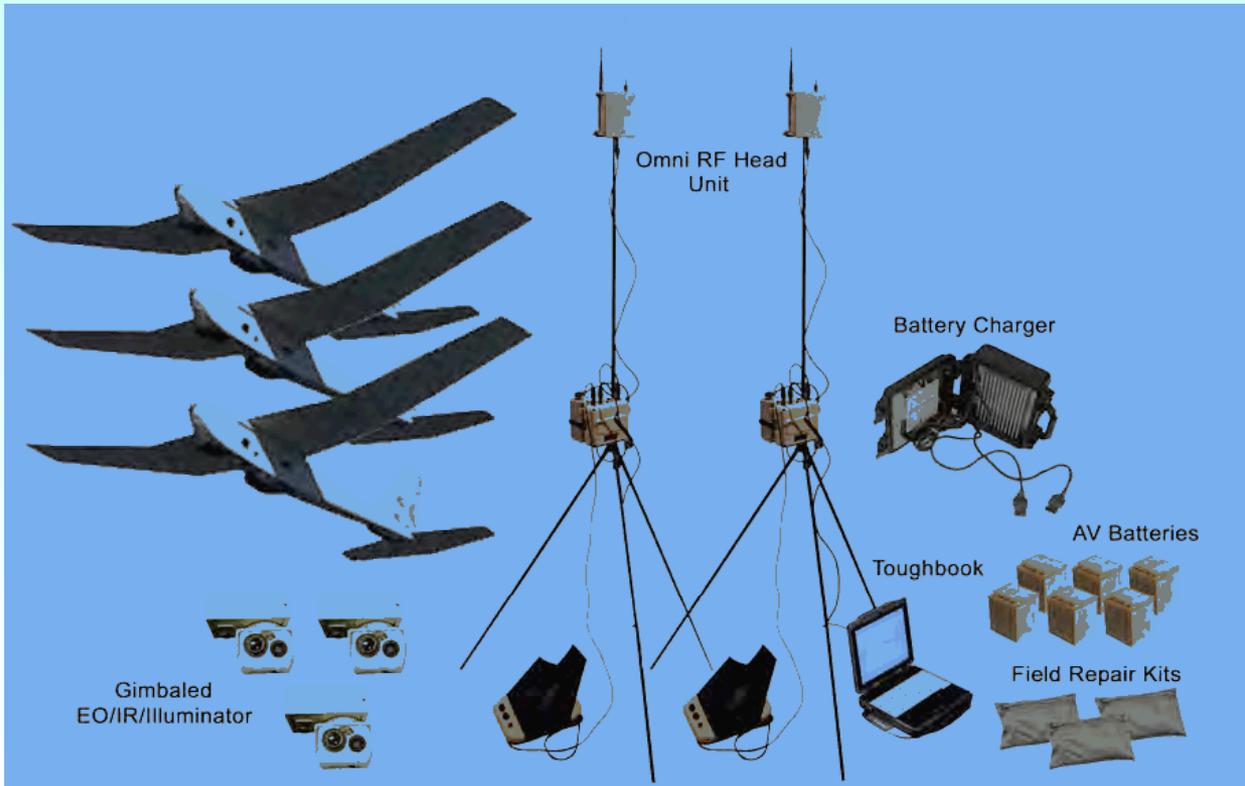


- Very high resolution imaging
- Short duration flights
- Issues with orientation and magnetometers
- No “waterproof” equipment available yet
- Some priced low enough to be “expendable”
- The enabling technology is battery power

AQ1



# PUMA AE System



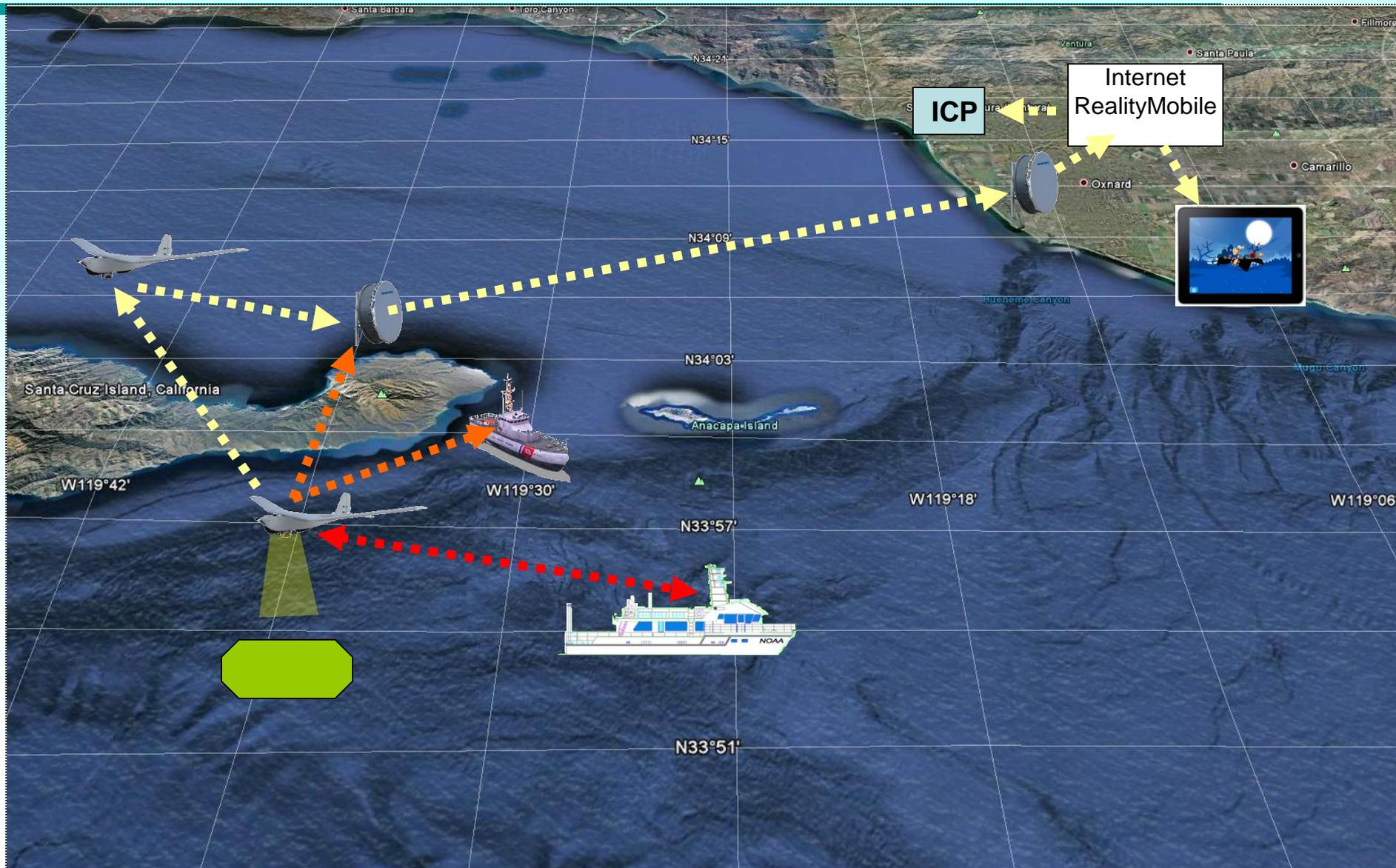
# The “holy grail”: Launching and recovering at sea



# AV GCS/RVT on R/V Shearwater



# Data distribution architecture



# Marine Resource Monitoring



## Blue Whale Tagging Support



# Marine Resource Monitoring



## Living Marine Resource Surveys

### Seabird Surveys



# Marine Resource Monitoring



## Living Marine Resource Surveys

- Pinnipeds



# Marine Resource Monitoring



## Habitat Mapping



# Marine Resource Monitoring



## Enforcement



2012-08-30 07:59:16.00Z  
11S KT 50470 60999  
Alt: 336 ft MSL  
True Heading: 126°



CFOV Heading: 31°  
CFOV Position:  
11S KT 50546 61077  
CFOV Alt: 3 ft MSL

FOV Corner Positions:  
UL: 11S KT 50535 61123  
UR: 11S KT 50606 61098  
LR: 11S KT 50554 61042  
LL: 11S KT 50509 61063

# Simulated seal and turtle



2012-06-20 20:15:55Z  
Lat/Lon: N 21° 39.329' W 158° 10.324'  
Alt: 213 ft MSL  
Mag: 49°



Gimbal  
FOV Data:  
Slant Rng: 99 m  
CFOW Hdg: 326°  
CFOW Lat/Lon: N 21° 39.362' W 158° 10.348'  
Horiz. FOV: 35.2°

ORIGIN Lat/Lon: N 21° 39.957' W 158° 10.519°  
RANGE → RANGE: 0.1 km  
BEARING → BEAR: 121°  
WIND SPEED: 16.5 kts  
WIND DIR: 84°

# Hawaii Marine Debris testing 6/12



2012-06-20 21:06:10Z  
Lat/Lon: N 21° 39.092' W 158° 10.676'  
Alt: 344 ft MSL  
Mag: 36°



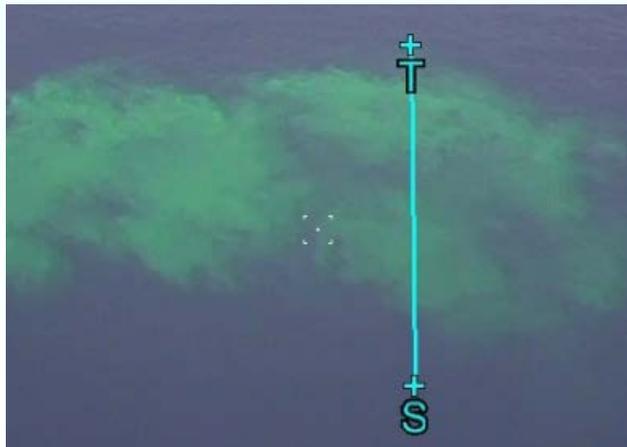
Gimbal  
FOV Data:  
Slant Rng: 184 m  
CFOV Hdg: 339°  
CFOV Lat/Lon: N 21° 39.203' W 158° 10.720'  
Horiz. FOV: 6.3°

ORIGIN Lat/Lon: N 21° 39.386' W 158° 10.509'  
RANGE -> HOME: 0.1 km  
BEARING -> HOME: 176°  
WIND SPEED: 00.0 kts  
WIND DIR: 68°

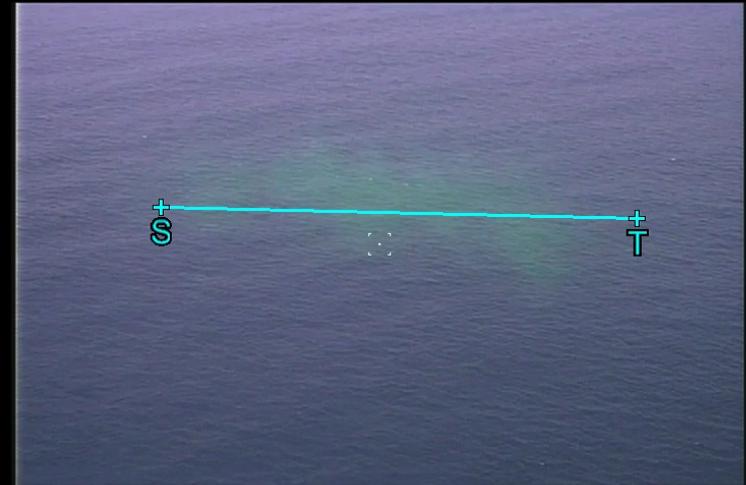
# Emergency Response & Oil Spill Simulation



Coast Guard UAS partnership study of oil spill monitoring in Santa Barbara channel



Lat/Lon: N 33° 48' 31.53" W 119° 46' 18.60"  
Alt: 351 ft MSL  
Mag: 39°

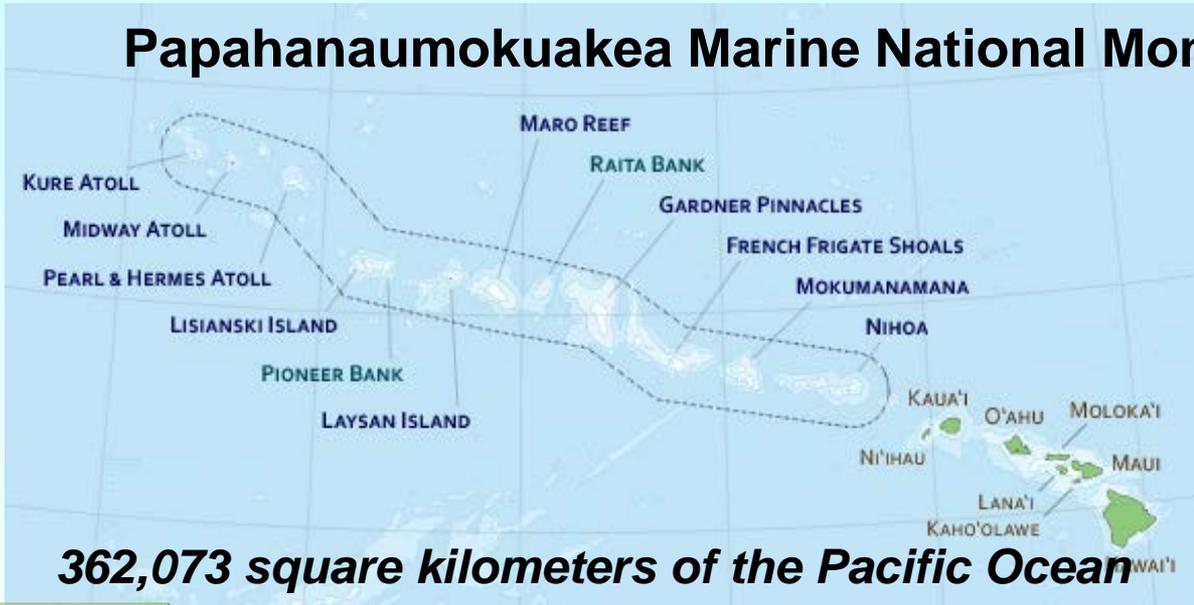


Gimbal  
FOV Data:  
Slant Rng: 259 m  
CFOV Hdg: 320°  
CFOV Lat/Lon: N 33° 48' 37.61" W 119° 46' 23.82"  
Horiz. FOV: 29.6°  
  
Targeting Data:  
Target S Lat/Lon: N 33° 48' 36.66" W 119° 46' 26.12"  
Target T Lat/Lon: N 33° 48' 39.29" W 119° 46' 23.45"  
ADD 94 m RIGHT 48 m  
Range: 106 m Mag Bearing: 27°

# Hawaii Activities



## Papahānaumokuākea Marine National Monument



*362,073 square kilometers of the Pacific Ocean*



# Puma Vessel Operations



# Trig Island, Puma Flight 14-006

## 19 June 2014, 1102L



2014\_06\_19\_21\_02\_39\_3QUG73564056  
-File Size: 1.74 MB (1,828,802 bytes)  
-Dimensions: 2592 x 1944 Pixels  
-Resolution: 96 x 96 dpi  
-Bit Depth: 24 (16777216 colors – 256 each RGB)

### Unofficial Species Counts

Monk Seals: about 20

Mother-Pup Pairs: about 6

Turtles on Beach: about 200

Turtles in Water: about 40

Birds: about 200

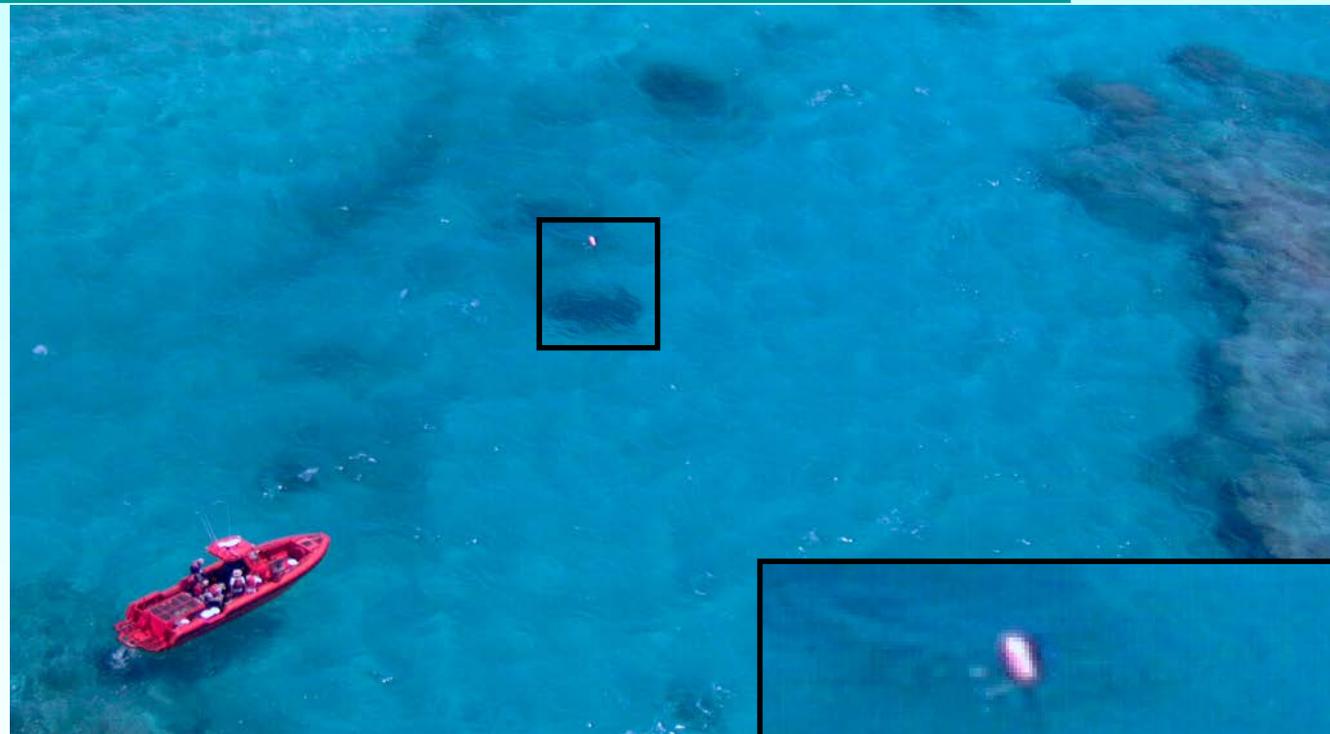
\* Derived from multiple images  
and video

# Trig Island, Puma Flight 14-006 19 June 2014, 1110L



Flight 14-006, 19 Jun 2014, 1110L  
Image 2014\_06\_19\_21\_10\_58\_3QUG73594061  
Left half of image

# Trig Island, Puma Flight 14-006 19 June 2014, 1148L



Flight 14-006, 19 Jun 2014, 1148L

Image 2014\_06\_19\_21\_48\_42\_3QUG72424081

Float in center of image

# Best Image of a Mother-Pup Monk Seal Pair



Flight 14-006, 19 Jun 2014, 1108L  
Image 2014\_06\_19\_21\_10\_58\_3QUG73594061  
Closest edge of image

# Turtle Counts, Morphology, Activity



Flight 14-006, 19 Jun 2014, 1108L

Image

2014\_06\_19\_21\_08\_47\_3QUG7349406

8

Edges, lower half of image



# Tern Island Birds and Vegetation



Flight 14-006, 19 Jun 2014, 1206L

Image 2014\_06\_20\_04\_05\_58\_3QUG69674057

Left edge of image

# EO to IR Comparison



2014-06-20\_04-40-01.00Z  
03Q UG 68978 40306  
Alt: 265 ft MSL  
True Heading: 83°



CFOV Heading: 46°  
CFOV Position:  
03Q UG 69204 40447  
CFOV Alt: 0 ft MSL

FOV Corner Positions:  
UL: 03Q UG 69211 4055  
UR: 03Q UG 69408 4048

Flight 14-008, 19 Jun 2014, 1840L  
Image

2014\_06\_20\_04\_05\_58\_3QUG69674057  
Entire image



Flight 14-008, 19 Jun 2014, 1840L  
Image 2014\_06\_20\_04\_05\_58\_3QUG69674057  
Entire image

# Launch and recovery at sea



# Arctic Support





# Operation Arctic Shield 2013 & 2014



# NOAA USCG Healy Deployment, Operational and Scientific Goals



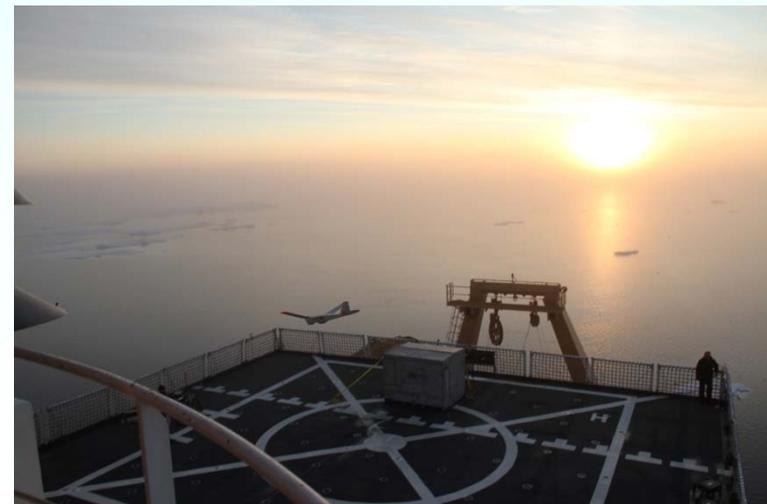
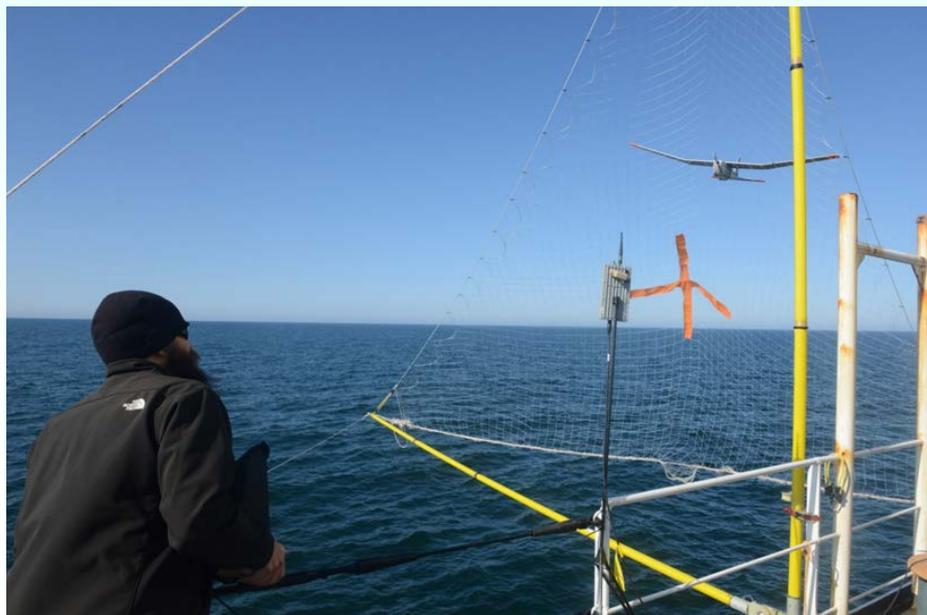
- ✓ **Conduct Puma AE "due regard" operations from USCG (Icebreaker) Healy**
  - ✓ Water and Ice Landings
  - ✓ Deck Landing
  - ✓ Net Capture System
  
- ✓ **Conduct Intelligence, Surveillance, and Reconnaissance (ISR) Operations Stream Full Motion Video (FMV), EO and IR from Puma AE for**
  - ✓ Detection and monitoring of oil spilled from ship or oil exploration
  - ✓ Detection and monitoring of marine debris from ship
  - ✓ Sea ice ridge detection/monitoring
  - ✓ Usefulness in search and rescue (emergency response) scenarios
  - ✓ Marine and marine mammal monitoring (opportunistically)
  - ✓ Producing a Digital Elevation Map (DEM) of ice ridge and surrounding area
  - Preparation for future boundary layer research from sUAS
  
- ✓ **Utilize the Environmental Response Management Application (ERMA)**
  
- ✓ **Coordinate with ONR Marginal Ice Zone Experiment (MIZOPEX) FY14**
  
- ✓ **Coordinate with the UAF for ScanEagle flight operations coordination and data exchange**
  
- ✓ **Coordinate with the NOAA NMFS Manned Marine Mammal Survey Flights**



# Puma “Due Regard” Ops & Recovery Testing



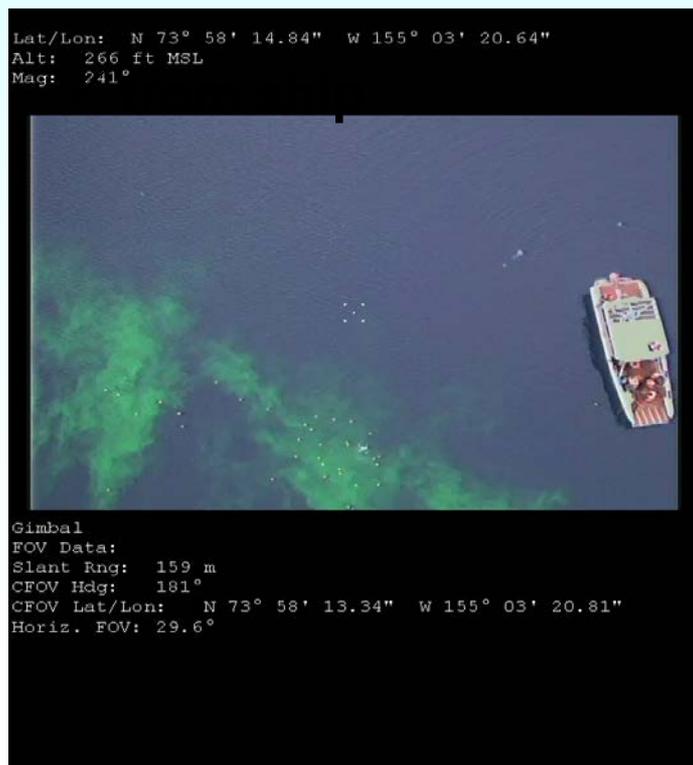
- ✓ Due Regard Operations
- ✓ Water and Ice Landings
  - ✓ Deck Landing
  - ✓ Net Capture System



# ISR Missions including Oil Spill & SAR



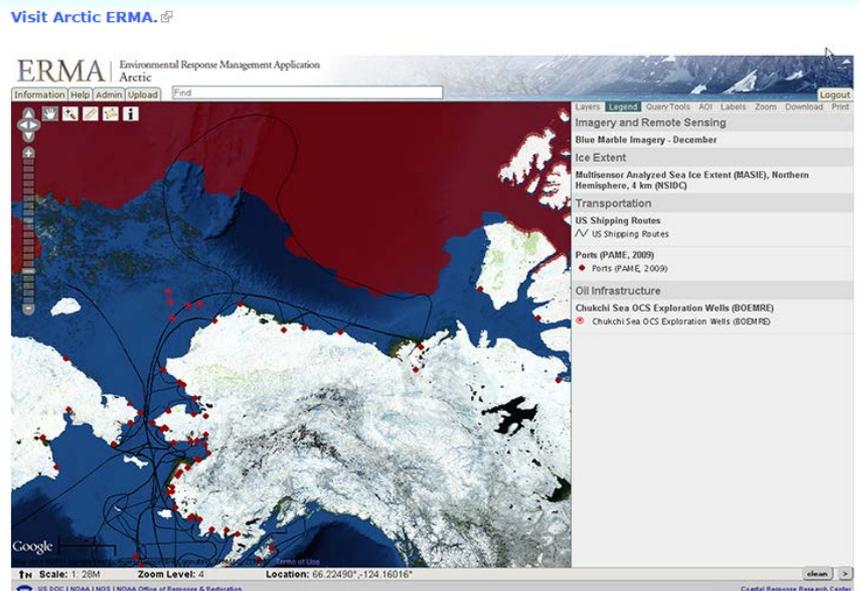
- ✓ Sea ice ridge detection/monitoring
- ✓ Usefulness in search and rescue scenarios
- ✓ Detection and monitoring of oil spilled from ship
- ✓ Detection and monitoring of marine debris



# ERMA Coordination



- ERMA® is an online mapping tool that integrates both static and real-time data, such as Environmental Sensitivity Index (ESI) maps, ship locations, weather, and ocean currents, in a centralized, easy-to-use format for environmental responders and decision makers. ERMA enables a user to quickly and securely upload, manipulate, export, and display spatial data in a Geographic Information System (GIS) map.
- Second year participations through the UAS Program.
- Software demonstration/ test with 2d3



## Software and Datasets

- [ADIOS](#), oil weathering model.
- [ERMA®](#), online mapping tool for environmental response data, adapted to a variety of regions.
- [GNOME](#), oil spill trajectory model.
- [GOODS](#), a tool that helps GNOME users access base maps, ocean currents, and winds.
- [NUCOS](#), a unit converter that includes units unique to oil spill response.
- [Spill Tools](#), a set of three programs: the Mechanical Equipment Calculator, the In Situ Burn Calculator, and the Dispersant Mission Planner.
- [Trajectory Analysis Planner](#), oil spill contingency planning software.
- [Environmental Sensitivity Index \(ESI\) maps and data](#), concise summaries of coastal resources that may be at risk in a spill incident.

# Arctic Shield Take Aways & Operational Assessment



- Arctic is a Challenging Environment
  - Platform flight envelope must be expanded
  - Platform recovery process and sensors must continue to be improved
  - “Due Regard” operations must be expanded
- Partnerships are crucial (Maritime Strategy)
  - People, property and platforms (data captured) are valuable
  - Must maximize operations and data sharing opportunities



# Where the Puma excels



**Puma is a great system. Important attributes for NOAA's work include:**

- **Durability:** Puma is tough and not overly complicated to repair and maintain. It takes a fair amount of abuse
- **Adaptability:** Puma's ability to be operated in all environments (as long as it isn't too rainy or windy...)
- **Transportability** and ability to be carried aboard, without modifications to the vessels
- Airworthiness documentation
- Spares and support
- Great support from AeroVironment

# sUAS requirements for NOAA's maritime and Arctic use

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- High resolution optical and infrared imagery
- Additional payloads:
  - Nadir mapping cameras
  - LiDAR
  - Multispectral
- Simple, non-proprietary interfaces to quickly ingest data into GIS systems
- Ability to tap into high resolution data stream with metadata in real-time and relay data to incident command centers via ship's satellite communication systems (Google Loon?)
- Ability to launch and recover aboard ship
- Ability to operate in up to 35 knots of wind
- Heated pitot tube
- Ability to sense icing or to de-ice the wings and control surfaces

# The future looks bright



- Routine VLOS operations in the NAS under new FAA rules
- More equipment and sensor offerings from industry
- BVLOS operation in the **Arctic** and remote oceanic areas for agencies
- Emergency operations
- Enforcement
- Ghost Nets and other unique missions...

