



NOAA's Marine and Arctic Monitoring UAS strategies

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NOAA UAS Program

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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

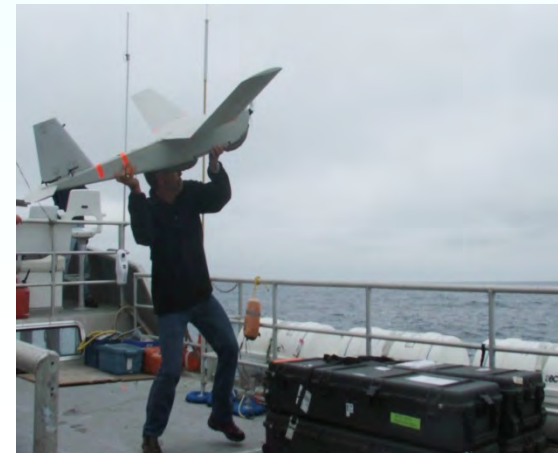




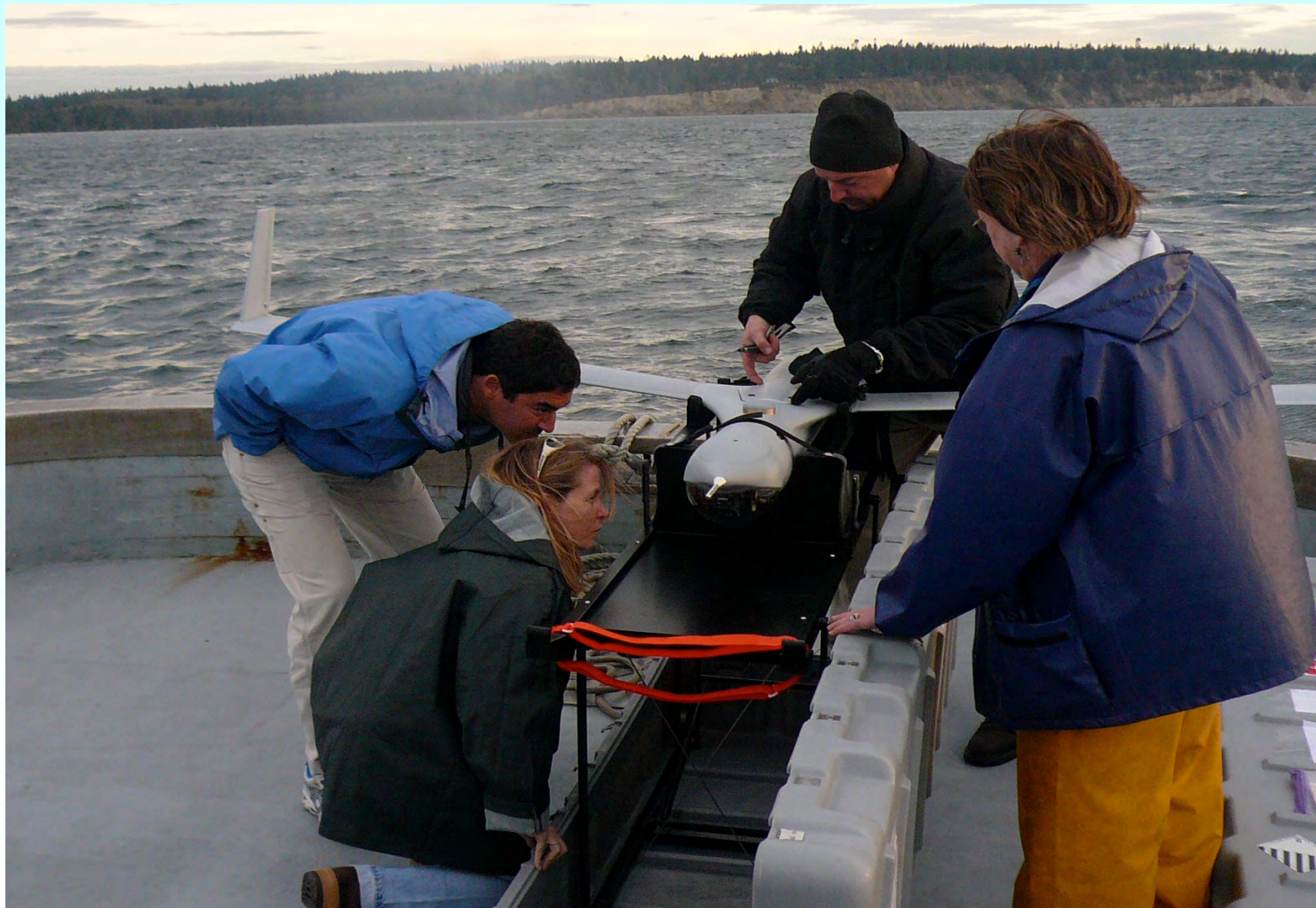
NOAA sUAS history



- 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

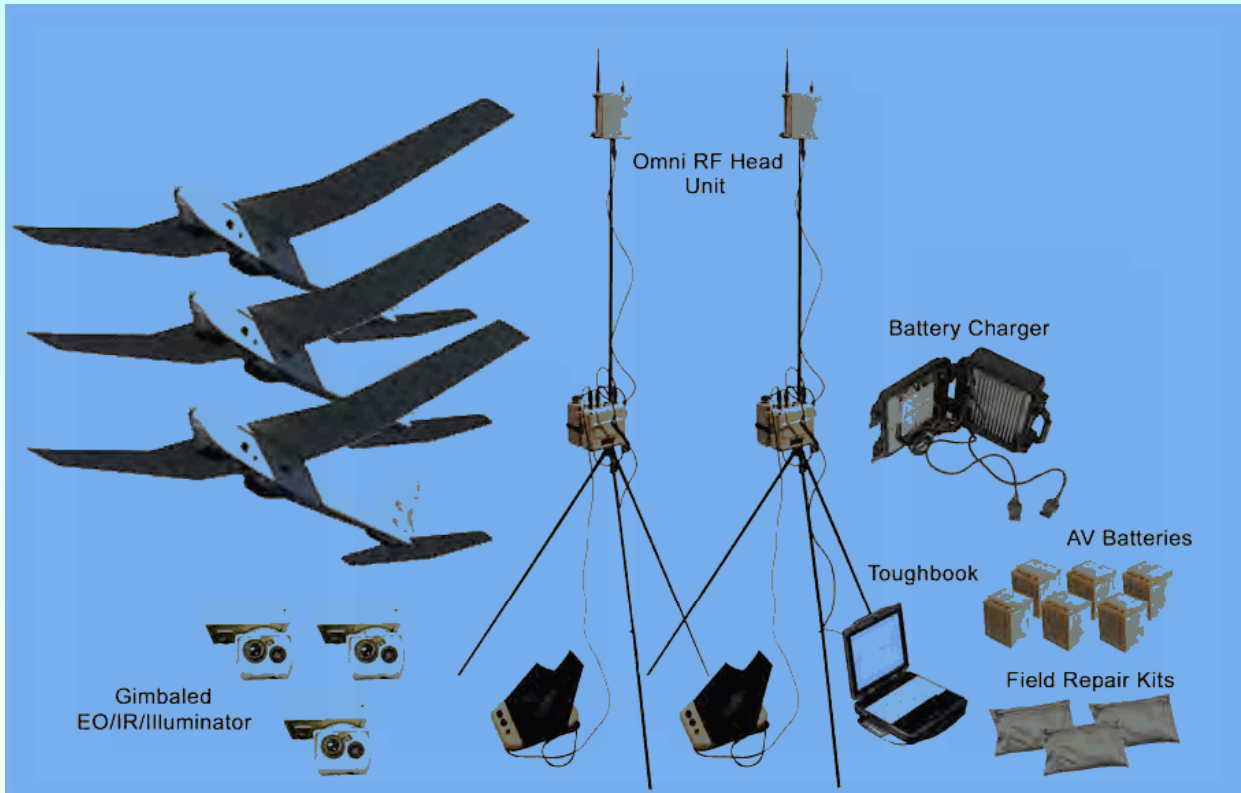


- Very high resolution imaging
- Short duration flights
- Issues with orientation and magnetometers
- No “waterproof” equipment available yet
- Some priced low enough to be “expendable”
- The enabling technology is battery power

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

The complex block contains a timestamp and flight data at the top. Below this is an aerial photograph showing a white boat on the surface and a small, dark, rectangular object (likely a submersible or ROV) in the water below. At the bottom of the block, there is additional flight data, including CFOV heading and position, and FOV corner positions.

Simulated seal and turtle



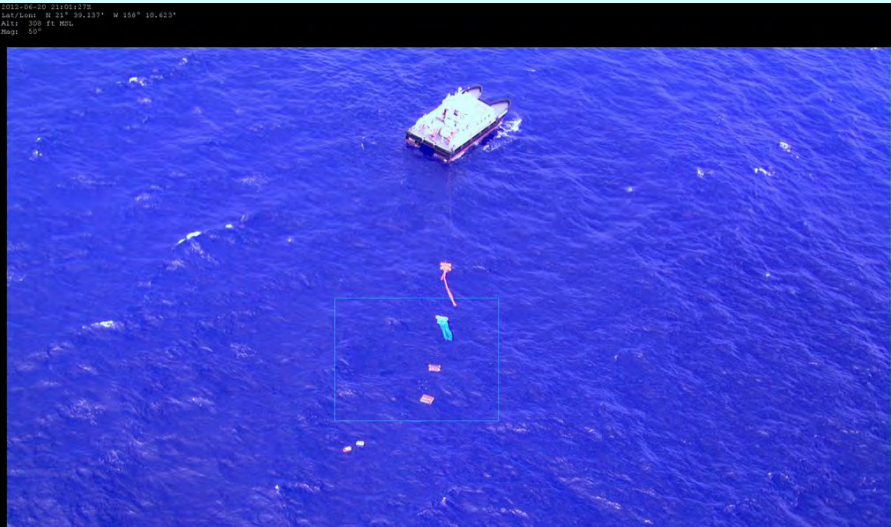
2012-06-20 20:15:55Z
Lat/Lon: N 21° 39.329' W 158° 10.324'
Alt: 213 ft MSL
Mag: 49°



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

ORIGIN Lat/Lon: N 21° 38.957' W 158° 10.518'
RANGE → HOME: 0.1 km
BEARING → HOME: 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°

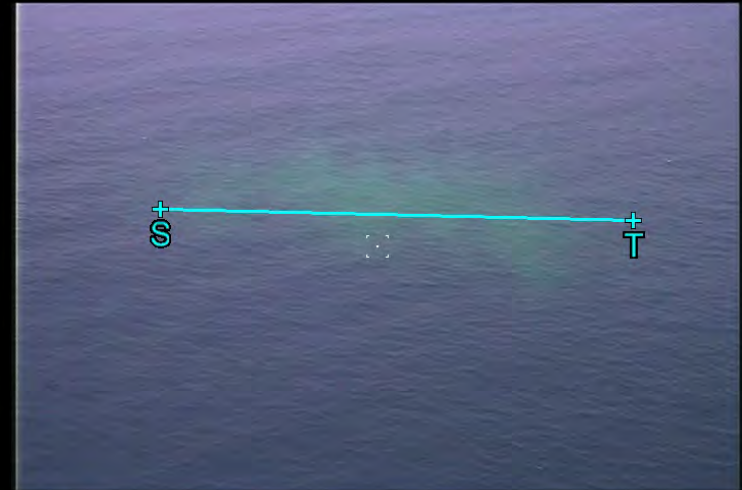
Emergency Response & Oil Spill Simulation



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°



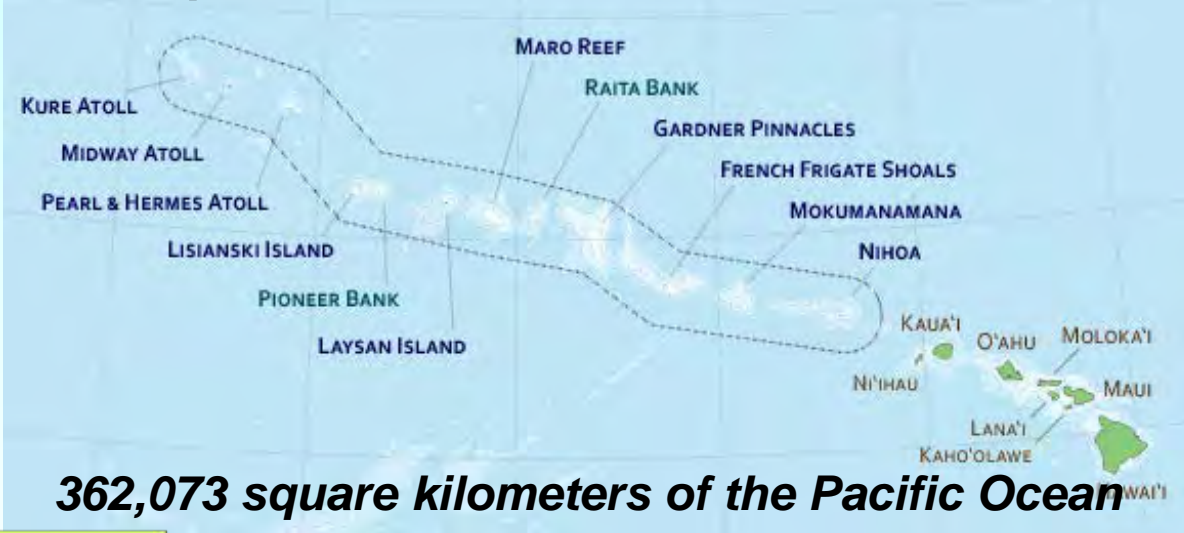
Gimbal
FOV Data:
Slant Rng: 259 m
CFOV Hdg: 320°
CFOV Lat/Lon: N 33° 48' 37.61" W 119° 46' 23.82"
Horiz. FOV: 29.6°

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°

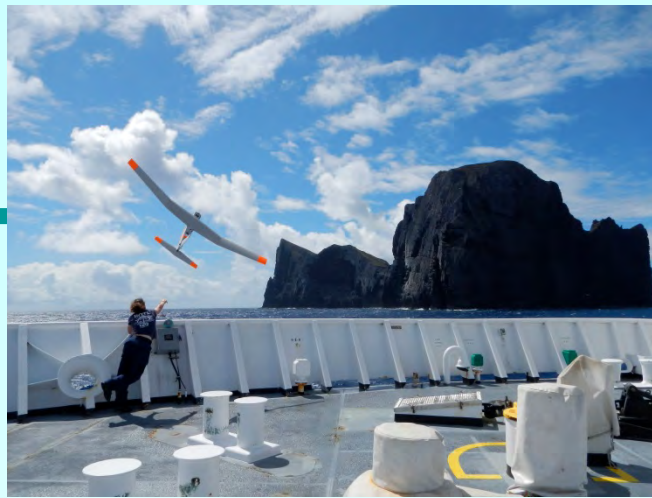
Hawaii Activities



Papahānaumokuākea Marine National Monument



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

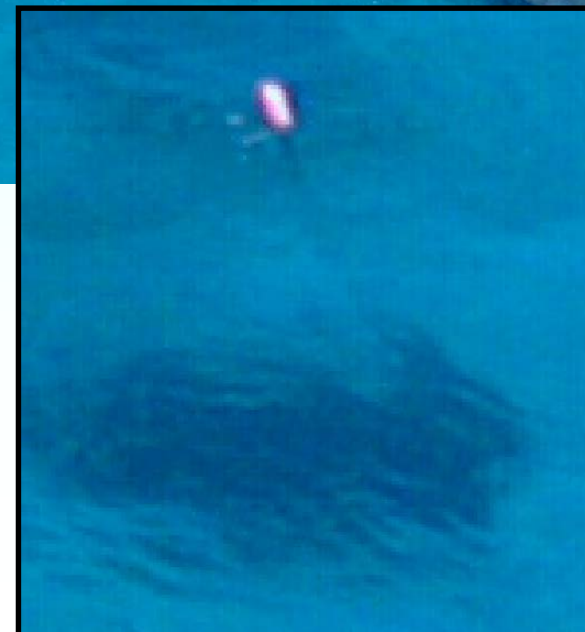
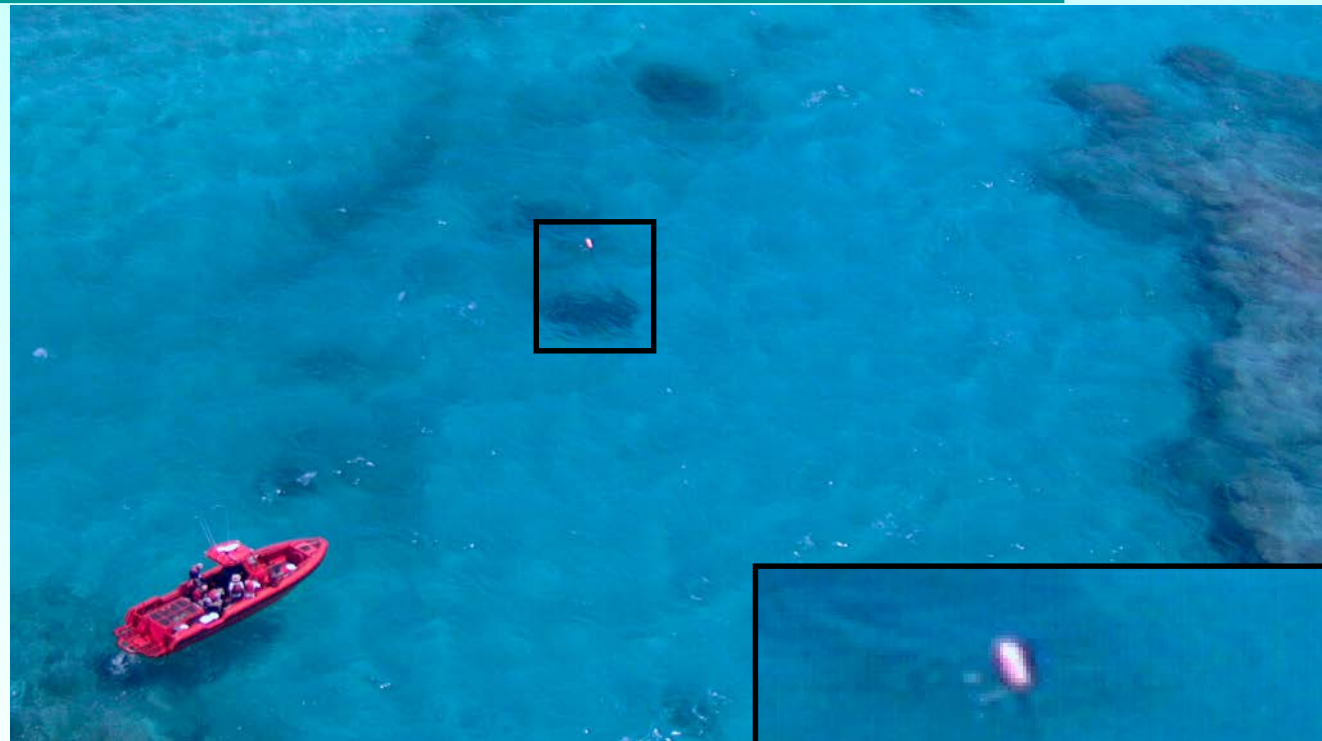
* Derived from multiple images
and video

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°

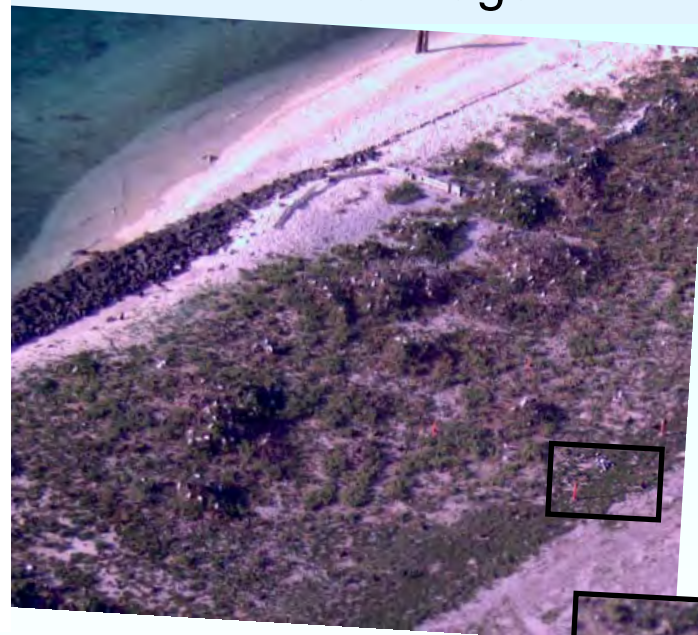


CFOV Heading: 46°
CFOV Position:
03Q UG 69204 40447
CFOV Alt: 0 ft MSL

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

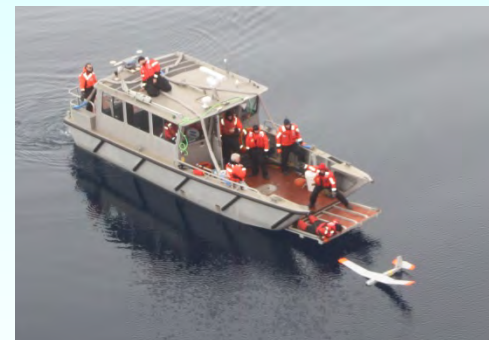
- ✓ **Conduct Intelligence, Surveillance, and Reconnaissance (ISR) Operations Stream Full Motion Video (FMV), EO and IR from Puma AE for**
 - ✓ Detection and monitoring of oil spilled from ship or oil exploration
 - ✓ Detection and monitoring of marine debris from ship
 - ✓ Sea ice ridge detection/monitoring
 - ✓ 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**

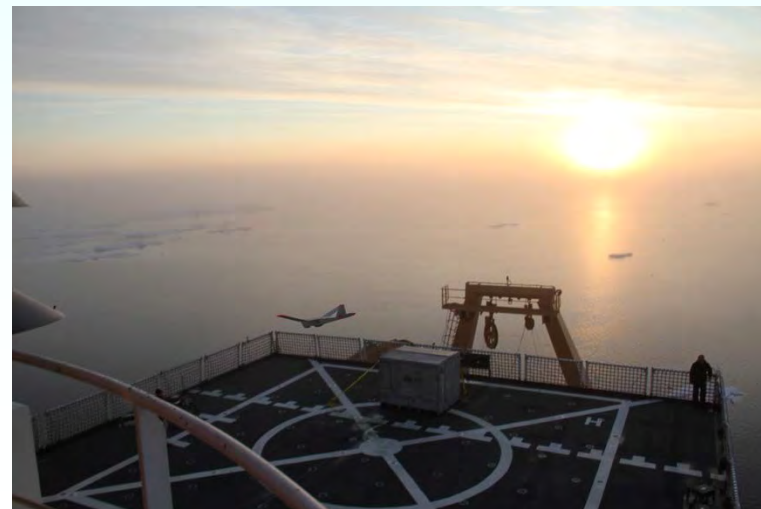
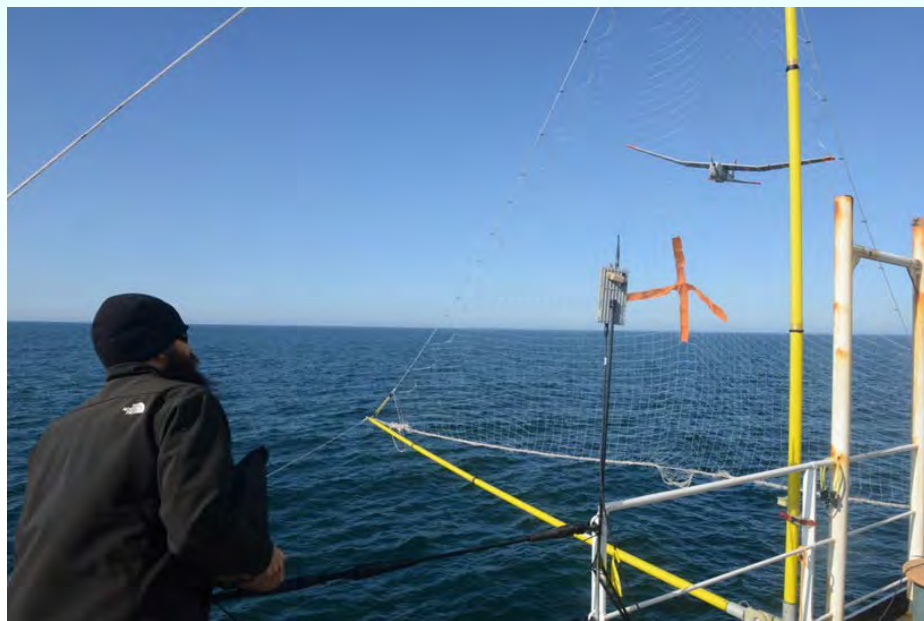
- ✓ **Coordinate with the NOAA NMFS Manned Marine Mammal Survey Flights**



Puma “Due Regard” Ops & Recovery Testing



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



ISR Missions including Oil Spill & SAR



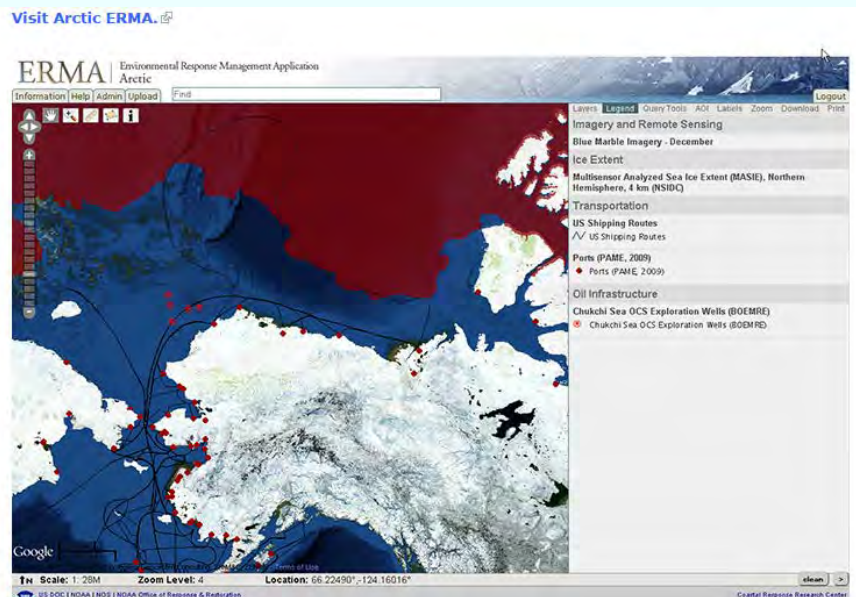
- ✓ Sea ice ridge detection/monitoring
- ✓ Usefulness in search and rescue scenarios
- ✓ Detection and monitoring of oil spilled from ship
- ✓ Detection and monitoring of marine debris



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



- 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...

