Summary of Final Report

UAS Survey of Marine Debris Generated by 2011 Japanese Tsunami
Japan Tsunami Marine Debris – Early Debris

Tsunami – March 11, 2011

Debris on March 13 off the Sendai coast
- Patches and fields
- Wood, construction materials abundant
- The debris dispersed, some sunk

Photos: US Navy Pacific Fleet
Japan Tsunami Marine Debris in Satellite Imagery

Right: NESDIS Satellite Analysis Branch map of marine debris locations 3/17/2011
Japanese Floating Dock (70 feet long) on Agate Beach Oregon – June 2012
This map includes all debris reported to NOAA as possible tsunami debris since December 2011. Confirmed sightings (red triangle) indicate objects that were identified and traced back to the tsunami impact area. Potential sightings (yellow circle) indicate objects that may be linked to the tsunami, based on location, type, and markings, but that may not have the unique identifiers necessary, such as a serial number or contact information, to confirm its origin.

Marine debris is an everyday problem, and not all debris found on U.S. shorelines is from Japan. It is important to note that potential sightings may not be from the tsunami impact area, but items lost or abandoned before or after the tsunami from sources around the Pacific Rim. For more information regarding tsunami marine debris from Japan please visit: http://marinedebris.noaa.gov/tsunamidebris
Project Participants

Principal Investigator: William Pichel – NOAA/NESDIS/STAR

Co-Investigators: James Churnside – NOAA/OAR/ESRL
Timothy Veenstra – Airborne Technologies Inc. (ATI)
Peter Murphy – NOAA/NOS/Marine Debris Division
Greg Walker/Marty Rogers – Univ. of Alaska, Fairbanks

Participants: Rosanne Bailey – Univ. of Alaska, Fairbanks
Curt Olson – Airborne Technologies Inc.
Kathe Rich – Univ of Alaska Fairbanks,
  Cooperative Institute for Alaska Research (CIFAR)
Xiaofeng Li – Global Sciences and Technology (GST)
  at NOAA/NESDIS

Key Participant – Todd Jacobs - Channel Islands NMS
Project Goals:
UAS Survey of Marine Debris Generated by 2011 Japanese Tsunami

Science - Search and map location of Japanese tsunami marine debris

Technical:  1) Determine optimum UAS sensor for marine debris,  
2) Determine effective UAS survey protocol  
3) Bring UAS systems to operational status for debris surveys  
4) Validate high-res multi-spectral satellite observations of debris
Mololo (Resolution Prototype) and Resolution Testing

Mololo Sea Trials - 2007

Resolution and Launcher - 2012

Mololo Tests on Oscar Elton Sette - 2008

Resolution Production Airframe Tests - 2012
UAS Characteristics – Puma and Resolution

AeroVironment “Puma” UAS
-- Wingspan = 9.2 ft
-- Weight = 13 lbs
-- Endurance = ~ 2 hr
-- Hand launch
-- Water recovery

Airborne Technologies Inc (ATI)
“Resolution” UAS
-- Wingspan = 7.8 ft
-- Weight = 15 lbs
-- Endurance = ~ 2 hr
-- Catapult launch
-- Water recovery
Phase 1
Detailed Project Definition, UAS Sensor Development, and UAS Demonstration in Hawaii
(May 2012 – December 2012)

Major Activities - Deliverables

- Detailed project definition
- Grant to UAF and subcontract to ATI
- Virtual Sensor Workshop
- Sensor Design Review
- Development of Mission Concept for UAS Marine Debris surveys
- Participation in 2-day Puma demo north of Oahu
- Integration of high-resolution camera into the Resolution-3
Puma UAS and Satellite
Marine Debris Detection Test in Hawaii – June 2012

Upper left – Test debris in water
Upper right – Puma flying from charter vessel
Lower Right – Puma sensor viewing screen
Debris Objects Imaged by Puma in Hawaii Tests – June 2012
Characteristics of Sensor System for Marine Debris Detection

1 camera with 1-2 cm resolution with swath 60-120 m
1-2 cameras with 5 cm resolution with swath 300 m
Detection - ability to detect a buoy 8” in diameter
Discrimination – discriminate between debris object and natural features
Dynamic range – 8 bits per channel
Downlink – downlink output of one camera in near real time
Anomaly detection – detect anomalies on board and send GPS of anomalies to ship
Filter - polarized
Picture of Dock from Samsung Camera - Test of Potential Resolution-3 UAS Camera
Phase 2
Olympic Coast Field Program
(January 2013 – August 2013)

Major Activities and Deliverables

• Ship requests for Fairweather and UxS Days at Sea
• Participation in Todd Jacobs’ Olympic Coast NMS field program
• Approval to fly both Puma and Resolution in Widbey Island Special Use Airspace
• Three marine debris sorties with Puma during one day aboard the R/V Tatoosh offshore of the Olympic Coast NMS
• Two pieces of debris observed
Puma Debris Search Pattern

Puma Search Pattern
Flying from R/V Tatoosh
Top left – Target (possibly kelp) on 6/22 Puma marine debris flight

Bottom right – Tatoosh and buoy from Puma camera on 6/22
Phase 3
Kodiak Island Field Program
(September 2013 – November 2013)

Major Activities and Deliverables

• COAs for both Puma and Resolution
• Successful Resolution Test Flights in Minnesota
• Successful Resolution tests of marinization in Alaska

Note:
• Field program was scrubbed due to weather
• Resolution flights not allowed by AOC due to insufficient Secondary Pilot qualifications
Resolution Test Flight in Preparation for Kodiak Island Field Program
September 7, 2013

Resolution-3 SN 005

Test Flight Pattern

Test Flight Image Locations
Resolution-3 Marinization Tests – September 2013

Catapult Launch

Resolution in Flight

Water Landing

Water Retrieval
Phase 4
Avon Park Demonstration
(December 2013 – June 2014)

Major Activities and Deliverables

• Curt Olson takes flight ground school, passes test, and obtains FAA Second Class Medical Certificate to serve as Resolution Supplemental Pilot
• Approval to use Avon Park facility for test flights
• Demo of Resolution for AOC personnel in Avon Park
• Presentation on Resolution for AOC personnel
• Reports on the demonstration
Avon Park Resolution Demo - June 6, 2014

Lower- Presentation of Resolution aircraft, launcher, and safety characteristics
Upper left – launch
Upper right – Resolution in flight
Avon Park Targets Imaged by Resolution Camera

Resolution Camera
From 300-400 feet

Hand Held Camera
From ground.

PVC Pipe – 1 foot long

½ inch chain
Phase 5
Channel Islands Field Program
(July 2014 – December 2014)

Major Activities and Deliverables

- FAA COA for Resolution
- Flight Readiness Review
- One day Cruise on Channel Islands NMS vessel
  - R/V Shearwater
- FAA Incident Report
- Field program reports
Upper Left – Launch of Resolution
Upper Right – Resolution in Flight
Lower Left – Post-Mission Discussion
Phase 6
Final Report Preparation
(January 2015 – March 2015)

Major Activities and Deliverables

• Final Project Report
• Post-Mission Review
• Project Spending Report
Accomplishments

We view the major accomplishments of this project to be:

(1) Definition of characteristics for consideration for a ship-launched UAS aircraft and camera system to be used for marine debris detection

(2) Development of a Concept of Operations for ship-launched UAS marine debris surveys

(3) Development and testing of a high-resolution camera system for small UAS suited for marine debris surveys.

(4) Development of software for mosaicking UAS camera imagery into a fully georeferenced mosaic image.

(5) Evaluation of the AeroVironment Puma as a platform for marine debris detection operations

(6) Partial evaluation of the ATI Resolution-3 as a platform for marine debris detection operations
UAS Technology Readiness Level for Marine Debris Surveys

TRL Change During the Project:

(1) Puma:

Start: 8
End: 9 for debris detection (needs higher resolution camera for debris identification)

(2) Resolution:

Start: 7
End: Ready for 8, but not there yet (needs reliability testing and at-sea testing) Has capability for both detection and identification.
Challenges

Impacting Science Objectives:

1. Lack of a dedicated survey platform
2. Dispersal of Japanese tsunami marine debris

Impacting Technology Objectives:

3. Puma camera development difficulties
4. Resolution-3 failures
5. Evolving FAA and NOAA UAS requirements
Recommendations

(1) Puma UAS –
   - Develop and test a higher-resolution camera
   - Improve software to make anomaly detection and post-mission analysis more efficient and easy to accomplish.
   - Work toward training operators on marine debris surveys and deployment on NOAA vessels

(2) Resolution UAS –
   - Conduct more extensive flight testing to assess system reliability
   - Perform sea trial to confirm the ship-centric flight capability
   - Complete and test the on-board anomaly detection system
   - Perform a full-up at-sea marine debris detection survey over a period of days

(3) Marine Debris Detection and Retrieval System –
   - When systems are ready and opportunity arises, test end-to-end marine debris detection and retrieval system to be prepared for major marine debris event such as tsunami or hurricane
GhostNet Operational Concept
Operational At-Sea Marine Debris Detection and Removal