Operation Deep Freeze 2016

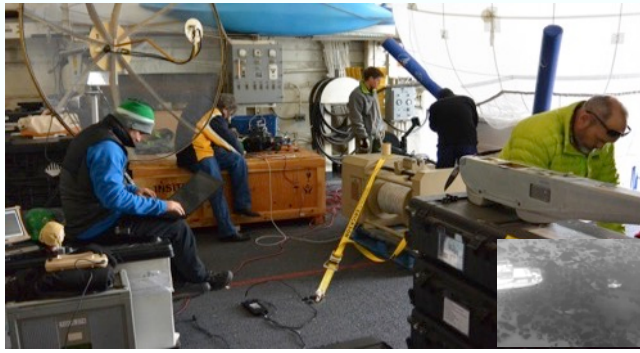
- NOAA and USCG
- Annual resupply mission to US National Science Foundation's McMurdo base in Antarctica
- Coordination between National Science Foundation, Department of Defense and US Coast Guard
- Physical and environmental challenges:
- Interesting/impressive statistics:
- Administrative and regulatory challenges: number of organizations involved in planning, review and execution of UAS operations

Antarctica

Background: Arctic Support 2013 - 2015

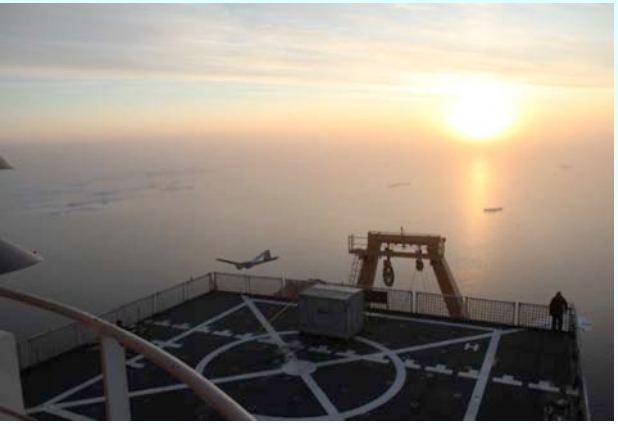
Arctic Shield 2015 Milestones

- Autonomous net recovery on helicopter deck
- BVLOS (5nm) operations by exercising “Due Regard”
- Real-time operations coordinated with two manned helicopters
- Long range communications for C2
- Ice-sensing and de-icing system
- Real-time data transmission to the Internet
- Success led to AV and NOAA supporting ODF-16 to Antarctica



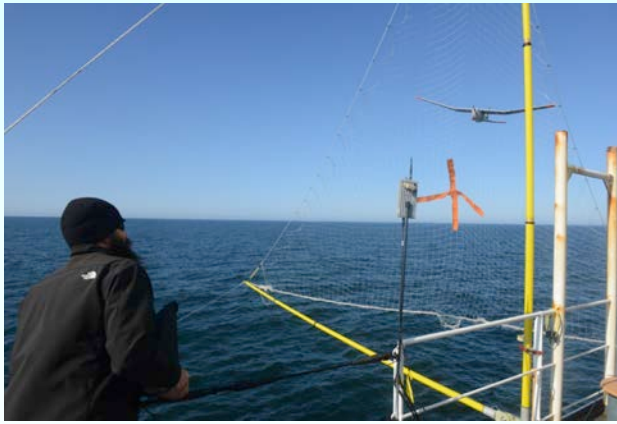
Puma “Due Regard” Ops & Recovery Testing

Due Regard Operations



Deck Landing

Water and Ice Landings



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 from ship

November 2015: Long Range Telemetry & Autonomous net capture testing

Testing aboard NOAA R/V Shearwater in the Santa Barbara Channel:

- Sea state 3
- 90+% Success Rate
- All Puma captures ended up in boat without significant damage to airframe or wings.
- This evolved from AS15 and set the stage for ODF-16.

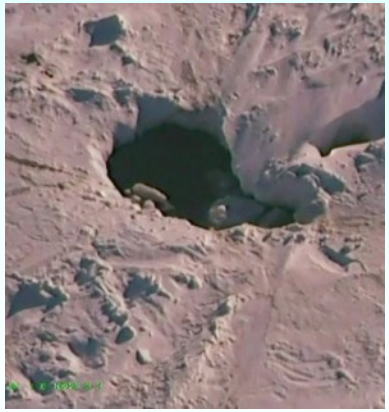
Operation Deep Freeze Background

- NOAA and USCG
- Annual resupply mission to US NSF McMurdo base
- Coordination: NSF, DoD, USCG
- Physical and environmental challenges
- Administrative and regulatory challenges

Deep Freeze Mission Objectives

- Forward scouting for icebreaking
- Collect ice data (images) to validate satellite-based forecasts
- Continue development of shipboard TTPs for small UAS operations in Antarctic and Arctic environments
- Demonstrate effective deployment of small UAS in extreme maritime operations
- Test new Puma UAS i45 camera payload and autonomous net capture system






Deep Freeze Operational Challenges

- Regulatory and administrative
- Environmental
- Ship Design
- Communications




Deep Freeze Operations

Deep Freeze Achievements

- 20 flights, including
  46 kilometer flight (BVLOS)
  - “12”hours of video
  - i45 high resolution nadir images
- Autonomous shipboard landings
- Concepts of operation developed and tested
- Performed missions in conditions in which helicopters could not operate

Key Requirements for Future Small UAS Operations

- General maritime operations
  - Pre-programmed operations with autonomous capabilities for data gathering and recovery
  - High wind capability (greater than 25 kts)
  - Safety and reliability
  - Range (BVLOS to 40+ kilometers)
  - Nadir mapping capability
  - Mode C or ADS-B transponder
- Polar maritime operations – most extreme conditions
  - Ice sensing and/or de-icing capability
  - Produce images and data of sufficient quality to support mapping

The Future of Maritime Small UAS in Polar Environments

- Routine BVLOS operations
- Improved safety
- Lower cost and lower risk solution than manned aircraft
- Regular, coordinated flight operations integrated with other air traffic
- Complemented by improved bandwidth & ability to transmit real-time data to decision makers