Scientific Committee on Oceanographic Aircraft Research (SCOAR)

Sept. 12, 13, 2019, Northeastern University, Boston, MA.

USCG Aircraft Operations Report Aug. 2018-2019

P. McGillivary, USCG PACAREA & Icebreaker Science Liaison, pmcgillivary@gmail.com

Photos: Aug. 2019

Above: HEALY transiting Alaska to Chukchi Sea

Left: Helicopter support for HEALY.

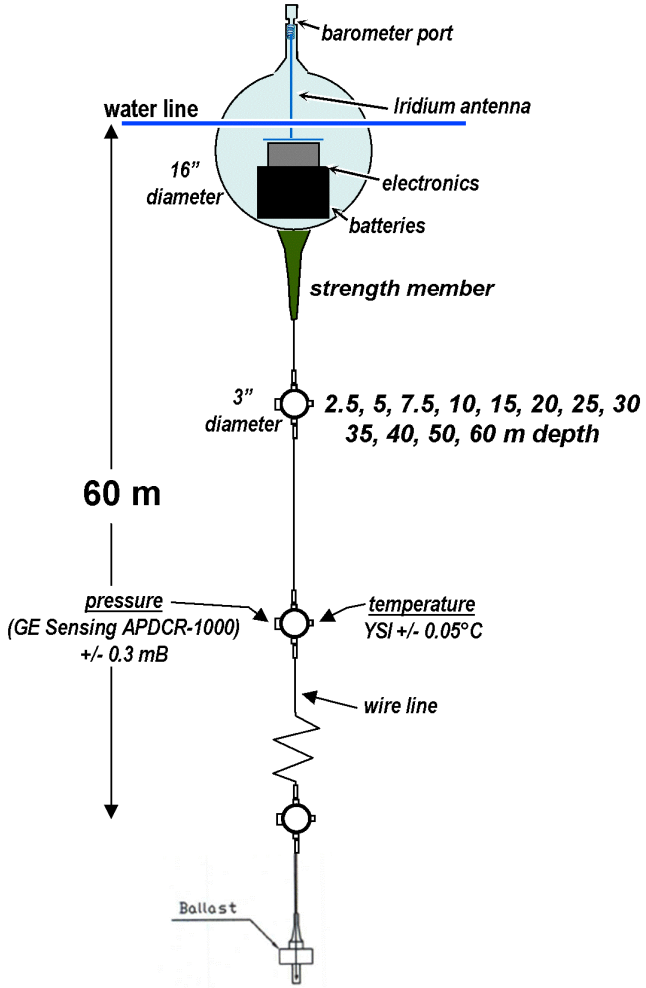
Right: C130 engine part air-drop to HEALY.

Navy/ONR C130-H & J flights (Aug.2018-Oct.2019)

- PI: Jamie Morison, UW
- Last C130-H flight: June 2019
- Completed ACCB (Aircraft Configuration Control Board) to adapt systems to C130-J, principal change being installation of a GPS repeater to provide GPS data to UW systems
- Continued flights on C130-J in July & Aug. 2019 with good results: C130-J “faster, better range, less electrical noise in system”.
- “Antenna connections for AXCTD, AXCP and Dropsonde receivers a big improvement over C130-H, esp. w AXCP “most noise-free velocity measurements we have seen.”

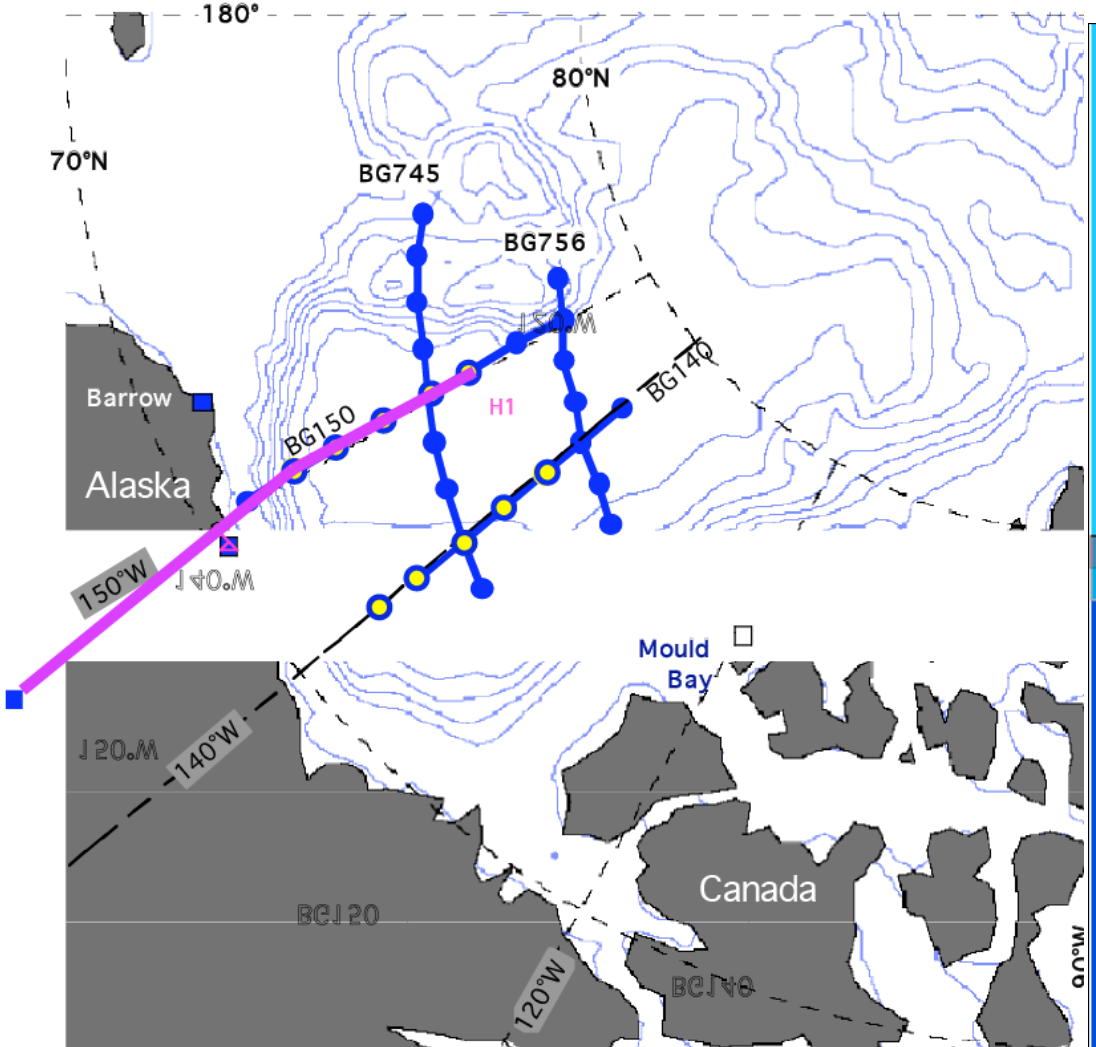
Navy/ONR C130-H & J flights (Aug.2018-Oct.2019)

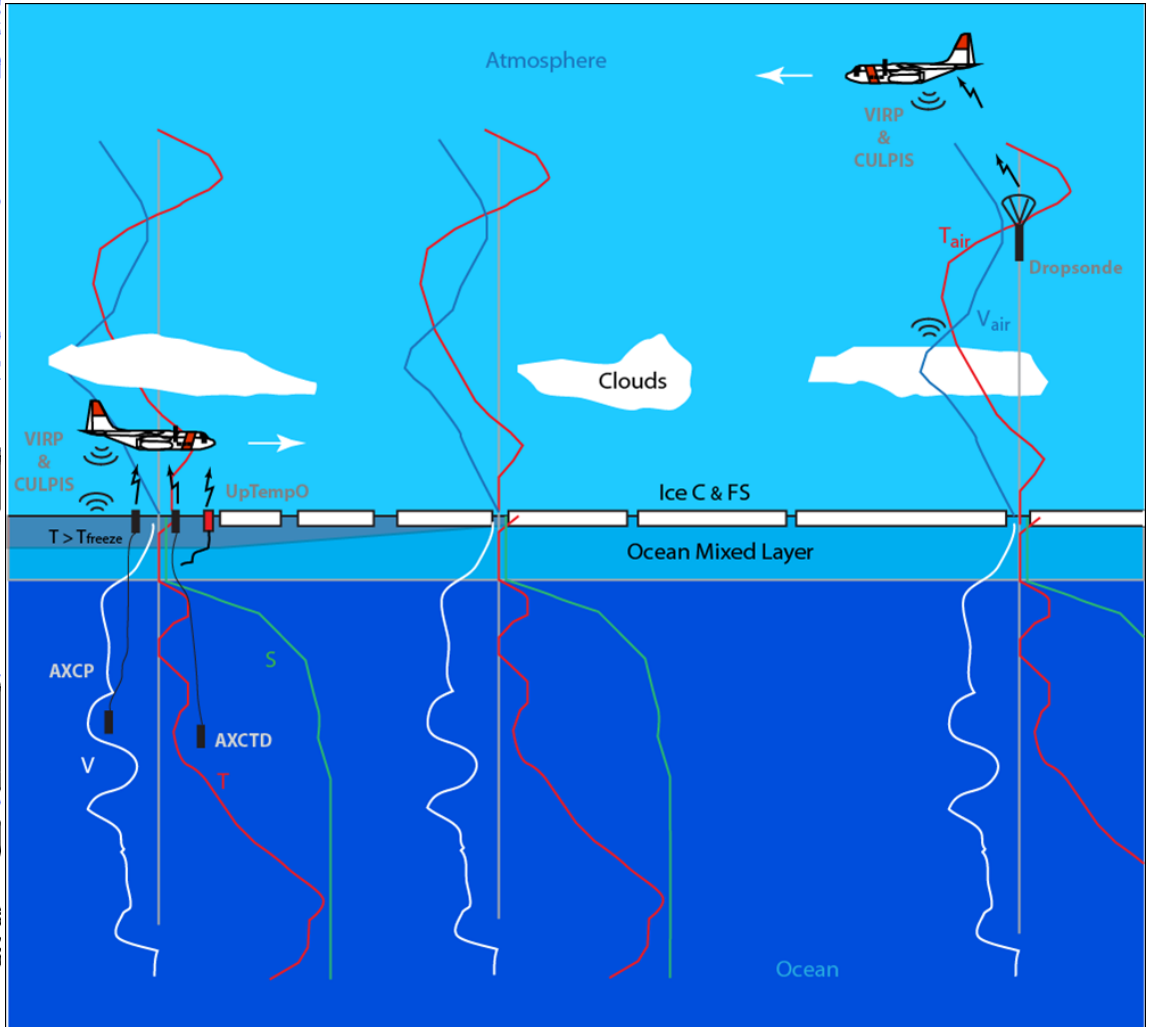
- Running line of 5 AXCTD & AXCP stations from 72°-76°N along 150°W
- Return along same line and do Dropsonde launches from 10,000’
- Also deployed Mike Steele’s (UW) UpTempO buoy at 72°N, 150°W on July & August flights (see: http://psc.apl.washington.edu/UpTempO/)
- Will also conduct two more flights this year, one mid-September, one mid-October



UpTempO buoy design

ONR SIZRS Program CG C130 Ops update
(P.I.: Jamie Morison, UW APL)
Left: map showing 150°W regular transect line (pink)
Right: typical aircraft AXCTD, AXCP and dropsonde deployments

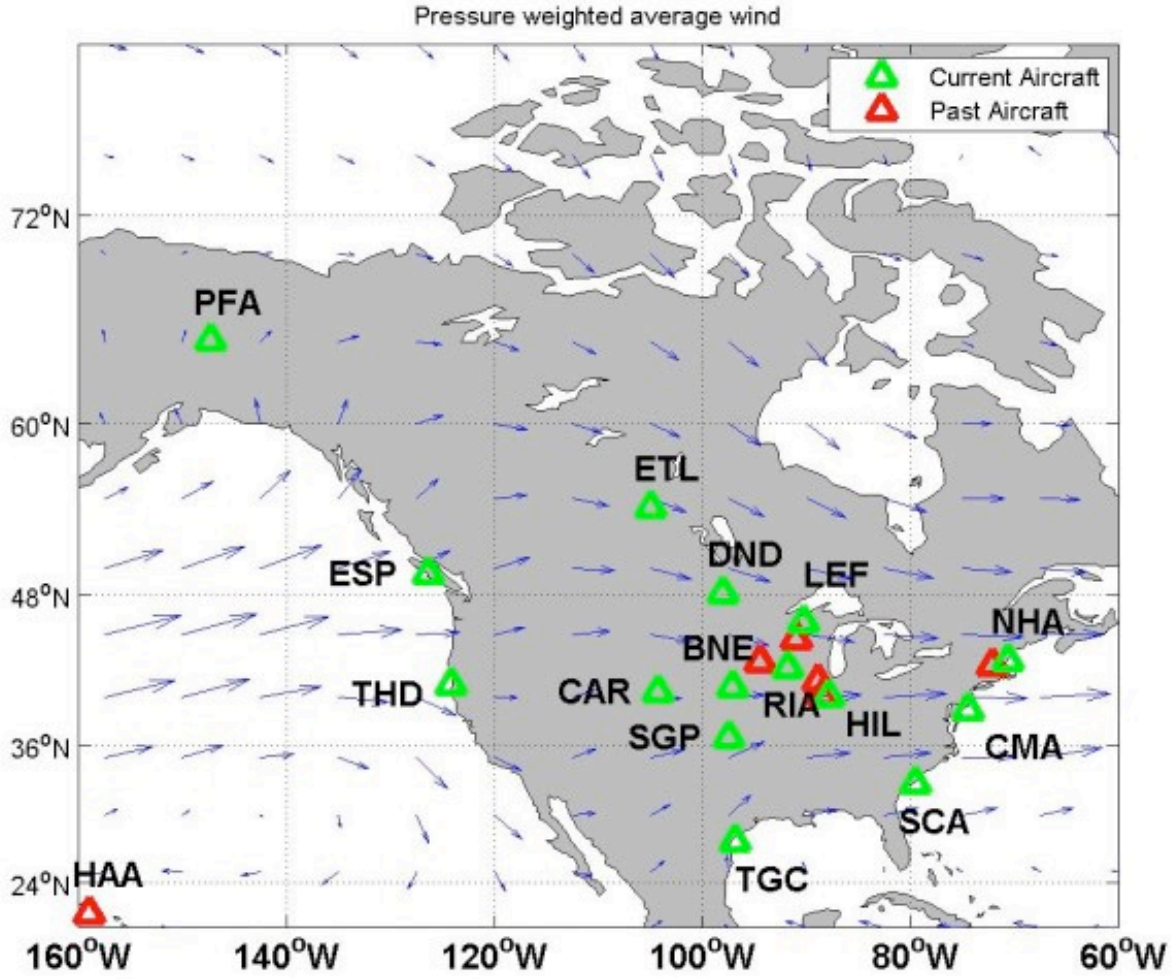


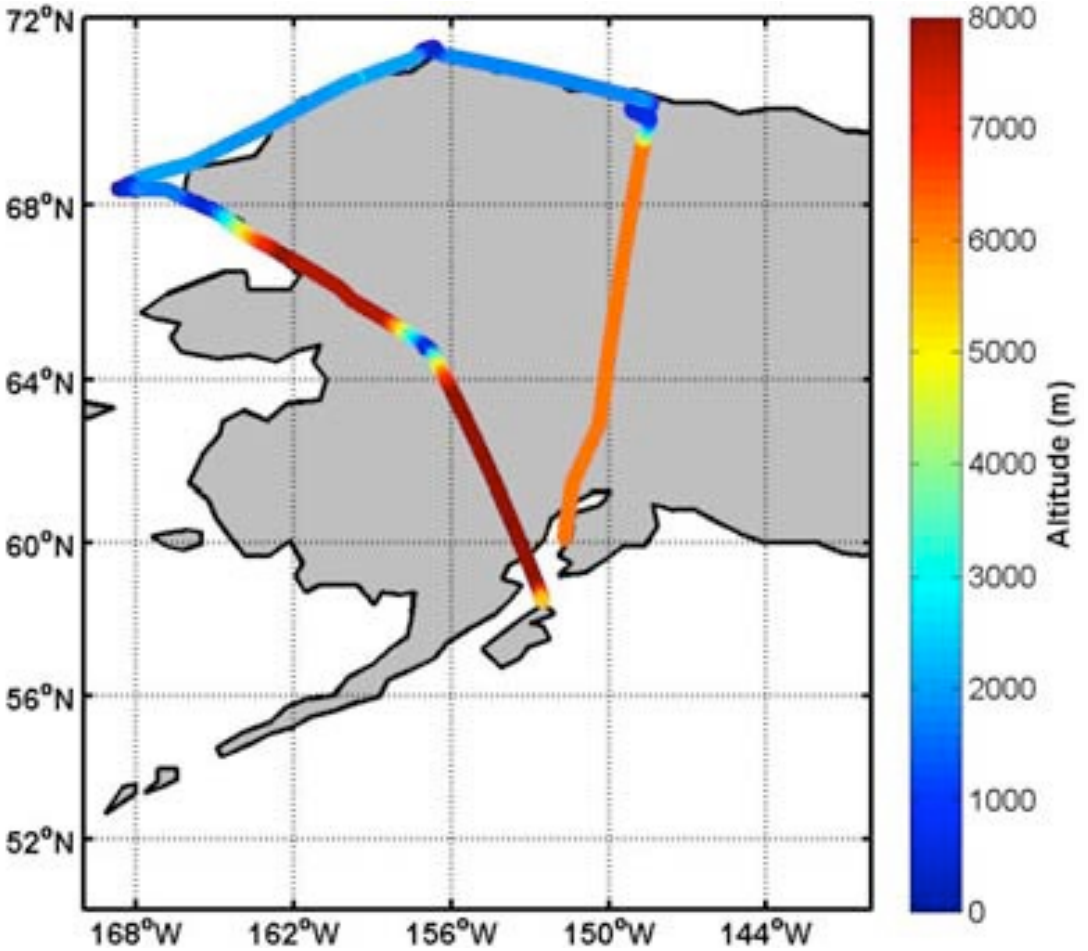


NOAA ESRL Global Monitoring Division
CG C130 Aircraft Air Sampling Network (Colm Sweeney, PI)

- Continued changes in NOAA C130 sampling system led to requirement for re-certification (ACCB)
- NOAA elected to wait until C130-Js came online, and is doing ACCB paperwork now for C130-Js
- NOAA did not conduct C130 flights in 2018 or 2019, but plans to resume them in 2020 if possible as part of large Arctic sampling program planned that year

2018 NOAA ESRL Global Monitoring Division
CG C130 Aircraft Air Sampling Network (Colm Sweeney, PI) (left), see:
http://www.esrl.noaa.gov/gmd/ccgg/aircraft.html ,
and typical Alaska flight pattern (right)





CG HQ and Research & Development Center UAS Projects

- CG HQ UAS Overview ppt presented in following brief
- CG RDC Robotic Aircraft for Maritime Public Safety (RAMPS) project – completed Feb. 2019 (see next slide)
- RAMPS concluded:
  - BLOS flights needed for optimal benefit of UAS ops
  - UAS in-water recovery not resource efficient
  - VTOL technology reduces flight deck LAR gear impacts on helo flight ops
- As a result of the RAMPS findings, RDC began project on BLOS UAS ops in March 2019, to end March 2022, with goal to identify & test technologies to enable "Due Regard" BLOS UAS ops. Not a field project, but a technology review project for systems to automate sense & avoid capabilities, improve airspace awareness and populate National Air Space and ICAO Air Space data fields. Tech considered will include: ADS-B, micro-radars, audio/visual sensors, and flight control algorithms for install on VTOL UAS and then ship testing (see following slide)

Robotic Aircraft for Maritime Public Safety (RAMPS)

Mission Need: Better understanding the risks, benefits and limitations of operating existing Commercial off the Shelf Small Unmanned Aircraft System (sUAS) technology in a maritime environment for cutter forces other than the National Security Cutter.

Project Objectives:

- Develop requirements, standards and Concept of Operations.
- Evaluate realistic maritime security and first responder scenarios.
- Create a knowledge resource database.
- Guide future platform and sensor development to meet maritime first responder requirements.
- Evaluate sUAS payloads in different environmental areas focusing on logistics, maintenance, and data dissemination with CGC assets.
- Conduct an assessment for potential demonstration and evaluation facilities with special use air space establishing an Federal Aviation Administration approved Certificate of Waiver or Authorization for Department of Homeland Security (DHS) use.

Key Milestone / Deliverable Schedule:

	Project Start	30 Oct 13 ✓
	RAMPS Request For Information (RFI) Release	10 Oct 14 ✓
	RAMPS Course Validation Phase I-A	28 Apr 15 ✓
	RAMPS Phase I-A Demos 01-05	10 Jun 16 ✓
★	**RAMPS Compilation Report Phase 1A**	**3 Oct 16** ✓
	RAMPS Phase I-B Issue Payload RFI	21 Feb 17 ✓
	RAMPS Phase I-B Re-Issue Payload RFI	Aug 17 ✓
	RAMPS Phase I-B Payload Demo	Nov 17 ✓
	Robotic Aircraft Sensors Program-Maritime (RASP-M) Capabilities Demos 01-05	Oct 18
★	**RASP-M Compilation Report Phase 1B**	**Jan 19**
	Project End	Feb 19

★ Indicates RDC product.

Sponsor: DHS S&T, CG-711

Stakeholder(s): CG-751, CG-761, CG-771, CG-931, JTF-E

Project #: 7807

Expected Benefit:
Direct Acquisition Support (MAR, MNS, CONOPS, ORD, AA, LCCE, T&E, etc.)

Notes:

- Partnership with DHS Science and Technology (S&T) Borders and Maritime Division.
- Establish Cooperative Research and Development Agreements with industry partners for sUAS demonstrations.
- Supports the Coast Guard Western Hemisphere Strategy.

RDC POC:	CG-926 Domain Lead:
Mr. Stephen Dunn	Mr. Scott Craig

For more information, call (860) 271-2600 or e-mail RDC-Info@uscg.mil

Beyond Visual Line of Sight (BVLOS) Technology for Coast Guard (CG) Unmanned Aircraft System (UAS) Operations

Mission Need: BVLOS operations for CG UAS.

Project Objectives:

- Leverage U.S. Southern Command (SOUTHCOM) efforts to explore Vertical Takeoff and Landing (VTOL) operations from a CG Cutter (CGC).
- Establish Integrated Product Team (IPT) to conduct BVLOS operations from a CGC [sUAS 1st].
- Submit a Request for Information (RFI) for sense and avoid technologies to assist BVLOS operations.
- Integrate sense and avoid technology for conducting BVLOS operations [sUAS 1st].
- Conduct land and vessel based evaluations using sense and avoid technology [sUAS 1st].
- Incorporate sense and avoid technology into VTOL platform.
- Conduct a VTOL BVLOS Limited User Evaluation from a CGC.
- Inform due regard parameters for CG BVLOS UAS operations.
- Establish a BVLOS Certificate of Authorization for Coast Guard operations.

Key Milestone / Deliverable Schedule:

	Project Start	13 Mar 19 ✓
	Establish IPT	Sep 19
	Submit RFI for BVLOS Technologies	Nov 19
	Coordinate VTOL Demonstrations from a CGC	Jul 20
★	**VTOL Operations from a CGC (Brief)**	**Aug 20**
	Integrate BVLOS Technologies into sUAS	Oct 20
	Conduct Land Based BVLOS Tech Demonstration with sUAS	Nov 20
	Conduct Vessel Based BVLOS Tech Demonstration with sUAS	Jan 21
★	**BVLOS Tech Demonstration (with sUAS) Results (Brief)**	**Feb 21**
	Integrate BVLOS Tech with VTOL Platform	Aug 21
	Conduct BVLOS Limited User Evaluation with VTOL	Nov 21
★	**Beyond Visual Line of Sight (Report)**	**Mar 22**
	Project End	Mar 22

Indicates RDC product.

Sponsor: CG-711
Stakeholder(s): CG-753, SOUTHCOM, JIATFS, NOAA

Project #: 7691

Anticipated Transition: **Knowledge Product**
Acquisition Milestone Support

Notes:

- Establish Memoranda of Understanding and Cooperative Research and Development Agreements as necessary with industry partners.
- Leverage efforts of SOUTHCOM, Federal Aviation Administration, National Oceanic and Atmospheric Administration (NOAA), Joint Interagency Task Force South (JIATFS), and other government agencies.

RDC POC:	CG-926 Domain Lead:
Mr. Stephen Dunn	Mr. Scott Craig

For more information, call (860) 271-2600 or e-mail RDC-Info@uscg.mil

CG PACAREA 2018/2019 UAS on HEALY & Other

- Only HEALY UAS ops was test of DJI Phantom Pro on cruise by Hanu Singh for ice profiling. DJI suggests latitude limits for ops, and indeed they had trouble with GPS fixes, IMU and compass interactions. So, using the 'canned' DJI software not recommended.
- For reference, NASA uses some DJI drones, but completely over-writes their control system with NASA's own software, including multi-satellite GPS fixes for high latitudes.
- Participated in May 2019 Federal Inter-Agency UAS meeting hosted annually by USGS and NASA Ames. Meeting included review of federal and COTS HALE UAS use/development; review of new NASA SIERRA UAS planned use; review of 13 NOAA UAS internal grants (75% of NOAA UAS are in NMFS), incl. for meteorology, hurricanes, flood & wildlife monitoring; NSF Antarctic UAS ops; NAVY non-military UAS use; Army Corp UAS use; FEMA UAS use; AF UAS use, incl. UAS launch from aircraft; EPA UAS use for Superfund site monitoring; USDA & Forest Svc. UAS use, incl. fires, alien species/weeds and fish spawning habitat mapping; Federal Highway Administration UAS use (bridges, roads); BLM UAS use for land management; USFWS UAS for fires and riparian habitat monitoring; and, USGS UAS use for hydrology, geology, and volcano monitoring. Discussion topics also included cybersecurity and data management issues, stream flow monitoring methods, and 3D mapping technologies (including COTS still and video method presentations).

DJI Phantom Pro Quadcopter

CG PACAREA UAS Activities

- Continued collaboration with NASA and NOAA on UAS icing studies in NASA Glenn icing tunnel (see poster from Federal Inter-agency UAS Workshop, May 2019).
- Sept. 10, 2019 submitted $3.6M Notice of Intent (proposal) for NASA ARMD (Aeronautics Research Mission Directorate) funding (P.I. Peter Webley, UAF) Strategic Thrust 6 (Assured Autonomy for Aviation Transformation), Topic 7: RVLT (Revolutionary Vertical Lift Technology) UAM (Urban Air Mobility) Icing Research Roadmap. Proposal includes a dozen individual partners (including companies).
- Will know in 60 days if full proposal is requested, if so due within 60 days; think odds are good.
- Proposed use of Iowa State Univ. Aircraft Icing Tunnel (managed by co-PI Hui Hu), which is superior to NASA Glenn Icing Tunnel in allowing: higher temperatures; lower wind speeds; and turbulent wind flow studies. Studies will include 2 years of tests of anti-icing technologies, development/testing of improved weather models for icing, and follow-on 2 years of field testing validation, and dissemination of results to industry.
- Began discussions with NOAA NWS personnel in Alaska (especially Barrow, POC Bryan Thomas) to improve aircraft icing forecast models for both unmanned and manned aircraft by improving vertical stratification data availability in the lower 1,000', and horizontally adjacent to the coastline. Some new technologies are being implemented at Barrow which could allow this capability in future.

National Aeronautics and Space Administration

Ames

Discovery Innovations Solutions

Experimental and Simulated Ice Accretion on Small UAS

Robert, P. Dahlgren[1]

[1] CSUMB/NASA-Ames Research Center (650) 604-0130 rdahlgren@csumb.edu

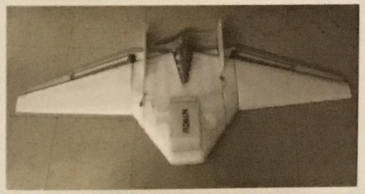
Abstract

As autonomous and unmanned aerial system (UAS) operations proliferate and are applied to broader geographic ranges, it is important to assess aircraft icing for UAS intended to be operated under conditions where icing may exist. Ice accretion modeling, testing, detection and mitigation are important in the context of scientific and commercial mission assurance. Urban air mobility (UAM) also has a requirement for reliable weather-tolerant operation, and as UAM and UAS become ubiquitous, de-icing technology will be a key enabler for year-round operations.

This work reports a joint study done by NASA, NOAA, DOE, the USCG, academic and industrial partners to do an initial evaluation of small UAS and an ice sensor in the NASA Glenn Research Center (GRC) Icing Research Tunnel (IRT) in Cleveland, Ohio.

ArcticShark UAS

SeaHunter UAS



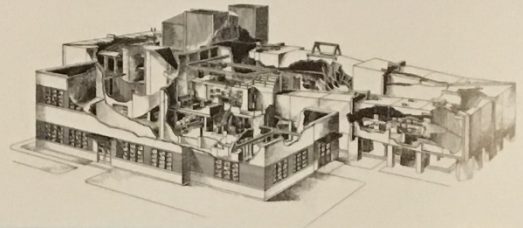
DataHawk UAS

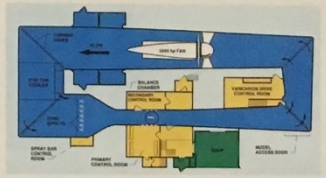
ASAPS Ice Sensor

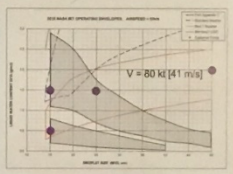
Introduction

For the experimental portion of the project, three test articles and the ice sensor were evaluated in the IRT. Two of the UAS were simulated using the GRC software package LEWICE. The test articles were:

- Navmar Applied Science "ArcticShark" wing section and winglet
- ACUASI "SeaHUnter" wing section and partial nacelle
- Colorado University "DataHawk" small UAS
- Pemdas "ASAPS" Ice Detection System







Experiment

The IRT is the worlds largest and oldest icing research facility, consisting of a large wind tunnel, refrigeration system, and spray system. A test matrix was developed for the 3 test articles, 2 different temperatures (-20°C and -40°C), two airspeed & AoA combinations, and 4 cloud conditions. These are four combinations of liquid water content (LWC) and mean volume diameter (MVD), identified on the plot with violet circles, were an attempt to have a consistent set of test conditions for all of the test articles, generating both glaze and rime ice. The ice sensor was evaluated at the same time as the UAS testing; in total there were five nights of testing at the IRT facility.

The test section of the IRT is 6ft by 9ft [1.8m x 2.7m] and could only accommodate wing sections from the larger ArcticShark and SeaHunter UAS, mounted on the turntable floor. The DataHawk was small enough that the entire UAS could be mounted on a "sting" and pylon in the IRT test section. The ice sensor was mounted on its own pylon during testing.

ArcticShark wing section

SeaHunter wing section

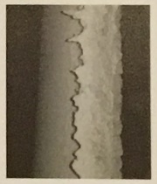
DataHawk on sting & pylon

ASAPS sensor (pylon not shown)

Results

A typical test run: Once the temperature and airspeed are stabilized, ice is accreted on the test article by turning on the spray system for 10 minutes, whether rime ice (droplets freezing on impact) or glaze ice is a function of temperature. After the test, the 3-dimensional ice shape is captured by a laser-scanning system, and the test article is carefully cleaned for the next test run. Other data include video, impingement length, calculated cross sectional area, rime ice thickness, glaze ice horn dimensions. There could be 8 or 9 runs performed per evening, with setup occurring during the day shift, resulting in a total of ~2TB of data captured and 1 gigajoule of energy used.

The IRT had never been operated at airspeeds below 50kt [25.7 m/s] and some of the test articles had a cruise velocity as low as 35kt [18.0 m/s]. GRC performed a low-airspeed calibration of the spray system to ensure the target cloud conditions could be met, prior to the commencement of test week.



Conclusions & Future Work

- The first time UAS were tested in an icing wind tunnel.
- Lots of surprises at low airspeed: Calibration, flow angularity, droplet stratification, off-axis forces, and the need for a datum on test articles.
- For rime ice, LEWICE tended to underestimate impingement length, ice thickness, and stagnation point thickness.
- For glaze ice, same problems as above, plus ice horn geometry had significant divergence with LEWICE predicted horn geometry.
- Don't retire the wind tunnels anytime soon!
- Need to test multicopter and ducted-fan UAS configurations.
- There is a gap of understanding of the scaling laws of full-size UAS.

CG PACAREA UAS Related Activities

- NASA Glenn releases LEWICE3D aircraft icing modeling software free to public, c.f.: https://www.rdmag.com/article/2019/04/nasa-software-innovation-models-aircraft-ice-accumulation?et_cid=6663745&et_rid=332197972&et_cid=6663745&et_rid=332197972&linkid=Mobius_Link
- A new aircraft icing forecast model was officially approved for use, see: Morcrette C, K Brown, R Bowyer, P Gill, and D Suri. 2019. "Development and evaluation of in-flight icing index forecast for aviation." *Weather and Forecasting*, 10.1175/WAF-D-18-01 https://journals.ametsoc.org/doi/abs/10.1175/WAF-D-18-0177.177.1. ONLINE at: https://journals.ametsoc.org/doi/abs/10.1175/WAF-D-18-0177.1
- Iowa State U. & NW Polytech U in China have tested/proposed active plasma generation on aircraft wings as an anti-icing system. Iowa State has a very advanced aircraft Icing Research Tunnel IRT) managed by Dr. Hui Hu that can do studies of low velocity air flow along with turbulent airflows. See ms at: https://www.ecnmag.com/news/2019/04/how-ice-proof-next-generation-aircraft?et_cid=6656397&et_rid=332197972&type=cta&et_cid=6656397&et_rid=332197972&linkid=How+to+Ice-Proof+the+Next+Generation+of+Aircraft
- UbiqAerospace got significant funding from James Murdoch to ramp up staff and sales of their D-Ice product for active UAS (and aircraft) anti-icing system, see:

https://www.bloomberg.com/news/articles/2019-06-28/james-murdoch-ventures-into-drone-technology-with-new-investment

Other UAS items of note:

- Sept. 25-27 NERACOOS & Alliance for Coastal Technologies (ACT) with US Integrated Ocean Observing System (IOOS) support hosted workshop Practical Uses for Drones to Address Management Problems in Coastal Zones at the Wells Nat. Est. Res. Reserve, Wells, Maine. Workshop report at the ACT website: http://www.act-us.info
- NC State & Teledyne demo'd a "Cross-domain autonomous vehicle" (XAV), a drone that can both swim and fly called EagleRay, which is a fixed wing VTOL w brushless electric motors, see: https://www.oceannews.com/news/science-technology/seabirds-inspire-a-hybrid-fixed-wing-uav-uuv-system and YouTube video at: https://www.youtube.com/watch?v=Aw01NnG9hu0
- Igloo Innovations demo'd 2 XAVs: 1) Seahawk Alfa which uses a tethered surface buoy to maintain comms, and can do 4 knots u/w to 50m w 1 hr endurance in air or water; and 2) Seahawk Chimera which stays at the surface but can deploy an ROV or AUV weighing up to 40 lbs., or can hover and collect samples near the sea surface. See: https://flyswimfly.com/