



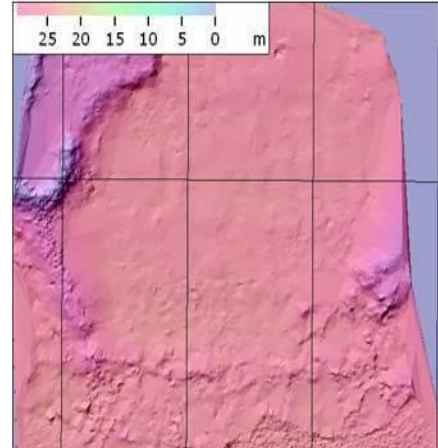
SCOAR 2012

U. Alaska, Fairbanks, Aug.14,15

US Coast Guard PACAREA Brief

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Clockwise: RAVEN UAS icebreaker launch, 88°N, summer 2011; UAS Ice Ridge height map, Nome, AK, Jan. 2012; HEALY from RAVEN UAS, summer 2011; Ice Ridges in IR from RAVEN UAS, summer 2011; CG C130 Arctic Domain Awareness flight; UAF Quadrotor UAS, Nome, Jan. 2012.





CG C130 Aircraft Bi-weekly (March-Nov.) Arctic Domain Awareness (ADA) Flights support ONR, NSF, NOAA & NASA science



Office of Naval Research: Lead PI Jamie Morison, UW

Current Project: SIZRS = Seasonal Ice Zone Reconnaissance Surveys on 3 ADA flights. Dropped 1000m profiling AXCTDs along section at 150°W at 72,73,74,75 & 76°N. Launched manually into leads, data telemetry to C130 by VHF radio. Only 2 of total stations had issues: (1) data comms/collection problems; (2) poor visibility of leads; all other 13 were good. Ongoing. Funding for 2012-2014.

Future work: Include AXCP (Air Expendable Current Profilers), atmospheric dropsondes and ice buoys of several kinds. These drops require submission to CG ACCB (Aircraft Configuration Control Board) for review, and the initial technical data has been submitted, and a Safety of Flight Test (SOFT) protocol is planned (done on land) for later in summer. This will review issues like EMI, etc.. Results of this will be submitted to ACCB for final review.

NOAA: PI Colm Sweeney, NOAA, Boulder

Current Project: Global Carbon Monitoring Program. Continuing fourth year along triangular course Kodiak-Barrow-Prudhoe-Bay, with continuous inlet sampling for 19 gases (CO₂, CH₄, CO, etc.). Also discrete flask sampling at locations including: Anvik, Kivalina, Barrow & Prudhoe Bay. 12 flasks sampled at: 500m, 1km, 2km, 4km, 6km, 9km, 12km, 14km, 17km, 20km, 23km, and 26km or top altitude. Recent results confirm large tundra methane fluxes around Anvik area.

NASA & Various agencies via US Arctic Research Consortium (US ARC): Pls Mark Tschudi & Jim Maslanik, U. Colorado

Current Project: CULPIS-X Lidar. Status: still waiting to get ACCB approval for their externally mounted lidar system for ice ridge height measurement. Funds from NASA via Univ. Colorado recently transferred for ACCB review. Status: Ongoing/active. Would be flown in conjunction with SIZRS flights if ACCB approved in 2013.

NASA: Lead PI: Charles Miller, NASA JPL

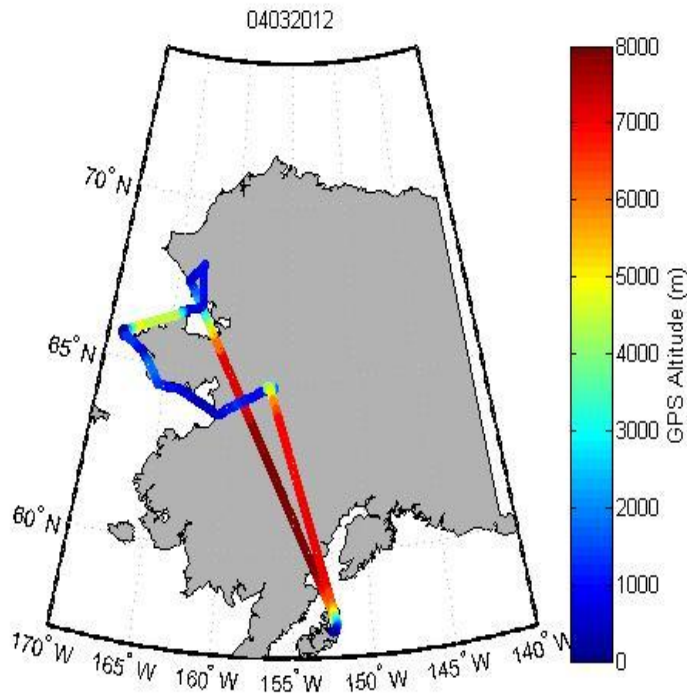
Current Project: Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) Program: Lidar system to measure atmospheric gases from aircraft to ground for NASA Orbiting Carbon Observatory (OCO) satellite calibration, and comparison with NOAA continuous CG C130 inlet continuous sampling, and periodic height flask sample gas data.

NOAA Boulder (C. Sweeney) Global Carbon Sampling project from CG biweekly CG C130 Aircraft Arctic Domain Awareness flights

See: <http://www.esrl.noaa.gov/gmd/ccgg/aircraft/alaska.html>

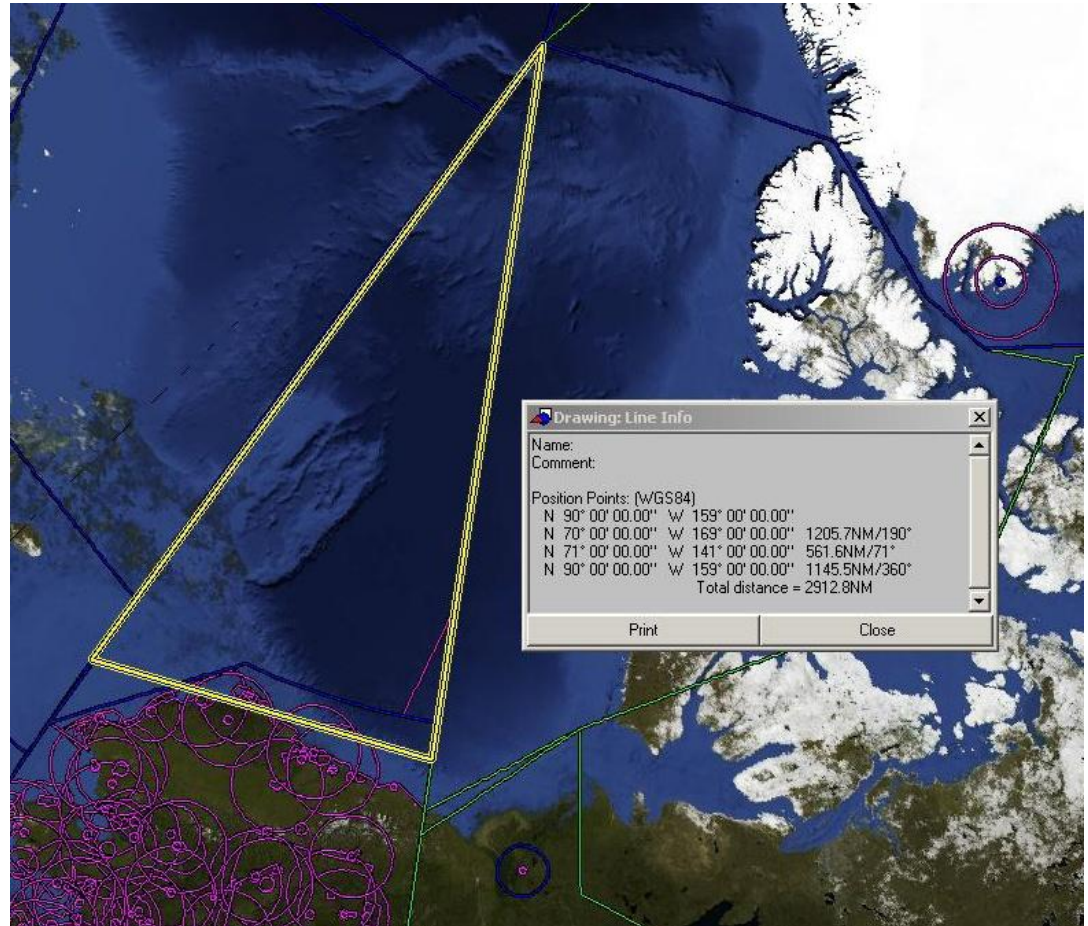
CG C130 Aircraft 4/3/2012 transit
example; 14 flights since 2011;
>40 flights since program started in
2009; @7-8 more upcoming in 2012

Air inlet port (now on 2 different CG
C130s), and interior sampling setup



HEALY summer 2011 UAS updates & results so far...

- G. Walker (UAF) insufficient time to get CG OK to fly ScanEagle off HEALY, mission delayed
- AF CAPT Steve Wackowski (Natl. Defense Univ.) got FAA COA to fly RAVEN UAS: largest COA ever granted (see figure atright). Furthest north UAS flight (@88°N), @100mi from N. Pole.
- Results of study:
 - 1) Ice ridges best viewed in IR, but multispectral not done (sensors arrived late!)
 - 2) UAS ice ridge data useful for ship routing
 - 3) UAS ice cover data useful for ship AUV deployment/recovery



Icebreaker UAS 2011: Results so Far

Launch of RAVEN from Canadian icebreaker LOUIS S ST LAURENT



HEALY from RAVEN (image degraded to abet transmission)



Icebreaker 2011: UAS Results so Far

RAVEN recovery by CCG cadet on flight deck of LOUIS ST LAURENT

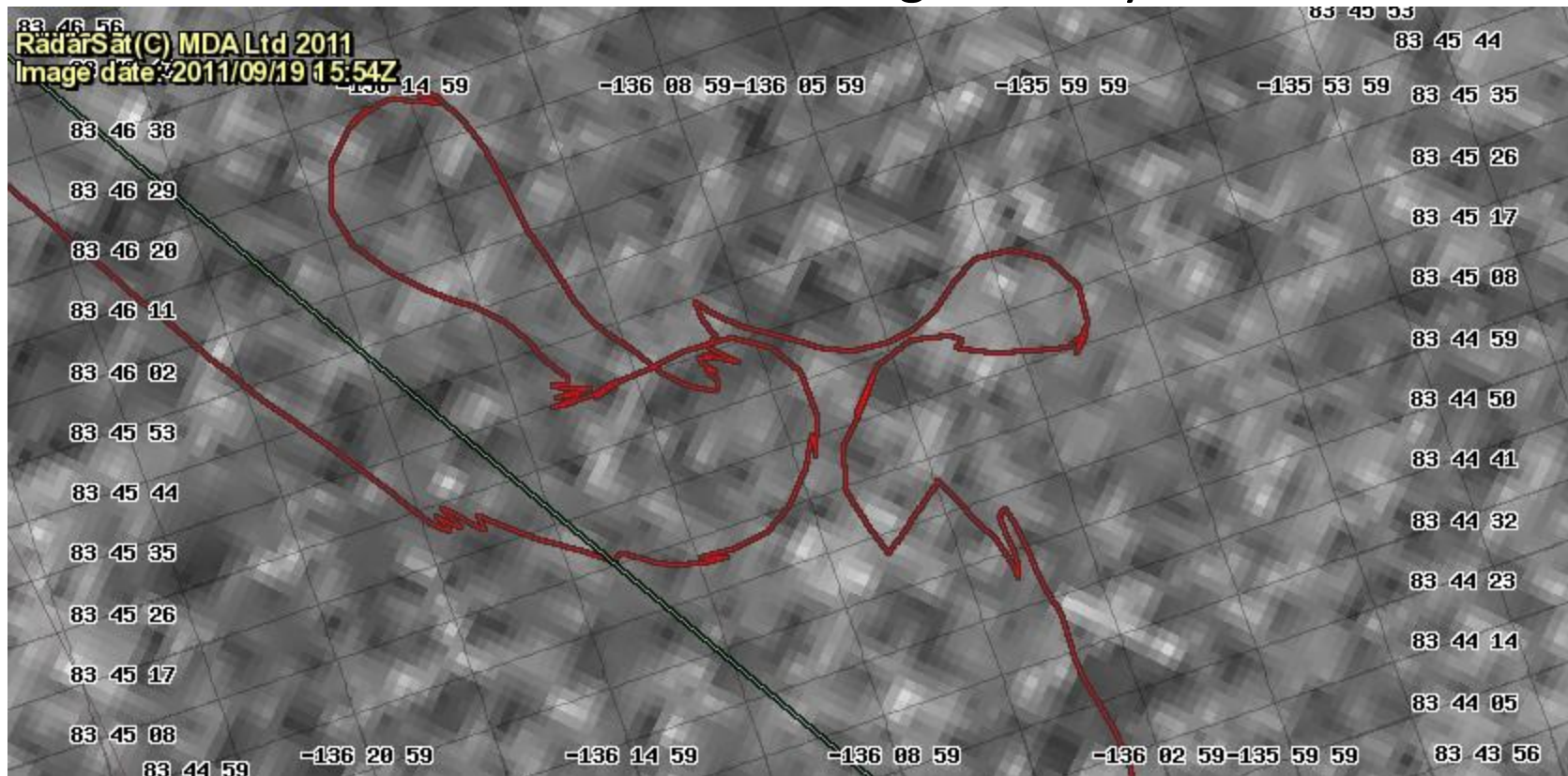


IR image of LOUIS ST LAURENT amid ice pressure ridges (white)



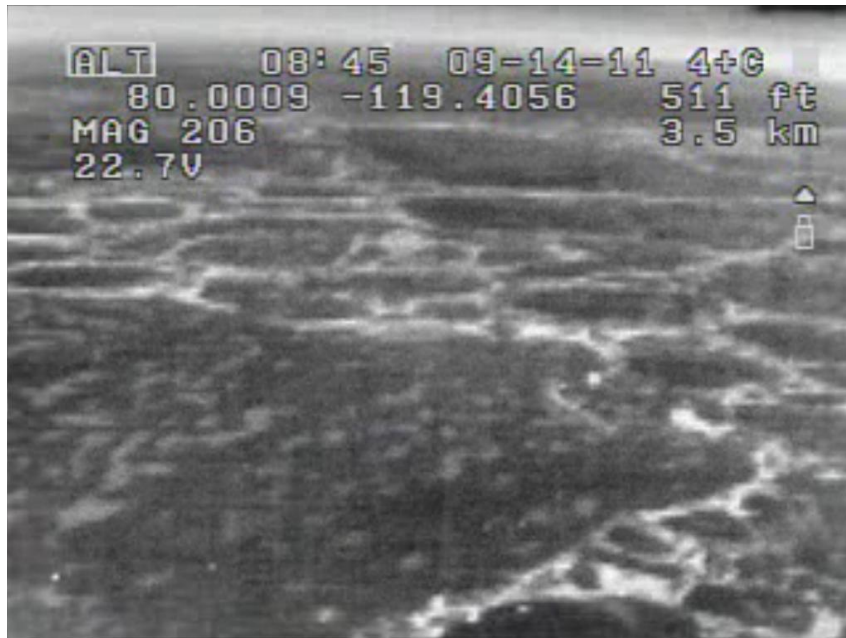
Icebreaker UAS 2011: Results so Far

Screen capture from HEALY Mapserver, showing desired icebreaker track (green) over actual navigation track (red) superimposed over National Ice Center highest resolution RADARSAT SAR image overlay



Icebreaker UAS 2011: Results so Far

IR image from RAVEN UAS showing ice ridging around HEALY

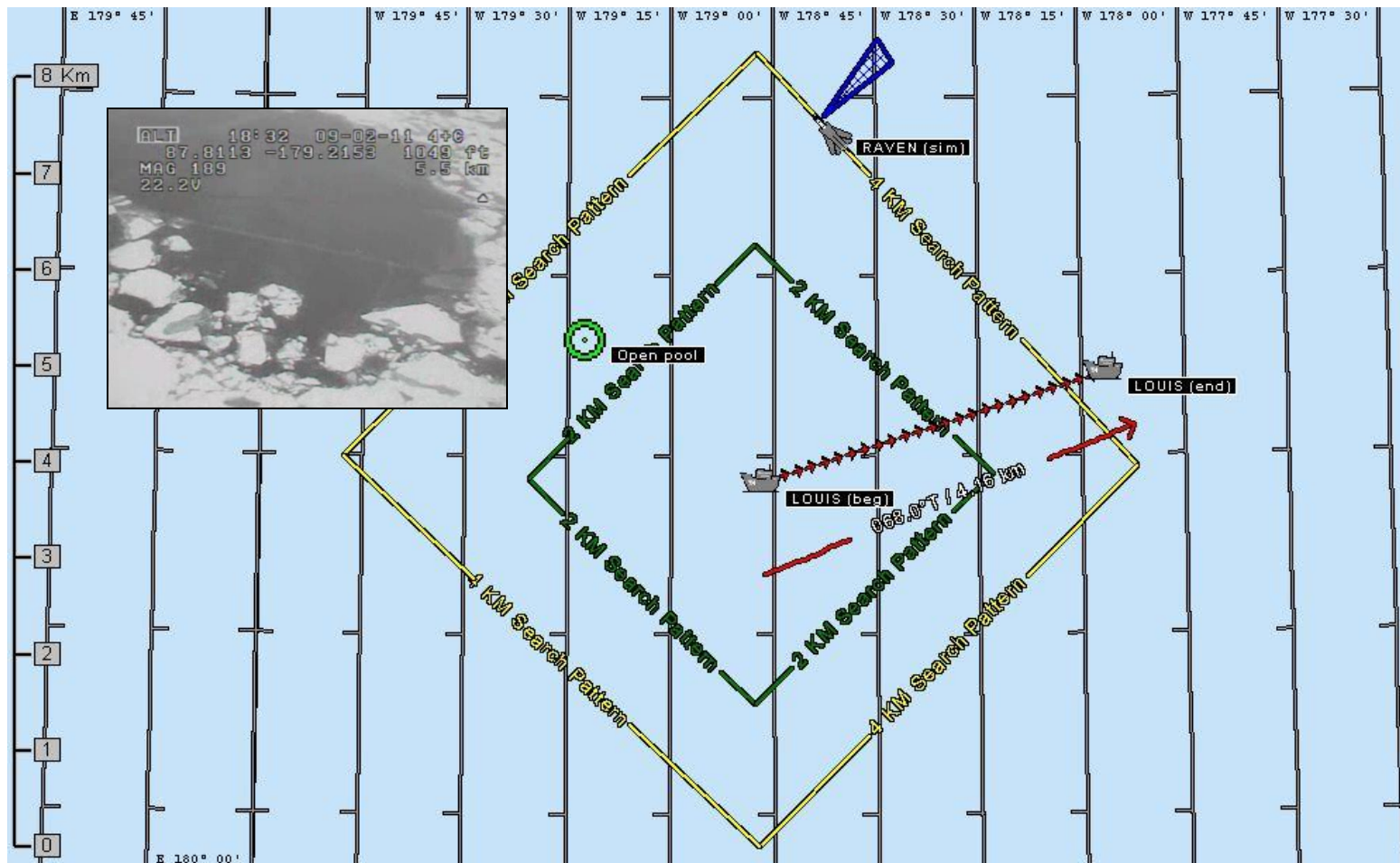


RAVEN UAS imagery used to find open water for launch and recovery of Canadian ISE AUV w multibeam



Icebreaker UAS 2011: Results so far

RAVEN UAS Mission reconnaissance plan to locate open water for AUV deployment/recovery (screen capture of pond overlay = area of small green circle)



Updates: April 2012

- New UAS RAVENs w gimballed camera w 4 zoom settings:

http://defense-update.com/20120402_raven_gimballed_eo_payload.html

- Innovative Automatic Technologies deploys AXO S-UAS for seabird & marine mammal studies.

See: <http://www.iat-llc.com>

- Israeli Co. Sky Sapience markets “Hovermast” tethered quad-rotor UAS for ship deployments to 50m to provide surveillance w/o FAA COA requirement. See:

<http://www.suasnews.com/2012/02/12294/hovermast-sky-sapience%E2%80%99s-autonomous-hovering-platform-makes-its-debut/>



Near Term UAS Ship Ops Needs

- Demonstrate utility of multi-/hyperspectral sensors & Interferometric SAR (ISAR) for studies of sea ice, marine mammals, search & rescue and oil detection
- Develop, implement, improve anti-icing for small UAS, including UAS & optical systems (video and still camera housings)
- Complete UAS video integration w HEALY MapServer & ship computer systems
- Current status CG Icebreaker UAS integration:
 1. On-land tests w canned HEALY video successful in testbed computer system. Overlay of UAS video imagery w shipboard Terascan satellite imagery not yet completed (Terascan doesn't work at dock).
 2. Conducted initial training program, but determined more funds will be required to support training for this capability in future, pending discussions w NSF.
 3. Purchase of video-archiving software completed. Servers identified and ready for purchase, w integrated ship tests to follow on POLAR STAR.
 4. CG funding of UAS on HEALY on hold pending successful UAS integration on CG National Security Cutter, but will likely be accelerated pending FAA approval of arctic as "Remote Operating Area" per Aug. 2012 Congressional deadline. SIO ship science data software running on icebreakers, but will need video ingest/archiving capability integration, and coordination w NSF/UNOLS R-2-R software committee.

CG Icebreaker HEALY escort of Russian Tanker RENDA to refuel Nome after onset of heavy ice, Dec.-Jan. 2012

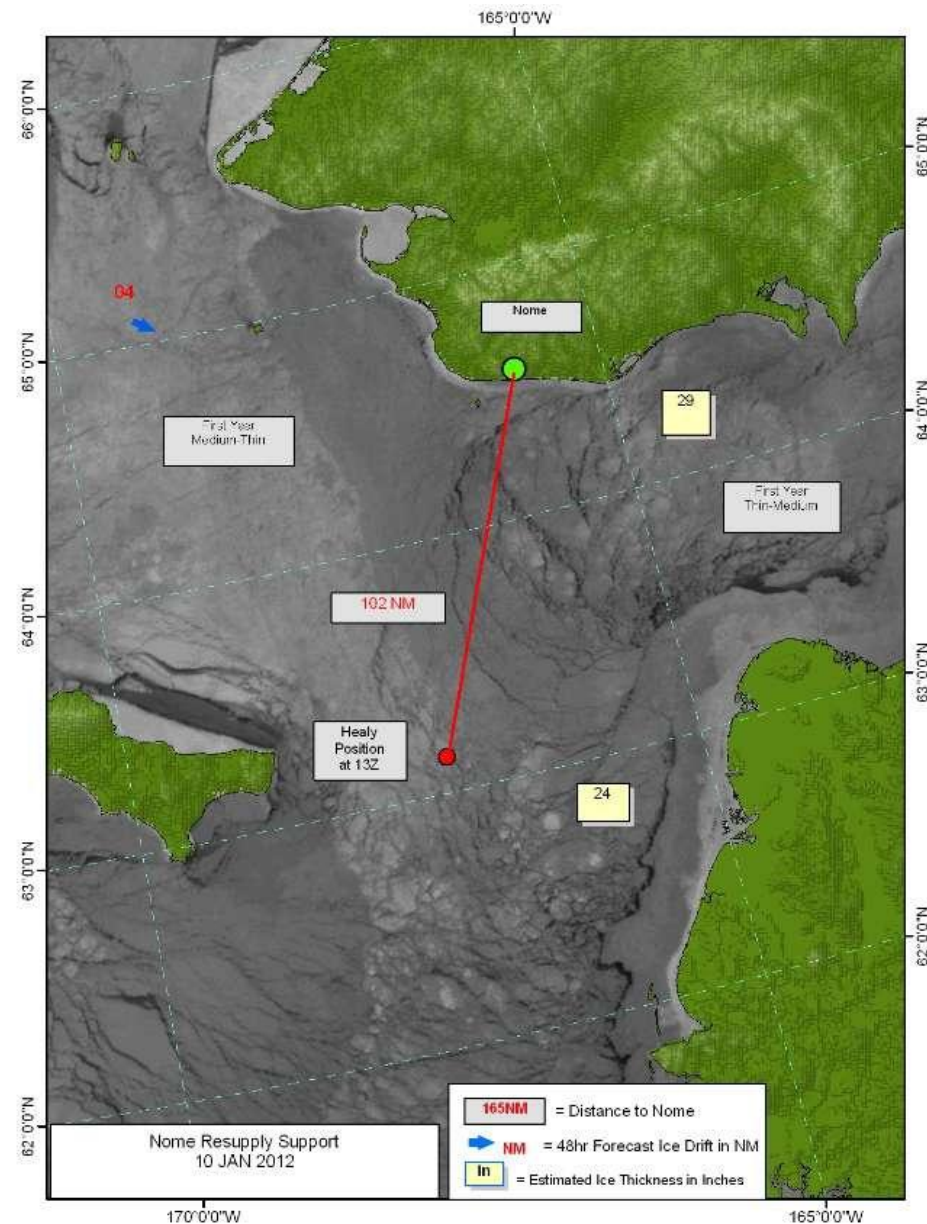
Winter storm onset w heavy ice conditions precluded heating oil resupply for Nome, AK

Colder temperatures led to unexpected heating oil shortfall

Ice developed faster than usual

Formation of strong ice ridges near Nome limited oil hose reaching fuel tank.

Quadrotor UAS used to map ice ridges to determine: 1) ship best approach to harbor; and, 2) optimal locations for oil hose pathway



Nome Harbor Oil Delivery Ops, Jan. 2012

Photos from Greg Walker, UAF

Updates at:

<http://dec.alaska.gov/Spar/rendera/index.htm>

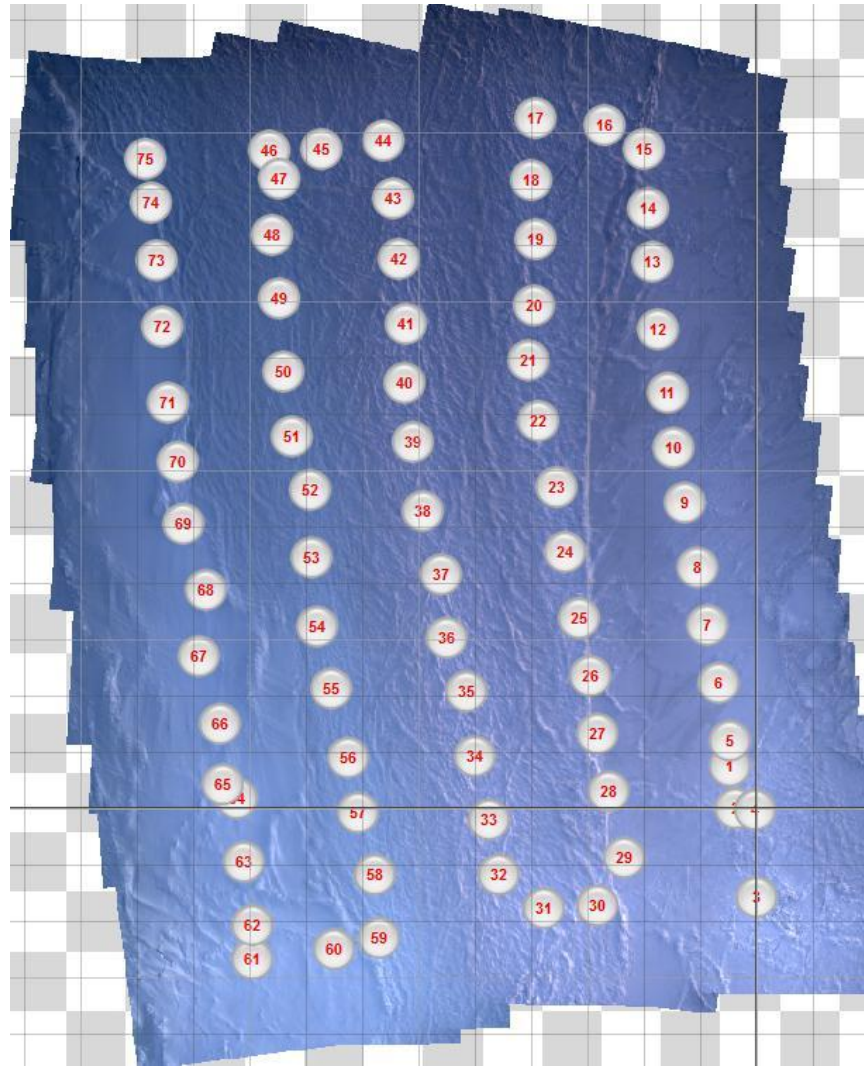
Aeryon Scout Quadrotor UAS

Ice ridge imagery from Quadrotor
with Nome dock



Results from UAS Surveys (G. Walker, UAF)

Nome Harbor UAS Pre-programmed Flight Path

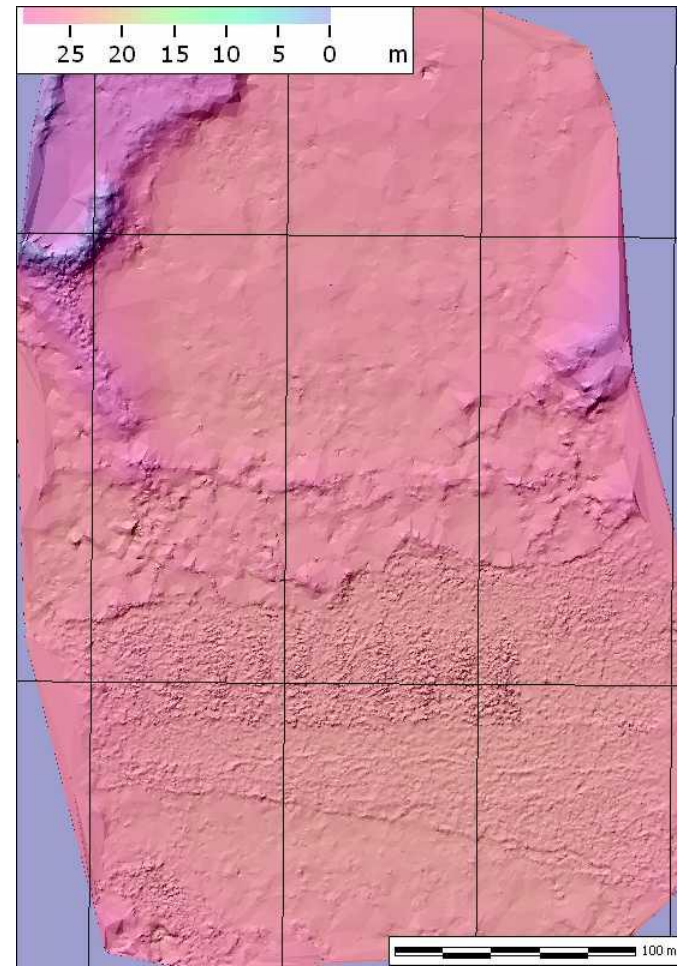


Results from UAS Surveys (G. Walker, UAF)

UAS Sea Ice Photo-mosaic
from feature-mapping software



UAS Ice Ridge Elevation Map
from sequential stereo imaging
and ground truth calibration



P.McG & USN LTJG W. Eucker Testing Helikites as UAS comms link & for atmospheric profiling at U. Cambridge Dept. Applied Math. & Theoretical Physics, 9/2011

Helikites: Allsopp Helikites www.helikites.com
@\$3.5K, 1000' elevation gives 100mi comms radius;
have been ASV deployed w automatic winch.



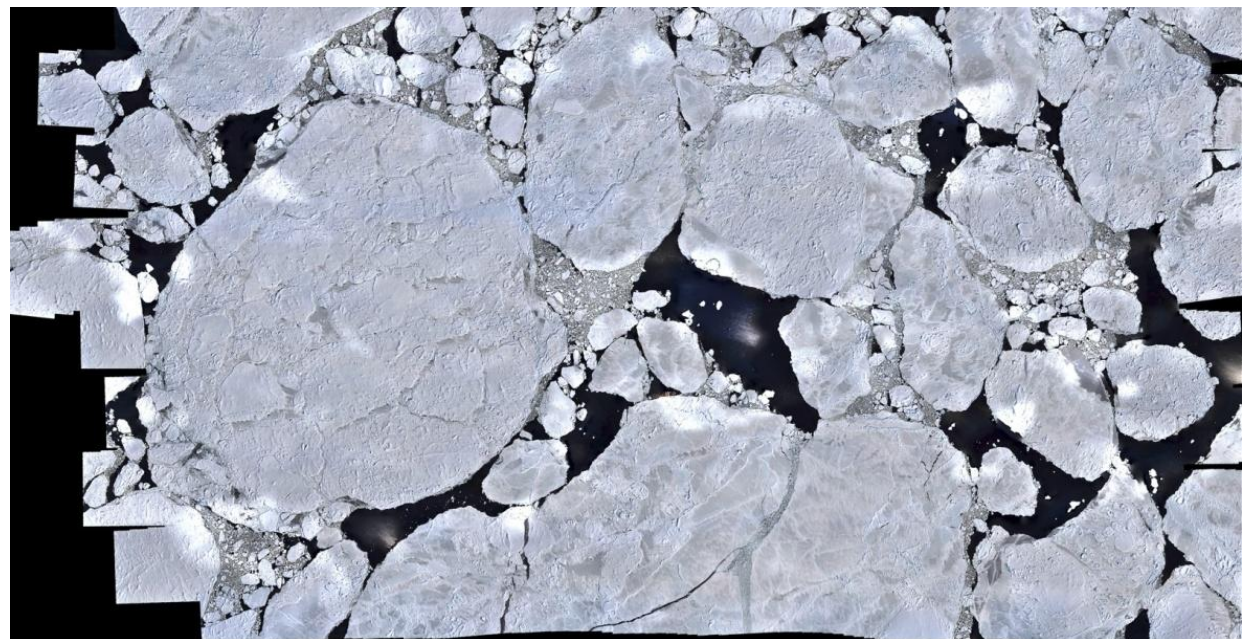
Work elsewhere:

British Antarctic Survey constructing UAS w fan-beam lidar for ice ridge measurements

In US...more routine use rapid photo-mosaic methods w corner & center geo-referencing

Left, top: Weddell Sea 2010 Sea ice photo--mosaic using 1200 images from Twin Otter w SLR camera. Area @3.3km x 9.1km. H. Singh lab, WHOI.

Left, below: John Bailey, WHOI, w Telemaster UAS, H. Singh lab.



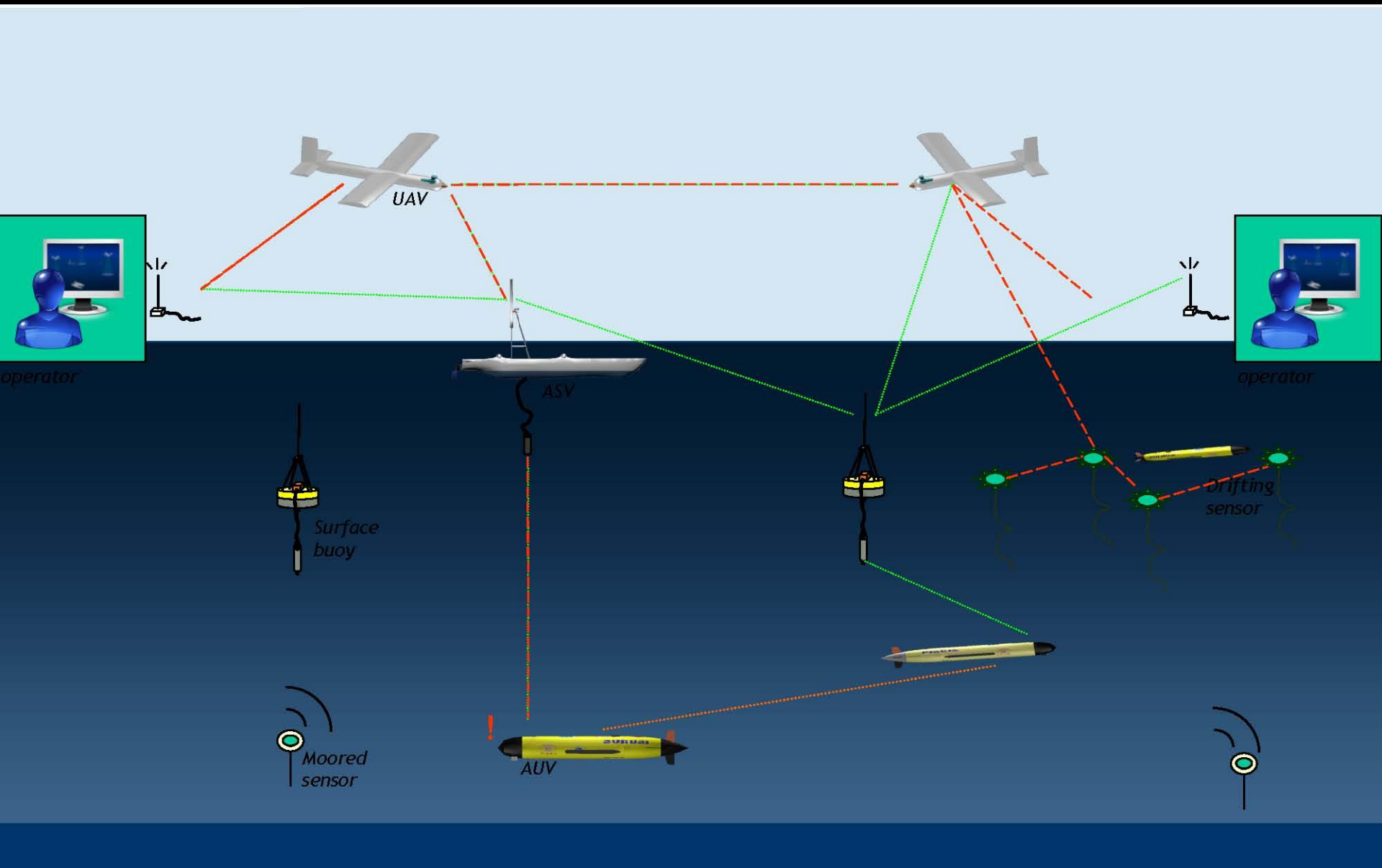
Delay & Disruption Tolerant Wireless Networking field tests w UAS:

REP12 Exercise conducted off Lisbon w U. Porto & NATO NURC personnel, also Spain and Norway participation. Successfully demonstrated DTN comms between AUVs using acoustic modems, and video transfer between UAS.

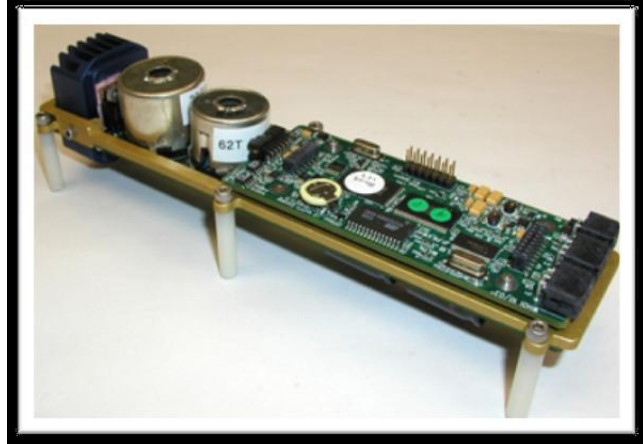
Results & other info see: July 26,27, 2012, Delay & Disruption Tolerant Wireless Networking Conf., convened by Vint Cerf, Google:

<http://down.dsg.cs.tcd.ie/dtnrg-at-google-12/>

Vision for 2012 (REP12 AUV)



REP-12 DTN tests used different acoustic modems for AUV and UAS comms



WHOI Micromodem

- Operational range: up to 1500 m
- nominal acoustic bitrate: up to **80 bps** (FSK), up to **5400 bps** (PSK)
- operational frequency band: 15kHz - 25kHz - 28 kHz

Evologics 18/34

- operational range: up to 4500 m;
- nominal acoustic bitrate: up to **13.8 kbps**
- operational frequency band: 18kHz - 34kHz

Evologics 8/16

- operational range: up to 8000m;
- nominal acoustic bitrate: up to **6,9 kbps**
- operational frequency band: 8kHz - 16kHz

Summer 2012 successful test of omni-directional ONR-funded laser comms system

60-100m range @20MSymbols/s (F. Dahlgleich, HBOI/FAU).

Transmission system on left; receiver on right.

Next: AUV-UAS comms tests!



NASA UAS programs

- Fall 2012 Global Hawk UAS fly from Wallops Island to N. Atl. Hurricanes for air-sea heat & gas flux study w NOAA Miami Hurricane Res. Div. and WaveGlider ASV for @1 month. Mission software to integrate data will be available online soon for teaching purposes. (See details next slide.)
- Jan. 2013 Global Hawk UAS Earth Venture ATREX (Atmospheric Water Vapor) project in Pacific to measure H₂O flux to Stratosphere.
- April/May 2013: IKHANA UAS arctic sea ice studies, J. Maslanik (U. Colo.).
- SIERRA UAS: 3 upcoming missions:
 - 1) NE CA Surprise Valley seismic fault mapping via wingtip magnetometer, early Sept. 2012;
 - 2) Sugarloaf Key, FL, new hyper-spectral sensor (not PRISM!) similar to GALILEO satellite to map coral reefs & seagrass for satellite cal/val.
 - 3) March 2013 Turrialba volcano, Costa Rica CO₂ flux study joint w tethered balloon.

NASA Global Hawk UAS Hurricane study

- 2012 mission late August-early October: 2 Global Hawk UAS
- Instruments on first Global Hawk UAS to study storms include: Scanning High-resolution Interferometer Sounder (S-HIS), Advanced Vertical Atmospheric Profiling System (AVAPS) (also known as dropsondes), and Cloud Physics Lidar (CPL). The Tropospheric Wind Lidar Technology Experiment (TWiLiTE) Doppler wind lidar to fly in 2013.
- Instruments on second Global Hawk UAS focus on interior of storm include High-Altitude Imaging Wind & Rain Airborne Profiler (HIWRAP) conically scanning Doppler radar, Hurricane Imaging Radiometer (HIRAD) multi-frequency interferometric radiometer, and High-Altitude Monolithic Microwave Integrated Circuit Sounding Radiometer (HAMSR) microwave sounder.

NASA UAS Ops (cont'd)

- 2012 Project ZEUS: UAS on Adventure Airship Zeppelin (to avoid FAA permission for UAS ops independently) test flight over L.A. w Picarro CH_4 sensor mapping La Brea Tar Pits plume =30X >background (@40ppm) vertically to 30K' high @>2ppm).
- 2012 NASA Ames gets @\$1M worth of Dragon Eye UASs from Marines/Dol: installs SO_2 sensors to map Turrialba volcano plume, Costa Rica for 2013 field campaign.
- 2013 CARVE (Carbon in Arctic Reservoirs Vulnerability Experiment), Charles Miller, JPL, PI. Using NASA SIERRA UAS for arctic CH_4 flux studies.



CULPIS-X Lidar in CG C130 FLIR tube...approval pending for external detector (basically telescope) about @4-6" cube. Allows ice ridge detection and mapping by laser.



NASA and ONR UAS Ops, continued

- Tom Wagner (NASA HQ) funds U. Colo. for CG C130 CULPIS-X lidar NAVAIR testing. U. Colo. submits CULPIS-X Finite Element Computer model to CG Engineers for review. If OK'd flights in spring 2013.
- ONR supported (M. Jeffries), Dale Lawrence and Axel Schweiger (PIs) development of small UAS dropsondes for deployment from back of CG C130s (not FLIR tube) to measure CCN (Cloud Condensation Nuclei) & cloud top/base altitudes.
- MIZOPEX (Marginal Ice Zone Observations and Processes Experiment) 2 yr project, using NASA IKHANA, G. Walker (UAF) ScanEagle & D. Lawrence micro-UAS. Flying from Oliktok Pt. to measure ocean skin temperature, also w imaging & sounding radars for ice thickness measurements in ice melt zones. Scan Eagle flights 2012, IKHANA 2013. Will use air dropped micro-buoys w 20m thermistor chains to get water temperature. Funded for 5 micro-UAS & 40 micro-buoys for offshore deployment. ScanEagles to fly over these mid-Sept. 2012. FAA COA request submitted.
- 2013: IKHANA to fly from Eielson , AK AFB to Oliktok Pt. and over ocean. NASA Dryden now working on FAA COA. NASA won't fly IKHANA <2000', so debating COA w FAA re offshore launch/recovery corridor restrictions (normally <2000'). [Had wanted SIERRA UAS, but booked. IKHANA lacks hi lat satcoms so requires modifications & also new sensor pod. ONR funded for 5 years to Mark Tschudi (U. Colo.)]

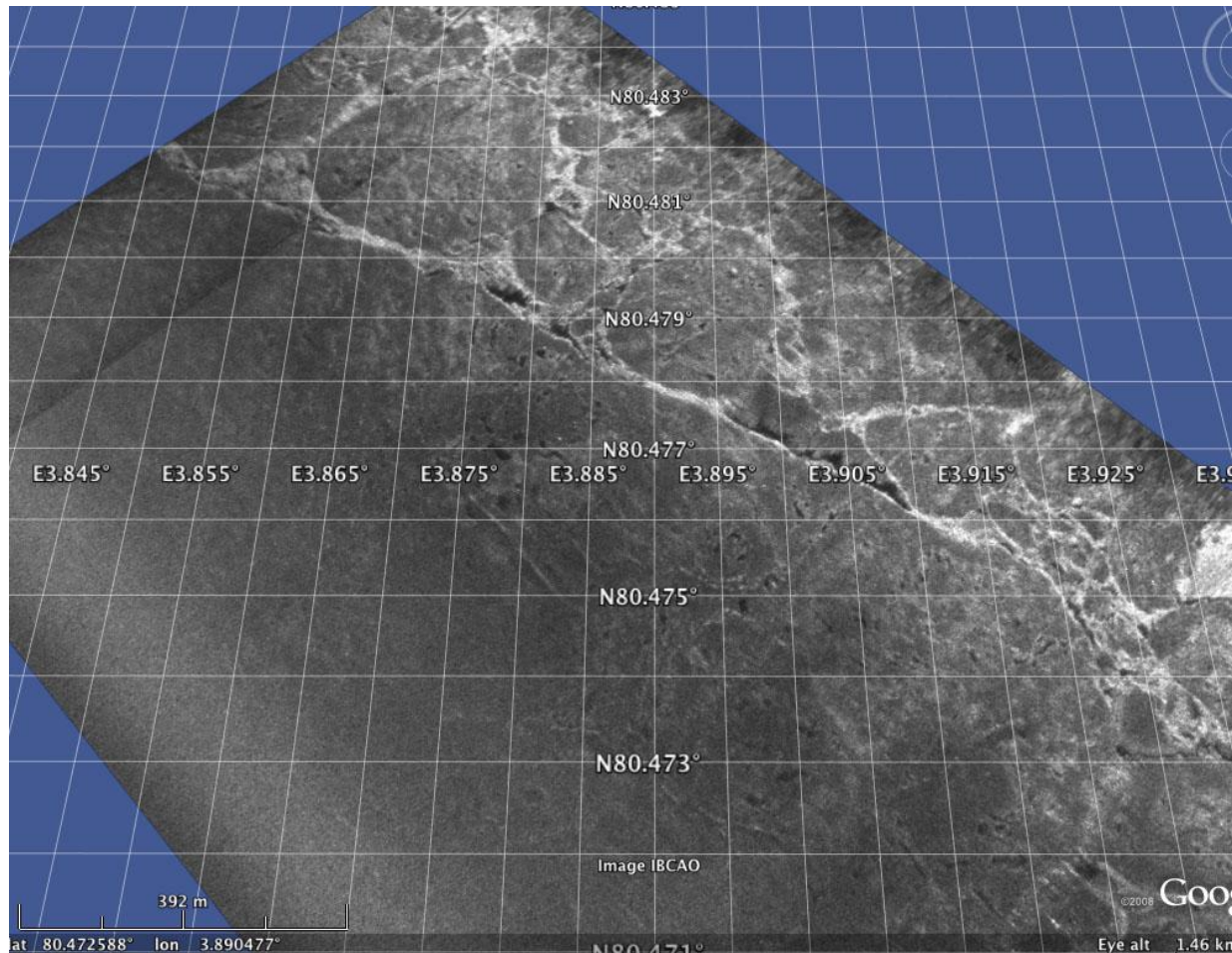
NASA UAS Ops, continued

U. Colo. UAS ops,
continued...Antarctica:
flew Aerosondes in 2010 in
John Cassano project
“Atmospheric Boundary
Layer & Katabatic Winds,”
hoping to continue
John Adler (NOAA & U.
Colo.) would like to access
Canadian airspace for
similar UAS ops.

NASA SIERRA UAS used by U.
Colo. at Svalbard, Norway, 2009
for ice albedo mapping



J. Maslanik (U. Colo.) UAS micro-SAR sea ice imagery off Svalbard, 2009, as example of resolution



NOAA PUMA use for NWHI (shown on right)

- NOAA to buy 2 PUMA Aerovironment UAS systems (of 3 UAS each) for NWHI debris, marine mammal & seabird studies after initial tests.
- Todd Jacobs NOAA UAS manager



German Alfred Wegner Inst. ElectroMagnetic ice thickness 'bird' deployed below helo, 6/18/12

<http://www.marinelink.com/news/northern-icefree-route345551.aspx>



**Dec. 2011: SeaShepherd NGO flies UAS from
M/V STEVE IRWIN in So. Ocean to track Japanese whalers**



2012 Greenpeace using UAS use in Arctic from M/V ESPERANZA

2012 M/V ESPERANZA in Chukchi w
2 Deepworker manned subs filming
abandoned oil drilling holes &
benthic hotspots. Alan Grieg using
2 “Flying Wing” UAS <400’ (“to avoid
FAA COA requirement”) for ice
surveillance to assist ship ops &
submersible launch/recovery.

UAS similar but different: One fully
autonomous, other Remotely
Controlled w video link from
onboard camera.

UAS from Ritewing Zephyr: wingspan
56”; weight @3 kilo, depending on
payload, battery, etc.; speed to 60-70
mph, usually 30-40mph; range @20-
30 min depending on battery.



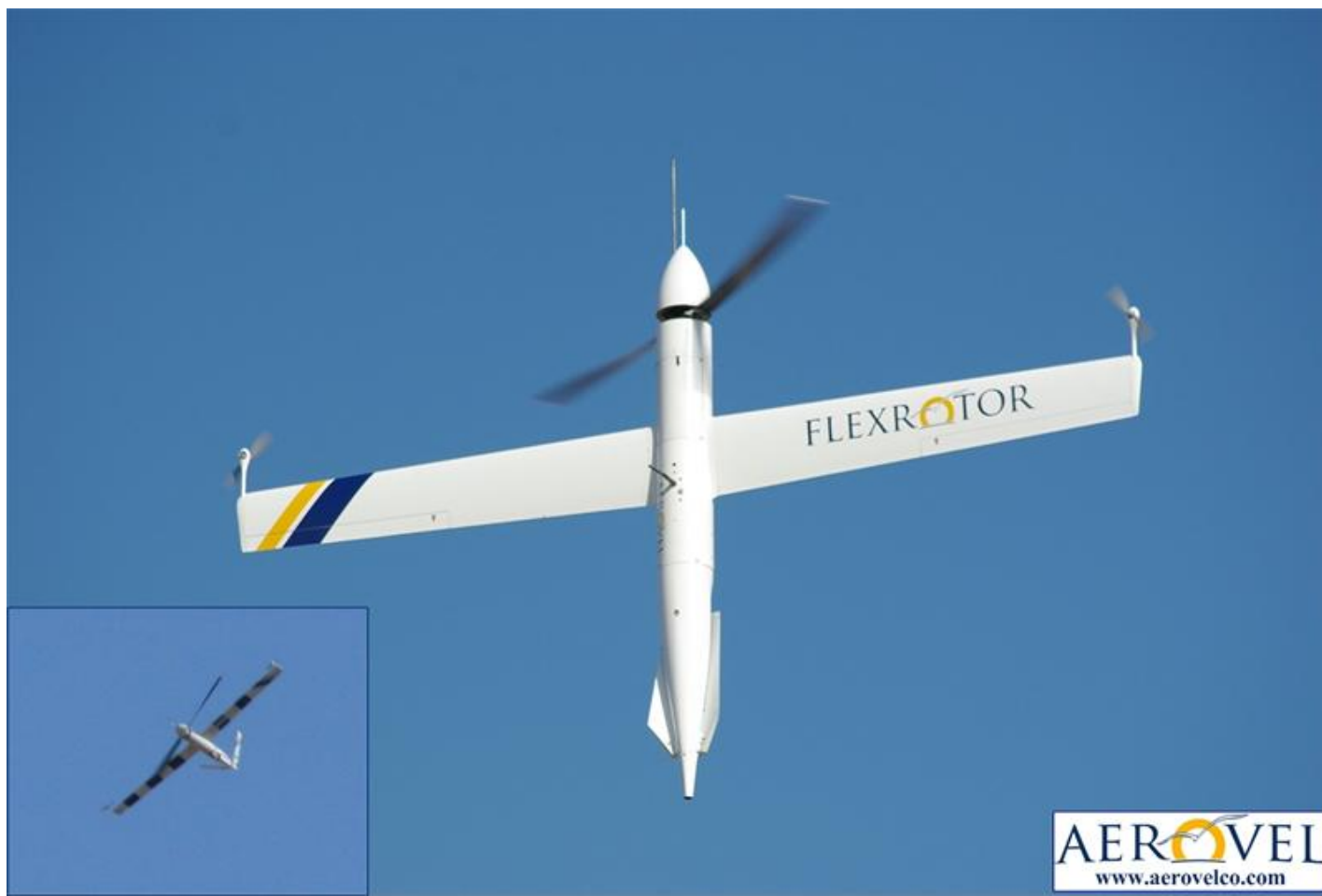
Additional UAS Updates

- Dec. 5-6, 2011 Airships to the Arctic VI Conf:
<http://www.airshipstotheartctic.com/>
- 4/2012: Boeing announces 20-lb fan-beam lidar for aircraft, UAS, to date only tested on balloons and helicopters however.
- 7/13/12: FAA FOIA request leads to release of all UAS COAs, including police & all Universities, see:
<https://www.eff.org/deeplinks/2012/07/faa-releases-thousands-pages-drone-records>

Aerovel Flexrotor: takes off and lands vertically;
converts to horizontal flight when aloft.

ONR contract May 2012:

<http://www.aerovelco.com/Flexrotor.html>



Strongest, lightest material developed: ideal for UAS

Alan Jacobsen (HRL Labs, joint w Cal Tech & UC Irvine) injects lattice tube grid w photosensitive resin , UV-hardens, then coats with nickel, and dissolves resin, leaving only hollow metal tubes. Coatings can be varied.

Strongest, stiffest, lightest material ever made: 99.99% air, 1/100th weight of styrofoam, but can carry a considerable load. Ideal for UAS.

See: Nov. 2011 Science:

<http://www.sciencemag.org/content/334/6058/962.full>

Pix: June 2012 Nat. Geographic

