USCG Report, SCOAR Meeting, June 4-5, 2014

Scripps Institution of Oceanography

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Ongoing CG Aircraft Oceanographic Research: NOAA

- NOAA Global Monitoring Division, Arctic Atmospheric Gas Monitoring from CG-C130s, P.I. Colm Sweeney
- 2013 flights:

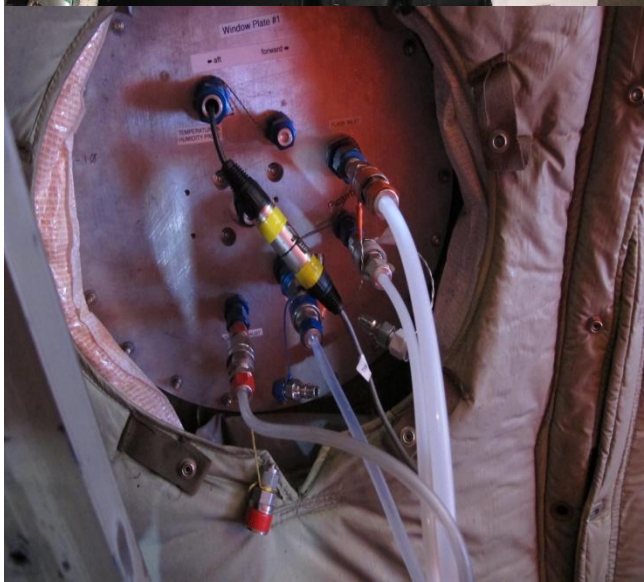
  April 23, May 21, June 18, 19, 20, 21

  July 16, Aug 13, 16, 17, and Nov 26 (though sampling problem meant no data on Nov 26 flight)
- 2014 flights currently done/scheduled:

  April 7-8, June 17, July 22-25 (w/ UW),

  Aug 12-14 (w/ UW), Sep 23-26 (w/ UW)

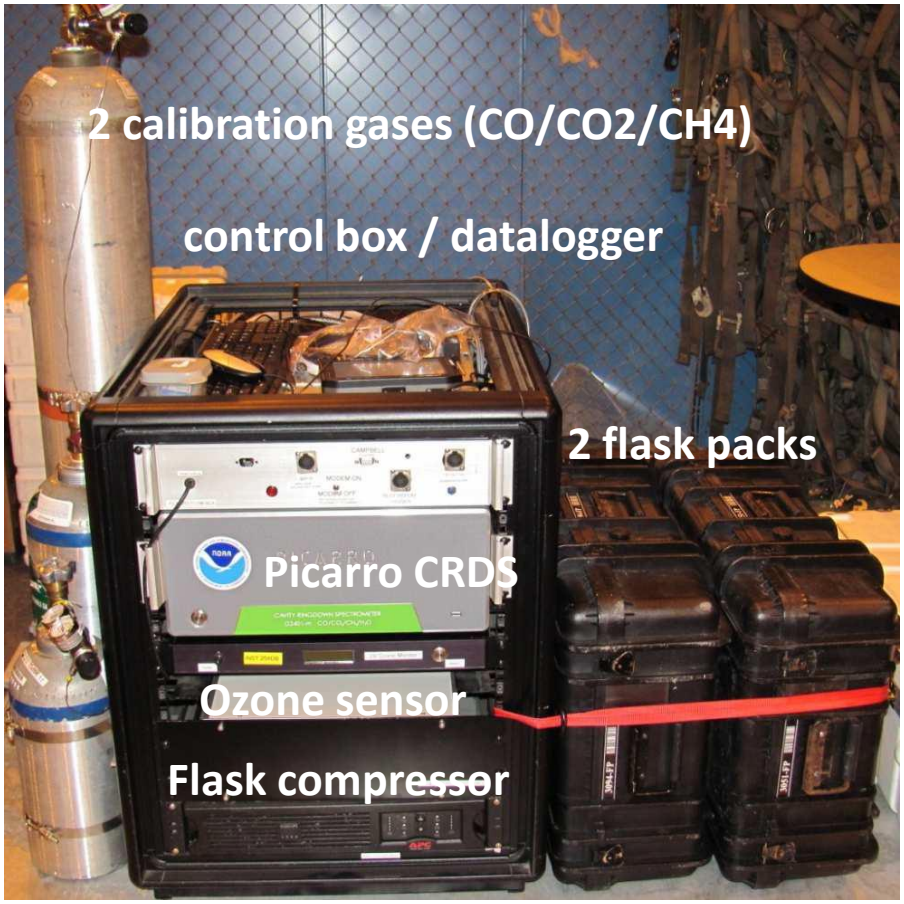
  Might be more in 2014: still TBD

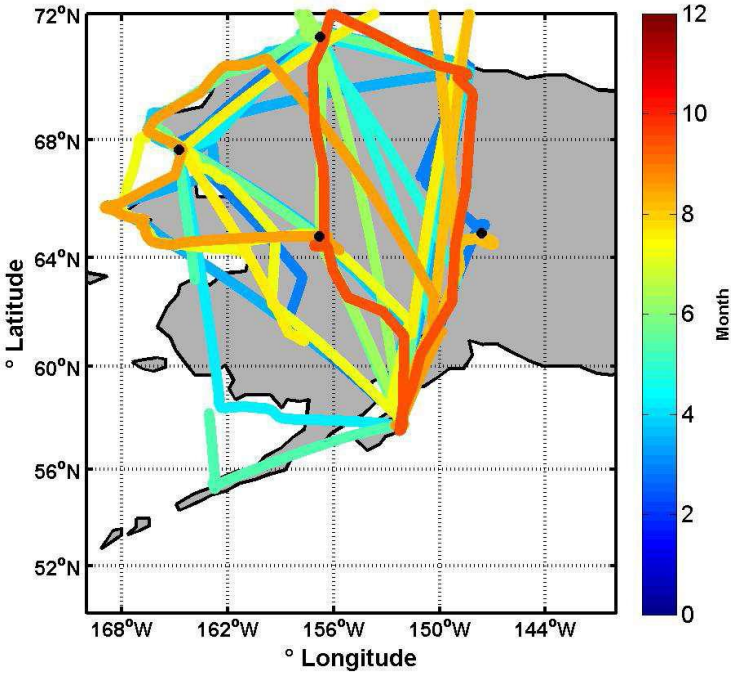


Ongoing CG Aircraft Oceanographic Research: NOAA

NOAA C130 program underway since 2009

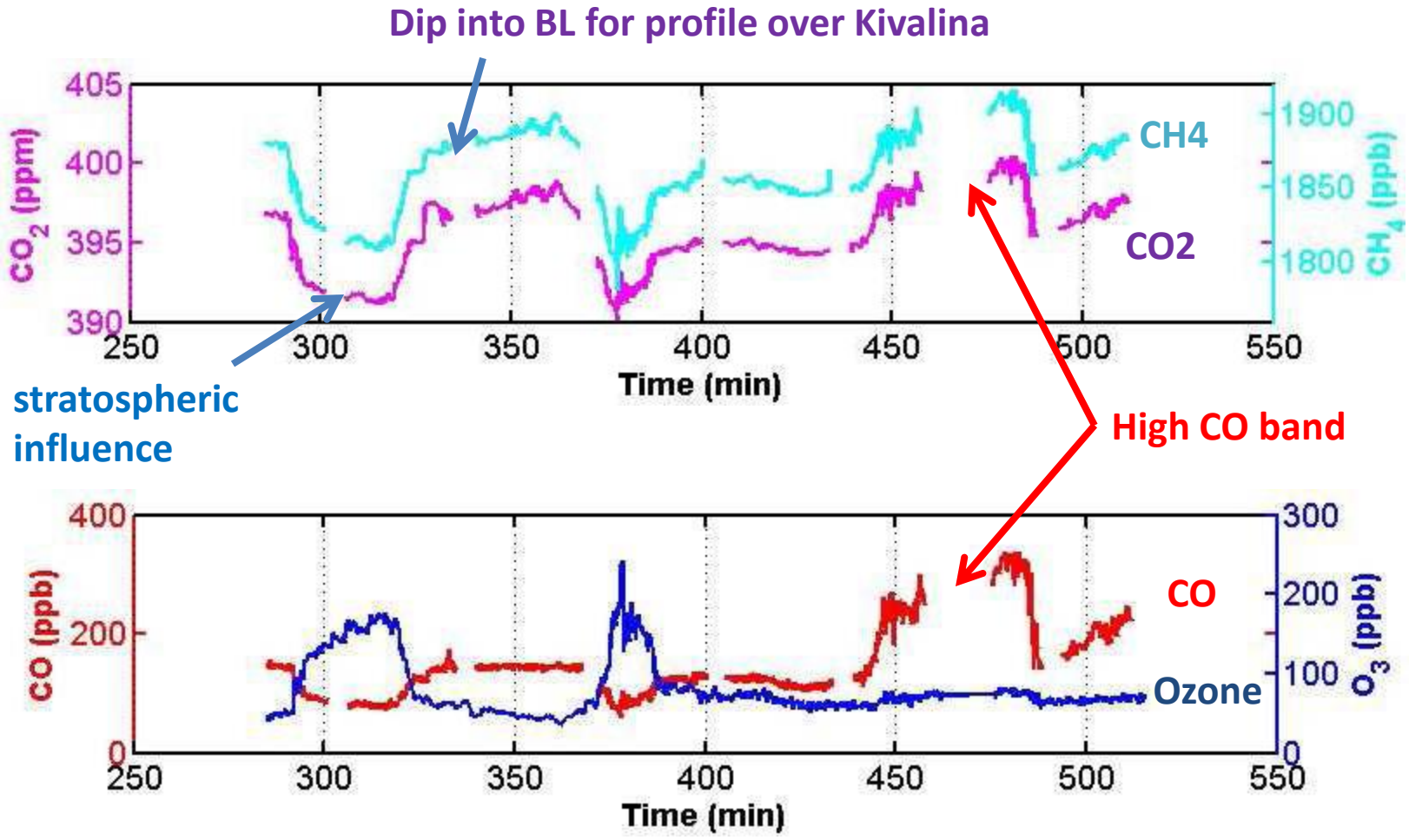
Below: Components of onboard atmospheric gas analysis system.





Above: Example of flight paths for one year of CG C130 flights for NOAA atmospheric sampling, generally Kodiak to Deadhorse to Barrow to Kivalina or Fairbanks, and return Kodiak.

Ongoing CG Aircraft Oceanographic Research: NOAA April sample gas results from one flight transect



Stratospheric air at high altitude shows hi O3, low CO, CH4, and CO2 (blue); polluted air (from Asia) w/ hi CO, CO2 & CH4 (pink). Higher CO2 & CH4 ~350 min at low altitude over Kivalina; do not correspond with hi CO, indicating natural source, eg wetlands.

Ongoing CG Aircraft Oceanographic Research: UW, Jamie Morison, PI

- Begun 2008, focus on data collection from ice melt season, including:
- Buoy deployments for International Arctic Buoy Program (IABBP);
- Typically 6 stations/flight deploying: Airborne eXpendable Ice Beacons (AXIBs); 1000m Aircraft Expendable Conductivity, Temperature, Depth probes (AXCTDs); and, Aircraft Expendable Current Profilers (AXCPs); and, Dropsondes for atmospheric temperature profiles
- Supports the Upper Temperature of the Ocean (UpTempO) project, and…
- Navy SIZRS (Seasonal Ice Zone Reconnaissance Survey) project

Fulfilling Coast Guard Arctic Strategy, released May 2013, to: "Assist government-sponsored scientific exploration to develop a greater understanding of the changing Arctic environment."

Ongoing CG Aircraft Oceanographic Research: UW, Jamie Morison, PI

SIZRS ADA missions are scheduled for :

- June 17
- July 22-25 four days w/ 2 overnights at Eielson
- Aug 12 (& 13,14 possible) w/ 2 overnights at Eielson
- Sept 23-26 four days w/ 2 overnights at Eielson
- Oct 14

Goal to overlap with ONR MIZ ops, and NASA MABEL (Multiple Altimeter Beam Experiment Lidar, on Proteus shown below, for IceSat-2 ice elevation calibration) and IceBridge flights.

CG UAS Ops, 2013

- USCG Icebreaker HEALY, Aug.6 – Sept.20, 2013, UAF Unmanned Aircraft Experimentation: USCG R&D Center (RDC), NORTHCOM & NAVY SupSALV re: oil spill response, incld. SORS (Spilled Oil Response System); and, “Polar Bear” skimmer, from RoClean Desmi Co., Finland.

- Flew two ‘Pointer Upgraded Mission Ability’ (PUMA) All Environment (AE) sUAS. One=NOAA PUMA flown by 2 NOAA operators; and, one=UAF and AFSOC PUMA with operator & technician funded by Center for Island, Maritime, and Extreme Environment Security (CIMES), the DHS Science and Technology (S&T) Directorate’s University of Excellence program center.

CG UAS Ops, 2013

- 2013 HEALY UAS ops=5nm from ship limit (NOAA)=not so useful
- Lessons learned:

1 - If 2 teams, let them schedule independently,
don't let one be 'in charge';

2 - Altitude separation helps w multiple UAS ops, also as possible separation of ops on ship (bow/stern), varied/alternated as needed.

3 - Schedule flights whenever there is downtime from other ops

4 - Avoid ops, esp. landings, at twilight/low light conditions; use UAS IR imagery as needed

5 - In advance of field ops, double check inter-agency UAS video delivery software performance/capability

6 - Waterproof UAS systems! Cannot be understated!

CG UAS Ops, 2013

- To -20^{o}C no temperature effect on PUMA LION batteries;
- Hi latitude compass data useless (+/-30 degrees), need GPS
- Icing can/did crash PUMA in @30 min.
- Human depth perception below 40’ altitude unreliable (re landing in leads, ie not crashing on ice)
- Video great during ops, but couldn’t be imported into ERMA* [*Since fixed we think! Testing in 2014.]
- No question UAS have potential for CG ops
- Desire to reduce paperwork permissions by:

  1) calculation of aircraft potential energy re impacts; and,

  2) pre-approval/paperwork for RFI/EMI comms interference

CG UAS Ops, 2014

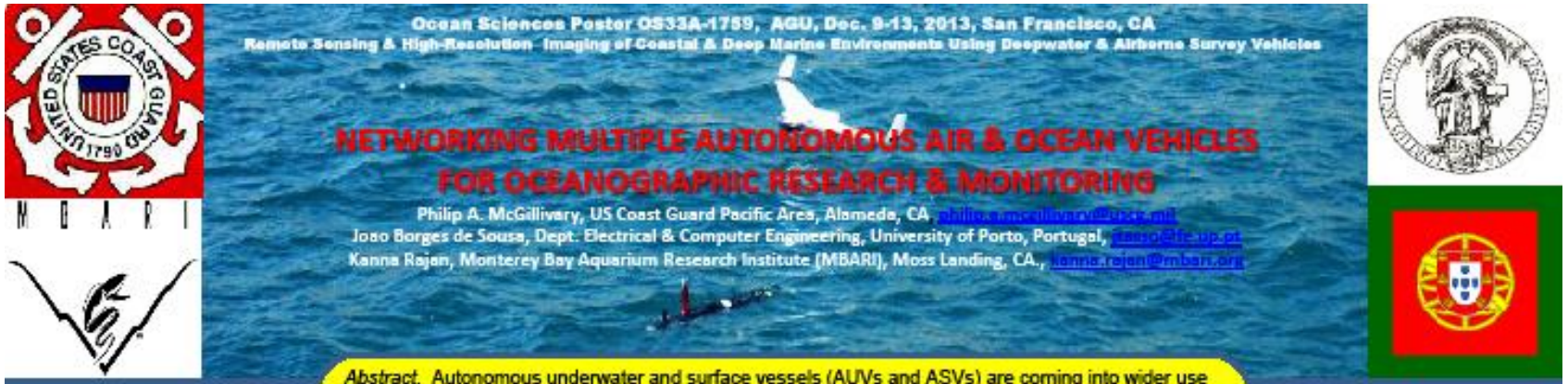
- CG RDC w upgraded NOAA PUMA deployments >12nmi offshore LOS only, this year test deck landings (vs water landings last year)
- Demo video integration into NOAA ERMA (vs not in 2013)
- Compare UAS w/ Aerostat ops re oil spill detection/response
- Not happening: coordination w/ Conoco-Phillips ScanEagle due to:

  1 - mandatory time requirements for govt & C-P legal paperwork

  2 - CG requirements for both NAVAIR & C4ISR & Cutter Configuration Control Board reviews. Also required: a Control Document, Engineering Change Proposal, Topside Analysis, and, Interim Authority to Test clearance. All these reviews require advance funding to CG RDC for implementation, failing which UAS ops not implemented.
- CG RDC plans to try to complete required paperwork by 2015 if C-P still willing to conduct joint operations.

PACAREA CG UAS Ops, 2013

Poster: AGU Dec. 2013 on UAS ops, Portuguese REP-13, July



Abstract. Autonomous underwater and surface vessels (AUVs and ASVs) are coming into wider use as components of oceanographic research, including ocean observing systems. Unmanned airborne vehicles (UAVs) are now available at modest cost, allowing multiple UAVs to be deployed with multiple AUVs and ASVs. Good communication and coordination among vehicles is essential for optimal use. We report on use of multiple AUVs networked in communication with multiple UAVs. The UAVs are augmented by inferential reasoning software developed at MBARI that allows UAVs to recognize oceanographic fronts and change their navigation controls. This allows UAVs to automatically map frontal features, as well as direct AUVs and ASVs to transit to such features and undertake sampling with onboard sensors to validate aerial maps. ASVs can also act as data nodes for communication between UAVs and AUVs, while AUVs can sample the water column vertically.

Below – AUVs used during REP 13 .

Below – UAV in flight during REP 13 .

PROJECT OBJECTIVES:

Combining UAVs, ASVs and AUVs allows improved phytoplankton biomass and productivity estimates, and with UAV air sampling can determine air-sea gas fluxes (e.g. CO2, CH4, DMS) affecting carbon budgets & atmosphere composition.

PROJECT ACTIVITIES:

Tests conducted in July 2013 off Sesimbra, Portugal with the Portuguese Navy had a goal of tracking large fish in the upper water column with coordinated air/surface/underwater measurements. An IR thermal gradient observed by a UAV was used to dispatch an AUV to obtain sea truth data to demonstrate the event-response capabilities using such autonomous platforms.

Photo left – Ship launch of modified X8 RC UAS atop control van using catapult .

Photo center – Antenna for communications & control of UAS .

Photo right – Recovery of UAV using net system mounted atop UAV control van .

FUTURE ACTIVITIES:

Future field studies will integrate multiple unmanned systems into ship operations. Hardware and software used will permit measurements of both ocean and atmosphere over spatial & temporal scales previously problematic.

FUTURE OBJECTIVES:

Methods demonstrated are well suited to studying ocean fronts or tracking & mapping oil spills and plankton blooms. With networked multiple autonomous systems individual components may be changed out while observations continue, allowing coarse to fine scale spatial studies over important temporal dimensions that would otherwise be difficult, including diurnal and tidal periods.

Above – AUV launch during REP 13 .

Summary: We demonstrated communication and control of multiple autonomous airborne, ocean surface and underwater vehicles to map ocean features using feature recognition and adaptive sampling software. Current constraints for these methods include coordination of data archiving with ship systems, familiarization of oceanographers with these methods, and meeting UAV airspace regulations. An important outcome of these methods is understanding the methodology for using multiple heterogeneous autonomous vehicles for ocean studies.

Above – AUV recovery during REP 13 .

PACAREA CG UAS Ops, 2014

Poster: Ocean Sciences, Feb.: Multi-UAS ops w/ “Albatross” flight.

Requires high resolution, real time pitch/roll/yaw, altitude & position info for accurate fused photo mosaic.

Technische Universität Hamburg-Harburg

NTNU – Trondheim
Norwegian University of Science and Technology

OPTIMIZING SURVEILLANCE BY MULTIPLE INTEACTING UNMANNED AIRCRAFT SYSTEMS (UAS) USING ADAPTIVE ALBATROSS FLIGHT CONTROLS

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Figure 1: Albatross fly many kilometers by dynamic soaring with minimal energy, which works best in seas with high winds.

ABSTRACT: Increased flight endurance for unmanned aircraft systems (UAS) is useful to improve surveillance duration and reduce launch and recovery logistics. To date technological approaches have largely focused on aircraft power systems. A more recent approach involves programming an individual aircraft to use albatross flight patterns: gliding in a vertically inclined figure path taking advantage of vertical differences in the distribution of wind speed and direction, and aircraft acceleration with changes in altitude to increase time aloft without additional energy expenditure. We extend this approach by proposing multiple interacting UAS using albatross flight patterns to evaluate the challenges to performance efficiency and optimization. This capability can be useful for three scenarios: 1) searching for and tracking objects on the sea surface; 2) mapping ocean surface features (e.g. fronts, oil spills); and, 3) mapping atmospheric features (e.g. gas or particulate plumes, or turbulence features). Conditions are evaluated over ice and ocean at various wind speeds and sea states to identify critical performance factors, capabilities and limitations of this method to optimize persistent surveillance of multiple interacting UAS.

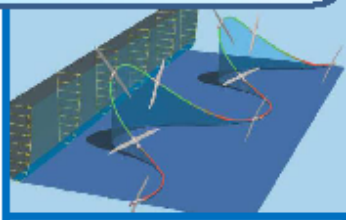


Figure 2: Albatross soaring relies on vertical wind change, resulting in vertical, horizontal & pitch/roll variations in trajectory (Sachs, 2005).

Use Case 1 - Frontal tracking & analysis:
Strong horizontal and vertical gradients in wind speed and direction at oceanographic fronts can be used by UAS for studies of these important oceanographic features.

Use Case 2 - Iceberg tracking & analysis:
Icebergs cause vertical winds which permit topographic soaring that can additionally be used to harvest wind energy for tracking and studies of iceberg effects on ocean ecology.

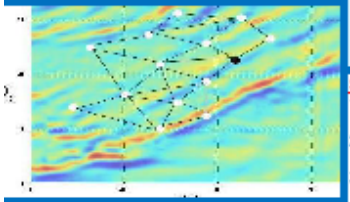


Figure 3: Trajectory planning can map thermal anomalies to abet soaring (Chakrabarty & Langelaan, 2010).

SUMMARY & CONCLUSIONS:

1) UAS wind speed and pitch & roll sensors can be combined with multi-AUV path planning algorithms for model-based field estimation modified to optimize wind field use for multi-UAS dynamic soaring.
2) A distributed network of multiple UAS with positioning sensors can provide accurate windfield measurement to optimize energy harvesting and anomaly mapping or feature tracking.
3) High bandwidth data streaming between multiple UAS and operators using Delay & Disruption Tolerant Wireless Networking (DTN) and optical stitching software abets UAS ocean studies.
4) We conclude field experiments using multiple UAS for dynamic soaring will be optimal in high wind ocean areas around icebergs or islands with steep topography. Use of multiple UAS for studies of oceanographic fronts or marginal ice zones provide other areas for further research.

Figure 4: Height and pitch/roll variations require position-based photo-stitching software (Chirayath, 2014).

References:
Allen, M. J. & V.Lin. 2007. Guidance & Control of an Autonomous Soaring Vehicle with Flight Test Results. *AIAA Aerospace Sciences Meeting, AIAA Paper* 2007-867, Reno, Nevada, January .
Bower, G., T.C. Flanzer and A.D. Naiman. 2010. Dynamic Environment Mapping for Autonomous Thermal Soaring. *AIAA Guidance, Navigation and Control Conference* Aug. 2-5, Toronto, Canada.
Chakrabarty, A & J. Langelaan, 2010. Flight Path Planning for UAV Atmospheric Energy Harvesting using Heuristic Search. *AIAA Guidance, Navigation & Controls Conference*, Toronto, Canada, August.
Chirayath. 2014. Optical software for image analysis from quadcopter drones. See: http://www.vedphoto.com/reactive-reefs
Edwards, D.J. 2008. Implementation Details and Flight Test Results of an Autonomous Soaring Controller. North Carolina State University, Raleigh, NC.
Hackbarth, A., Kreuzer, E., & Schröder, T. 2014. CFD in the loop - ensemble Kalman filtering with underwater mobile sensor networks. In *International Conference on Ocean, Offshore and Arctic Engineering*. ASME.
Makovkin, D. & J. Langelaan. 2014. Optimal Persistent Surveillance using Coordinated Soaring. *Procs AIAA Guidance, Navigation & Control Conference*, National Harbor, Maryland, January 13-17.
Richardson, P., 2011. How do albatrosses fly around the world without flapping their wings? In *Progress in Oceanography, Vol. 88.*
Sachs, G. 2005. Minimum Shear Wind Strength Required for Dynamic Soaring of Albatrosses. *Ibis* (147):1–10.

USCG PACAREA UAS Ops, 2014

- Ocean Sciences, Feb.: UNOLS booth display of UAS demo of "Fluid Lensing" method from Ved Chirayath (Stanford University) showing application for 3D mapping of American Samoa National Park corals. See: http://www.vedphoto.com

  (Apologies to Ved for not getting him in picture!)

USCG PACAREA UAS Ops, 2014

Hosted Stanford UAS Club talk by Finnish team w/ COTS quadrotor fan-beam lidar=cheap, <$5K, not super-accurate (>20cm) but adequate for ice ridge mapping; will improve w/ newer technology. Talk was by Tero Heinonen[1] & Anttoni Jaakkola[2] ([1]Sharper Shape, www.sharpershape.com , and [2]Finnish Geodetic Institute, both Helsinki, Finland).

Ref. Ms: Jakkola et al., 2010: ISPRS J. Photogrammetry & Remote Sensing, pp.514-522.

USCG PACAREA UAS Ops, 2014

Hosted Dmitri Tseliakovich, CEO Escape Dynamics, at Stanford UAS Club and NASA Ames for talks on coordinating field demo of UAS powering by microwaves using rectifying antenna on UAS. Planned for fall 2014.

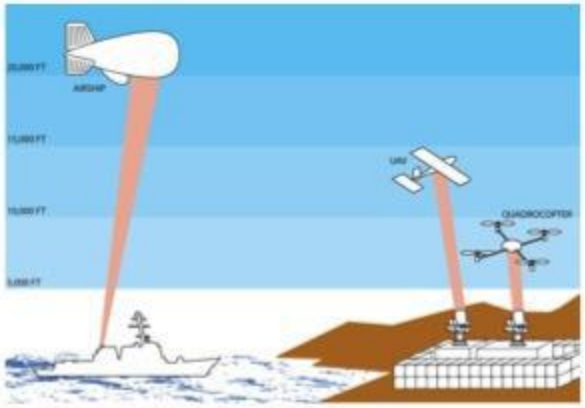
USCG PACAREA UAS Ops, 2014

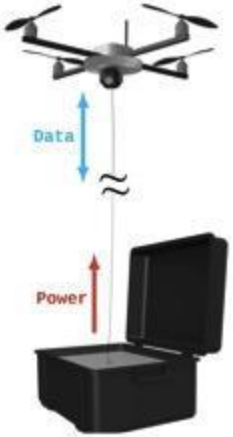
Still planning on trials with LaserMotive w/ NASA asap (fall 2014).

UAV Endurance via Optical Power

Optical power has:

- "Infinite" Endurance
- Low weight (1/100x solar)
- Long range, large power





Lightweight tether option

Tom Nugent: 253.872.3300
Tom.Nugent@LaserMotive.com

LaserMotive

USCG PACAREA UAS Ops, 2014
Norway, Iceland

- Continued work w NTNU, Trondheim on deployment by 2017 of national UAS coastal surveillance network.
- NTNU PhD student Kim Sorensen successfully developed and tested anti-icing carbon nanotube coating for UAS, which requires very little energy. Will be coming to NASA Ames fall 2014 to begin chamber and field tests of this treatment.
- NTNU UAS project manager Tor-Arne Johansen taking sabbatical (as of July 1) to Queensland Univ. Technology, Brisbane to work with UAS teams there, including deployment of multispectral sensors on UAS for stromatolites in Shark Bay, Australia. Will use same photo-transects conducted by Ved Chirayath (Stanford) and Pam Reid (RSMAS).
- Attempting to negotiate deal for Riegl $150K fan beam lidar (<10lbs, highly accurate <10cm) for ice ridge mapping

USCG PACAREA UAS Ops, 2014

Co-convened w. Google Oceans & Stanford Law School Center for Ocean Solutions Conference on Maritime Domain Awareness, which included multiple talks on UAS use, including by NOAA, NASA, CG, SPAWARs, InSitu. See: http://www.oceanagenda.org (Talks under "Blog"). Conference included Stanford UAS Club demo of Quadrotor flight on/off 16' WAM-V (http://www.wam-v.com). (See aerial pix of Conference attendees from Quadrotor below.)

USCG PACAREA UAS Ops, 2014
Mozambique / East Africa

Continued working w/ SPAWAR San Diego and Stanford Law School PhD student (K. Olemoiyoi) on IUU fishing off Mozambique and East Africa, including plans for deployment of three UAS in the countries' three Marine Protected Areas in Sept. 2014 as part of Conference on Mozambique's Oceans convened by Chissano Foundation (http://www.fjchissano.org.mz) of former President of Mozambique.

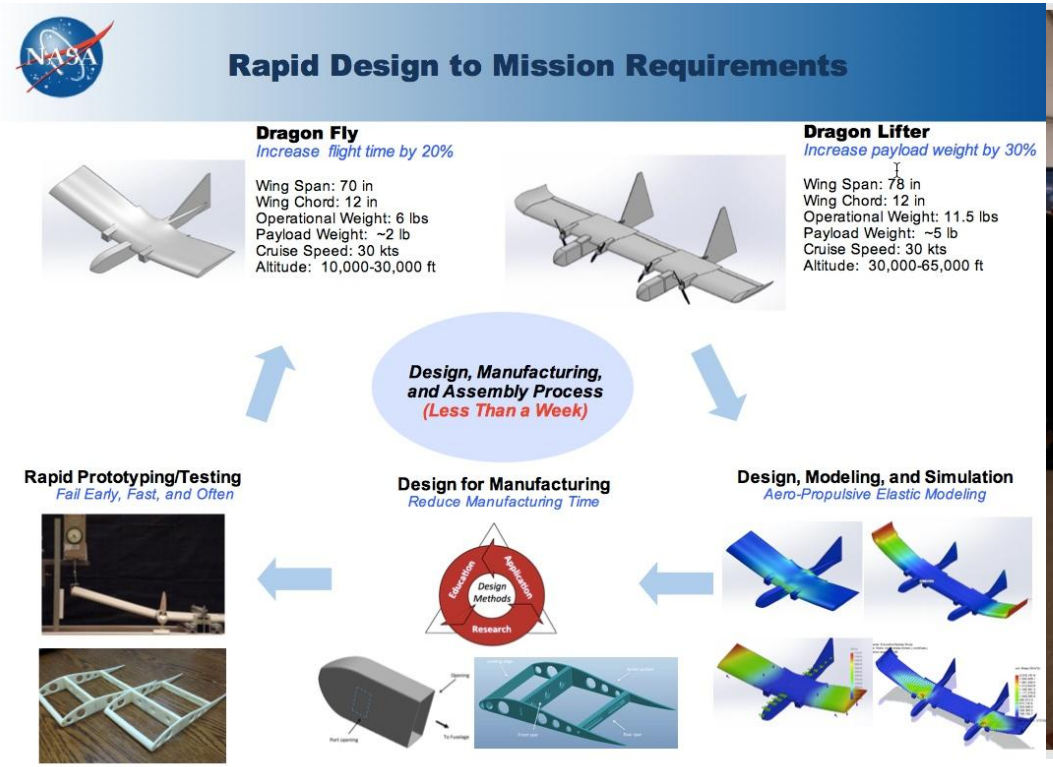
Mozambique has invested $272M for new tuna and patrol boats being built in France by CNM in Cherbourg for coastal MDA and IUU interdiction, which will include military UAS as part of their construction, c.f.: http://www.bloomberg.com/news/2013-11-13/mozambique-tuna-bonds-fund-anti-pirate-fleet-in-surprise.html

USCG PACAREA UAS Ops, 2014

Coordination with Shah Selbe, NGS Emerging Explorer, for use of UAS for conservation in Mozambique and other MPA areas.

USCG PACAREA UAS Ops, 2014

Cooperating with NASA Ames S-UAS group and Stanford University “Design for Manufacturing” course (in ME) on 3D printing of UAS parts. Allows rapid modification for laser or microwave repowering capabilities in wing design.



USCG PACAREA UAS Ops, 2015

- Coordinating w/ Maria Vernet (Scripps) use of multiple "Albatross" UAS and other unmanned systems to study Pine Island Glacier berg (B27) as it drifts across Ross Sea, Antarctica for iron meltwater fertilization effects on productivity/CO_2 fixation/fluxes.

UAS Legal doings in EU

- 2/17/14: France 1st country to establish UAS civil airspace legislation from French Civil Aviation Authority ("DGAC") by mid-2014 in association with Federation Francois de Drones: http://uasvision.us2.list-manage.com/track/click?u=a32b39b68dd99ad58d8db5aca&id=ece30c3685&e=9bb7d5959c . UAS Legislation is to be based on:

1) the notion of avoiding 'populated areas';

2) training requirements;

3) enforcement of laws against violators;

4) enforcement of existing privacy regulations (still TBD legally re UAS);

5) Enforcement of Airworthiness Certification per 12/24/13 French law.

- 1/28-30/14: Spain…Spanish ASEA (Spain's CAA) and AERPAS (Spanish RPAS Association) Workshop to establish RPAS legislation. Meeting was joint with EUROCONTROL & JARUS and included DGAC, see:

  http://uasvision.us2.list-manage1.com/track/click?u=a32b39b68dd99ad58d8db5aca&id=8a761a0e8c&e=9bb7d5959c

UAS Legal doings in EU

- 2/3/14: ULTRA project (Unmanned AerialL SysTems in EuROpean Airspace) funded by the European Commission 7th Framework Programme to propose, based on currently available technology, a way forward for the short term insertion of civil Light RPAS in European Airspace. Project finalized in Dec. 2013, plan presented at RPAS CivOps 2013 conference in Brussels, Belgium. Plan under "Deliverables" at:

  http://www.ultraconsortium.eu
- This study identifies gaps, suggests existing technology solutions, and identifies and addresses social concerns with a goal to speeding UAS (RPAS) use in EU civil airspace.
- This is an offshoot/extension of the earlier JARUS effort

  (see next slide).

UAS Legal doings in EU

- 1/29/14: JARUS delivers document “Scoping Paper to AMC RPAS.1309*” on UAS legislation for EU, available at the JARUS website under the “Draft Deliverables” tab at: http://www.jarus-rpas.org ;comments ended 3/28/14.

  [*AMC=Acceptable Means of Compliance; 1309=Regulation for Requirements of Certification]
- JARUS (Joint Authorities for Rulemaking on Unmanned Systems) is a group of experts drawn from national aviation authorities from around the world, including the European Aviation Safety Agency (EASA) and EUROCONTROL. Its purpose is to recommend a single set of technical, safety and operational requirements for the certification and safe integration of Remotely Piloted Aircraft Systems (RPAS) into airspace, see: http://www.jarus-rpas.org/

UAS Legal doings in USA w FAA (and Canada)

- FAA issues COAs to Conoco-Phillips Oil company, USCG, NOAA and NASA for UAS operations in 2013 from Oliktok Pt and Wainright, Alaska, completes Hotwash Report, is planning 2014 ops now.
- FAA signs MOU with Canada CAA to permit UAS ops across Canada. This allows for possibility of trans-Arctic UAS flights.
- 11/1/13 FAA signs MOU with Iceland for UAS ops there (jointly w UAF).
- 11/7/13: Natl. Res. Council Canada coordinates w COTS UAS maker Bricam Flight Systems on a Civilian UAS program, standardizing on their TD-100 UAS to develop 'sense & avoid' and anti-icing technologies.

http://uasvision.us2.list-manage.com/track/click?u=a32b39b68dd99ad58d8db5aca&id=3c35c40b3a&e=9bb7d5959c

UAS Legal doings in USA w FAA (and Canada)

- 3/18/14: FAA Awards UAS grant to Rutgers University to develop UAS, currently used by the military, for civilian use. FAA plan is to take results from the project to Congress to create more concrete parameters for UAS system designs, with a goal to create reliable UAS that can be integrated into civilian airspace with communication capabilities and airworthiness standards as important factors for certification:

  http://uasvision.us2.list-manage.com/track/click?u=a32b39b68dd99ad58d8db5aca&id=47b42eea94&e=9bb7d5959c

  This would address the issue that currently most FAA certified UAS are military, and standards are needed for certifying non-military UAS, but the FAA doesn't itself alone want to draw up standards.

UAS Legal doings in USA w FAA (and Canada)

- 3/31/14: FAA announces bids for UAS Center of Excellence for Unmanned Aircraft Systems to be selected within the next year, for criteria, etc., see:

  http://uasvision.us2.list-manage.com/track/click?u=a32b39b68dd99ad58d8db5aca&id=ddc755434d&e=9bb7d5959c

  Given they just selected 6 UAS Research Centers, unclear what exactly this is intended to be, although there was 'comment' that it was 'surprising' that Oklahoma's strong UAS program did not get accepted as a Research Center, so maybe this is a way to throw them some money…or…??? This is a hypothesis given a key CoE selection criteria of having "established a national UAS Air Transportation program," which U. Oklahoma has done. Will have to wait and see…

UAS Legal doings in USA w FAA (and Canada)

- 2/7/14: FAA announces that a contract has been let to Unmanned Experts LLC (UMEX) and Solentus to perform support services for UAS research within the FAA Office of Advanced Concepts & Technology Development for simulations at the NextGen Integration and Evaluation Capability (NIEC) lab to provide responses to various UAS in NAS scenarios (e.g., acceptability of control latency, level of workload, and timeliness of collision avoidance manoeuvre).
- This initial phase of work under this agreement is expected to be complete in April 2015.
- Keep in mind FAA has a goal of UAS incorporation into NAS by 2015. To some degree.

Recent UAS tech developments of note

- 3/24/14: Thales Stratobus = half drone, half satellite. Prototype due in 5 years for surveillance, comms, public events, etc.. 70-100m long, 20-30m wide.

  https://www.thalesgroup.com/en/worldwide/space/case-study/stratobus-halfway-between-drone-and-satellite

Recent UAS tech developments of note

3/12/14: Singular Aircraft Co. successfully demos floating UAS:

http://uasvision.us2.list-manage1.com/track/click?u=a32b39b68dd99ad58d8db5aca&id=7d61f480f8&e=9bb7d5959c

Recent UAS tech developments of note

Google-X buys Titan Aerospace to develop HALE (Hi-Altitude, Long Endurance) Solar UAS to act as ‘satellite’ to bring Internet to the ‘Unserved’ will provide useful info for USCG as well . Details still TBD.

Recent UAS tech developments of note

- 2/10/14: Queensland Univ. Technol. (Brisbane), working w/ Boeing, develops 1st successful onboard UAS "Sense & Avoid" system under direction of Duncan Campbell:

  http://uasvision.us2.list-manage.com/track/click?u=a32b39b68dd99ad58d8db5aca&id=2ce9caa994&e=9bb7d5959c

- Stanford invited Campbell as Distinguished Lecturer to discuss this

Recent UAS tech developments of note

- 2/24/14: Horizon Energy Singapore & Israeli co. announce first ultra-light H2 fuel cell for UAS..COTS used on BLUEBIRD UAS (see pix below):

  http://uasvision.us2.list-manage1.com/track/click?u=a32b39b68dd99ad58d8db5aca&id=c50e2d9945&e=9bb7d5959c

- 2/25/14: Pletek Consulting (UK) develops radar that can track small, slow-moving UAS, and distinguish that & birds, etc.:

  http://www.uasvision.com/2014/02/25/new-radar-technology-detects-small-uas/?utm_source=Newsletter&utm_medium=email&utm_campaign=79832e9637-RSS_EMAIL_CAMPAIGN&utm_term=0_799756aeb7-79832e9637-297552653

USCG PACAREA UAS/Aircraft Ops,

1933: ADM Byrd w/ CGC BEAR in Ross Sea, Antarctica
w/ PEP Boys Gyrocopter