Issue 35 Jan 2014

CRUSER NEWS

Consortium for Robotics and Unmanned Systems Education and Research

From Technical to Ethical...From Concept Generation to Experimentation

Contents

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The Use of Unmanned Systems for Environmental Sampling and Enhanced Battlespace Awareness in Support of Naval Operations

by Dr Peter Guest, NPS Faculty, Environmental Effects Group (EEG), Department of Meteorology
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I. Introduction

The general objective of this CRUSER-funded research in FY 2013 was to test and explore the potential use of unmanned aerial systems (UAS) for collection of environmental data in support of Navy missions. The special emphasis was on atmospheric factors that affect the transmission of radio frequency (RF) electromagnetic radiation. Understanding these factors is crucial to predict the performance of radar, communication, jamming and electronic surveillance systems. There were two aspects to this research: (1) performing key measurements in the Trident Warrior 2013 (TW13) field program and (2) testing the use of the InstantEye UAS as a platform for meteorological measurements.

II. Trident Warrior 2013

Trident Warrior 2013 (TW13) was a Navy operation which occurred off the coast of Virginia 13-18 July 2013. During TW13, the author and colleagues used the research vessel R/V Knorr as a platform for performing measurements using unmanned aerial vehicles (UAVs). These data were then input into the Navy's primary mesoscale (2- 200 km) weather prediction model, COAMPS, and the AREPS RF prediction model to test the usefulness of the UAV data in a simulated operational setting.
The primary UAV platform used was a Scan Eagle. These measurements were complemented by our radiosonde (weather balloons) and tethered balloon and kite system measurements (Figure 1). Due to lack of NAVAIR flight clearance, the author was not able to perform atmospheric measurement flights with a mini quad rotor UAV. However, kite and tethered balloon platforms served as close proxies for miniature UAV measurements (Figure 2).

Figure 1. Tethersonde operations from a small boat during TW13. A radiosonde (not visible) is attached below the balloon which is raised and lowered several times from 1 m to 200 m elevation. These measurements were a proxy for mini quad rotor UAV sampling of the atmosphere.

The author's kite and tethersonde measurements demonstrated the importance of low level features in controlling RF propagation over the ocean (Figure 3). Some of these features were too low to sample with the Scan Eagle and because they were not included as input into the prediction models, they were not forecasted. The author believes a viable alternative or complement for fixed-wing UAV measurements from platforms such as Scan Eagle for obtaining crucial information in the lowest 200 meters of the atmosphere (and especially the lowest 30 m) would be the use of mini quad rotor UAVs.

III. Mini Quad Rotor UAVs

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CRUSER's New Website is now Live

We're still at **http://CRUSER.nps.edu**, but check our new site for information on our monthly meetings, CRUSER sponsored events, CRUSER community-wide calendar items, Completed Research, other Resources, and much more.

Director's Corner

What an exciting time for the CRUSER community! Hardly a day goes by that does not include a major media outlet doing a story about drones and/or robots. The Navy and Marine Corps are both being seen as leaders in the domain with UCAV and mules both being the subject of lots of attention. Almost as exciting - CRUSER's new web site, optimized for viewing on mobile devices, went live this month! Check it out for the latest goings on in the COI.

Not all is going well, several major analysts have warned that the U.S. may fall behind in the robotics race towards the future due to over regulation. This makes is very important for the CRUSER community to remain engaged at all levels, from STEM to fielding systems, to ensure that policy makers and citizens are provided solid information and facts with regards to the promise of these systems to save lives and improve military performance. The next iteration of Robo-Ethics (see page 3) will tackle some of these issues head on.

Dr Ray Buettner, CRUSER Director

Springer Handbook on UAVs, forthcoming 2014. 2 Vols.

Edited by Kimon P. Valavanis and George J. Vachtsevanos

This forthcoming two-volume reference work is a comprehensive resource for the academic and research communities, industry, and governmental organizations that use Unmanned Aerial Vehicles (UAVs) in a wide spectrum of applications. The Handbook covers all aspects of UAVs, from design to users. It is an exhaustive reference to the literature for a wide spectrum of people and will be covering aspects such as science, engineering, development, design and modeling, applications, military and civilian use, suitable for not only those who need 'just information' about UAVs but also to the scientists, engineers and practitioners who work in the area of UAVs.

The handbook editors commissioned a special section on "ethical, legal and social implications" of UAVs, edited by NPS Professor George Lucas, and prepared with support provided by CRUSER. This section contains an introduction and brief survey of ELSI issues by the Prof. Lucas, and concludes with a transcript of his testimony on these topics for an investigative commission of the American Academy of Sciences/National Research Council, funded by DARPA. The section otherwise contains important reprints of peer-reviewed articles on "current and international governance" of UAVs (from the Columbia Science & Technology Law Review), ethical debates, pro and con, by computer scientists Ronald Arkin and Noel Sharkey, and a path-breaking work on UAVs and targeted assassinations by NPS Assistant Professor Bradley J. Strawser (from the Journal of Military Ethics).

For additional information: Dr. George R. Lucas, Jr. (Ph.D.), NPS Professor of Ethics & Public Policy, grlucas@nps.edu

Updated NPS UxS Bibliography Now Available

Dudley Knox Librarian Greta Marlatt updated the NPS CRUSER UxS Bibliography in December 2013
http://1.usa.gov/1hQmMVG

Unmanned Systems Integrated Roadmap FY2013 - FY2038

A 25-year technical vision of Unmanned Systems
http://www.defense.gov/pubs/DOD-USRM-2013.pdf

CRUSER Monthly Meetings

Mon 27 Jan, 1200-1250 (PST)
Mon 24 Feb, 1200-1250 (PST)
Mon 17 Mar, 1200-1250 (PST)

Root 272, VTC, or dial-in 831-656-6685
contact us at cruser@nps.edu for the passcode

Short articles of 500 words for CRUSER News are always welcome - cruser@nps.edu

- Unmanned Systems/Robotics research
- New Program/Systems/Projects
- Other aspect of Unmanned Systems/Robotics

AN INTEGRATED ARCHITECTURE OF LIVE, VIRTUAL, CONSTRUCTIVE AND AUTOMATED ELEMENTS FOR UAS EXPERIMENTATION AND TRAINING

by Tom Vogl, Rockwell Collins, Advanced Technology Center, tlvogl@rockwellcollins.com

Article by: Thom McLean, Jaclyn Hoke, Tom Vogl, Thomas Schnell

We describe an architecture developed by the Advanced Technology Center (ATC) at Rockwell Collins and the University of Iowa Operator Performance Lab (OPL) team to make use of both real and virtual worlds for exploration of new technical and training paradigms for unmanned airborne systems. The concepts are applicable for both military and civilian domains with applications extending from Concepts of Operation (CONOPS) development, to integration into the National Airspace Systems (NAS). This architecture is based on a unique live, virtual, constructive (LVC) experimental framework built over the last six years between ATC, OPL, and several government, academic and industry partners. The most defining characteristics of this framework are its ability to create composable systems, and its online, game-like persistence. Distributed operations with heterogeneous systems have been going on, virtually uninterrupted for the last three years. The second important characteristic of the Rockwell Collins LVC framework is the complexity of the Live participant integration. OPL has provided 24/7 access to two LVC capable training jets, one instrumented helicopter and more recently a Skunkworks QR425S Quadrotor Unmanned Aerial System (UAS) for the researchers to conduct concept of operations and technology maturation experiments. The network is always on and includes ground based flight simulators, the OPL jets, helicopter and the QR425S. A rich set of constructive (computer simulation) entities is provided by scriptable semi-automated forces (SAF) software. In this paper, we describe our experience and methodologies for creating persistent distributed networks for UAS research and training in a live, virtual, constructive, automated (LVCA) environment. We describe our techniques for virtualization and partitioning of airborne and ground-based systems. Finally, we present recent advances in datalink and networking technologies that allow low cost reliable connectivity of live assets with virtual simulations.

Contact Tom Vogl at tlvogl@rockwellcollins.com for a copy of this article

Upcoming CRUSER Sponsored Events

http://CRUSER.nps.edu for additional information on these events and the opportunity to participate remotely

Robo-Ethics San Diego 2014: 24 March 2014

Our third opportunity to explore some of the legal, ethical, cultural, and social issues arising from the use of unmanned systems/robotics. A panel discussion by leading thinkers with diverse perspectives. The panelists will each be given an opportunity to respond to a scenario, then a moderator will facilitate a discussion of these responses with audience questions incorporated into the discussion.

CRUSER TechCon 2014: 8-9 April 2014

This annual event gives NPS Faculty an opportunity to explore selected concepts developed during the September Warfare Innovation Workshop in support of our 3rd Innovation Thread - "Distributing Future Naval Air and Surface Forces." Faculty presentations will discuss how to prepare a concept for field experimentation over the following year.

4th Annual Robots in the Roses: 10 April 2014

CRUSER's annual event at NPS that features NPS Faculty and DoD Labs showcasing their researching which gives them an opportunity to recruit NPS Students to complete graduate-level thesis research in support of their projects. Robots in the Roses also features a STEM activity for K-12 students making it a great opportunity for children to attend a learn more about the unmanned systems and robotics.

STUDENT CORNER

Student: LT Joshua Weiss, USN

Title: Real-Time Dynamic Model Learning And Adaptation For Underwater Vehicles

Curriculum: Mechanical Engineering

Link to Completed Thesis: http://calhoun.nps.edu/public/handle/10945/37741

Abstract:

Precision control of unmanned underwater vehicles (UUVs) requires accurate knowledge of the dynamic characteristics of the vehicles. However, developing such models are time and resource intensive. The problem is further exacerbated by the sensitivity of the dynamic model to vehicle configuration. This is particularly true for hovering-class UUVs since sensor payloads are often mounted outside the vehicle body. Methods are investigated in this thesis to learn the dynamic model for such a hovering-class UUV in real time from motion and position measurements. Several system identification techniques, including gradient estimation, Bayesian estimation, neural network estimation, and recursive linear least square estimation, are employed to estimate equations of motion coefficients. Experimental values are obtained for the surge, sway, heave, and yaw degrees of freedom. Theoretical results are obtained for the roll and pitch degrees of freedom. The experimentally obtained model is then compared to the true vehicle behavior.

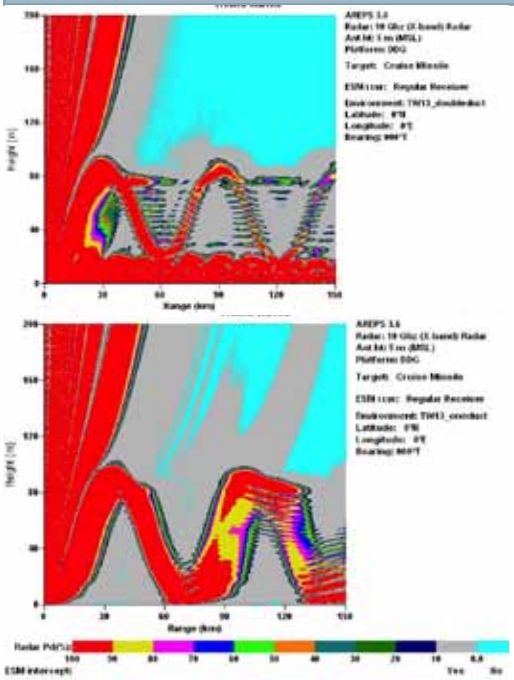

Figure 3 Top: AREPS predictions of coverage for X band radar based on the tethersonde data shown in Figure 2. Vertical axis is height and horizontal axis is range. Red indicates 100% predicted probability of detection. Bottom: The same prediction that would occur if the low level surface duct feature was not sampled, as would be the case for normal free balloon radiosonde measurements and most fixed wing aircraft. This shows that accurate radar performance predictions often require high resolution sampling of the lowest levels of the atmosphere, a measurement that requires special sampling techniques that could be performed by small quad rotor UAVs.

Continued from Page 1

The second main aspect of these CRUSER-funded efforts involved the testing of various UAVs as platforms for meteorological measurements. During TNT and JIFX field programs the author tested this concept on several UAV platforms using radiosonde sensors, including small delta wing types (not shown). Another tested platform was the InstantEye mini quad rotor UAV manufactured by Physical Sciences Incorporated (PSI).

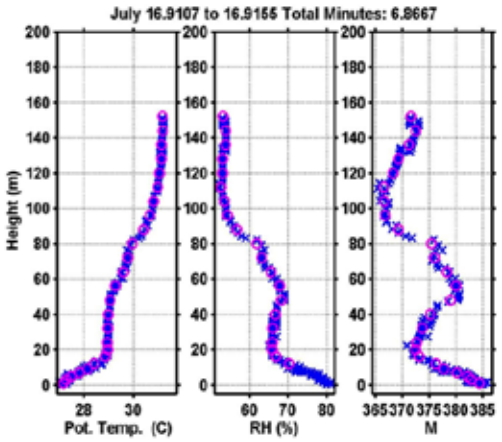

Figure 2. Tethered balloon (UAV proxy) profiles of Potential Temperature , Relative Humidity (RH) and Modified Refractivity (M) on 16 July, 2013 during TW13. Note the complicated low level structures in M, negative gradients indicate ducting conditions. These structures cannot be resolved by operational numerical models nor can they be sampled with normal radiosondes on free balloons or fixed wing manned or unmanned aircraft.

The author performed several tests (with PSI pilots) at McMillan field, Camp Roberts using the InstantEye UAV with radiosonde sensors attached. The InstantEye was flown next to an instrumented meteorological tower to quantify the accuracy of the measurements (Figure 4). The results show that InstantEye can perform accurate low level measurements of pressure, temperature and humidity. The air motion created by the propellers helps ventilate the temperature and humidity sensors, which is needed to prevent solar and infrared radiation contamination. In the lowest two meters above the surface, the downwash interacts with the ground and the mixing of this low level air layer creates some errors if strong temperature or humidity gradients are present. These effects need to be quantified more precisely.

1V. Conclusions

There is a need in the US Navy for more accurate characterizations of the RF environment than can be provided by numerical weather forecasts based on routine environmental inputs. The TW13 results showed that including in situ data from UAVs usually results in improved forecasts, but it is not clear if this improvement is worth the cost and logistical needs required. In the context of naval operations, the most valuable use of UAVs for atmospheric measurements appears to be in providing detailed information on current conditions rather than as input into numerical model predictions of future conditions. This means that an ideal UAV for use when there is a need to quantify refractive conditions should be rapidly deployable and easy to operate. Mini multi-rotor UAVs (InstantEye is one example) appear to be able to fill this role for characterizing low level RF refractive conditions.

Figure 4. InstantEye UAV with Vaisala RS-92 radiosonde attached on bottom. The UAV is hovering next to a temperature/humidtiy sensor (left side) to verify and validate the UAV/radiosonde measurements.