Wearable Control and Communications System for use with UAVs, UGVs and UGSs

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I. ABSTRACT

The US Marine Corps Warfighting Laboratory (USMC-MCWL) is currently funding the development of MOWC (Modular Wearable Computer), a ruggedized wearable computer and communications system to control its own Unmanned Assets for application in the Air (UAV-*DragonEye*), Ground (UGV-*DragonRunner*) and stationary Sensors (UGS-*SUSS*). This paper will present the details (architecture, engineering) and detail the tested prototype(s) and field-data gathered to date. The key to this system is to be seen in the successful development and demonstration of a (i) small-scale, (ii) ruggedized and (iii) ultra-portable unobtrusive control/communications system to allow a single field-operator in military conflict settings, to control multiple unmanned air-, ground- and sensory-assets using a single integrated system. The demonstration of this capability is an important milestone in advance of the development of the CC (*Centralized Controller*) being undertaken separately as part of the ongoing FCS program.

II. BACKGROUND

The urban environment is undoubtedly a center stage for future U.S. combat operations. Potential adversaries have studied past and present U.S. military operations and know that it is prohibitive to fight toe to toe, in open terrain, where air supremacy, fluid command and control, and joint interoperability are dominant. The realization is that to achieve success against such a force, one will have to pull it into areas where it is off balance: the urban environment being one such possibility. Confronting forces that use the asymmetric nature of urban areas to their advantage poses a real challenge to any military planners. This confined space battlefield limits the advantages of maneuver warfare, degrades the effective ranges of direct fire weapons, and limits the use of indirect fire weapons. In addition, the mixing of combatants and non-combatants remains a constant challenge.

Unmanned/robotic platforms have proven themselves in recent conflicts to be effective tools for dealing with these confined battlespaces in urban settings. The use of remote and/or robotic equipment has become a more common sight for forces operating on the ground, supported by UGVs and UAVs as part of their maneuvers. These systems are controlled by operators in the field, which have themselves many other jobs and need to carry a substantial equipment load that does not leave much spare room, if any (see Figure 1),

Figure 1 : Overloaded infantryman

for additional control equipment. The challenge to be faced by the development program detailed herein, was how to allow a single human operator control over diverse ground (UGV, UGS) and air assets in support of their platoon (or larger entity's) operations on the ground, with only a single light, small and intuitive control, communications and power-support system, without overburdening them with even more bulky and heavy gear.

III. INTRODUCTION

The Naval Surface Warfare Center, Dahlgren Division (NSWCDD) is currently supporting the development of the Modular Wearable Computer (MOWC), an effort funded by the Marine Corps Warfighting Lab (MCWL). The goal of this effort is to prove the notion that a modular, lightweight, wearable Ground Control Station (GCS) can be developed for the control of a suite of unmanned sensor systems, whether ground- (UGV, UGS) or air-based (UAV). Specifically, the U.S. Marine Corps (USMC) is interested in achieving a common-use GCS for (i) its Unmanned Ground Vehicle (UGV) platform Dragon Runner, (ii) its Unattended Ground Sensor (UGS) SUSS, and (iii) its Unmanned Air Vehicle (UAV) Dragon Eye (being replaced by Raven) and Wasp (small-scale hand-launched UAV). These systems are depicted in Figure 2.

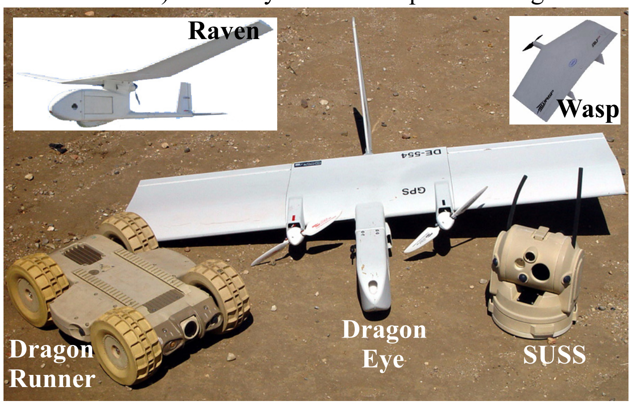

Figure 2 : USMC-sponsored UAVs, UGV and UGS

This common GCS also aims to improve operator performance by reducing training time, combat load and fatigue, and by increasing usability, sensor flexibility, commonality, situation awareness and mobility over baseline operator control units (OCUs). The program is focused on the development of a prototype MOWC system that is usable, does not interfere with the warfighters' gear or their ability to conduct tactical combat operations, and does not diminish the tactical capability of any baseline ground/air system (UGV/UGS/UAV). Following development, the MOWC prototype system will be subjected to extensive testing in a Limited Technical Assessment (LTA) of the technology.

IV. REQUIREMENTS & SPECS

The programmatic requirements stated clearly that a single wearable OCU was to be able to control all the main USMC Uxx assets, including Dragon Eye (now Raven), Wasp, Dragon Runner and SUSS.

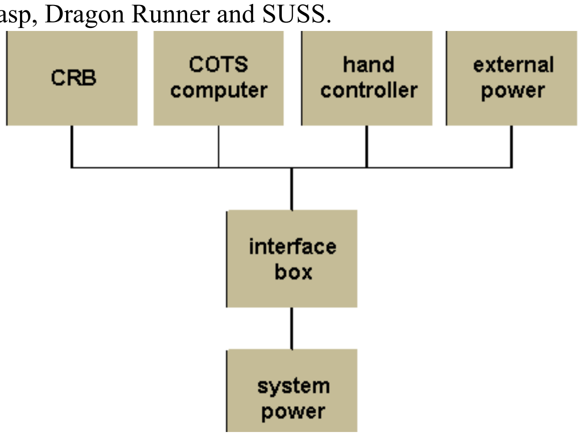

Figure 3 : USMC-sponsored UAVs, UGV and UGS

The main elements common to all these systems was early on identified as (primary) the RF-unit and control/ communications electronics and (secondary) the central computer and the battery-power unit. System commonality was also present and enforced at the radio-unit hardware (supplier and frequencies) level. The type of central computer was suggested to be common and low-cost, driving the selection to a COTS system - a Win-based OS was required in order to run the UAV mapping software. The battery-power was required to be hot-swappable and portable, but without yet requiring a Mil-Spec option (due to CONUS testing only). The man-machine interface controller was selected based on the ***PortaCon*** handcontroller for Dragon Runner and SUSS, and upgraded to include a larger dual-mode (NTSC & RGB) video screen and appropriate input devices (button, toggles, joysticks, etc.). Additional requirements were placed on the system in terms of size and weight, interface types and standards, packaging, dust/rain resistance, etc. The overall functional diagram provided by MCWL/ NSWCDD for the overall system is shown in Figure 3.

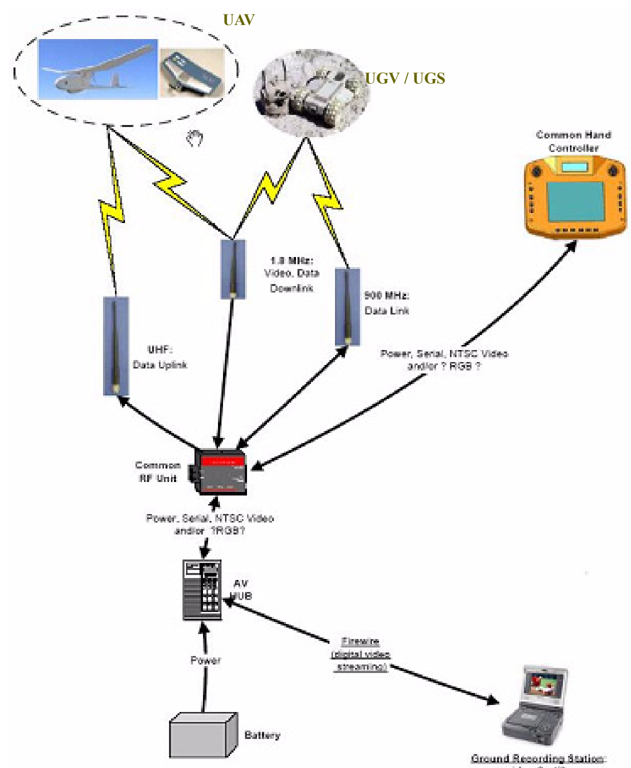

Figure 4 : Overall MOWC Architecture Layout

V. SYSTEM DESIGN

The ***MOWC*** system architecture is based on a modular principle for its main components: man-machine interface, radio-unit, CPU processing unit and battery power-module, allowing for technology upgrades over time (see Figure 4). The main elements of the ***MOWC*** system include the (i) Common HandController (CHC), (ii) the Common Radio Unit (CRB), (iii) the Kontron CPU and dock-module, and (iv) the hot-swap battery-unit. The development was undertaken as a joint effort between Symbionics (Kontron-CPU & Battery), AeroVironnment (UAV Control CPU, DEye/Wasp UAVs), Automatika (CHC electronics, DR-UGV and SUSS-UGS) and Carnegie Mellon (CHC Housing, RF-stages, Control-CPU and systems integration).

A layout of the system depicting these elements in the final design stage in CAD, is shown in Figure 5 (excluding the CHC).

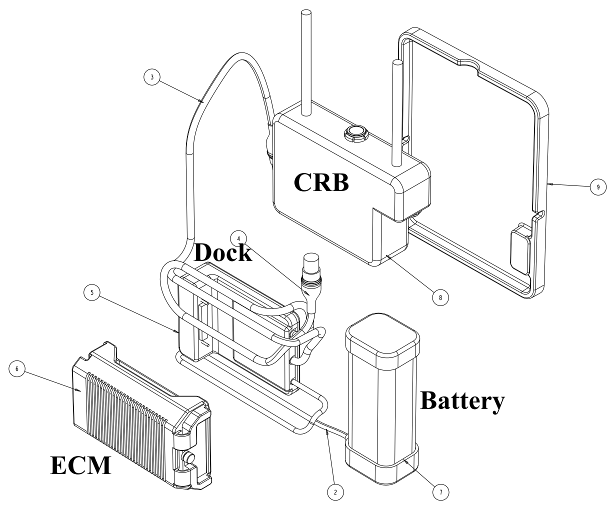

Figure 5 : MOWC-I System - Overall exploded Assembly

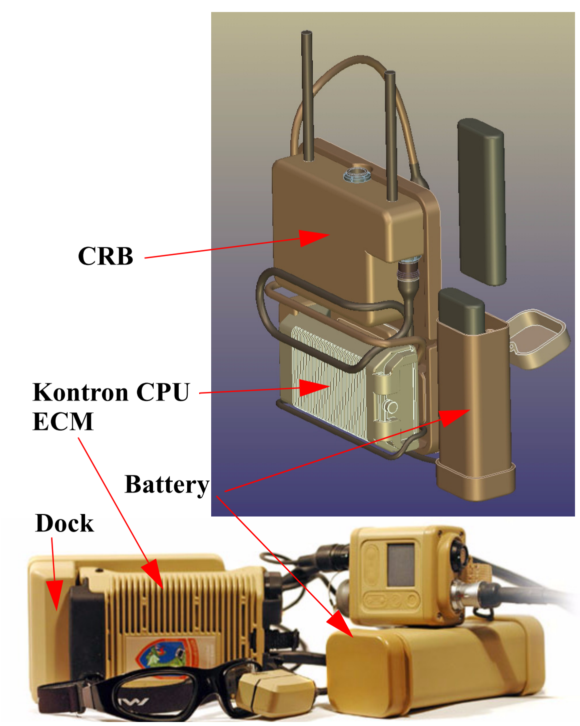

Figure 6 : MOWC-I System View - excl. CHC

The design of the integrated system is reflected in Figure 6. An OEM-supplied Kontron ruggedized PC-CPU was mated to a custom mating-dock, providing for access to all the I/O, including, RGB video, USB, serial/ethernet, etc. The power-module was wired to the CPU-dock to allow for hot-swapping batteries, housed in a separate container and controlled through a soft-switch on the dock. The CRB is connected to the CPU for power, data and video, while also providing antenna-connections for video/data links, as well as a bulkhead connector for interfacing the CHC. A see-thru view of the CAD-version unit and the final prototype, are shown in Figure 7.

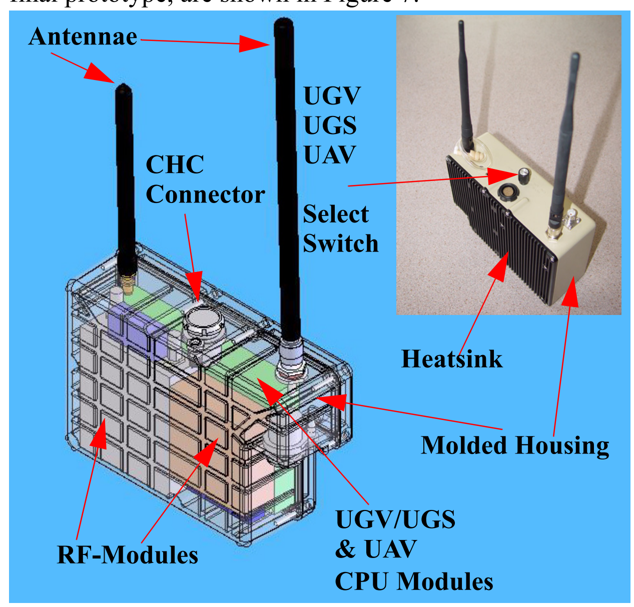

Figure 7 : MOWC-II's CRB - See-thru and prototype

The CHC is based on the ***Dragon Runner*** UGV hand controller. The electronics are identical, with modified interfaces for a size-increased transflective daylight readable display capable of NTSC and RGB input (switchable). A new housing was designed to house the OEM electronics and upgraded display and drive/ backlight electronics - it is shown in Figure 8:

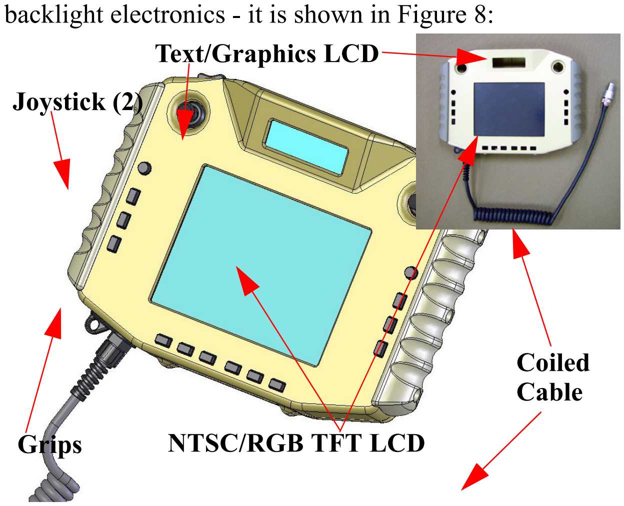

Figure 8 : MOWC-II CHC - CAD & Prototype

The control overlay (3M glue-on decal) was laid out with the assistance of the human-factors engineer from the NSWCDD. The prototype overlay for button- and joystick-mapping to capture the UGV (Dragon Runner), UGS (SUSS) and UAV (DEye/Raven/Wasp), is depicted in Figure 9, and depicts the different hard-button mappings for all Uxxs (black) and specific button functionality mapped to UGVs (green), UAVs (blue) and UGSs (red). Cutouts in the overlay are to accommodate the TFT color display (center), the LCD alphanumeric display (center-top) and the two 2-axis joysticks (top-/left & -right).

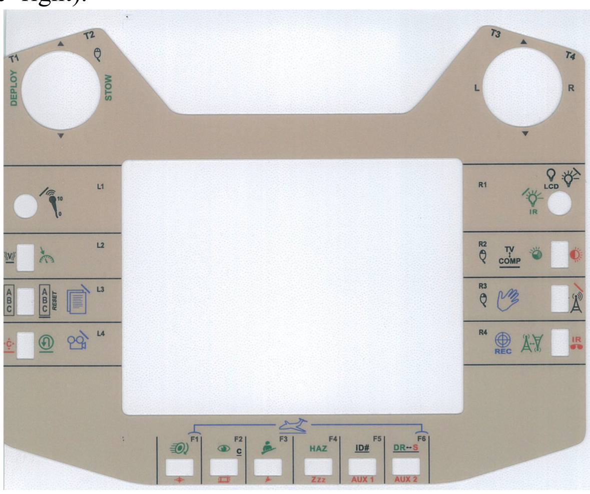

Figure 9 : CHC I/O mapping overlay decal for Uxxs

The backpack design was based on a modified Tsunami-pack, where only the shoulder-/backstrap portion was reused, with two custom pouches added to carry the ***MOWC*** unit. The bottom pouch houses the Kontron-CPU and battery-module, while the top pouch houses the CRB, with reinforced penetration for antennae and wire-passages between pouches.:

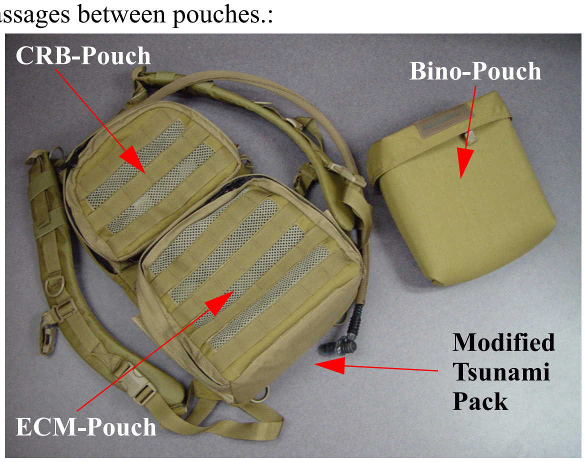

Figure 10 : MOWC prototype backpack unit (bino-pouch for optional AV-hub hardware)

The entire system is worn as a backpack, with the retractable cord connecting the CHC to the CRB running through the shoulder-strap and allowing the CHC to be hooked into the same using a carabiner (when not in use). The modified OEM prototype unit is shown in Figure 10.

The electronics interconnect diagram for the MOWC-system is shown in Figure 11. Notice that power is supplied by the battery pack to all subsystems.

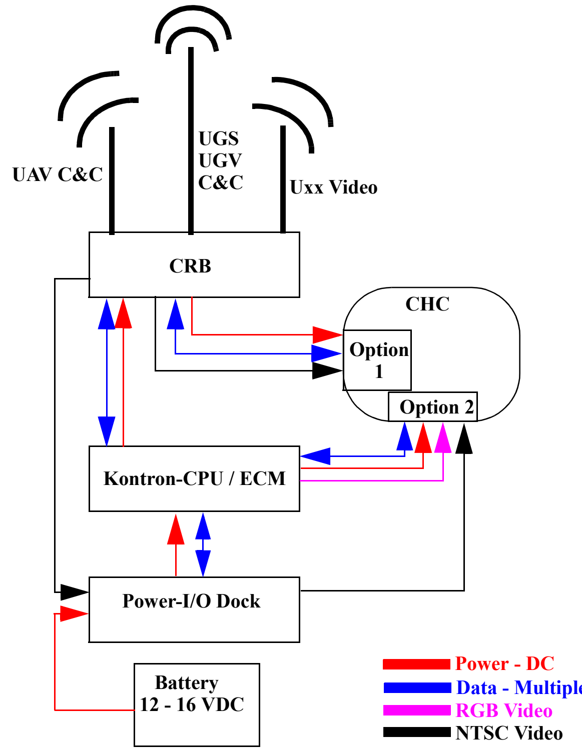

Figure 11 : MOWC Interconnect Wiring Diagram

The Kontron-CPU (or ECM) runs all the data-processing and command-and-control (C&C) software and communicates to the CHC for input commands it relays to the Uxx via the CRB, while receiving status messages from the CRB, which it processes and sends to the CHC for display or embeds in an RGB video signal. The CHC is able to be connected to the MOWC by either (i) the CRB (Option 1), or (ii) the ECM (Option 2). In both cases video is sent to the CHC, while Option 2 also offers RGB video tot he CHC. The CHC is able to be switched between the two source-types (analog NTSC and RGB), depending on whether the operator chooses to watch raw video from the UXX, or computer-processed/displayed data (such as from *FalconView*^{TM} for the UAVs) on the daylight-readable backlit TFT LCD display.

The software architecture from a high level perspective is identical to that for the individual Uxx systems. The UAV data stream (when in UAV mode) is passed through by the CRB to the ECM for processing; control data-streams from the ECM are forwarded to the UAV C&C-radio when in UAV mode, and to the UGV/UGS C&C-radio when in other modes. The video coming from the Uxxs is both available (NTSC) at the CRB, as well as passed through to the ECM in digital form for inclusion in the RGB display signal, allowing for dual connection options for the CHC.

All button-pushes and joystick commands are digitized and forwarded to the ECM, where they are processed based on which mode the CRB control-switch (OFF, Uxx) has been set to. Application-specific software runs under the Win OS to interpret and decide on the actions taken (data sent to the CRB for UXxx control, or to the CHC for display/operator-feedback).

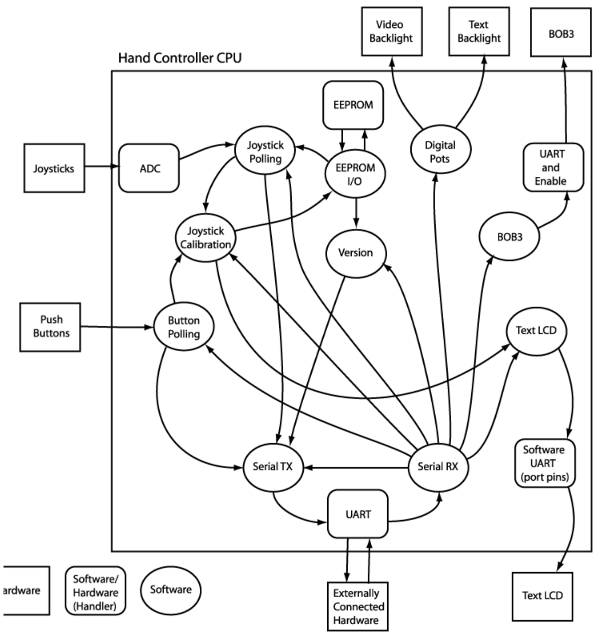

Figure 12 : CHC software-task and -interconnect chart

As an example, the CHC-software has been structured using a real-time 8-bit microprocessor OS/scheduler, running multiple software threads, servicing the individual hardware elements of the CHC. A software-module and -interconnectivity diagram is depicted in Figure 12.

VI. PROTOTYPE OVERVIEW

The main components of the ***MOWC-II*** unit, including the CHC, CRB and ECM + Dock as well as all wiring harnesses, and the backpack they all are fitted into, comprise the main elements of the system. Their benchtop interconnected layout is shown in Figure 13, as is an arrangement of both the pre-packed and fully enclosed MOWC-II unit. Notice that the CHC also includes a tethered touch-pen (housed inside coiled-cable for transport). The batteries are no longer housed in a separate enclosure like in MOWC-I, but rather included (allowing access for interchange) as part of the base of the dock the ECM is mated to.

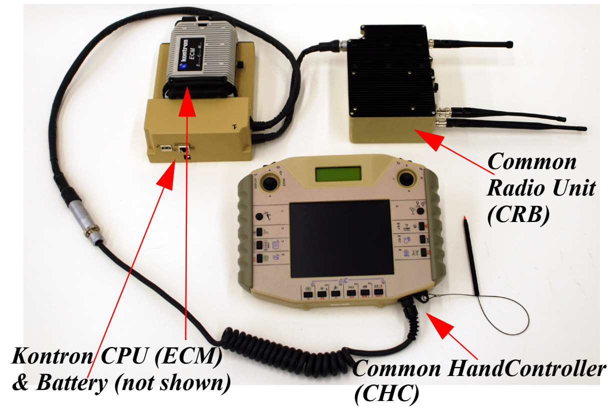

Figure 13 : MOWC-II prototype unit elements

Figure 14 : MOWC-II backpackeable unit configuration

Wearability was another critical aspect of the final prototype. The ***MOWC-II*** prototype unit is assembled and using a typical flak-jacket and military attired individual. The CRB and the ECM+Dock were fitted into a modified Tsunami backpack, with larger pouches and reinforced harness-wiring and antenna-port feedthroughs (see Figure 14). The CHC interconnect-cable was fed through the shoulder-strap (user can pick left/right strap) to bring the connector-mate over the desirable shoulder and closer to the unit itself. The final worn assembly is depicted in Figure 15.

Figure 15 : MOWC-II prototype wearable configuration

VII. PROTOTYPE TESTING

The prototype MOWC-II unit was functionally tested with the Dragon Runner (UGV) and SUSS-II (UGS) units in early May 2008, and delivered to NSWC-Dahlgren and USMC-MCWL (see Figure 15).

Figure 16 : MOWC-II with DR and SUSS-II

Interoperability testing, to include UAVs (Raven and Wasp) will take place later in summer 2008, when CMU, NSWC and MCWL are planning a week-long Limited Technical Assessment (LTA) in California with all ground and air assets, to evaluate the performance of the MOWC-system when operated by DoD personnel in a combined system setting.

VIII. FUTURE PLANS

The MOWC system will continue to evolve over time, pushing the boundaries on size-reduction and even broader interoperability for the ever-growing ground and air assets, including the ability of combined UGV/UGS operations as well as potentially USV integration for sea-to-shore operations. It is clear that interoperability and cooperative operations are the way of the future, where we expect MOWC to play a substantial role in paving the way.

IX. ACKNOWLEDGEMENTS

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We wish to further acknowledge the participation in this multi-phased program by Symbionics (Kontron-ECM Integrator), Icuiti (now Vuzix; *MOWC-I* ECM-dock, I/O box and power-unit), IPT (*MOWC-II* ECM-dock & power-unit), and AeroVironment (*CCB-Lite* RF-Avionics).

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