ARMY RESEARCH LABORATORY

Controlling Unmanned Systems in a Simulated Counter-Insurgency Environment

by Bruce S. Sterling and Chuck H. Perala

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14. ABSTRACT
The U.S. Army is planning for future operations in a counter-insurgency (COIN) environment. A characteristic of this environment is random encounters with small bands of insurgents who are conducting hit-and-run missions, versus more conventional enemy formations (e.g., brigades, battalions) or more conventional terrain-oriented missions (e.g., attack, defend). In a virtual reality experiment at the Unit of Action Maneuver Battle Lab at Fort Knox, Kentucky, we examined the workload and stress of participants controlling unmanned aerial vehicles (UAVs), unmanned ground vehicles (UGVs), and unmanned ground sensors in a COIN environment. Results showed that workload and stress for all the independent variables that we examined were less than half the possible scale level. Workload and mental stress were higher for specific COIN-type missions (e.g., over-watch raid on safe house, locate vehicle-borne improvised explosive devices) than for more conventional missions (e.g., route or site reconnaissance). Workload was higher for participants in combat vehicles than at headquarters and for participants in infantry vehicles in particular. Mental stress was highest for participants in mounted combat vehicles. Workload was higher for participants controlling both UAVs and UGVs. Stress was about equally high for operation of one or both types of sensors. Workload and stress were about equally high for simultaneous versus sequential operation of sensors, but because of the type of control involved, participants could only view images from one camera at a time in both types of operations. Recommended interface improvement included the ability to easily change unmanned vehicle (UV) routes, automatically track a target, rotate the camera while flying, send a UV to a given grid coordinate, see grid coordinates more easily, improve simulated night vision, provide multiple simultaneous video camera feeds, and provide an interface to improve situation awareness (e.g., mission overlays, chat capability).

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1. Introduction

1.1 Project Background

Modern combat frequently involves asymmetrical operations. Instead of fighting structured enemy forces consisting of brigades, battalions, companies, and platoons, oriented on attacking or defending traditional objectives, coalition forces of the ongoing Global War on Terrorism often find themselves battling small groups of insurgents who quickly appear, strike at a target, and then blend with the local populace. This type of numerous, small group operation warfare is quite different from traditional warfare.

Moreover, future operations will often be in support of an existing local government. Thus, it is important for coalition forces to appear as supporting the forces of the existing local government in order to add legitimacy to that government, as opposed to acting independently. The demands on reconnaissance assets in this environment are quite different from those of traditional reconnaissance. Typically, reconnaissance assets acquire information and pass that information to local government forces for action. In future operations, targeting for long-range fires for coalition forces (a typical mission for Future Combat Systems [FCS] reconnaissance assets) will be the exception rather than the rule.

The goals of the exercise named "Urban Resolve[1]" were to establish a legitimate functioning government with a self-sustaining legal economy that provided essential services and security and served the rights and interests of all its citizens in a peaceful and stable environment. The background (or "road to war") for achieving Urban Resolve's goals was through a counter-insurgency (COIN) experiment, set in the 2015 to 2016 time frame. In this experiment, Operation Iraqi Freedom ends in 2009, with the establishment of a viable Iraqi democracy. In 2010, Baghdad is stable and prosperous. The prosperity leads to an influx of poor, rural immigrants from throughout Iraq. By 2012, the infrastructure of Baghdad is deteriorating under its population load, and the central government has not adequately funded its repair and upgrade because of the funding of projects elsewhere in Iraq. By 2013, the Baghdad local government seeks greater economic control and political autonomy. By 2014, the majority of the Baghdad local government resigns and becomes the core of a growing insurgency. By 2015, the government of Iraq asks for help from the United Nations (UN) in quelling the growing insurgency and restoring order to Baghdad. A UN task force deploys in April 2015 and in five days, completes major combat operations, defeating organized resistance. In May 2015, 30 days after the end of major combat operations, stability operations are complete. This is the beginning of Urban Resolve (the previous series of experiments). At the completion of Urban Resolve, the Joint Task Force (JTF) forces are deployed in

[1] A Soldier-in-the-loop simulation exercise conducted by U.S. Army Training and Doctrine Command battle labs to explore challenges encountered by coalition forces operating in an urban, counter-insurgency environment.

the Baghdad area. The JTF continues full spectrum operations in the area of responsibility. The JTF strategy is to isolate and control remaining insurgents.

This sets the stage for the current COIN experiment. In this experiment, the Iraqi Prime Minster requests U.S. and coalition forces to remain in support of national elections scheduled for 31 January 2016. The U.S., coalition, and Iraqi forces coordinate COIN operations to counter increased violence, and the national elections become the focus of operations.

In this context, it is critical to “put an Iraqi face” on all activities. That is, the coalition forces must stay in the background, providing information to Iraqi forces, who mostly interface with the public and take direct action. The coalition forces act directly and independently only when directly threatened or when Iraqi forces are unable to cope with the threat and request support.

The workload and stress for operators of robotic surveillance platforms involved in supporting diverse missions in COIN operations are not currently known. Relevant missions for this environment include raids, monitoring or quelling civil disturbances, mounted and dismounted patrols, fixed site security (e.g., providing protection of election sites), route security and convoy operations (e.g., very important person [VIP] escort, resupply convoy escort), Army air space command and control (e.g., reaction to unknown aircraft), quick reactions (e.g., to kidnappings, hijackings), and operating different types of robotic reconnaissance assets (i.e., unmanned aerial vehicles [UAVs] and unmanned ground vehicles [UGVs] as well as unmanned ground sensors [UGSs]). A somewhat related study by Parasuraman, Galster, Squire, Furukawa, and Miller (2005) found that operators controlling simulated robots in a computer game had higher workloads when opposing forces were organized in a defensive formation versus an offensive formation.

There is limited information concerning workload and stress involved for operators in different duty stations in COIN environments. Prior research (Sterling & Perala, 2007) suggested that operators of unmanned vehicles supporting infantry troops incur higher workloads, possibly because of the increased vulnerability of dismounted Soldiers.

The workload and stress involved in controlling different types and numbers of robotic assets during asymmetrical operations are not well known. Prior research on control of robotic sensors in a virtual environment shows that control of multiple robotic sensors results in higher workload levels than control of single robotic sensors (Chen, Durlach, Sloan, & Bowens, 2005). The same research also indicates that operators detected no more targets with three robotic sensors than with one. Furthermore, fewer participants completed the mission within the time limit using three sensors versus using only one, possibly because of the increased workload associated with controlling three robotic sensors simultaneously. These findings parallel those of Dixon, Wickens, and Chang (2003) who found that pilots controlling two UAVs detected fewer targets than pilots controlling one UAV. Similarly, Rehfeld, Jentsch, Curtis, and Fincannon (2005) found that in a virtual urban environment and in difficult scenarios, operators detected fewer targets operating two robotic sensors than when operating only one. Sterling and Perala (2007) found that operators using UAVs, UGVs, and UGSs had higher workloads than operators using only one or two of these unmanned sensors.

1.2 Research Objective

This research had four main objectives. The first was to determine the workload and stress of universal controller (UC) operators for different missions in a virtual COIN environment. Missions included raids, monitoring or quelling civil disturbances, mounted and dismounted patrols, fixed site security (e.g., providing protection of election sites), route security and convoy operations (e.g., VIP escort), Army air space command and control, and quick reactions (e.g., to kidnappings, hijackings). The second was to determine the workload and stress of UC operators in different duty positions (e.g., infantry vehicle, armor vehicle, company or squadron headquarters). The third was to determine the workload and stress of UC operators controlling different types and numbers of sensors (e.g., single UAV, multiple UAVs; UAV and UGV, etc.). The fourth was to determine what human factors changes need to be made in the UC in order to facilitate Soldier-system interface.

2. Method

2.1 Instrumentation

2.1.1 Interface

The UC system used in this experiment consisted of a keyboard, mouse, joystick, display, and software. Figure 1 shows the UC input device used during this study. Figure 2 shows a screenshot of the UC display. The UC operators used the mouse to select the robotic asset they were going to control (one at a time) from a menu of possible assets assigned to them. Robotic assets included UAVs, UGVs, and UGSs. Once selected, the UC operators then used the mouse to plot the route for the robotic asset on a situation map displayed on the monitor. They could use the keyboard to assign the altitude (if a UAV), speed, and radius of the surveillance circle when the sensor reached its location. After the route and other attributes were assigned, the plan was executed and the robotic asset automatically followed the assigned route. If the sensor detected a potential target, it placed an icon of the target on the situation map. A view of the sensor's camera display was also available on the monitor. Operators could use the joystick to control the camera view. After operators classified, recognized, or identified the target, they provided a spot report concerning the target via the software interface.

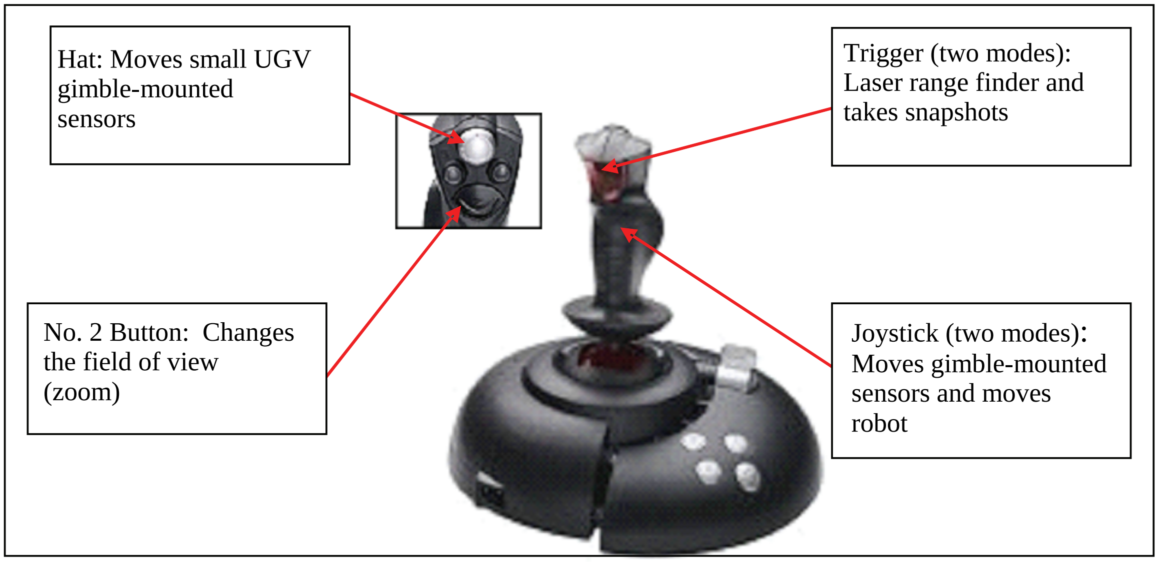

Figure 1. Universal controller input device.

Figure 2. Universal controller display.

2.1.2 Demographic Questionnaire

A brief demographic survey was administered to collect background data such as gender, age, rank, time in service, and experience with operating robotic entities and various control devices. The survey is included in appendix A.

2.1.3 Workload

To measure subjective self-ratings of perceived workload, the NASA-Task Load Index (TLX) was used. The NASA-TLX (Hart & Staveland, 1988) is a multi-dimensional rating procedure that derives an overall workload score based on ratings from six subscales. The subscales include Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort, and Frustration. Each subscale is rated on a 20-point scale, with a total possible workload of 120. Ratings are collected via a questionnaire. This instrument is included in appendix A.

2.1.4 Subjective Measures of Stress

A one-item rating scale was used to measure perceptions of physical stress and mental stress. These measures were used in previous research involving future battlefield scenarios (Perala & Sterling, 2007). The scales are adapted from Fatkin's work on stress and salivary amylase (Fatkin & Hudgens, 1994; Hudgens, Malkin, & Fatkin, 1992; Hudgens, Malto, Geddie, & Fatkin, 1991). These scales are in appendix A.

2.1.5 Interview

An interview was conducted with the UC controllers to examine human factors issues with the interface and workload. The questions are in appendix A and responses are in appendix B.

2.2 Participants

Seventeen participants volunteered as UC operators of robotic sensors in the Unit of Action Maneuver Battle Lab (UAMBL) COIN experiment. All participants were at least 18 years old and consisted of 15 males and 2 females. Among the participants, 15 were active duty Army Soldiers and 2 were civilian contractors. Of the 15 military, six were military occupational specialty (MOS) 19D (Scout), two were 19K (Armor Crewman), two were 11B (Infantry), two were 96B (intelligence analyst), one was 25B (Information Systems Operator-Analyst), one was 25U (Signal Support Systems Specialist), and one was 63X (Vehicle Maintenance). Of the military participants, four were Specialists (E4), three were Sergeants (E5), four were Staff Sergeants (E6), and four were Sergeants First Class (E7). Mean age was 32 years, mean time in service and MOS (for military) was 7.5 years, with 28 months mean time in current grade. Of the military participants, 12 had been deployed to a combat zone, with 11 in Iraq and one in Afghanistan. Mean time in the combat zone was 14 months. Of the 16 who reported dominant hand, 12 were right handed (four left handed). Participants had taken part in an average of 2.1 previous virtual reality experiments. Type of experience with controlling robotic entities is reported in table 1. Nearly all experience was with simulated UVs. About half (nine) had at least some experience controlling unmanned vehicles (UVs) using fixed UCs; most (11) had experience controlling UCs using other joysticks and controlling simulated UVs; and nearly all (15) had experience in computer games in which a vehicle was controlled. Only one had experience controlling UVs in an operational setting and only four had experience controlling live UVs in non-operational settings, or controlling UVs with a dismounted controller.

Table 1. Experience with UCs and UVs.

Amount of Experience	Fixed UCs	Dismounted UCs	Other Joystick UCs	Simulated UVs	Live UVs - Operational Setting	Live UVs – Non Operational	Games Where a Vehicle is Controlled
None	9	13	6	6	16	13	2
Basic	5	2	6	4	1	2	8
Intermediate	0	0	2	2	0	0	4
Advanced	3	2	3	5	0	2	3

2.3 Training

Participants received a week of UC operation training from experienced battle lab personnel for the robotic reconnaissance assets embedded in the force structure and missions described. Although there was no formal test to determine proficiency, the trainers ensured that each participant was adequately trained to perform his or her role before the start of the experiment, through observation and understanding of the participant's actions.

2.4 Procedure

The workstation consisted of the apparatus described in the interface section, situated on a table. Participants sat at each workstation in an office-type chair and operated the UC. Each experimental session began at approximately 0900 each morning and ended at approximately 1700 each afternoon, with at least a 1-hour lunch break around 1200 each day. Participants took bathroom breaks as necessary. The surveys and interview were administered at the end of each day. Each of these daily survey sessions took approximately 10 minutes. A baseline survey of workload and stress was administered on the day before the start of the experiment. Participants recorded their workload and stress for the task of driving to work that morning. No video or voice recordings were made during the experiment.

The COIN experiment at the UAMBL was a virtual constructive experiment, held from 5 to 16 March, 2007. The focus was on an FCS combined arms battalion (CAB), supporting elections in an urban COIN environment. Missions included assisting host nation forces with tasks such as raids, monitoring or quelling civil disturbances, mounted and dismounted patrols, fixed site security (e.g., providing protection of election sites), route security and convoy operations (e.g., VIP escort), Army air space command and control, and quick reactions (e.g., to kidnappings, hijackings). The CAB consisted of a headquarters company, two infantry carrier vehicle (ICV) companies, a mounted combat system (MCS) company, a reconnaissance troop, a non-line-of-sight (NLOS) mortar battery, a route-clearing platoon, a civil affairs team, and a psychological operations team. It also included attached units consisting of a company from a heavy brigade combat team, a Marine Corps company and a company of troops from the United Kingdom. A separate reconnaissance, surveillance, target acquisition (RSTA) squadron provided additional UAV support. The CAB was paired with an Iraqi battalion of security forces, with each coalition company paired with an Iraqi company. Total host nation forces consisted of the Iraqi security police, the Iraqi special police, and the Iraqi traffic police. There was no formal chain of command between coalition and host nation forces (i.e., Iraqi forces were not under the command of coalition forces). The opposing force consisted of loosely connected groups of local insurgents and foreign fighters.

Most units were played constructively, that is, having a commander only assigned for the company or battery and subordinate units controlled by research volunteers, following orders of the company commander. However, some units had complete platoons, with virtual reality simulations of combat vehicles, manned by complete crews of Soldiers from various Army units. The UC operators, the participants of interest for the ARL analysis, conducted operations in virtual simulation. The staff of the CAB was played in virtual simulation command and control vehicles (C2Vs). The UC operators operated their robotic reconnaissance platforms in support of the missions described here.

2.5 Independent Variables

The three independent variables were *type of mission performed* (such as raids, monitoring or quelling civil disturbances, mounted and dismounted patrols, fixed site security [e.g., providing protection of election sites], route security and convoy operations [e.g., VIP escort], Army air space C2, and quick reactions [e.g., to kidnappings, hijackings*]); type of duty station* (e.g., infantry vehicle, armor vehicle, company or squadron headquarters) and *number and type of robotic reconnaissance platforms controlled* (e.g., single UAV, multiple UAVs; UAV and UGV, etc.). However, the independent variables were not controlled, so that each controller did not necessarily perform each type of mission while controlling each type of robotic platform.

2.6 Dependent Variables

Dependent variables were measures of workload and subjective stress. Interview results also served as subjective dependent variables.

2.7 Data Analysis

Because of the relatively small number of participants and the lack of control over the independent variables, only descriptive statistics were performed. This included means for the dependent variables by type of mission, type of duty station, and by number and type of robotic asset(s) controlled. Interview results of human factors issues with the interface and observations supporting the data analysis were also summarized. A description of variables by objective is given in table 2.

Table 2. Variables by objective.

	Objective			
	1- Mission	**2- Station**	**3 - Robot controlled**	**4- Human factors**
Independent variable	Type mission	Duty station	Type and number of robot controlled	None
Dependent variable	NASA-TLX Perceived stress Interview	NASA-TLX Perceived stress Interview	NASA-TLX Perceived stress Interview	Observations Interview

3. Results

3.1 Workload by Type of Mission

Seven missions had 10 or more data points. These were raid, vehicle-borne improvised explosive device (VBIED), mortar attack, civil disturbance, fixed site security, route security, and IED planted somewhere. Figure 3 shows the workload for these missions plus baseline. It appears that, except for IED, missions that involve a unique activity related to a COIN environment such as providing over-watch for a raid, searching for a suspected VBIED, preventing a mortar attack, or over-watching a civil disturbance, have higher workload than missions that involve routine activity (over-watching a fixed site such as a polling place for signs of trouble; providing route security for a convoy). Perhaps IEDs are an exception since they were ubiquitous and perhaps in only a few instances were listed as a unique mission by participants. Even so, no level of workload approaches half of the maximum possible workload (60 on a 120-point scale) for a given mission.

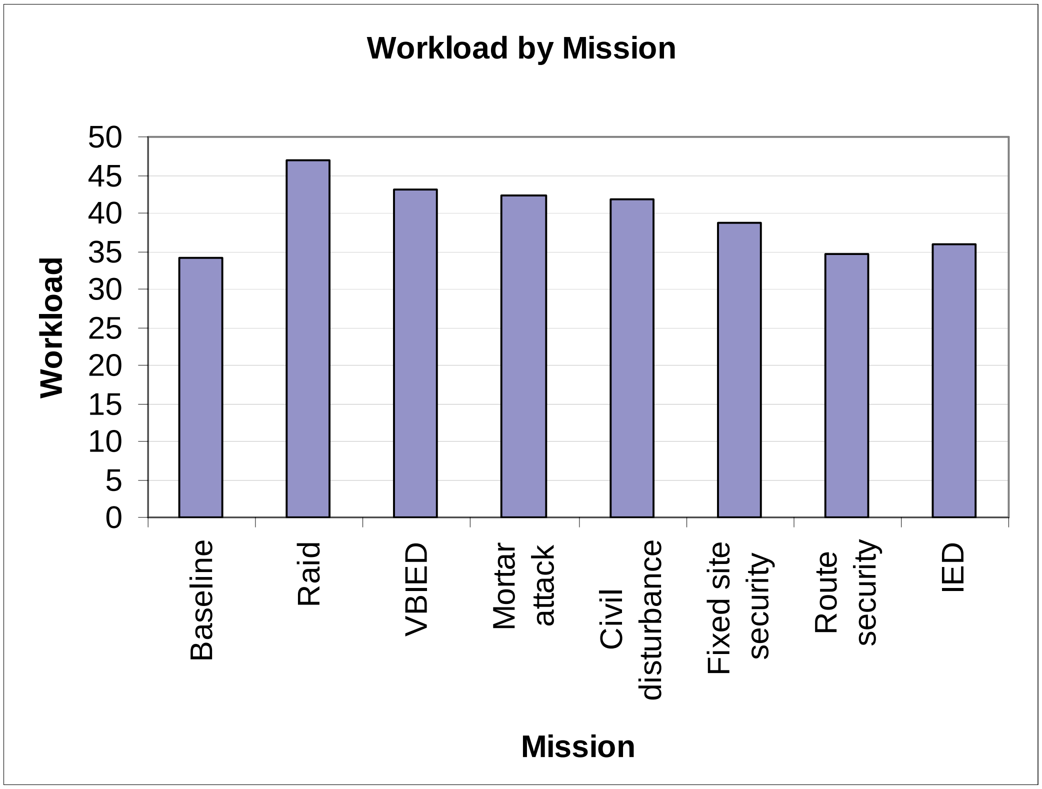

Figure 3. Workload by mission.

3.2 Workload by Duty Station

Figure 4 shows workload by the controller's station. The two highest workloads were for those stationed in a combat vehicle (ICV or MCS). Workload for those in an infantry platform was the highest. Controllers in combat vehicles would be directly responding to a company commander or platoon leader in the same vehicle. This workload is a few points higher than the workload reported by controllers at RSTA squadron headquarters. Controllers at company headquarters had a workload lower than baseline. No level of workload approaches the midpoint of possible workload (60 on a 120-point scale) for a given mission.

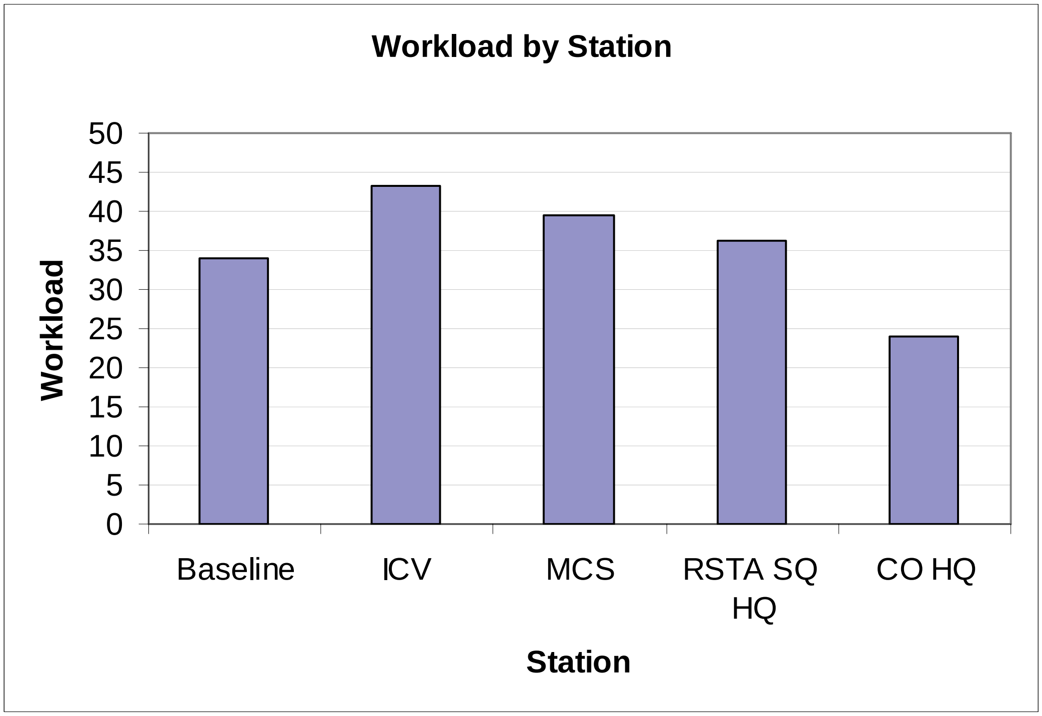

Figure 4. Workload by station.

3.3 Workload by Asset(s) Controlled

Figure 5 shows workload data by assets(s) controlled. The two highest workloads reported are for participants controlling UAVs and UGVs. There is less workload in controlling a UAV and a UGS, probably since the UGS is stationary and alerts the user if there is anything detected. However, no level of workload approaches half of the maximum possible workload (60 on a 120-point scale) for a given mission.

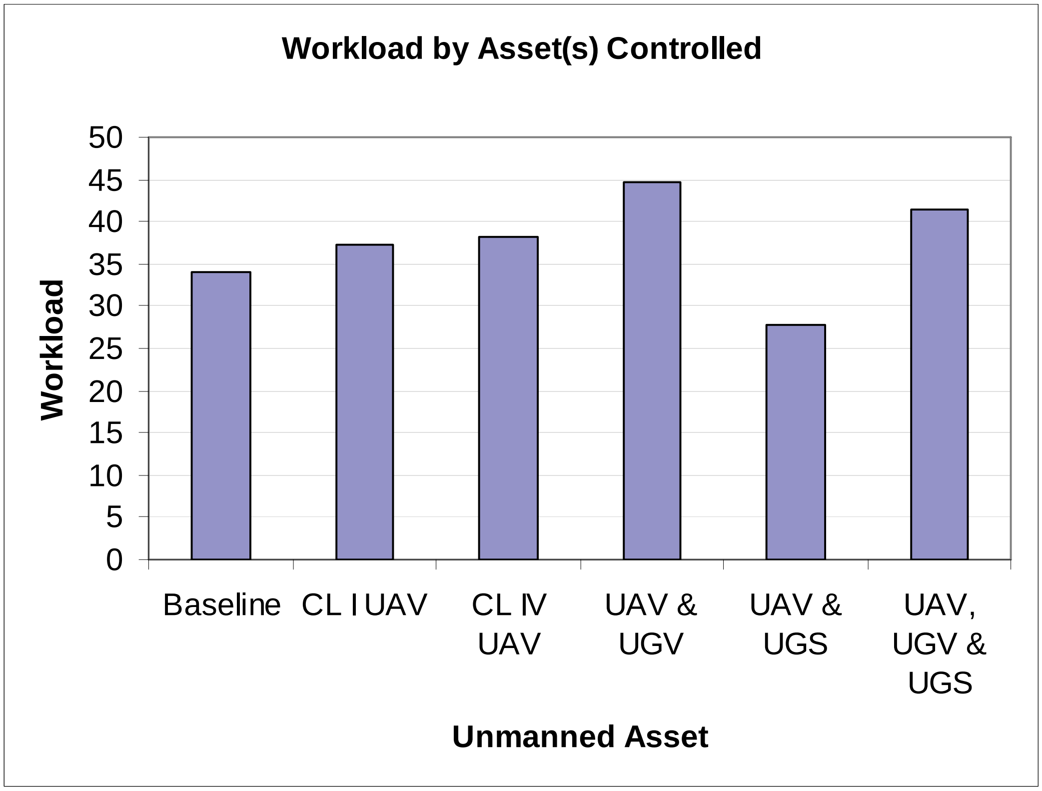

Figure 5. Workload by asset(s) controlled.

Figure 6 shows workload by simultaneous versus single (one at a time) control of unmanned assets. Single control represents participants controlling one or more than one unmanned asset but not switching views. Simultaneous control represents participants controlling more than one asset and switching between views. Workload is virtually the same. Perhaps this is because only one camera view is possible at a time with this interface, and participants can pay full attention to whatever camera view is being presented at the time.

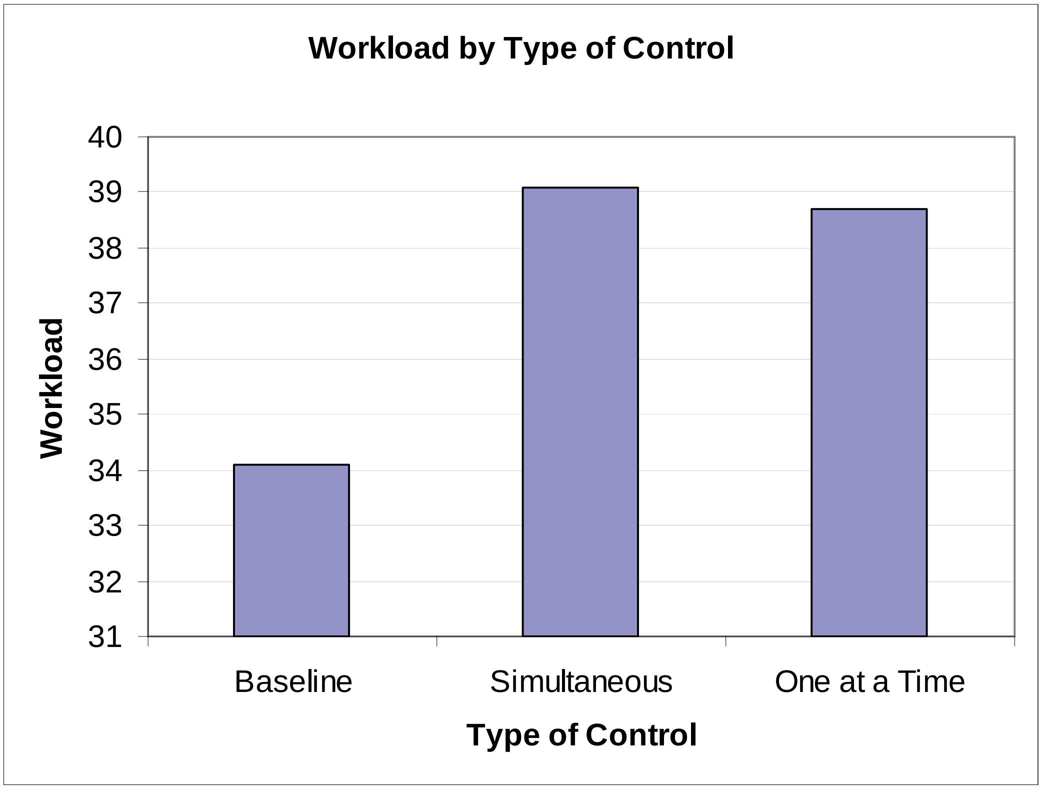

Figure 6. Workload by type of control.

3.4 Stress Level by Type of Mission

Figure 7 presents data about stress level by type of mission. In general, physical stress level is generally low and reaches 3 on the 10-point scale only for the VBIED mission. Like workload, mental stress level tends to be higher for unique missions related to a COIN environment versus routine surveillance missions, although mental stress level is as high for fixed site security as it is for a mortar attack. Mental stress level for all missions is higher than baseline mental stress level (i.e., over 3 versus under 3). Even so, mean stress level for no mission reaches 5, the mid-point on the stress scale.

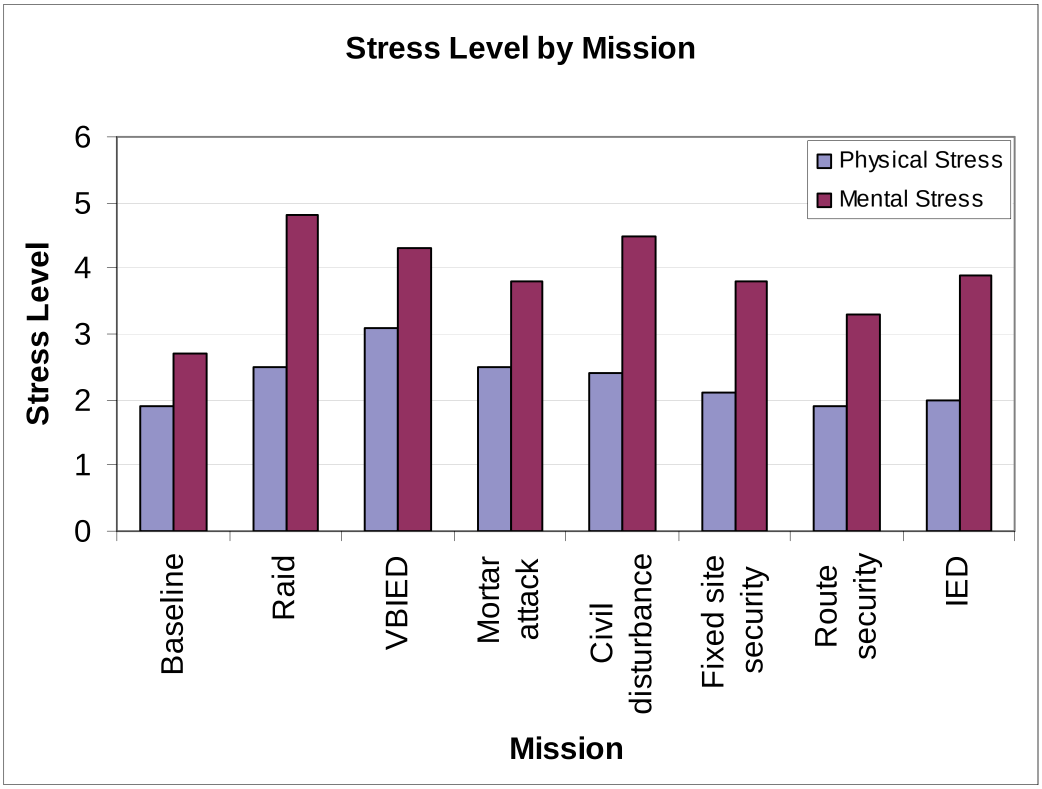

Figure 7. Stress level by mission.

3.5 Stress Level by Duty Station

Figure 8 presents stress level by duty station. Physical stress level is relatively low and exceeds 2 on a 10-point scale only for those at ICV stations. Mental stress level exceeds baseline stress level for three of the four duty positions (all but company headquarters). Unlike workload, mental stress level was highest for those in the MCS and about equally high for those in an ICV and RSTA headquarters. The MCS is more likely to be used for direct fire engagements than the ICV, so perhaps this is why there is more mental stress. Even so, mental stress level for no duty position reaches the mid-point (5) of the scale.

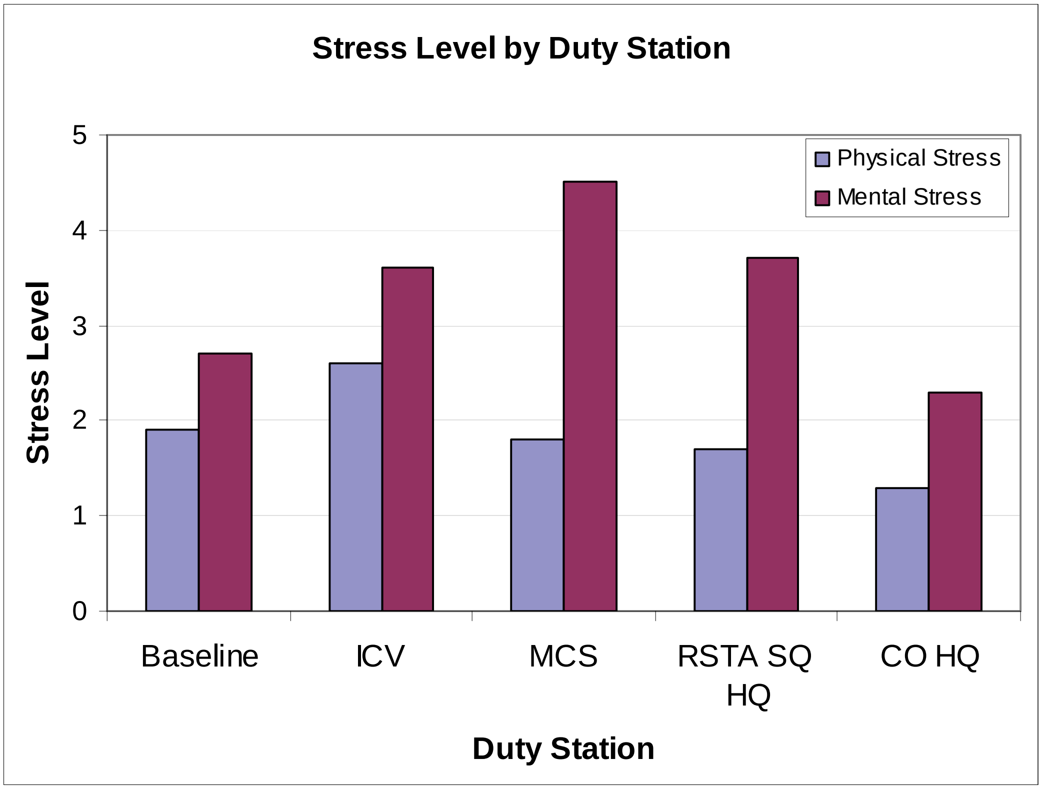

Figure 8. Stress level by duty station.

3.6 Stress Level by Asset(s) Controlled

Figure 9 presents data for stress levels by asset(s) controlled. Physical stress level is rather low and undifferentiated, exceeding 2.5 only for controlling UAVs and UGS. Similar to the workload data, mental stress level is highest for controlling UAVs and UGVs. However, unlike workload data, mental stress level is almost equally high (within 0.3 point) for controlling only Class IV UAVs, and for controlling UAVs and UGS. The Class IV UAV was an important asset, capable of detecting targets at a considerable distance. Thus, perhaps although the workload for this platform was no higher than a Class I UAV, the stress level involved in its operation was higher. Workload was not similarly high for controlling UAVs and UGS. Again, perhaps although adding control of UGS to a UAV did not increase workload, the stress level of detecting more targets, given more assets, was higher. Another possible reason for the added stress level was the number of false alarms that UGS emitted in an urban area. Also, stress level for controlling all three types of assets was lower than baseline, although workload for controlling all three types of sensors was second highest. There is no ready explanation for this anomaly. Also, stress level did not exceed the scale mid-point (5) for controlling any mix of assets.

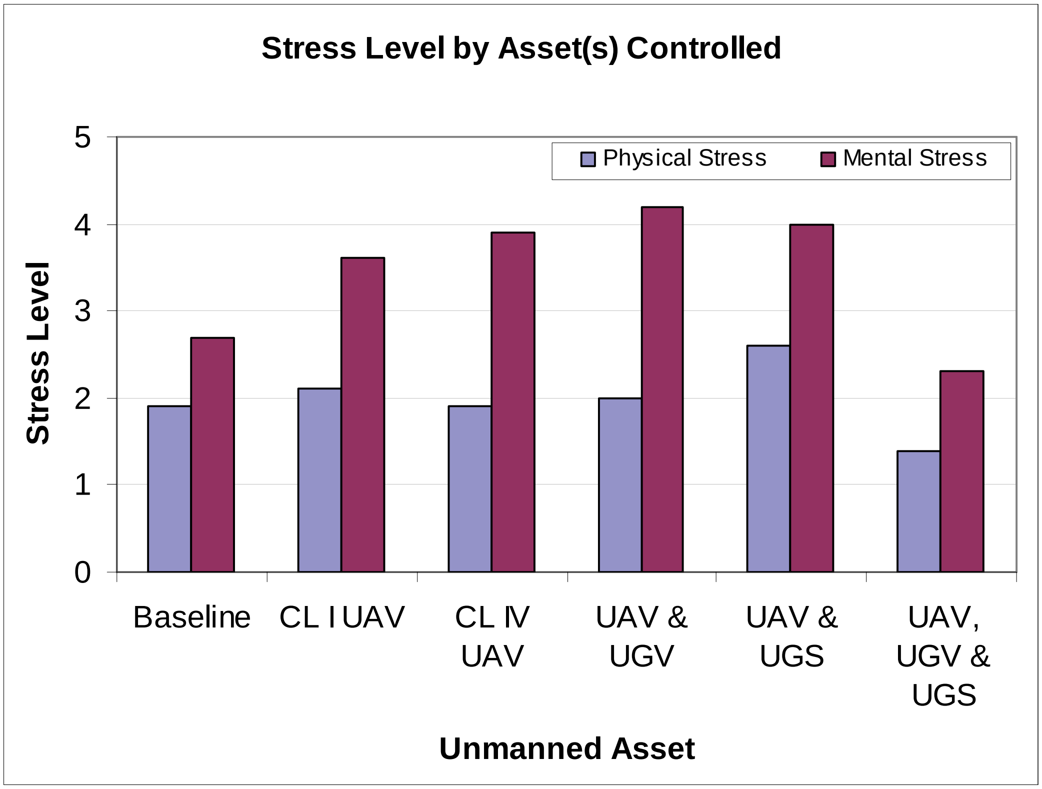

Figure 9. Stress level by asset(s) controlled.

Figure 10 shows stress level for controlling assets simultaneously versus one at a time. Again, physical stress level was generally low and undifferentiated. There was little difference between the two control conditions with mental stress level, but ironically, sequential (one at a time) control had slightly higher mental stress level, unlike workload data. However, for neither workload nor mental stress level was there much difference between the two types of control, perhaps because participants did not have to share attention between two screens in either condition. Again, stress level did not exceed the scale mid-point (5) for either type of control.

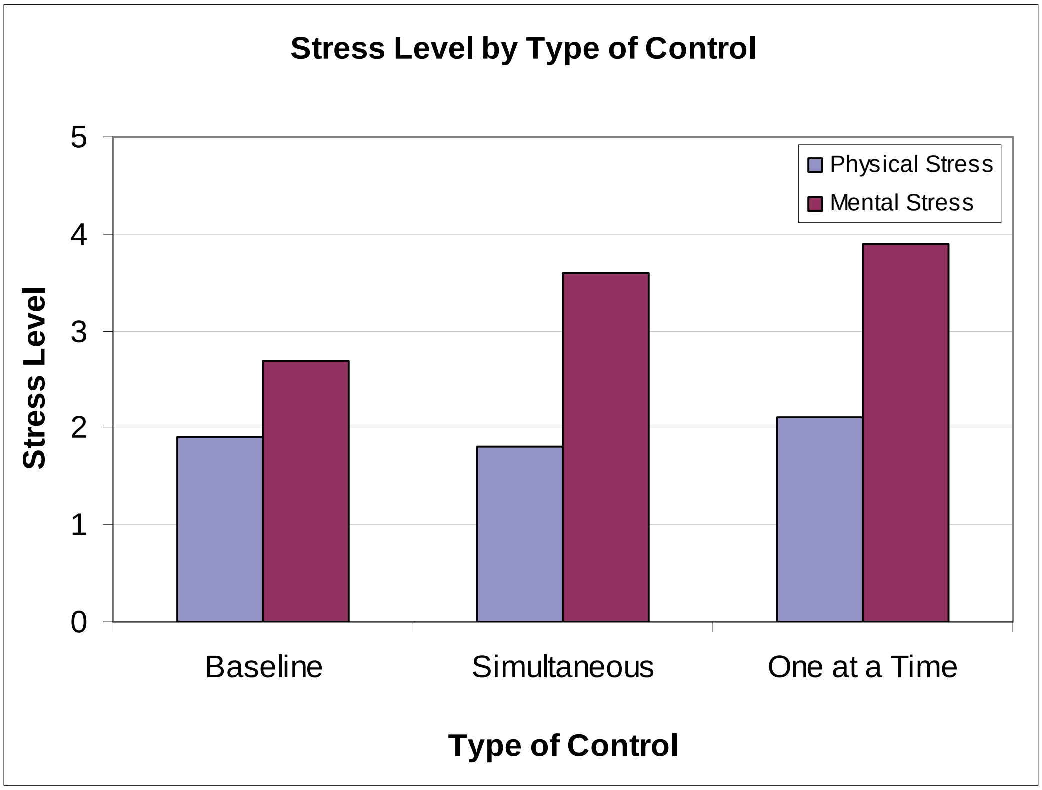

Figure 9. Stress level by asset(s) controlled.

3.7 Interface Improvements

Participant comments on the UC interface are shown in appendix B. Several interface improvements suggested were similar to those in Sterling and Perala (2007). These include an ability to easily change unmanned vehicle routes, rather than have to cancel and re-plan the entire route; an ability to "lock onto" a target and track it (camera stability and camera rotation as the UAV flew were major problems cited); and an ability to send an unmanned vehicle to a grid coordinate (versus having to plan a route). It was also reported that grid numbers were difficult to see on the interface. Other improvements suggested were improved night vision on the cameras, ability to have a camera view of more than one sensor at a time, and adding a maneuver command and control (MC2) station for the controller. This latter comment indicates that controllers had no warfighter-machine interface, so they had no view of the common operational picture, with mission graphics, etc. This led to a lack of situation awareness among controllers.

Participants had numerous responses to the end of experiment survey (after-action review-type survey). So far as suggested improvements in training, the most frequent comment was that there was no formal hands-on training. Participants were given briefings with slides in an open area but had no access to UCs during the briefings. They seemed to want hands-on training so that when the instructors described how to do something, they could practice doing it.

Problems with the interface echo the daily survey comments. These included adding an ability to easily change routes, go to grid coordinates, track targets, and have an MC2 available for overlays, chat, and checking grid coordinates.

Other factors that interfered with controlling UVs were mostly other duties. Two specifically mentioned were intelligence, surveillance, and reconnaissance (ISR) and monitoring the radio. These duties would likely have been performed in combat vehicles, indicating why the workload there was higher. One comment was that a controller in a vehicle would be tasked “100%” by the company commander.

Suggested changes in the interface were very similar to comments about problems with the interface: an ability to send UVs to grid coordinates, fly the UAV and move the camera simultaneously, track targets, better night vision (specifically, a wider view in thermal mode), and having an MC2 with “chat” capabilities available to controllers.

Participants indicated that items they liked about the interface included the laser range finder, the ability to easily take and send snapshots to the MC2, smooth control with the joy stick, and the simple operation of the controller.

Difficult missions included escort missions, including convoy support, nighttime route clearance missions (because there was no good camera view from the platform), and missions requiring the tracking of targets. The difficulty of reconnaissance missions is surprising in that these missions were not rated high in workload. Also, over-watching a small area and tracking a target were seen as difficult missions since there was no ability to automatically track targets.

Easy missions were mostly fixed site security and wide area surveillance, which tracks with workload ratings.

The most difficult sensors to operate were UGSs because of the number of “false positives” they provided in an urban environment, the ease with which an unattended sensor could be stolen, and the difficulty in planning for meaningful placement of the sensors in a dynamic, urban environment.

Conversely, the easiest sensors to control were the UAVs, especially the Class IV UAVs. They were reported to be fast and easy to maneuver.

Participants’ consensus in the number of sensors that they could control at a time was one for actively searching and about two for passively searching (assuming aided target recognition capacity).

4. Discussion

4.1 Workload

Overall workload for any of the independent variables did not reach half of the possible workload level. Workload seemed to be higher for specific missions (such as locating a VBIED or over-watching a raid) than for more general missions (such as route or fixed site security). Since many of the specific missions seem more likely in a COIN environment, perhaps workload in this environment may be higher than more traditional environments. Workload was higher for participants in combat vehicles and specifically in ICVs. This latter finding seems to track with that of Sterling and Perala (2007) who found that workload was higher for UC operators supporting infantry troops. The higher workload in combat vehicles may be related to workload closer to where the "rubber meets the road" and where one is more readily accessible to demands by platoon leaders and company commanders. Workload was also higher for operating multiple unmanned vehicles, which again is similar to the findings of Sterling and Perala (2007). However, workload is not substantially higher for operating sensors simultaneously than singly (sequentially). Perhaps that is because in reality, all sensors are operated sequentially in that only one camera view could be seen at any one time. Participants were therefore not forced to share attention between two or more screens at one time, as in previous research.

4.2 Stress Level

Stress level, especially physical stress level, was relatively low, never reaching the scale mid-point for any independent variable. Mental stress level was somewhat higher for specific, COIN-related missions in that two of the three lowest mental stress level ratings were for route reconnaissance and fixed site (similar to observation point) reconnaissance. Mental stress level was highest for those in MCS units, perhaps because of greater likelihood of involvement in direct fire engagements. However, mental stress level was more or less equally high for those in MCS, ICV, and RSTA headquarters. Compared to baseline, mental stress level was generally equally high for controlling all types of sensors except for all three (UAV, UGV, and UGS) together. This anomaly lacks a cogent explanation and may suggest that further study in this area is warranted. However, it does appear that although workload involved in controlling multiple classes of sensors is different, stress level in locating targets is about the same. As with workload, there does not seem to be a considerable difference in mental stress level when one is controlling sensors simultaneously or sequentially, probably for the same reasons.

4.3 Interface Improvements and Survey Responses

Several interface improvements were clearly desired. These included the ability to easily change routes, automatically track a target, rotate the camera while flying, send a UV to a given grid coordinate without developing a route plan, improved night vision, multiple simultaneous video camera feeds, and an interface to provide situation awareness (e.g., mission overlays, chat capability).

4.4 Future Research

In this experiment, as most current experiments, only surrogate systems for controlling unmanned vehicles were used. Thus, there is a potential for different results when actual future systems are used. That is, depending on the design and capabilities of these future systems for controlling unmanned vehicles, workload and stress could be higher or lower than in the current experiment. In future research, it is recommended that research with the actual systems to be used in controlling unmanned vehicles be used. An opportunity for this may exist at the Integrated Mission Test simulation, scheduled for the summer of 2008 at White Sands Missile Range, New Mexico.

Also, while the researchers in this experiment were adequately trained to evaluate the workload and stress of the participants, they would have benefited from more training in the capabilities of the simulations in this experiment. In future research, researchers should have more hands-on training on the interface used to control unmanned vehicles.

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Appendix A. Surveys

Participant ID (last 4-SSN):________________ Date:___________________

General:

1. Age : ________ 2. Sex: M / F 3. Handedness: Right / Left

4. Rank: __________

5. Time in service: Yrs:______Mos:______

6. Time in grade: Yrs:______Mos:______

7. MOS/Specialty: ______________________

8. Time in MOS/Specialty: Yrs:______Mos:______

9. Combat experience: Y / N If Yes, Where? __________________ How long? ________

Experimentation:

10. How many Army experiments (i.e., simulations in the battle lab) have you participated in? (if none, indicate 0): ______________

11. Indicate whether you have had experience, and at what level, for each the following:

a. Use of fixed/stationary Army Universal Controller Unit

____None ____Basic ____Intermediate ____Advanced

b. Use of dismounted Army Universal Controller Unit

____None ____Basic ____Intermediate ____Advanced

c. Use of other, similar joystick-type controller unit

____None ____Basic ____Intermediate ____Advanced

d. Control of simulated unmanned systems (e.g., UAVs, UGVs, other)

____None ____Basic ____Intermediate ____Advanced

e. Control of live unmanned systems under operational conditions (e.g., during combat operations)

____None ____Basic ____Intermediate ____Advanced

f. Control of live unmanned systems in a non-operational setting (e.g., testing, experimentation, etc.)

____None ____Basic ____Intermediate ____Advanced

g. Do you have any experience with computer games where you control a vehicle?

____None ____Basic ____Intermediate ____Advanced

U.S. Army Research Laboratory
Human Research and Engineering Directorate

Universal Controller Surveys

Date: ____/____/____

Last 4-SSN: _ _ _ _

Run: ☐ **Morning** ☐ **Afternoon**

Station: ☐ **ICV** ☐ **MCS** ☐ **C2V** ☐ **RSV** ☐ **M2**
☐ **M1A2** ☐ **Bde-HQ** ☐ **RSTA Sq-HQ** ☐ **NLOS Bn-HQ**
☐ **D Co.-HQ** ☐ **Recon Trp-HQ**

PLEASE COMPLETE THIS SURVEY PACKET AND LEAVE AT YOUR UNIVERSAL CONTROLLER STATION. AN ARL REPRESENTATIVE WILL COLLECT THESE AT THE END OF EACH EVENT.

For questions and comments, please contact Dr. Sterling or Dr. Perala at (502) 624-1964 or (502) 624-8778.

1. Indicate the type of mission(s) that you completed.

____ Mortar attack

____ Vehicle borne IED

____ Civil disturbances (political rallies, sectarian violence)

____ Fixed site security (e.g., political rally, polling station)

____ React to insurgent propaganda distribution

____ Insurgent transportation of weapons to safe house

____ Army airspace command and control (react to aircraft, enemy UAV)

____ Quick reaction (e.g., kidnapping, hijacking)

____ Route security-convoy escort (route clearance, escort VIP)

____ IED (in place) attack

____ Sniper attack

____ BLUEFOR raid

____ Insurgent assault

____ Other (indicate)

2. What types of asset(s) did you control with your universal controller?

____ Class I Unmanned Aerial Vehicle(s) (UAV)

____ Unmanned Ground Vehicle(s) (UGV)

____ Unmanned Ground Sensor(s) (UGS)

____ Class IV UAV

3. If you controlled more than one type of unmanned vehicle did you control them simultaneously (two or more at once) or in sequence (one at a time).

___ Simultaneously (i.e., had several on routes and switched between video feeds)

___ One at a time (specify order) ___________________________________

4. What problems did you encounter in your ability to control your unmanned system?

Please complete the following **SHORT** surveys for the missions that you just performed.

Date:________

TLX Workload Scale

Please rate your workload by putting a mark on each of the six scales at the point which matches your experience.

Mental Demand

Very Low — Very High

Physical Demand

Very Low — Very High

Temporal Demand

Very Low — Very High

Performance

Very Poor — Very Good

Effort

Very Low — Very High

Frustration

Very Low — Very High

Subjective Stress Rating Scale

1. The scale below represents a range of how PHYSICALLY stressful the mission might be. Check the block indicating how PHYSICALLY stressful the mission you just participated in was.

Task	Not at All Stressful 1	2	3	4	5	6	7	8	9	Most Possible Stress 10
a. Overall stress										

2. The scale below represents a range of how MENTALLY stressful the mission might be. Check the block indicating how MENTALLY stressful the mission that you just participated in was.

Task	Not at All Stressful 1	2	3	4	5	6	7	8	9	Most Possible Stress 10
a. Overall stress										

Interview Questions

Was your training or prior experience adequate to use unmanned vehicles effectively to perform your mission? If not, how could the training or experience be improved?

What problems did you have doing your job with the interface provided?

Did you have any problems that were not interface related (e.g., network, other responsibilities interfering with controlling unmanned sensors, etc.)?

What changes would you make to this interface?

What did you like must about this interface?

What mission(s) was/were the most difficult to control and why?

What mission(s) was/were the least difficult to control and why?

What types of unmanned assets (UAs) were the most difficult to control and why?

What types of UAs were the least difficult to control and why?

What was the maximum number of UAs you think you could have successfully controlled?

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Appendix B. Participant Comments

What problems did you encounter in your ability to control your unmanned system?

5 MARCH

- Turning the camera
- Difficult to make quick route changes
- Inability to "Send Task" in the Route Planner. Could not tell if/when the task would be accepted
- The OTB operator doesn't see what we see on the UC, so they don't fly the way we would fly (altitude, route, speed, etc.)
- Camera stability and rotation
- Want more control over UAV
- Poor visibility

6 MARCH

- Hand controls change
- Number for grids are too small to read
- Frustrating to use during night time operations due to difficulty of identifying if targets are friendly or threat since all we have is visual for ID
- The UC stations without MC2 leaves us "in the dark" as far as COMS since so much information is sent on chat and not on the radio
- Camera control while UAV is mobile

7 MARCH

- Ability to load overlays from MC2/OTB would be most helpful when planning routes, escorting vehicles, etc. When references are made to FOBs (forward operational bases), AOs (areas of operation), safe house #149, etc., we don't always have that information available to us. I am on a UC station that does not have MC2.
- Only being able to observe one at a time and not multiple views simultaneously is a problem

8 MARCH

- Difficult to pick up targets inside 500m in white/black hot mode
- Severe straining of eyes during night missions led to headache and eye ache
- Camera visibility

9 MARCH

- Cannot read grid numbers on LWIR/DVO display
- The use of chat would be helpful for UC operators
- Night vision optics are poor for scanning an area at night

12 MARCH

- Maneuvering camera when looking straight down
- Access to chat room

13 MARCH

- Camera angle while UAV is in motion

14 MARCH

- Need wider view when in thermals
- Need ability to use chat rooms
- When tasking the UAV, it is very frustrating when other icons pile on top of the UAV icon, making it difficult to select the UAV for tasking
- Camera difficult to adjust when looking straight down

15 MARCH

- Not having full flight control to move faster without using computer to move UAV

AAR Questions

Was your training or prior experience adequate to use unmanned vehicles effectively to perform your mission? If not, how could the training or experience be improved?

- Real life, hands on equipment. SIM is good, VR is better
- No, train to use all aspect, i.e., OTB, UAs, etc.
- Never received a block of instruction. The OJT was sufficient enough for me to run both the UC and OTB simultaneously
- An area where the controllers could be on a UC as they received training would help

What problems did you have doing your job with the interface provided?

- The ability to create routes for our system. We had to rely on the OTB operators for the implementation of routes
- Making and changing routes and moving the map around should be more like MC2 and not OTB
- No ability to enter grids for monitoring
- No ability to lock on target without lasing
- No real-time control
- I would like to have a simply joystick and leave the keyboard to the flight operator
- Limited situation awareness, no overlays, no chat, no grid locations for checkpoints

Did you have any problems that were not interface related (e.g., network, other responsibilities interfering with controlling unmanned sensors, etc.)?

- My computer was bought from the lowest bidder
- ISR responsibilities interfered
- No adherence to collection plan due to command guidance
- If not for Fires acting as RTO, I wouldn't have been free to do any UC work
- 100% positive UAs controller at Co. level will be tasked by commander
- Locking in and tracking targets
- Other icons would appear on top of the icon that I was trying to task making it difficult to select my platform for tasking

What changes would you make to this interface?

- Implement a grid location finder
- Provide the ability to actually fly UAV and move the camera simultaneously
- Add ability to monitor grid location
- Make each UA have only 1 camera for realism sake – all objectives see what controller sees
- User friendly overlays for orientation
- Allow for locking onto grid location or building rather than vehicles or people
- I would make it possible to track inanimate objects as well as anything else
- The map display needs to show ground truth. There are too many "ghosts" or icons of entities that are not there
- Add the ability to chat
- A wider view when looking through thermals

What did you like must about this interface?

- The different views from each one
- LASER range finder
- Ability to take snapshots and transfer to MC2 easily
- Control of joystick was smooth
- Familiar, generic computer platform for controlling the UAV
- Simple to use

What mission(s) was/were the most difficult to control and why?

- Escorting missions – changing a route on the fly is a pain
- Night route clearance – no system was adequate, as CLIV flew too high and CLI has very poor night options, caused headaches and would not allow for sustainable operations
- It would be nice to be able to lock grid on current location (e.g., sequence should be current location, future location, elevation, speed, and go!)
- Small area overwatch, since you can't track a certain area without a vehicle or person, it is almost impossible to move and keep eyes on area
- Convoy support. Camera does not action as fast as I would have liked when in close.
- Night missions due to the limited FOV
- No mission seemed harder than any other

What mission(s) was/were the least difficult to control and why?

- Fixed situation – put the UAV up and let it scan
- Fixed site security – ability to lock on nearby vehicle made observation hands off and simple
- Wide area surveillance, because it was easy to scan with the joystick
- Area surveillance during the day

What types of unmanned assets (UAs) were the most difficult to control and why?

- UGS – too much traffic in urban environment
- CLIV green only option is low detail and system bounces too often
- UGS – once control was taken it took too long to relinquish the field
- UGS because it took so much time to plan routes

What types of UAs were the least difficult to control and why?

- UGS; not too much movement
- SUGV – only controlled the camera
- If not CLIV, then must be CLI – low flying gave good visibility and rather easy to monitor as long as in orbit or rounded paths
- CLIV – fast and high – like a Cadillac
- TUGVs because they were just on and off
- UAVs – easy to maneuver

What was the maximum number of UAs you think you could have successfully controlled?

- Two with live feeds; sensors are a different story, i.e., UGS
- Successfully and to the benefit of the mission and unit, only one at a time – controlling – and occasionally looking through others
- Passively, 2 or 3; actively searching, 1; fixed site security, 2 or 3
- Four
- Three or four
- Two
- Two or three max

Synopsis of UC Operator feedback:

- 5 Turning the camera – camera control – esp. when looking straight down
- 5 The UC stations without MC2 leaves us “in the dark” as far as COMS since so much information is sent on chat and not on the radio – Need chat at least
- 4 Camera stability and rotation while UAV is moving
- 4 Frustrating to use during night time operations due to difficulty of identifying if targets are friendly or threat since all we have is visual for ID – poor optics – need wider thermal view
- 2 Want more control over UAV – Not having full flight control to move faster without using the computer to move the UAV
- 2 Number for grids are too small to read
- 1 Difficult to make quick route changes
- 1 Inability to “Send Task” in the Route Planner. Could not tell if/when the task would be accepted
- 1 The OTB operator doesn’t see what we see on the UC, so they don’t fly the way we would fly (altitude, route, speed, etc.)
- 1 Poor visibility
- 1 Only being able to observe one at a time and not multiple views simultaneously is a problem
- 1 Difficult to pick up targets inside 500m in white/black hot mode
- 1 When tasking the UAV, it is very frustrating when other icons pile on top of the UAV icon, making it difficult to select the UAV for tasking
-

AAR Feedback

Training
Need OC training – only received OJT

Interface problems
Need ability to create routes – like the MC2 style/method over OTB
Need ability to enter grids
Need real-time control and ability to lock on target without lasing
Limited SA; no overlays, no chat, no grid locations for checkpoints

Non-interface problems
ISR responsibilities interfered
Other icons pile up on top of UAV icon making it difficult to select the platform for tasking

Changes to interface
Add grid location finder and provide ability to monitor grid location
Allow grid locking/tracking on location or building rather than just vehicles or people
Fly UAV and move camera simultaneously
One camera per UAV – all objectives see what controller sees
Overlays
Need ground truth on maps – too many 'ghost' icons of entities that aren't there
Add chat
Wider thermal view

Positive Interface features
Ability to take snapshots and transfer to MC2 easily
Smooth control with joystick
Familiar software interface
Simple to use

Difficult missions
Escorting missions – changing a route on the fly is a pain
Night route clearance – no system was adequate, as CLIV flew too high and CLI has very poor night options, caused headaches and would not allow for sustainable operations
Small area overwatch, since you can't track a certain area without a vehicle or person, it is almost impossible to move and keep eyes on area
Convoy support. Camera does not action as fast as I would have liked when in close.
Night missions due to the limited FOV

Least difficult missions
Fixed site missions – put the UAV up and let it scan
Wide area surveillance – easy to scan with the joystick
Day surveillance

UAs difficult to control
UGS (3) – too much traffic in urban environ, too much time to plan routes

UAs least difficult to control
CLIV – fast and high – like a Cadillac
UAVs – easy to maneuver

Max # UAs to control
Actively searching = 1
Passively monitoring = 2, 3

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