

**Safe Operations of Unmanned Systems for Reconnaissance
in Complex Environments–Army Technology Objective
(SOURCE ATO) Field Experimentation
Observations and Soldier Feedback**

by A. William Evans, III

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14. ABSTRACT Experiments evaluating Soldier performance using robotic assets provide information about what improvements in mission capability can be expected with the new technologies. However, subjective data, such as formal and informal interviews and questionnaires, can equally provide helpful insight into which new capabilities will be most welcomed and understood as valuable to mission success for each Soldier. This report focuses on subjective data obtained from several Soldiers at the FY11 SOURCE ATO field event regarding their views and opinions of robot use in the military. This data has been compiled to provide some basic guidelines helping to direct future research in human-robot interaction.					
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1. Introduction

As robotic asset technologies become more complex, so do their uses within the U.S. Army. However, simply creating more sophisticated and capable robotic assets does not guarantee their acceptance by those who are intended to benefit the most from their use. Soldiers need to see the value in the use of robotic assets, and even further, should be involved in the process of determining where and how robotic assets can most benefit the Army in both the short and long term time frames.

Experiments evaluating Soldier performance using robotic assets provide information about what improvements in mission capability can be expected with the new technologies. However, subjective data, such as formal and informal interviews and questionnaires, can equally provide helpful insight into which new capabilities will be most welcomed and understood as valuable to mission success for each Soldier.

The study of Human-Robot interaction (HRI) has grown, in some part, from roots in user interface design and usability engineering (Nielsen, 1993). As such, similar research methods as those used for user interface designs may be useful in HRI research. One such method is heuristic evaluation. As stated in Nielsen and Molich (1990), “Heuristic evaluation is an informal method of usability analysis where a number of evaluators are presented with a system and asked to comment on it.” The following are the results of a heuristic evaluation, based on informal interviews with Soldier users of experimental robotic technology, regarding what they would like to see available in future military robotic technologies. The Soldiers interviewed were participants in a multi-organization field experiment evaluating ground robotic assets and situation-awareness (SA) increasing sensor platforms for Soldier use.

The field experiment was performed as part of the Safe Operations of Unmanned Systems for Reconnaissance in Complex Environments–Army Technology Objective (SOURCE ATO). The purpose of the SOURCE ATO program is to integrate autonomous navigation sensors, processing hardware, and software algorithms onto the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) Autonomous Platform Demonstrator Unmanned Ground Vehicle (APD UGV) in order to complete autonomous reconnaissance missions in populated dynamic urban environments. These missions are to occur in collaboration with human Soldier teammates and should enhance Soldiers’ overall SA for enhanced survivability. The autonomous systems produced are expected to operate safely in conjunction with both mounted and dismounted Soldiers as well as within civilian populated areas. The SOURCE ATO is lead by the Tank and Automotive Research, Development and Engineering Center (TARDEC) in partnership with the US Army Research Laboratory (ARL) and Engineer Research and Development Center (ERDC), and has taken place during the period of FY09–FY12.

2. Method

The participants involved in these interviews included five U.S. Army Soldiers, all stationed with the Ft. Lewis, WA, Stryker Brigade Combat Team. The Soldiers included one Sergeant (E-5), two Specialists (E-4), one Private First Class (PFC) (E-3), and one Private (E-2). Each of the Soldiers had experience with reconnaissance missions and scouting, and this area of expertise was the focus during the interview process.

All of the Soldiers interviewed for this report were present at Camp Lejeune Marine Corps Base, NC, as part of the SOURCE ATO field experiment, which evaluated ground robotic assets and SA increasing sensor platforms for Soldier use, which took place in September 2011. The Soldiers were interviewed in between experimental sessions, when they were not involved with the other field experiment activities. These interviews occurred on an informal basis, both as individuals and as a group, depending on the availability of the Soldiers.

Notes of each interview were recorded by hand and then later organized based on the relevant information provided. Most of the information obtained could be fit into one of three main categories; Controllers, Robot Operators, and Dismounted Support. In this report, these three categories will be used to document the information provided by the Soldier interviews. Each of these categories is defined and discussed in the following section.

3. Informal Interview Observations

3.1 Controllers

Laboratory-based studies have shown that console based controllers (e.g., Xbox 360 controllers) outperform other common controller devices (e.g., flight stick style controllers, track ball controllers, steering wheel controllers) for the task of operating robotic assets (Pettitt et al., 2011).

However, in some practical situations, such as operating from a mounted position in the rear of a Stryker vehicle, the performance advantages may not be as great as expected. The Soldiers interviewed during this event voiced opinions that favored the flight stick-style controllers over the gaming console style counterparts. When asked why they held this opinion, Soldiers stated several reasons. The first reason was *familiarity*. The flight stick-style controller is already in use with current equipment so Soldiers have already gained a certain amount of experience and comfort with its use.

The second reason was related to *ergonomics* and *space constrained positions*. Soldiers cited the difficulties of using gaming console style controllers, which require two hands, while they are in

full gear or operating in a confined space (such as the back of a Stryker, where these Soldiers were operating). The Soldiers expressed a desire for controllers that were easy to access and control but did not have a large space requirement within the vehicle.

Additionally, the Soldiers pointed out that the game controller that requires the use of two hands limits their *ability to use other equipment simultaneously*. In this specific case, Soldiers were utilizing a touch screen display in the rear of the Stryker vehicle. If a game style controller was being used they would have to choose which piece of equipment to utilize at any given moment. However, with a flight-stick style controller, they could potentially use both technologies' controls together.

Finally, *mission flexibility* was cited as a reason for their preference for the flight-stick style controller. Soldiers pointed out that it is rare that they are operating using a single piece of equipment or a single technology. As such, the need to have both hands on a gaming style controller limits their effectiveness in using other technologies, such as a touch screen display (as is found in the rear of the experimental Stryker unit).

3.2 Robot Operators

Who will be the robot operator/supervisor and what tasks will be required of those operators are two important issues that are yet to be determined. During the interview process several issues, concerns, and potential solutions to these issues were voiced by the Soldiers. The Soldiers involved at Camp Lejeune were excited to see that robotic assets are being further considered and researched by the Army. However, they did express some concern about who in their unit would serve as the robot operator. In some previous studies (Chen & Joyner, 2009; Chen & Terrence, 2009), researchers investigated utilizing the 'gunner' crew member as the robot operator, but the five Soldiers present at this study made it clear that they would *never* support this idea. In the minds of the Soldiers, the gunner's duties related to local area security are far too important to have any of their attention diverted for completing other tasks. Moreover, for two-man teams (vehicle commander and driver), the responsibility of local security falls to the commander, leaving virtually no extra resources to commit to robot operation.

The vehicle driver was also discussed as a potential robot operator. The rationale behind recruiting the driver for this role involved their familiarity with navigating a vehicle in a given environment. However, for the driver to be able to serve as robot operator, their primary vehicle (in this case the Stryker) would need to be in a stationary position. Unfortunately, remaining in a stationary position could leave the primary vehicle and its crew vulnerable to attack, in which case the driver would need to abandon any robot operator tasks to engage in immediate primary vehicle control. In turn, this would then leave the robotic asset(s) unattended and vulnerable to attack. This may require decision support for the commander during mobile operations (Chen & Barnes, in press).

One Soldier also pointed out that currently there is no available dedicated option for a robot operator in dismounted units. However, he recognized that the more roles a robot is able to take on the greater the opportunity to free up a dismounted Soldier for dedicated robot operations. Specifically, he made reference to the role of heavy weapons support, but other nonlethal roles could pay similar dividends with fewer risks.

3.3 Dismounted Support

Dismounted support, as it relates to robotics, refers to the tasks and functions for which robots can be used to lessen physical and mental workload on Soldiers. There are many areas in which robots capabilities can be utilized to reduce workload, some of which were mentioned in detail during the interview process. Potentially, the dismounted Soldier will have a variety of options for robotic support including small robots for improvised explosive device (IED) exploitation and building surveillance/mapping; moderate size Mules for equipment support and casualty extraction as well as larger unmanned systems for reconnaissance and heavy weapons support (Barnes & Evans, 2010).

Some areas, beyond heavy weapons support, discussed with the Soldiers included equipment transport, casualty removal, short range video reconnaissance, and report generation (not only for dismounted troops, but rather in general). This led to a discussion about the roles that large and small robotic platforms could play cooperatively with Soldiers. One Soldier expressed interest in having a large robot fulfill the roles requiring strength (load carrying, casualty removal, and heavy weapons) while the smaller ‘stealthier’ robots (air and/or ground) could help increase SA on the fly. Certainly, the idea of distributing Soldier load via robotics is of interest in the current military science community and will see a great deal of investigation in the coming years. Part of that research will include efforts investigating Soldier trust and acceptance of a robotic asset in the squad. It is interesting and encouraging that such a role for robots was expressed by the Soldiers.

3.3.1 Dismounted Support Robot Control

One Soldier openly wondered why robot control similar to that of unmanned aerial vehicle (UAV) operators could not be employed for dismounted support or for ground operations in general. That is, he specifically mentioned a desire for a robot operator who is disconnected from the rest of the fight. He saw several advantages to this. First, this style of robot operation would keep the operator from harm’s way, thus increasing safety for the operator. Because of this increased safety, robot operators could be dedicated to that job without worry about local area security or other critical tasks involved with ground missions, keeping plenty of cognitive resources available for the robotic operation task. Additionally, operators would be more likely to remain calm during times of panic, such as a fire fight, increasing the robot’s overall effectiveness, especially during moments of critical support need for dismounted troops.

3.3.2 Information Generation

Just by looking at all of the equipment used at the field event it was clear to the Soldiers that a lot of information was being generated through sensors and other systems. Having a background in scout reconnaissance, each Soldier had a developed desire to seek out useful information and this case was no different. The Soldiers believed video reconnaissance from robotic assets could provide valuable information relevant from the squad level on up to the company level, if not higher.

However a lot of discussion went beyond simple raw video data. Soldiers talked about how useful overlay information could be. Using hand-held devices, smart phones, or flexible displays, mission information, such as global positioning system (GPS)-marked mission objectives or laser marked targets, could be overlaid in real-time on video data to provide quick salient information to help increase SA, down to a squad or even individual Soldier level. One Soldier said even something as simple as an overlay with Blue Force Tracker information would help to reduce fratricide.

3.3.3 Report Generation

Of the tasks involved with reconnaissance missions, generating reports is one of the more tedious responsibilities for Soldiers to complete. More importantly, it requires enough cognitive resources to remove Soldiers from engaging in immediate SA tasks within their surroundings. Robotic assets could help lessen this burden through automation. One Soldier expressed that it would be extremely helpful if robotic assets could, at a minimum, help to populate a portion of the information needed in a standard spot report, based on sensor information already being collected by the robot and/or its sensors.

The Soldiers said auto-completion of reports would help limit some or both of the physical and cognitive workload, for dismounted troops and reconnaissance teams, associated with completing such reports. Yet the reports would still provide an ample amount of information to decision makers up the chain-of-command. Additionally, auto-completion of reports would allow robotic operators (whether dismounted, seated in the back of a command vehicle, or located away from the battle space as mentioned earlier) to concentrate more on the current, incoming data being sent by the robotic asset. The increase in allocated attention to incoming data could result in fewer missed or misidentified targets, thanks to increased target interrogation time, as well as an increased and more consistent SA of the battle space.

4. Other Observations about Human-robot Teams

In addition to the observations from informal interviews conducted during the course of the field experiment, observations were made throughout the SOURCE ATO field event that addressed

the aspects of the interfaces that have or could affect Soldier performance and mission success. The following observations were made by researchers, outside of the Soldier interviews. Some of these observations are already well-known concepts while others represent potentially novel ideas in the incorporation of robotics into Army units.

- *Crew size is set and additional tasks are required that may or may not be related to robotic activities. Robot operators are likely to be overburdened and need control systems that will help reduce cognitive and physical workload (Barnes & Evans, 2010).*

It is extremely likely that whoever is assigned the task of robotic operator will have other duties that must also be attended to. This means that for robotic assets to be effective they will need to have as many autonomous functions as possible. Yet the robot control interface will still need to be salient enough for Soldiers to quickly be able to switch tasks and still have an understanding of the robots situation, needs, and outputs, without overburdening cognitive or physical workload.

- *Understanding of one's environment (local SA) and the robots' environment (mission SA) is a critical piece of team effectiveness.*

Distributed SA will be required to fully incorporate robots as effective members of existing teams. Robots will be expected to venture into areas deemed too dangerous for Soldiers to tread. As such, robot operators will need to have an understanding of the robots' surroundings, as well as maintaining awareness of their own local area and mission.

- *Individual differences can play a significant role in Soldiers' ability to manage multiple and diverse tasks (Chen & Barnes, in press).*

Spatial ability and trust level and other individual factors are sure to play a role in Soldiers' ability to effectively operate robotic assets. Training will be needed to address effective operation, and ensure that all robot operators meet minimum capability requirements.

- *Interface designs could potentially help to reduce workload and improve the acquisition and maintenance of SA (Barnes & Evans, 2010).*

Interface designs needs to present comprehensive *information* to users as opposed to simply relaying *data* from sensors. This could help to reduce cognitive workload,

as well as reducing users' 'head-down' time trying to comprehend all of the information being presented to them. A focus on providing information should also aid in users' ability to gain and maintain SA.

- *Team performance is tied to the ability to understand and anticipate teammate behavior (Cannon –Bowers & Salas, 1998).*

Anticipating teammates' behavior has been shown to be an indicator in team success. In the case of Soldier-Robot teams, the Soldier needs to understand what, why, and how the robot is performing and the robot must understand Soldier intent during mission activities. Autonomous assets will have interactions with humans in several different relationships that could benefit from anticipatory behavior; Robot-Soldier/Teammate, Robot-Robot/Teammate, Robot-Civilian/non-combatant, Robot-Enemy/hostile to name a few.

- *Hand-held devices can be used to relay information to lower echelons and to have some limited control functions related to robotic assets (Pettitt et al., 2011).*

Novel control solutions for hand held devices could improve performance and potentially shorten training duration (Evans, Gray, Rudnick, & Karlsen, 2012). Smaller form factors for displays and controls could allow devices to be carried by every squad or even every Soldier, expanding the reach of information provided by robotic assets.

- *Robot asset's addition to the team should result in a shift of tasks suited to machines away from Soldiers and allow for more Soldier focus on tasks that machines traditional perform poorly at or are unable to complete, such as planning adjustments, behavioral inference, target engagement, etc. (Hoffman et al., 2002).*

5. Conclusions

Overall, it is encouraging to see Soldiers with so much to say about their potential robotic teammates. It shows that while issues still remain, many Soldiers not only welcome the inclusion of robots in the Army but have already thought about what tasks they would like to see the technology accomplish. As researchers, we have only begun to tackle the laundry list of ‘wants’ that Soldiers have, but continued communication, like these interviews, help us to focus on real world issues that Soldiers are facing.

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List of Symbols, Abbreviations, and Acronyms

APD UGV	Autonomous Platform Demonstrator Unmanned Ground Vehicle
ARL	U.S. Army Research Laboratory
ERDC	Engineer Research and Development Center
GPS	global positioning system
HRI	Human-Robot interaction
IED	improvised explosive device
SA	situation-awareness or situation awareness
SOURCE ATO	Safe Operations of Unmanned Systems for Reconnaissance in Complex Environments–Army Technology Objective
TARDEC	U.S. Army Tank Automotive Research, Development and Engineering Center
UAV	unmanned aerial vehicle

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