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The Use of Robots in Army

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Abstract – New technology may be able to help answer the cries to reduce casualities resulting from friendly fire and collateral damage,as well as assist the military in performing urban operations.Unmanned vehicles,whether air,land or sea,are one means to get our airmen,soldiers,marines and sailors out of harm's way and are most likely a key driver to an upcoming revolution in military affairs(RMA)for all services.The major objective of the paper is to bring attention to the current and immediate Tactical Mobile Robots(TMR) capabilities,key logistics concerns regarding maintaenance,supply and transportation and the possible scenario of an unconstrained battlefield.

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INTRODUCTION

Most people think of robots, they envision mammoth automatons made of metal with almost human-like features. Today, there is a significant delusion of what robots can really do and what they should look like. Also, some would argue that the scientific community has spent too much time trying to replicate human-like features. However, it wasn't until the scientific breakthroughs in computers and micro-miniature technology during the last 15 years that ground robots could even become possible.New technology may be able to help answer the cries to reduce casualties resulting from friendly fire and collateral damage, as well as assist the military in performing urban operations. Unmanned vehicles, whether air, land or sea, are one means to get our airmen, soldiers, marines, and sailors out of harm's way and are most likely a key driver to an upcoming revolution in military affairs (RMA) for all services. The major objective of the paper is to bring attention to the rapidly moving field of Tactical Mobile Robots (TMR) and hopefully encourage follow-on studies to cultivate an enthusiasm to employ them correctly. The paper begins with a brief history on the field of robotics and the five imperatives that define operational use for these platforms. Next, it discusses the current and impending TMR and sensor capabilities. The paper then addresses potential missions for robotic platforms by discussing tactics and employment considerations and looking at the issues concerning robotics and loss of life. This section concludes with two possible operational scenarios. The first is a combat undertaking using robotic platforms in an unconstrained battlefield to determine the feasibility of an airstrip for a SOF mission. The second scenario portrays how TMRs could be used in an urban environment to help remedy a hostage situation. Next, the paper addresses key logistics concerns regarding maintenance, supply, and transportation.

HISTORY

The military has attempted to insert robotic technology into aerial platforms since World War I, where attempts primarily focused on remotely controlling dirigibles. The first real breakthrough was in World War II when a modified B-17 successfully performed unmanned flights.[1] Unmanned Aerial Vehicles (UAVs) have had much more success than their ground counterparts because they do not have to contend with obstacles, and the means by which aerial vehicles maneuver is easier to control.[2] Aerial flight maneuvers do not have to contend with surface-to-surface frictions (wheels steering on a ground surfaces). Instead, they move surfaces to redirect airflow. The lack of obstacles (for the most part) and similar flight characteristics as aircraft have also allowed Unmanned Underwater Vehicles (UUVs) to progress faster than robotic ground vehicles. Additionally, UUVs became essential for exploration, rescue, and recovery operations in the vast ocean depths. Humans cannot remain for extended periods below 200 feet or even dive at all to much greater depths. So for operations to take place in deep seas another means had to be developed. Naval submarine operations also help justify the requirement for UUV rescue operations. The Navy had deemed UUVs as mission essential and needed to meet various requirements. On the other hand, requirements for robotic ground vehicles were often seen as a luxury or unjustifiable. In addition to UUVs with submarine or 3 aircraft like features for water operations, there is also an almost science fiction looking crab called the Autonomous Legged Underwater Vehicle (ALUV) as shown in Figure 1.

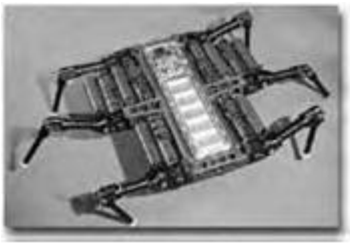

Figure 1

The ALUVs will be deployed into the surf zone from UUVs where they will then maneuver to a preprogrammed search area (shallow water and beach) to detect mines and barricades. They can also double as reconnaissance scouts.[4] Tactical Mobile Robot development did not truly begin until the early 1990s. Until then, the military's primary focus for ground robotics was in developing Unmanned Ground Vehicles (UGVs).[5] For purposes of this paper it is necessary to differentiate between UGVs and TMRs. UGVs are vehicles that have been equipped with robotic technology and are transport oriented or perform tasks normally in their line-of-duty. For example, remote controlled dozers moving dirt or tanks accomplishing de-mining operations are categorized as UGVs.[6] Robotic platforms that are task or work oriented, did not previously exist as a vehicle, and are normally small enough to accommodate no more than a two-person carry will be considered TMRs.

Current Robotic Capabilities

Numerous robotic systems and sensors available. Many were developed for commercial uses and are ideal for commercial off-the-self (COTS) acquisitions. Universities, National Aeronautical Space Administration (NASA), and private industry have also developed various systems ranging from anatomically functioning legs to a TMR like system that operates on Mars. This section will focus only on a few of the systems the SOF community is currently studying.

UAVs

At this time, AFSOC is primarily focusing their attention on CL-327 as shown in Figure 3. The CL-327 is a rotary-winged, vertical takeoff and landing (VTOL) UAV which can carry a variety of sensor packages. It has 220lbs cargo capacity and 6.24 hr flight endurance.[23] See Appendix A for additional pictures and specifications.

Figure 3 CL-327 Preparing for Launch

TMRs

There are several contractors and universities developing various families of TMRs. To avoid the perception of government bias, pre-selection, evaluation, or competition, the three TMR families listed below were chosen based upon my familiarity with them.

Lemming. The Foster-Miller Inc. TMR Lemming family began as amphibious robotic platforms as shown in Figure 4. They have functioned in depths up to 60 feet and surveyed areas over six miles long.[24] They have evolved into numerous other platforms to include the Lightweight Unexploded Ordnance Reconnaissance (LUXOR) and its unexploded ordnance-handling partner Tactically Adaptable Lemming Ordnance Negotiator (TALON). They can be controlled either by preprograms or operator commands via a wire or fiber optic tether, radio frequency (RF) signals or ultra wide (UW) acoustic modems.[25] See Appendix B for more pictures and specifications.

Figure 4 Foster-Miller Lemming

RATLER

Sandia National Laboratories' Intelligent Systems and Robotic Center (ISRC) originally developed the Robotic All-Terrain Lunar Exploration Rover (RATLER[tm]) as a prototype vehicle for lunar exploration missions.The RATLER comes in a range of sizes from eight inches up to three feet long, is

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lightweight, can be equipped with tracks or wheels, and demonstrated the ability to perform such tasks as surveillance, perimeter control, rescue, and chemical detection. The perimeter detection and control is performed with at least three RATLER^tm derivatives.[27] The United States Special Operation Command's (USSOCOM) is procuring Sally, the latest addition to the RATLER^tm family see Figure 5.

Immediate Future Capabilities

Users' requirements will soon drive future capabilities. As users become more familiar with the potential for robotic platforms and the assortment of available sensors, the requirements may become continuous. Consequently the capabilities will become endless.

UGVs

New Concepts, Massachusetts Institute of Technology's (MIT) research in developing robotic legs that functioning like a human leg has already demonstrated the technology is attainable and executable. This type of technology has several possibilities to include man assist units that give man greater ability to lift and transport items and more maneuverable robotic units. For example, a legged platform is more adaptable to rough terrain than one with wheels or tracks and may even have potential in prosthesis applications.

New Platforms. The Robotic Combat Support System (RCSS) is a robotic soldier assistant. The RCSS includes a mini-bucket loader, mini-forklift, multi-task attachments, and hydraulic tool power cell. It also has the ability to clear anti-personal land mines.[36] For missions which require more than one TMR, one possibility is the ISRC's four-wheel drive all-terrain vehicle (ATV) Surveillance And Reconnaissance Ground Equipment Robot (SARGE) shown in Figure 7, which can carry a considerable payload. SARGE is also equipped with video cameras, a microprocessor control system, a line of site radio link, and ISRC's Scanner Range Imager System.

Batteries. Better energy sources and further advances in micro-circuitry are on the mediate horizon for TMRs. Besides trying to improve upon the traditional type batteries, Sandia National Laboratory is exploring fuel cells. These are electrochemical devices that convert a fuel's energy directly into electrical energy, which is an endless (never need recharging) source of energy.

Sensors

Sensors, like the components on their TMR hosts, continue to get smaller and more capable. As technology continues to improve upon and go beyond the five human senses, sensors will soon have few boundaries. Bandwidth, or the amount of information that can be passed over a given communication link in a given time, is quickly becoming the biggest constraint. Frequently, more information is available than communication data links are able to transfer. The AFSOC community is currently developing an Operation Requirements Document (ORD) for an Advanced Remote Ground-Based Sensor (ARGUS).[42] Their immediate need is for an industrial strength, man-portable, ground-based, remotely monitored, surveillance system with the capability to detect, locate, and identify targets in denied areas. The purpose is to fill existing ISR collection gaps to support Intelligence Preparation of the Battlespace (IPB). AFSOC wants the system to have the ability to identify travel routes, force composition, high and low activity areas, aircraft and helicopters presence, and activities at dispersed airfields, and underground facilities.[43] AFSOC identified the requirement to employ ARGUS from any type aircraft or UAV, but did not mention TMRs. The sensor package must quickly detect, locate, identify and track targets; and then either handoff to other ISR collection assets or to a shooter for attack. The ORD does an excellent job of documenting requirements and justifying continued sensor development, but it misses the opportunity to incorporate ARGUS into a TMR, or at least TMR deliverable. The next big challenge is to develop lightweight, wearable, and user-friendly operator-robot-sensor interfaces, which do not hinder in anyway the special tactical teams ability to accomplish their missions.[45] They are under development, and like TMRs need documented requirements to become a fiscal reality.

Employment Considerations

The first hurdle that must be overcome before any TMRs are employed in the field, is our current military culture.[11] There are numerous cultural barriers that still plague TMRs and even a few for the UAVs. These must be overcome before TMRs are accepted as vital military element.[12] Many still view TMRs as an unproven technology with unknown or little benefit. One major fear is increasing manpower to maintain this new technology that appears to be a potentially huge headache with little capability increase.[13] Even worse is the fear of having manpower reduced because these platforms are perceived as being able to do the work of people, thus justifying the need for fewer people to meet the mission.[14] LTC Blitch believes by the time TMRs are fielded, the technology will have developed the reliability and maintainability requirements such that the "care and feeding" will be minimal. He also stresses the TMR's augmentation role in tactical teams is as a force multiplier and a means to reduce risk…not reduce manpower. The key to resolving these cultural fears is to get the "word out" by demonstrating TMR capabilities.A problem that plagues both UAV and TMR platforms is who should fund their development? Downsizing and constrained budgets have kept robotics from achieving highpriority acquisition status.[16] The mentality appears to be, "let someone else pay to prove its worth, then we'll jump on the bandwagon to reap the benefits." Until TMRs demonstrate the same success stories as the UAVs and UUVs, this type of thinking will retard real progress. Even though UAVs had great success over the last few years, their capabilities are still not widely known and excluding reconnaissance, their potential growth into other areas is still limited.[17] Besides cultural hurdles there are still technological issues that must be resolved. At a minimum, the five TMR imperatives must be quantitatively met before TMR platforms can be employed in the field.[18] The dilemma in premature employment could spell disaster for TMRs and create obstacles that will take an inordinate amount of time to overcome. On the other hand, the sooner this technology gets in the hands of its target audience, the sooner the real benefits will come to fruition…to include getting soldiers and airmen out of harm's way.

LOSS OF LIFE

Out of Harm's Way

Placing robotics on the modern battlefield, more pointedly in the hands of our soldiers, airmen, and sailors, will not always prevent lose of lives. However, it will go a long way to help reduce a significant amount of inherent risk. Using robotics via UAVs to collect information from a safe standoff zone is one way our military services have already benefited. Another is just now happening with TMRs in Bosnia.[20] In response to an urgent request from the Army, two prototype Foster-Miller TMRs (shown in Figure 8) were assembled and are currently assisting the 766th Explosive Ordnance Detachment (EOD) to locate, identify, and disarm unexploded bomb ordnance.[21] One TMR uses laser technology and four mini-cameras to locate and identify the ordnance. Then, a larger version TMR equipped with six cameras, an articulating arm, and a claw like hand is used to move the ordnance to a three-sided enclosure where it is safely disarmed.[22] With the help of TMRs, a single detachment was able to set a record disarming eleven unexploded ordnance devices in one day.[23] Officially these TMRs are undergoing a field test however according to the team leader Sgt. Platt, "This is real-life…There's nothing more real than this."[24] Similar uses might include sending in TMRs to assess damage, and even possibly make repairs, during nuclear catastrophes like Chernobyl. TMRS could measure radiation or use chemical and biological sensors to determine if a building or an area is safe for humans. Additionally, they could infiltrate a highly secure area to collect audio sounds, map obstacles, locate individuals, and monitor movements.

Nonlethal Weapons

Besides keeping our military members out of harm's way, robotic technology also has the capability to gain control of a situation using non-lethal weapons.[25]The use of nonlethal weapons has become an option popular with the American media and several liberal human rights groups. However, military commanders are extremely nervous about this option because our men and women, by the nature of our mission, are trained to destroy their enemy.[26] Our troops are trained and then briefed on the appropriate "use of force" for each mission.[27] Frequently, peacekeeping missions do not require lethal force, but have the potential to become extremely volatile. These situations could cost our troops their own lives because they may spend an additional second trying to decide whether or not to use a lethal weapon or if they incorrectly choose to use a nonlethal weapon.[28] Robotic technology, specifically TMRs, could very well be one answer. TMRs equipped with nonlethal weapons and controlled by a trained tactical team operating from a safe standoff position could gain control of the situation without lethal weapons, or at least without putting troops in harm's way if a nonlethal weapon was not the right choice.[29] Teleoperated TMRs have the ability to shoot and discharge adhesives, which prevent the target from escaping and nets, which tightly encase the target and prevent them from using their legs, arms, and hands. TMRs can discharge chemical agents like, pepper sprays, and tear gas, which incapacitates or renders the target harmless. Also, they can fire various nonlethal projectiles such as rubber bullets, rubber balls, or bolas. If a human can shoot a weapon via a handheld device, then a TMR can be equipped to do the same, to include lethal weaponry.

Potential Firepower

Platform size, cargo capacity, and stability during firing are limitations any delivery system, including TMRs, must contend with when determining munitions delivery ability. As discussed earlier, besides these factors, lack of operational imagination is probably the most likely inhibitor for TMRs or any robotic platform. Another major contribution TMRs could provide to improve firepower and targeting, is ground guidance.[35] Transmitter or laser equipped TMRs could be maneuvered to a target, then emit a beacon or laser designator that an aerial weapon uses to home in on. The transmitter selection would depend upon accuracy and clandestine requirements of the mission. Also, TMRs could be equipped with laser targeting equipment and various optic sensors, which would allow for multiple targeting solutions even during night or cloud covered operations. TMR operators would be able to maneuver the platform from one area to the next in order to identify numerous targets. Also, operators could use the optical sensors to determine ground zero battle damage, thus eliminating the need to re-attack targets which have been destroyed or rendered useless, and at the same time, reattack targets, which are still commission.

LOGISTICAL CONCERNS

Logistical Concerns

If robotic vehicles are to be successful, they will not only have to be technically sound and enhance operation capabilities, but also be highly reliable and easy to maintain without a significant logistics tail or increased manpower. This section will look at the three primary logistical concerns that must be addressed with any weapon system: maintenance, transportation, and supply.

In the Field

The success of a mission could easily rely on how quickly an individual or team can get a malfunctioning robot up and running again.[1] Due to the nature of SOF missions, Organizational level maintenance will be the primary means for repair and will most often take place in the field. Only in large contingencies or at permanent forward operating locations would Intermediate maintenance capabilities ever be deployed.[2] The success of SOF missions relies heavily on bringing the smallest mobility footprint possible; hence, tactical teams cannot bring test equipment or spare parts, for they must stay light and lean. Therefore, they must have highly reliable systems, which have components that are interchangeable between other systems. This allows them to cannibalize parts from one system to fix another.[3] Due to the differences in size and the various families of robotic systems, the interchange ability requirement may have to be specific to those of like systems. Modular LRUs are imperative for this maintenance concept to be viable.

Design Configuration

Modularity encompasses more than simply having the ability to plug-in components. It is essential that the components not only have plug in capability, but also have no requirement to test or align the components or the system after replacement. This requirement should exist for both new and replacement parts, as well as those parts cannibalized from another system. Just as important, the modularity design must ensure that components are removed and replaced easily, yet have safeguards to prevent improper installation. Ideally, the remove and replace procedures will require simple common-user tools.

If possible, the modularity concept should apply to sensors as well. This would enhance maintainability and provide greater flexibility. If the sensors had the same modularity requirements, field tactical teams could reconfigure the robotic platforms to meet the mission, compensate for mission changes, adjust for unforeseen situations, or cannibalize from another platform. This flexibility would allow the tactical teams to make appropriate decisions when a primary sensor is malfunctioning or no longer viable. The modularity requirement should also be such that it allows members of the tactical team to maintain the system without the need for extensive training, additional personnel and support equipment, or an umbilical cord to the Intermediate maintenance shop or contractor.

CONCLUSIONS

Robotics, and TMRs in particular, are at a stage similar to aircraft during World War I, but without the urgency of a war to justify incurring significant development or study. Without the war, aircraft technological advancements and military applications would have been much slower, if conducted at all. Without the war what would have driven the requirements? Before the war, and even during the early years of WWI, the airplane was seen as a fad or at best only a reconnaissance platform. Sound familiar? Yet by World War II, the airplane was considered indispensable and some 50 years later, many argue airpower is the only weapon needed, or at least the weapon of choice. It appears that there is little urgency or hard-driving requirements allowing TMR and other robotic technology to progress at other than its own pace at our civilianinstitutes.

Besides sustaining a reasonable pace, program managers must also avoid chasing after technology. Often users, and sometimes program managers, fall into the same trap; just about the time a system is ready to go, they discover a new technology they must have and end up delaying the program while trying to get it.

Trying to keep up with technology changes is a dual-edged sword. On one hand, change is needed to justify staying ahead, conversely, any change costs time and money. The advancements in robotic technology and sensors are currently improving at an almost monthly rate. To strike the right balance requires not only very knowledgeable program managers, but also very knowledgeable users who are actively involved.

The key is to get these robots, especially TMRs, in the field as soon as possible and let them develop and advance from there. Thanks to the fast pace of technology improvements, modification is now a way of life. The pace is continually getting faster, and the best way to deal with it is recognize it and prepare to modify . In the near future robotics will become a viable military option, and in the not to distant future, a military necessity. Who knows, 50 years from now robots may be considered the weapon of choice.

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