Unmanned Aerial Vehicles as Assisting Tools in Dismounted Company Attack

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***Abstract*—This paper presents an idea-phase introduction of how to utilize swarms of Unmanned Aerial Vehicles (UAVs) in performing a dismounted company attack. UAVs are used in the process of data gathering and as tools to increase overall Situational Awareness (SA). A company represents a basic military unit performing time-critical tasks whose completion is mandatory for operational survival. The discussed idea-stage solution relies on using UAVs as tools of military commanders to act as data collectors, hub-stations and tools to gather data from the areas of interest. Since the tempo of operations at tactical level (battalion and below) has increased, the amount and type of data gathered are crucial in terms of operational success. The need for timely and accurate data from a designated area is necessary for improved decision making process, which is dependable on Situational Awareness and Common Operational Picture (COP). Once the critical data have been gathered and analyzed, UAVs act as versatile assisting tools in military operations in the roles of collecting and forwarding data to support processes of control and command. The main contribution of this paper is to identify the possibilities and the process of how to improve the overall performance of military troops by utilizing UAVs as assisting tools in gathering real-time data required for decision making.**

Keywords-Unmanned Aerial Vehicles (UAVs), dismounted company attack, real-time data, military decision making process.

I. INTRODUCTION

Militaries all over the world continue developing methods for saving the lives of own troops. The reason for this is the downsizing process of armies in western countries. Battlespace is the environment where military operations are executed. The number of soldiers in combat units decreases, and simultaneously the number of personnel to take care of the logistics and maintenance issues increases as the maintenance of machinery utilized in the battlespace asks for ever increasing resources. The overall aim of militaries continues to be the sustained capability to improve operational performance despite the downsizing and minimized number of soldiers in combat. The key for this is in attempting to increase SA. This asks for the use of UAVs to produce the required data for analyzing purposes.

Creating a simulation to model a UAV assisted operation is at present unfortunately not feasible on the grounds that neither funding nor facilities are available. To measure the utilization of UAVs in a dismounted company attack would require real functioning swarms of UAVs. No funding is available for this at the moment.

A company attack, typically a dismounted company attack, is a demanding military operation, which requires constant real-time data to allow executing all the phases of an operation to achieve the set goal. It comprises several phases of action, the first of which is reconnaissance. An attacking unit must find out the composition and location of the opposite entity before the attack can be executed. Once the reconnaissance data have been gathered, the planning sequence of the operation begins by implementing the process of Military Decision Making Process (MDMP). In this process, it is possible to benefit from automated assisting tools. When the MDMP has been carried out, it results in different types of Courses of Action (COAs). These COAs represent different alternatives to military commanders on how to organize the attack. Once the optimal COA has been chosen, the maneuvre named dismounted company attack can be ignited. A Dismounted Company Attack is composed of the phases outlined in the following Figure 1: Assembly area, dismount line, line of departure, engagement, combat and the objective.

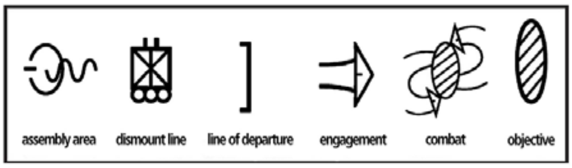

Figure 1. Dismounted Company Attack as a process [1.]

As an example of examining COAs, Figure 2 depicts two different types of COAs in the battlespace. In the first COA, the objective is to stop an armored enemy by deploying a flanking movement, whereas in the second COA, the objective is to destroy an enemy command post by direct engagement.

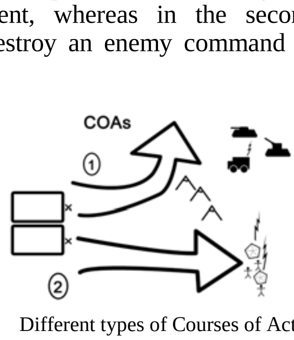

Figure 2. Different types of Courses of Actions.

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The utilization of UAVs can be seen as having a central role when real-time data are required for rapid decision making. UAVs can be seen as a resource for military commanders in that they offer the advantage of surprise in an attack by producing the real-time data needed for decision making. If a commander fails in surprising the enemy, he or she loses the possibility to take the initiative in the operation. The ability to take and maintain the initiative is usually a must in a successful military operation, especially in a dismounted company attack. When real-time data are available, an improved decision making process and its outcome become possible.

The utilization of Unmanned Aerial Vehicles is necessary to get the correct information from enemy space as rapidly as possible in the hectic tempo of operations, save soldiers' lives and support the morale of troops performing the maneuvres in an operational area. Furthermore, the use of unmanned machines can be seen as part of optimizing the existing resources of military units as machines continue performing fearlessly.

When militarily utilized, UAVs can be used for varying tasks: performing terrain reconnaissance in the area of objective, performing reconnaissance of the use of Nuclear, Biological and Chemical substances, maintaining reconnaissance engagement by providing data on enemy movements, and monitoring the actions of enemy troops (direction and speed of movement, location, size, formation, action). UAVs can also be utilized in the targeting process in that UAVs can be sent airborne to the designated areas for the reconnaissance and targeting of the potential enemy targets. UAVs can act as relay stations for sustaining the constant capability to communicate and control the troops and machines in the hostile area.

Collected data from the designated areas is utilizable in the MDMP. This process is linked to gaining SA and choosing between different COAs. These data can be collected more safely, if an appropriate number of UAVs of the necessary type are available for these operations. When UAVs are used aside the soldiers, to complement the data gathering, it is optimal to combine the capabilities of soldiers and machines. Machines can be sent out to the most dangerous locations while soldiers remain in charge of the less lethal task, if ever possible in a battlespace.

The use of machines gives an advantage for commanders. First, UAVs can be sent to the areas of interest, days ahead, if required. UAVs can be shut down or reactivated via electrical signals when necessary. This gives commanders the advantage to transport the UAVs as reconnaissance resources to the designated areas well in advance and at the chosen moment. When UAVs have been flown to the area and shut down, they will not consume any energy, the saved energy can be used at a chosen moment and in the wanted operation, which supports the own battle plan and own objectives. Commanders can plan these actions well in advance and have UAVs transported to the areas when appropriate and safe. UAVs can be ready and standing by well in advance, in a chosen area, with the chosen sensors embedded in the UAV platform.

To summarize: commanders can benefit from the use of push and pull factors. Commanders can push the UAVs to the optimal area of battlespace at a chosen moment. The optimized location of UAVs guarantee the improved performance in own oncoming military maneuvers. The pull factor means pulling the data from the designated areas at a chosen moment. These data are pulled to increase the performance of own operations in analyzing the collected data. The collected data are raw material for defining SA and COP. The accrued data are utilized in the MDMP and in the process of choosing between different COAs.

Communication is critical in the execution process of command and control. The lack of communication results in an ineffective military operation. When the possibilities offered by the Wireless Polling Sensor Network (WPSN) are taken into active use together with using One Time Pads (OTPs), two communication goals become achievable: the covert network and security in messaging. This is discussed more in Section V.

When machines, such as UAVs, are utilized, Service Oriented Architecture (SOA) becomes applicable. In digitized battlespace and in digitized operational planning, SOA is utilizable in the allocation processes of own existing resources and optimizing the use of troops in correct time and in the correct operational area. SOA is also useful in offering assistance in the overall planning process. SOA can be used in optimizing the timing of the different actions, also while the dismounted company attack is in progress, and in automating the MDMP. By automating the MDMP and using UAVs, commanders can save time, resources and lives as well as achieve the set objective.

The rest of this paper is organized as follows. Section II concentrates on the related work, Section III discusses Unmanned Aerial Vehicles, and Section IV concentrates on the essence of communication. Section V deals with Wireless Polling Sensor Networks and the use of One Time Pads, Section VI deals with Military Decision Making Process, and Section VII focuses on the Situational Awareness and Common Operational Picture. Section VIII discusses the significance of sensors, and Section IX looks at SOA in relation to MDMP and reorganizing the chain of command in troops. Section X comprises discussion, Section XI concludes with the results, and Section XII addresses the requirements for further studies.

II. RELATED WORK

Several researchers have been studying the use of UAVs in accruing data to support SA, COP and MDMP by increasing the performance of different types of networks. Moreover, the studies listed here have concentrated on increasing the speed, safety and capability to communicate in an improved manner.

As demonstrated in [2], ad-hoc networks can create a UAV access net ensuring communication among mobile or stationary users. These ad-hoc networks support Blue Force Tracking, as indicated in [3]. When UAVs are equipped with Free Space Optics (FSO) communication links, operations can be executed by avoiding to become sensed by means of electrical reconnaissance detection, as concluded in [4]. FSO represents an optical communication technology that uses light propagating in free space to transmit data from point-to-point (and multipoint) by using low-powered infrared lasers, which can also be used for localization purposes, if range and orientation information is available FSO-technology offers high-speed, up to 10 Gb, reliable and cost-effective connectivity for heterogeneous wireless services provision in both urban and rural deployments when Dense Wavelength Division Multiplexing (DWMD) is utilized in Radio-on-FSO (RoFSO) system.

In vision-based tracking, pan-tilt gimbaled cameras using Commercial off-the shelf (COTS) components can be used as well as calculation algorithms and advanced controlling systems for integrated control of a UAV and an onboard gimbaled camera, see [5]. Along with the availability of both low-cost and highly capable COTS-based UAVs and Unmanned Ground Vehicles (UGVs) and communications equipment, it is reasonable to apply quick and inexpensive means for surveillance, tracking and location purposes, as discussed in [6]. UAVs of varying types and sizes can be used in aerial surveillance and ground target tracking, see [7]. To boost the performance of a single UAV, swarms of small UAVs can rely on airborne MANETs, as indicated in [2]. Transmit antennas are significant in the process of operating UAVs, as indicated in [8]. When swarms of UAVs are utilized for navigation, localization and target tracking, information synchronization is important, as discussed in [9]. In present battlespace miniature UAVs are becoming increasingly significant among surveillance applications, as shown in [10]. Remotely controlled UAVs can act as an assisting tool in tracking and monitoring, as discussed in [5]. Remotely controlled UAVs can enhance SA, Blue Force Tracking (BFT), thereby enforcing the probability of success in missions, even when operating beyond line-of-sight, see [11]. The means for exploiting UAVs and UGVs in the processes of data collection and the distribution of near real-time COP to be implemented in Shared SA are discussed in [12]. Battle Management Language (BML) can be seen as a common language enabler between machines and interfaces along with almost ubiquitous swarms of UAVs [9.]. For example, networks utilizing COTS components mounted on of UAVs add survivability and remove the need for a line-of-sight connection, as described in [6.].

This present paper examines the topic from a different angle by focusing on how to facilitate a dismounted company attack with the use of UAVs. This means aiming at optimizing the use of existing resources and automating the attack to the extent feasible. The objective is to contribute to the overall goal of increasing safety in military operations by means of improved use of resources resulting in decreasing numbers of casualties as well as increasing the tempo of own military operations.

III. UNMANNED AERIAL VEHICLES

Unmanned Aerial Vehicles utilized in a dismounted company attack can be autonomous or guided platforms built with COTS material ensuring the relatively inexpensive price tags on the UAVs. The main function of UAVs is to produce real-time data for commanders for decision making purposes. The use of swarms of UAVs ensures the gathering of data behind the visual horizon. Distances between command link and the swarms of UAVs are typically few kilometers. Typically, if a UAV has been identified by the actions of an adversary, the particular UAV ends up becoming annihilated. Therefore UAVs have to be built to be disposable elements. Once the UAVs are used as swarms, the combat survivability of the system can be increased.

This paper examines only UAVs because of their versatility compared to the other Unmanned Vehicles (UVs), such as Unmanned Ground Vehicles (UGVs). When a small tactical level military unit, such as a company, is performing a complicated maneuver, a dismounted company attack, the UAVs represent the only reasonable type of UVs to be utilized. UAVs are capable of monitoring the designated target areas and transmitting real-time data to the base-station simultaneously when monitoring the area. See Figure 3.

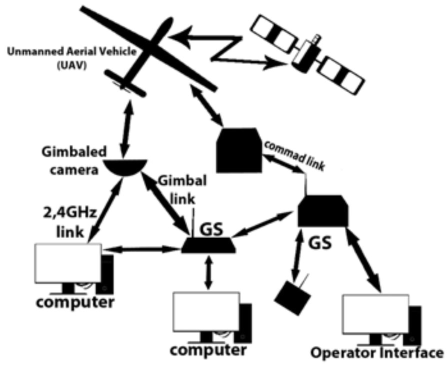

Figure 3. UAVs and the data transmission.

Typically, when flight times are short, less than an hour, engines and sensors embedded into UAVs can be powered by liquid fuel batteries to ensure adequate level of energy. Liquid Polymer (LiPo) batteries are utilizable for their capacity. Electrical surveillance components, guidance systems, and command systems are depend on adequate electricity level.

Typically, the distance between a communication link and a swarm of UAVs is few kilometers, and therefore 2,4 GHz Ultra-Wideband Network system between the communication link and the base station is applicable for these distances. The typical speed of swarms of UAVs is tens of kilometers per hour. This is a chosen speed to balance the energy consumption and the range of transmission power and movement.

UAVs are most versatile with their capability for quick deployment. UAVs tend to be miniature-sized airplanes, drones and helicopters, weighing few kilograms. The range of these vehicles can vary from few hundred meters to few kilometers as can their mass and size. The same applies to the payload. The payload can be measured from tens of grams to few hundred grams depending on the use and measurements of UAVs.

The typical payload of UAVs can comprise varying sensors, such as: acoustic-, seismic-, magnetic-, visible image-, shortwave infrared (SWIR)-, thermal-, infrared-, low-light television (LLTV)-, and sensors for laser tracking and spotting, and for facial recognition. These sensor packages can be also deployed into the area of interest at a desired moment. If the area of interest is known well in advance, a UAV and the sensor package can be flown into the perimeter in advance and been dropped in the chosen area. In addition, a UAV can be guided close to the area of interest. The UAV can then be parked, for example, on rooftops and cliffs to wait for the command to start the reconnoitering mission. This saves time and positions the UAV in nearby perimeters of the desired area. The UAVs remain hidden and hard to detect, and when detected, it is too late anyway.

IV. COMMUNICATION

Communication between different troops and inside the company remains vital from the perspective of a successful military operation. The sustained capability to communicate between troops (soldiers) and machines (UAVs) must be maintained throughout a military operation. Without communication there is neither command nor control between the entities. Communication can be described as comprising three layers. These layers are sensor-layer, C^4I^2SR –layer and shooters –layer. The layers are connected with the existing communication networks. Different layers are depicted in Figure 4.

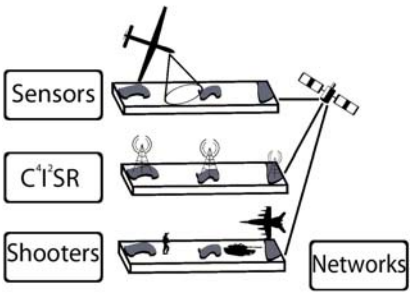

Figure 4. Communication network from sensor to shooter.

The depicted layers communicate and forward data via UAV –radios, which can utilize the output of GPS/GLONASS receivers for automatic position reporting. When Software Defined Radios (SDRs) are embedded onboard UAVs, typical SDRs' features can be included into transmission protocols. These include: Multiband 30 – 512 MHz, multimode, multi-mission, software programmable architecture, Low Probability of Detection (LPD) and Low Probability of Identification (LPI), simultaneous voice and data, near-real time data transfer from sensor to decision maker and onwards to the shooter applications. Lightweight UAV –implemented radios offer low consumption transceivers operating in the frequency of 2.4 GHz Industrial, Scientific and Medical (ISM) band. The use of this frequency offers very low Radio Frequency (RF) signature modulation scheme based on spread spectrum technology (DSSS) and provides a robust, reliable and low probability of detection time division multiple access (TDMA) waveform. Radios typically feature advanced encryption standard (AES) encryption providing a very high security level on the transferred audio and data systems, while security keys can be downloadable. UAV -radios can provide several tactical communication services: full-duplex voice conferencing, GPS reporting, e-mail, chat, file transfer, and real-time video streaming.

When properly adopted into active use, UAVs can be seen as flying hubs or flying relay-stations, tools of communication. When UAVs are used to secure communication, as depicted in Figure 4, the throughput of communication can be maximized. Furthermore, the swarms of UAVs end up creating an own data communication system, as depicted in Figure 5. This ensures that the data transmission distances between UAVs remain short and become operationally secure. This aids in meeting the requirements of Low-Probability of Detection (LPD) and Low-Probability of Identification (LPI). The described delicate system introduced is a new one and based on ideas that can be executed by utilizing existing COTS- technology [13].

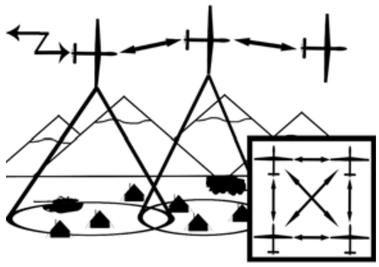

Figure 5. A data exchange process inside the swarm of UAVs.

Figure 5 describes the idea of using UAVs as swarms. The number of UAVs used in each scenario varies depending on the commanded mission and its speed and other set requirements.

V. WIRELESS POLLING SENSOR NETWORKS

A battlespace tends to be embedded with different types of sensors found from the soil, airborne or attached into various types of manned and unmanned vehicles. The utilization of Wireless Polling Sensor Network (WPSN) together with OTPs can be seen as one possible solution for communication system between sensors and UAVs, as indicated in [14]. WPSN can be viewed one possible solution when gathering data from different sensors and sensor networks. When a swarm of UAVs are utilized in forming an ad-hoc network and polling a large number of fixed sensor nodes, a secure network system can be created. The WPSN system is more robust in the military environment than traditional Wireless Sensor Networks (WSNs). Although WSNs have been used for a long time, they demonstrate particular disadvantages. These include the fact that multi-hop transmission fails when nodes are destroyed in military environments, battery lifetime creates limitations, and security challenges remain unsolved. A WPSN has advantages in all of these areas compared to other proposed

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solutions. WPSN comprises a small mobile ad-hoc network of UAVs and a high number of fixed ground-based sensors, which are periodically polled by the UAVs.

The advantages concerning WPSN and OTP include that in the WPSN solution the fixed sensor nodes remain concealed, yet active, because the sensor nodes of WPSN do not communicate with each other but only respond to polling by the mobile nodes. The WPSN node communicates with a UAV through encrypted messages. Thereby, WPSN responds only after a UAV has submitted a polling request with a specific code. The routes of UVs can be fed into the systems early enough to gain the needed information from the designated areas [14].

When speaking about a battlespace and actions taking place in this hostile environment, it is mandatory that some of the UAVs be shot down or destroyed by other means of contemporary warfare. This possibility must be recognized prior to engagement. UAVs must be designed so that once malfunctioning, they will get automatically destroyed (software and hardware) to become instantly useless for the adversary. Yet, this destruction of one UAV does not jeopardize the concept of sustained secure communication, for the network composed by remaining UAVs will reroute itself automatically.

VI. MILITARY DECISION MAKING PROCESS

In military operations performed at tactical level, i.e., battalion and below, the significance of tempo and timing becomes critical. In the MDMP all the raw data collected by UAVs have to be analyzed and taken into account as they are directly connected with targeting systems, weapon selection processes, COP, SA and Control, Command, Computers, Communication, Information, Intelligence, Surveillance and Reconnaissance (C^4I^2SR).

Here, automation and mathematics can be seen as assisting tools in the process of making rapid and reliable decisions. When mathematical methodology is implemented, measuring the additive value model is the simplest and most commonly used mathematical model in multiple objective decision analysis. As described in [15], the additive value model is given by the equation:

$$v(x_j) = \sum_{i=1}^{n} w_i v_i(x_{ij}) \qquad (1)$$

where

$v(x_j)$ is the total value of alternative *j*,

$i = 1$ to n are the value measures specified in the qualitative value model,

x_{ij} is alternative *j*'s score (raw data) on value measure *i*,

$v_i(x_{ij})$ is the single-dimensional value of alternative *j* on value measure *i*,

and w_i is the swing weight of value measure *i*.

Equation (1) is the simplest and most commonly used mathematical model in multiple objective decision analysis.

Obviously, mathematics alone cannot solve the dilemma of making the correct operational decision quickly in a chaotic combat setting. When a decision is made between different COAs, mathematics and probability prognosis can only be seen as assisting tools. The human commander is the only one who is responsible for sensible and applicable decision which can be converted into commands to be issued and executed in an operation.

VII. SITUATIONAL AWARENESS AND COMMON OPERATIONAL PICTURE

The term Situational Awareness has been given an apt definition in the Army Field Manual 1-02. SA can be understood as knowledge and understanding of the current situation, which promotes timely, relevant and accurate assessment of friendly, competitive and other operations within the battlespace in order to facilitate decision making. SA, furthermore, equals an informational perspective and skill that fosters an ability to determine quickly the context and relevance of events that is unfolding. The term SA comprises three levels: 1) perception, 2) comprehension and 3) projection. [16]. SA, or, the lack of it, remains critical in performing military operations successfully. The means to increase SA can and must be fostered and developed, since the loss or deterioration of SA results in inaccuracies, human errors, and eventual casualties and fratricide. The military operation in progress usually fails because of poor level of SA.

Situational Awareness has a strong relation to COP. COP represents an overall understanding of the prevailing situation in the battlespace. COP can be displayed on the screen of a computer or a digital device, and by using markers and traditional maps. COP features elements, such as individuals of friendly forces, neutral entities and the adversary, presented by symbols of various types.

To complete the list of phenomena affecting the MDMP, C^4I^2SR needs to be taken into account. UAVs are utilized to assists the MDMP performed in C^4I^2SR environment. When combined together as swarms, UAVs form tools for accruing data, forwarding and analyzing these data into the form of information to create COP and increase SA.

To sum up, all these listed elements are linked to the MDMP. The decisions made as part of the MDMP can also be seen as tools in targeting and weapon selection processes. Figure 6 explains the relations and functions inside MDMP when the use case is related to targeting and weapon selection systems. In the MDMP the end-come is the optimal use of weapon systems to avoid collateral damage and fratricide.

Figure 6. Decision making system in targeting and weapon systems.

VIII. SENSORS

In order to achieve the set objective in a given military setting, it makes sense to utilize maximally the data produced by various types of sensors when accruing data from hostile environments. In some cases, especially when the weather conditions are challenging, for example, the wind speed exceeds 10 metres per second, the UAVs cannot be used or they are too slow and there has to be an alternative possibility to deploy sensors for accruing real-time data. Some of these sensors can be deployed to the area of interest with the assistance of artillery fire produced by mortars or cannons. Rapidly deployable airborne sensors represent relatively inexpensive and versatile tools for low-level battalion and company operations. As indicated in [17], light sensor munition can be deployed behind enemy lines. An example of sensors' deployment, when UAVs are not applicable, is Sensor Element Munitions (SEMs). SEMs can be manufactured of composites surfaced with materials capable of absorbing radar beams, making the SEM less visible in enemy counter-artillery radars. In any military operation, airborne sensors are important for missions, such as force protection, perimeter control and intelligence utilization, as discussed in [18]. Transmitting the accrued data to prevent cases of fratricide and to ensure success in operations presupposes optimal communications. WiMAX transmission offers applicable possibilities in forwarding collected data. The distances in the transmission process are relatively short, ranging from 1 kilometre to few kilometres in conditions of clear Line-Of-Sight.

The sensor package inside SEMs (Sensor Elements, SE) is made of COTS-products comprising sensors capable of sensing most of the phenomena occurring in the electromagnetic spectrum. Overall, COTS-products are relatively inexpensive and reliable in terms of function, as explained in [19]. Sensor Elements can contain the same sensors as UAVs. The command post has the capability for the data fusion of all the accrued sensor information.

Once an SE is airborne, it immediately starts to transmit the gathered data to friendly troops either directly or, if the transmission distance exceeds the capability of the transmission unit, the SE transmits the data to another airborne device, which acts as a relay station in relation to own troops. The SE communicates with the receiver station and other sensor element packages over a 2,4 GHz Ultra-Wideband Network system. The accrued data are encrypted for security reasons. The composition of SEMs is depicted in Figure 7.

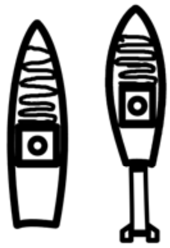

Figure 7. Structures of Sensor Element Munitions (SEMs): An artillery SEM (left), a mortar SEM (right) [17].

SEMs can be deployed to the target area with manned artillery weapons or unmanned remotely controlled pieces of artillery or by using mortars, as mentioned earlier. The process of deploying SEM to the area of interest is depicted in Figure 8. SEM ejects the Sensor Element (SE) which in turn reports the gathered data to the base station [17].

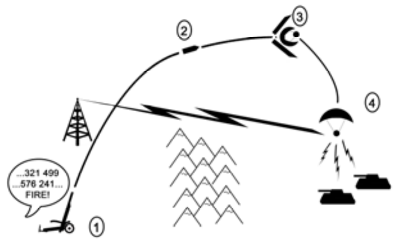

Figure 8. Process on how to deploy an SE to an enemy territory [17].

Figure 8 presents a typical use case, in which a company is executing a military operation supported with an artillery or mortar unit. The reconnoitering range tends to vary from one to few kilometers. When a dismounted company attack is supported with units of UAVs tailored for Close-Air Support (CAS), the data exchange transmission process for the target data is depicted in Figure 9.

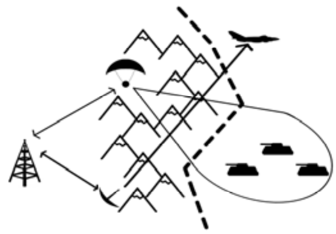

Figure 9. The process of detecting target to the shooter [17].

The UAVs of CAS units optimize the speed and destruction power used in proximity to destroy the designated targets. When a small unit operates, it needs to achieve results in short time in order to maintain the initiative and reach the set objective. A company is a small military unit, which has to maximize the momentum offered by the performance produced by CAS units. UAVs must be utilized as tools to evaluate the outcome of the executed CAS fire-mission. If the result of CAS fire-mission is reported not to fulfil the requirements set, the new round of CAS fire-mission must be performed to destroy the chosen target.

IX. Service Oriented Architecture

SOA offers a variety of possibilities to improve the performance in military operations. SOA can be exploited when needing to reorganize the military organization after casualties affect the chain of command in a dismounted company. This process is described in [20]. Military operations nowadays usually demonstrate features of Network Centric Warfare (NCW) in which one key aspect is to be able to offer a valid and accurate COP for the operating troops in the battlespace. A basic requirement for a military commander is the ability to command the troops and sustain optimal SA and COP. An important aspect in distributing information in the battlespace is the amount and quality of information shared at different levels. SOA can be seen as a useful tool in distributing data in a preprogrammed manner. The amount of information allocated must be set to a level where the decision maker can perform timely and draw accurate conclusions. In the battlespace units suffer from casualties and the chain of command never remains intact.

A constructive idea in SOA is in its process ideology. In a dismounted company, the composition of the unit and its performance are critical in executing the operations. Military units suffer from casualties and their mathematical performance value tends to change in an unpredictable manner. The performance of a military organization, such as a dismounted infantry company, can be mathematically calculated as explained in [20].

Behind these mathematical values is a Psycho Physical Factor, described in [20]. The process of creating this factor is described in [21] and the formula may be useful in calculating the performance of a military unit.

The implementation of SOA is described in [20]. A key aspect in the presented architecture [20] is the dynamically changing architecture. Benefitting from the possibilities offered to orchestrate data and services with the assistance of SOA allows for improved performance in the execution of operations. SOA can be utilized in the process of choosing between different COAs. Eventually, the chosen COA will be fine-tuned into commands and maneuvres of a dismounted company attack.

In applying SOA paradigms, loose coupling, dynamic binding and independency of development technologies, platforms and organizations, as well as locations, all these become advantages in that the use of SOA typically encourages reusing services. The identified assets belong to military units, but military units offer their responsibilities through services, and capability deployment requires invoking and integrating a number of services. Figure 10 depicts the relations of services, assets and capabilities of a military unit.

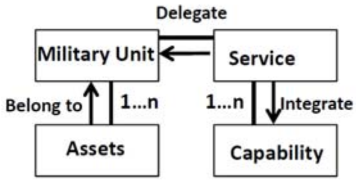

Figure 10. Conceptual model of C^4I^2SR capabilities based on SOA [22].

In a dismounted company attack, all operating military platoons use the same services and assets of a dismounted company. In this case, SOA itself offers a flexible approach to identify C^4I^2SR capabilities when several platoons benefit from the services and assets of a dismounted company. SOA enables a company to respond more quickly to the changing battlespace situations and requirements to execute the given missions in the given time and with the allocated resources.

X. Discussion

When the UAVs are successfully utilized in the different phases in a dismounted combat attack, the results can be optimally utilized. These gained results can be identified and evaluated in relation to the different stages of the process of a dismounted company attack. When the need of a requested service is identified, automated systems assist to fulfil the need of any type (need of data, resupply, firepower, evacuation).

As noted in the Related Work –Section, the use of UAVs has been identified as critical and effective for a successful military operation. UAVs can be used for collecting near real-time data, as a flying hub-station and in assessing the impact of artillery fire. Using swarms of UAVs enables quick, reliable and effective data collecting from a specified area. Furthermore, when UAVs function as the communication link, the chain of command and control remains secure as regards communication.

By exploiting the data accessed by means of using UAVs it is possible to enhance a dismounted military operation: readjusting the direction and action of combat units and increasing their speed. The communication between UAVs and ground base-stations is encrypted. This ensures that the data collected and communication transmitted remain intact and coherent. UAVs may fly via automated waypoints or serve as fighter-operated systems. UAVs can be designed to be disposable, self-destroyable, once their task has been completed, or in case of malfunction, or if encountered by enemy. The use of SEMs becomes applicable in cases when the weather conditions are challenging, for example, the wind speed exceeds ten metres per second, or if data concerning a target must be rapidly accessed.

Compared to traditional WSN-systems, WPSN allows for improved security protocol in the communication between UAVs and sensors. Data collecting systems gather raw data on battle space phenomena, for example troop movements and action. These raw data feed the MDMP and facilitate speeding up the decision making. Using mathematical models and –programs produces improved SA and COP, compared to non-automatized human decision making performance. The improved SA and COP allow for significant increase in efficiency as regards planning and implementing the tactical use of destructive fire power.

As the raw data collected by UAVs are already in electronic form, SOA can be utilized in planning, distributing and optimizing resources: evacuation, supplies, use of artillery fire. When the described systems for data collecting, analyzing, and communicating function as planned, it becomes possible to carry out an automized, computer-assisted attack as described in Figure 11. Utilizing FSO communication links fosters reliable, secure and coherent communication in command and control processes.

If and when all the accrued data can be properly processed and analyzed in MDMP with the assistance of SOA, the performance of troops can result in an automated dismounted company attack as depicted in Figure 11.

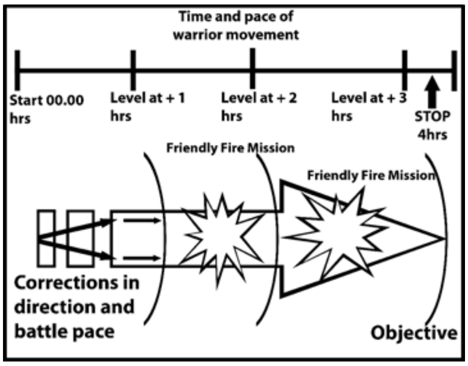

Figure 11. An automated attack operation. [1]

Figure 11 aims to visualize the goal of commanding military troops with the assistance of a computerized Artificial Intelligence (AI). The final commands for the military units to move and execute are given by a human commander, not by a machine. UAVs can be seen as tools in monitoring and assisting in an operation when re-adjusting its pace: If the pace of the units or an individual soldier is too slow, the data transmitted by UAVs is utilized to fine-tune the speed and direction of the operating troops. The SA data acquired by means of UAVs must be used in taking the iniative and translating it into success in battle and eventually meeting the set objectives of the given military operation.

XI. CONCLUSIONS

This paper has focused on observing how to utilize the real-time data collecting ability provided by UAVs in order to improve the performance of a dismounted company attack. The approach adopted equals idea-stage examination and as such aims to examine grounds for further planning of how to execute military attack missions with the assistance of UAVs. This paper introduces a concept of benefitting from the use of UAVs as part of a dismounted company attack. When doing so, it also points out the necessity of rapid data collection to support the fast MDMP.

The utilization and performance of UAVs can be seen as data collectors in the battlespace. Sensors embedded into the UAVs used can produce different types of data from the designated area. UAVs can be deployed to the designated areas in most weather conditions and immediately when required, as there are no latency times. The data collected by UAVs are then transmitted to the command posts. The collected real-time data remain critical for the MDMP. The data accrued must be in a pre-defined digitized form, which is applicable in digitized decision making systems exploited in the battlespace. The level and quality of SA continues to be critical at the soldier level, whilst the level of COP plays an important role in command posts, where operations are planned, commanded and controlled.

The data for the MDMP are collected by using various types of sensors embedded into UAVs and SEMs. The key issue is the speed of deploying the sensor package to the area. The prevailing combat situation in the battlespace determines the selecting of the type of UAV and sensor package embedded. The data accrued must be in a digitized form applicable in the software environment used. SOA can be used in re-organizing troops and allocating resources.

The ultimate goal of a dismounted company attack is to execute the mission with the resources allocated and to obtain the set objective. This asks for sustaining timely performance with a minimal number of casualties, no instances of fratricide and with the least possible amount of collateral damage. The objective is difficult to obtain, when using soldiers prone to making human errors. However, operational performance can be improved if the data collected via UAVs is reliable and can be adopted in active use in near-real time. This may result in increased individual and collective performance. With improved levels of SA and COP, the safety of operations may be sustained.

With computers acting as assisting tools in the MDMP offering suggestions as commands to the commander of attacking troops, the role of the commander is to either approve or reject the suggested commands. Thus a human decision maker remains critical in the chain of command.

XII. FUTURE WORK

Because a dismounted company attack represents a time-critical maneuvre in the category of tactical military actions performed at a company level, any efforts to improve the company’s capability are worthwhile. This asks for developing a ruggedized system based on the idea-phase description outlined in this paper. Attention must be paid to planning the utilization of UAVs together with accounting for the operational security issues concerning using software and hardware in the battlespace.

The usability of UAVs to create a functional communication network requires field testing in combat exercise settings prior to any operational use. UAVs have to be remotely destroyable both physically and digitally. The capability of UAVs to self-destroy when malfunctioning or having been shot down must be tested. Other identified challenges are related to maintaining an adequate level of constant energy flow and protecting against violations caused by electronic warfare.

The use of SOA in assisting the MDMP has to be studied in combat exercise settings as well in order to gain realistic and relevant data on human commanders evaluating COAs when planning a dismounted company attack.

REFERENCES

[1] T. Saarelainen and J. Jormakka, “Interfacing collaboration and command tools for crises management military command and control systems”, International Journal of Electronic security and Digital Forensics, vol 3, No. 3, 2010, pp. 249 – 264.

[2] S. Chaumette, R. Laplace, C. Mazel, and A. Godin, “Secure cooperative ad hoc applications within UAV fleets”, IEEE Conference on Military Communications Conference (MILCOM 2009), 18-21 Oct. 2009, Boston, MA, pp. 1 – 7, doi 10.1109/MILCOM.2009.5379819.

[3] E. Loren., L. Riblett, and J. Wiseman, “TACKNET: Mobile ad hoc secure communications network”, in Proceedings of 41st Annual IEEE International Carnahal Conference on Security Technology, 8-11 October 2007, Ottawa, Ontario, Canada, pp. 156 – 162.

[4] C. Chlestil, et al., “Reliable optical wireless links within UAV swarms”, in Proceedings of Transparent Optical Networks, 18 – 22 June, 2006, Nottingham, Great-Britain, pp. 39 – 42, doi 10.1109/ICTON.2006.248491.

[5] V.N. Dobrokhodov, I.I. Kaminer, K.D. Jones, and R. Ghabcheloo, “Vision-based tracking and motion estimation for moving targets using small UAVs”, Proceedings of the 2006 American Control Conference Minneapolis, June 14 - 16, Minnesota, USA, pp. 1428 – 1433, doi 10.1109/ACC.2006.16564418.

[6] D. Hague, H.T. Kung, and B. Suter, “Field experimentation of cots-based UAV networking”, in Proceedings of IEEE Conference on Military Communications (MILCOM2006), 23-25 Oct. 2006, pp. 1 – 7, doi 10.1109/MILCOM.2006.302070.

[7] A. Ruangwiset, “Path generation for ground target tracking of airplane-typed UAV”, Proceedings of the 2008 IEEE International Conference on Robotics and Biomimetics (ROBIO), Bangkok, Thailand, February 21 – 26, 2009, pp. 1354 – 1358, doi 10.1109/robio.2009.4913197.

[8] C-M. Cheng, P-H. Hsiao, H.T. Kung, and D. Vlah, “Transmit antenna selection based on link-layer channel probing”, in Proceedings of IEEE Conference on World of Wireless, Mobile and Multimedia Networks, 18-21 June 2007, Cambridge, MA, U.S.A. pp. 1 – 6, doi 10.1109/WOWMOM.2007.4351703.

[9] Y. Qu, Y. Zhang, and Q. Zhou, “Cooperative localization of UAV based on information synchronization”, in Proceedings of the 2010 IEEE International Conference on Mechatronics and Automation, August 4 – 7, 2010, Xi’an, China, pp. 225 – 230, doi 10.1109/ICMA.2010.5589081.

[10] M. Pachter, N. Ceccarelli, and P.R. Chandler, “Vision-based target geo-location using camera equipped MAVs”, in Proceedings of 46th Conference on Decision and Control (CDC2007), 2007, pp. 2333 – 2338, doi 10.1109/CDC.2007.4434038.

[11] B. Cummings, T. Zimmerman, B. Robinson, and M. Snyder, “Voice over blue force tracking”, Proceedings of IEEE Conference on Military Communications Conference (MILCOM 2006), 23-25 Oct. 2006, Washington, DC, pp. 1 – 5, doi 10.1109/MILCOM.2006.302173.

[12] J. Harrald and T. Jefferson, “Shared situational awareness in emergency management mitigation and response”, in Proceedings of 40th Annual Hawaii International Conference on System Sciences (HICSS 2007), Jan. 2007, Waikoloa, HI, pp. 23 – 23, doi 10.1109/HICSS.2007.481.

[13] M. C. Zari, et al., “Personnel identification system utilizing low probability-of-intercept techniques: prototype development and testing”, in Proceedings on The Institute of Electrical and Electronics Engineers 31st Annual 1997 International Carnahan Conference on Security Technology, 15-17 Oct 1997, Canberra, ACT, pp. 224 – 230, doi 10.1109/CCST.1997.626274.

[14] J. Jormakka and T. Saarelainen, “UAV-based sensor networks for future force warriors”, International Journal On Advances in Telecommunications, vol 4, numbers 1 and 2, 2011, ISSN:1942-2601, pp. 58 – 71.

[15] R. Dees, S. Nestler, R.Kewley, and K. Ward, “WholeSoldier performance: A value-focused model of soldier quality”, 77th MORS Symposium, WG20- Manpower and Personnell, 35 pages, 7 Dec 07, 21.6.2010, accessed on 5.2.2015.

[16] Field Manual FM 1-02, www.armypubs.army.mil/doctrine/Active_FM.html FM 1-02, accessed on 8.12.2012.

[17] T. Saarelainen, “Targeting situational awareness beyond the event horizon by means of sensor element munition,” ICDT 2012, The Seventh International Conference on Digital Telecommunications, pp. 8 – 14.

[18] P. Buxbaum, “Denying access”, Special Operations Technology, July 2010, Vol 8, Issue 5, pp. 26 – 27.

[19] R. Kozma, et al., “Multi-modal sensor system integrating COTS technology for surveillance and tracking”, Radar Conference, 10-14 May 2010, pp. 1030 – 1035, doi 10.1109/RADAR.2010.5494467.

[20] T. Saarelainen and J. Timonen, “Tactical management in near real-time systems,” IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support, (CogSIMA2011), Miami Beach, Florida, 22.–24 Feb 2011, U.S.A., pp. 240 – 247, 10.1109/COGSIMA.2011.5753452.

[21] M. Phillips, “Air-to-Ground and ground-to-air communications”, Military Technology, Vol XXXVII, Issue 6/2013, pp. 66 – 67.

[22] Z. Ying, W. Zhixue, L. Xiaoming, and C. Li, “C4ISR capability analysis based on service-oriented architecture”, The Fifhth IEEE International Symposium on Service Oriented System Engineering, 2010, pp. 179 – 180, DOI 10.1109/SOSE.2010.41.