Enhancing Situational Awareness by Means of Combat-ID to Minimize Fratricide and Collateral Damage in the Theater

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***Abstract*—The Future Battlefield has expanded to a battlespace where its commanders rely on SA-tools to perform optimally in their given tasks. Operations may include combat settings as well as counter insurgency actions, peace-keeping operations and disaster relief activities. In multi-national operations taking place in versatile and hostile environments, it is essential to detect, classify and identify the encountered objects in the battlespace early enough. The concept of war has changed in the direction of multi-symmetric warfare involving enemy troops, own forces and impartial entities. This paper describes existing technical solutions and oncoming tools applicable in enhancing Situational Awareness (SA) and minimizing fratricide and collateral damage in the battlefield. This paper adopts a meta-analytic approach and examines the current capability of utilized Combat Identification (CID) systems to minimize fratricide and avoid collateral damage in the theatre as described in relevant existing studies and military exercises. This, furthermore, involves introducing means to enhance the overall SA in the battlespace.**

Keywords - Situational Awareness (SA), Common Operational Picture (COP), fratricide, collateral damage.

I. Introduction and Definitions

This paper begins by first taking a look in Combat Identification (CID) issues. Secondly, a comprehensive approach to Target Combat Identification (TCID) is discussed. Thirdly, the paper examines how an ongoing training program, the Bold Quest 2011, is testing these presented methods. Lastly, the concept of Shared Situational Awareness (SSA) is introduced with the help of utilizing Unmanned Aerial Vehicles (UAVs) and Unmanned Ground Vehicles (UGVs). Combining a swarm of UAVs with Free Space Optics (FSO) offers a reliable platform for aerial ad-hoc networking [6]. The capabilities of these platforms are implemented by enhancing SA and data distribution to enable near real-time Common Operational Picture (COP) to be implemented into SSA. Once the location data of different entities can be reliably forwarded to respective command posts, the number of fratricide incidents and collateral damage can be significantly minimized. The significance of Target Combat Identification (TCID) in minimizing fratricide is introduced.

Once the information and its distribution in the battlespace is defined as the key in Network Centric Operations (NCO), every effort to ensure the information flow between own warriors and sensors needs to be analyzed [5]. Contemporary weapon systems require greater amounts of intelligence data at a higher fidelity than ever before [19]. Since operations tend to be multi-national, different sensors and systems are required to communicate understandably between each entity to minimize fratricide and collateral damage by maximizing the distribution of the near real-time Common Operational Picture (COP). One solution is to utilize Battle Management Language (BML) [5].

This paper tackles the following three questions: What are the means to locate the soldier by employing the existing CID and SA technology? How to increase SA with the available technical solutions? And, furthermore, how to test these technologies in peace-time?

As for defining terminology, a new network structure called the Wireless Polling Sensor Network (WPSN) is explained in [1]. Since nodes do not form a network per se but rather are polled by a selected node of the mobile network, they remain undetected due to their passive nature. The network structure offers a new and ubiquitous way to share and forward all kinds of data, including data collected by various sensors. Moreover, the outdated Identification Friend or Foe (IFF) systems are replaced and supplemented with effective and accurate means to identify the prevailing objects.

Examining the means to minimize fratricide and collateral damage presupposes applying the model presented in Figure 1 below. This terminologically updated model emphasizes how Tactics Techniques and Procedures (TTP), CID, COP, and SA play a central role in minimizing incidents of fratricide and collateral damage.

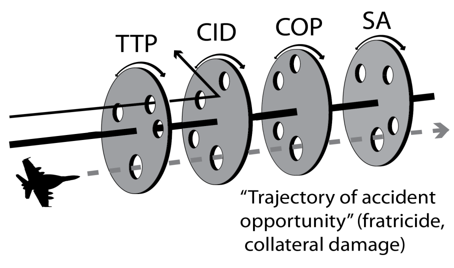

Figure 1. The Reason's Swiss Cheese Model updated by applicable terminology as a tool to explain the mechanism of avoiding fratricide and collateral damage, Blue-on-Blue (BoB).

 ISBN: 978-1-61208-127-4

An applicable definition for SA is given in Army Field Manual 1-02 (September 2004): "Knowledge and understanding of the current situation which promotes timely, relevant and accurate assessment of friendly, competitive and other operations within the battle space in order to facilitate decision making. An informational perspective and skill that fosters an ability to determine quickly the context and relevance of events that is unfolding."

The process of determining the affiliation of detected objects in the battlefield equals Target Identification (TI) [4]. When using this categorization, blue denotes the friendly force, red the enemy, and white refers to neutral (impartial) entities. The traditional method of TI is based on visual signature of the object of interest. In contemporary warfare TI is also based on utilizing the electromagnetic spectrum of the target. Properly applied data and sensor fusion can be seen as a means to prevent collateral damage and fratricide. As a matter of fact, TI can be divided into two categories: Cooperative Target Identification (CTI) and Non-Cooperative Target Identification (NCTI). CTI allows a human shooter or sensor to interrogate a potential target and thereby forces the potential target to respond to the interrogation in a timely manner as described in Figure 2 [3].

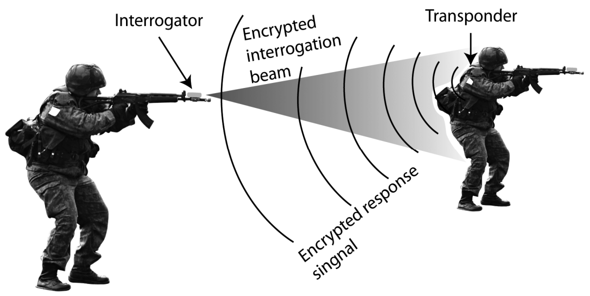

Figure 2. The process of Cooperative Target Identification (CTI).

NCTI in turn does not require a cooperative response from the target. NCTI involves systems or methods which exploit physical characteristics of entities in the battle space to help identify and determine affiliation. NCTI systems include optics such as Thermal Weapon Sights (TWS), night Vision Goggles (NVG), Forward Looking Infrared Radar (FLIR), as well as vehicle and personnel markings such as Joint Combat Identification Marking Systems (JCIMS). JCIMS are used in conjunction with TWS, NVG and FLIR assisting in friendly identification at the point of engagement [4].

CID can be defined as a process of attaining an accurate and timely characterization of detected objects in the joint battle space to the extent that high confidence, timely application of military options and weapons resources can occur [4][25]. An extension of this can be understood as a process of accurately characterizing the detected objects via the operational environment sufficiently to support engagement decisions [4]. The purpose of CID is to enhance unit combat effectiveness and simultaneously minimizing fratricide. In the form of an equation CID reads as: SA + TI = CID [4].

The core capability in SA is COP that fosters effective decision making, rapid staff actions, and appropriate mission execution [4][26]. COP is employed to collect, share and display multi-dimensional information to facilitate collaborative planning and response to security incidents. Each organization involved in applying COP typically comprises three types of modules: 1) information gathering sources that observe events and report information to the command and control module, 2) a command and control module that makes decisions based on both information received directly from its information gathering sources and information reported by other peers, and 3) display units at the emergency location that receive instructions from the command and control module [4].

The acronym MOUT (Military Operations on Urbanized Terrain) denotes military actions planned and conducted on a terrain complex where manmade constructions impact the tactical options available to commanders. Urban combat operations may be conducted in order to capitalize on the strategic or tactical advantages gained by the possession or control of a particular urban area or to deny these advantages from the enemy [1]. The characteristics of MOUT include complex situations brought about by urban environments (ambushes, civilians). The maze-like boxed surroundings hamper command and control leading to combat engagement taking place at squad level with low coordination with higher echelons.

Combat Effectiveness (CE) can be defined as the ability of a (friendly) unit to rapidly and accurately sort and characterize detected objects into categories (blue, white, red) and make a decision as to whether or not to employ deadly force against the identified object/target. Effectively applying the CE guarantees a minimum level of collateral damage and fratricide. Now, to exemplify the previously defined terms, the following briefly examines Rules of Engagement (ROE) together with tactics, techniques and procedures (TTP). ROE defines the situations and guidelines which then support an individual in a situation when a decision is made about whether or not to open fire. TTP supports the decision making process regarding force implementation in the Area of Operations (AOR). Depending on the ROE formulations, the orders concerning using force may vary as indicated in Figure 3.

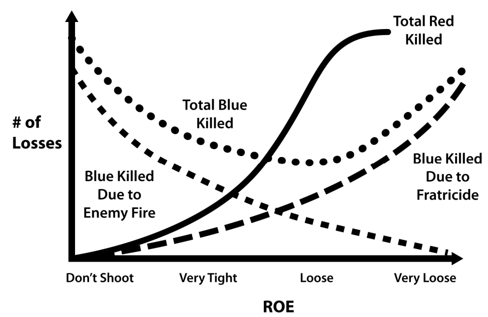

Figure 3. ROE in a relation to the number of troops killed (blue, white, red) and the number of losses and fratricide.

All warriors depend on SA [2] which can be provided also by using WPSN-systems introduced in [1]. The Blue Force Tracking-systems (BFT) along with the White Force Tracking (WFT) presented in [3] provide vital information for improving commanders' decision-making and avoiding fratricide and collateral damage. Blue Forces, allies and White Forces need to be constantly precisely located. It is crucial to improve the efficiency of dismounted operations with smaller and more capable units. These units require a great degree of flexibility and reliability to obtain their set goals to ensure the desired end state.

This paper discusses recent research in the Finnish Defence Forces and elsewhere on Combat Identification. Since the author's research has targeted the networking of the future warfighter in particular, this paper examines components relevant in this regard. The remaining of the paper is arranged as follows: Section II introduces the related work, Section III describes challenges in combat identification, Section IV explains the process of the comprehensive targeting process, Section V deals with the problems causing fratricide, whereas Section VI explains the challenges in distributing the SA, Section VII focuses on problems designated in Military Operations in built-up areas, Section VIII introduces the Bold Quest exercise, and finally, Section IX concludes the paper.

II. RELATED WORK

In military operations in the Persian Gulf, BFT was used during Operation Iraqi Freedom (OIF) for coordinating operations among the Joint Services and with allies and resulted in reduced causalities due to enhanced SA [21]. Obviously, Soldier Modernization Programmes (SMPs) are significantly important in enhancing the performance of the militaries. These SMPs concentrate on improving and updating dismounted soldiers' equipment. These Future Soldier Programs are currently underway along with a series of demonstrations and exercises in which collateral damage and fratricide are to be minimized, whereas the means to increase SA via improved BFT and WFT are also in progress. One example of these is a series of Bold Quest (BQ) exercises carried out since 2007. The incoming Bold Quest 2011 (BQ11) features a primary emphasis on enhancing the capability of CID as related to the needs of dismounted coalition warfighters and those providing them with timely and effective supporting fires.

The principal contributing efforts, technical and procedural, involve the following [21]. First, CTI, automated query or response systems for dismounted personnel and light vehicles need to be addressed. Secondly, a means to share SA systems for employment at the platoon, squad, team, and individual levels must be applied. Thirdly, digitally-aided supporting fires' coordination and control must be defined. Fourth, Digitally-aided Close Air Support (DCAS) coordination and control has to be applied. In addition, challenges with Combat Identification Server (CIS) interoperability and Personnel Recovery command and control (C2) need to be solved. Lastly, marking and beacon systems for dismounted personnel, light vehicles, and friendly locations need to be applied. In fact, the US Army is fielding its new SA system known as Force XXI Battle Command and Brigade and Below (FBCB2) [2][21]. There is also a European Defence Agency (EDA) proposal, named the SAFE, a cancelled project, which was to increase SA and efficiency in crisis management operations in the urban environment ranging from mid-intensity battle to peace keeping operations. One of the keys into the success is careful mission analysis and thorough evaluation of Courses of Actions (COAs). Both processes can save time and minimize collateral damage. The use of available Blue and friendly Forces and resources can be optimized. This increases efficiency and along with minimum casualties, leads to minimum recovery times.

Another objective of the BQ11 for the Finnish Defence Forces (FDF) is currently developing new joint fires and joint C2 capabilities both for national defence and coalition combined operations [22]. The recent progress involves starting to develop tactics, TTP for Air-to-Ground (AG) operations and Joint Fires (JF). One of the Finnish goals involves purchasing an interoperable, net-enabled and digitally-aided material solution for close air support. Engaging the target accurately and cost-effectively is vital especially for a nation with limited resources. At the moment, fourteen nations participate in the BQ11 exercise to improve the outlined objectives [21].

Obviously, all nations want to enhance the SA, minimize fratricide and collateral damage in the battlespace. This paper provides a meta-analysis and describes the results gathered in existing studies and military exercises thereby highlighting the significance of technology in maximizing the effectiveness of own forces. This is applicable until robotic armies replace human warriors in the battlespace. Until then, the continuous developing of the SA and CID systems in instrumental for saving lives in the ongoing and ensuing conflicts.

III. CHALLENGES IN COMBAT IDENTIFICATION

In military operations everything is done to prevent BoB. Currently, identifying a warrior regardless of the visibility conditions is essential. As evident in Figure 2 above, both an interrogation unit and a responder unit are necessary, presupposing, first of all, that the systems are fully operational, and, secondly, that the distance between the warriors is appropriate. In case the identification system doesn't reply, a human is making the decision to open fire based on the TTP. The Identification to whether or not to open fire is based on the visual signature of the uniform, weapon and gear [23].

However, one needs to keep in mind that there is always the possibility that the location device gets stolen or misused by a third party, for example, an insurgent tries to function as a member of the White Force (WF) [3]. In order to increase the reliability of the system, the tracking devices have to be pre-coded and tied in pairs in advance before entering the battlefield to prevent the stealing of the tracking device. Once paired devices are torn apart, they stop functioning as planned – and devices become dysfunctional [3]. After the separation process, the devices must be re-paired and re-coded by the operator. During this process, the operator re-identifies the person.

IV. COMPREHENSIVE TARGETING PROCESS

When returning to ROE/TTP (whether or not to open fire), a link behind the targeting process deserves a closer look. The process is known as Detect, Identify, Decide; Engage and Assess (DIDEA) [4]. The DIDEA provides an iterative, standardised and systematic approach supporting targeting and decision making, being generic enough to be used as a systematic process for C2 node targeting and decision making. Separate actions inside DIDEA area as follows:

Detect: The process of acquiring and locating an object in the battle space by analysing the phenomena in the electromagnetic spectrum.

Identify: The process of classifying an object into the category of blue, white (neutral) or enemy. This represents a primary step where specified CID tasks are accomplished.

Decide: The decision making process that follows the detection and identification phases. This is the most generic step within the process and represents the primary step where a specific ROE application occurs. In the decision-making phase the executive officer/warrior has to decide and define what type of weaponry is appropriate for to the mission. In cases of opting for the use of deadly force, the following questions need to be addressed: 1. Can I engage (ROE application)? 2. If there are several targets, what is the order to engage the selected targets? 3. Which one is the most appropriate weapon system (most cost-effective, least collateral damage and fratricide causing).

Engage: The execution of selected weapons in a selected order starting from the most dangerous target moving on according the panned sequence.

Assess: Monitoring the gained effects with the use of destruction power. Employing the force of various weapon systems available is repeatedly executed until the required level of destruction is achieved.

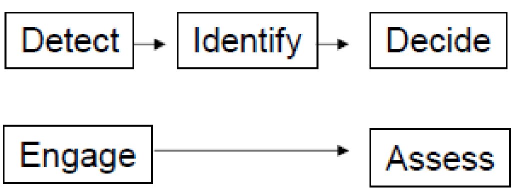

Figure 4. The simplified DIDEA process.

V. WHAT IS THE PROBLEM?

Self-evidently, cases of BoB and collateral damage are bound to surface to some extent. Militaries are interested in locating own troops and increasingly also in the neutral entities of Non-Governmental Organizations (NGOs) and Governmental Organizations (GOs), the WF, the members of which can be tracked by using WFT described in [5].

Briefly put, the problem relies in relating the TTP, CID, COP and SA to the rules of ROE. This involves dealing with the balance described in Figure 2. If ROE formulations are too strict – for example, the commander's intent is to avoid the use of deadly force unless it is absolutely certain that the targeted object is positively identified to be an enemy – the Blue Force will suffer on the basis of actions caused by the enemy. And, if ROE formulations leave too much room for interpretation, various types of casualties (red, blue and white) are bound to occur. Thereby the transmission of combat-critical location and identification data plays a crucial role in the battle space.

A warrior can be equipped with the appropriate locating devices as presented in Figure 5, but this not, however, apply in the case of representatives of the White Force.

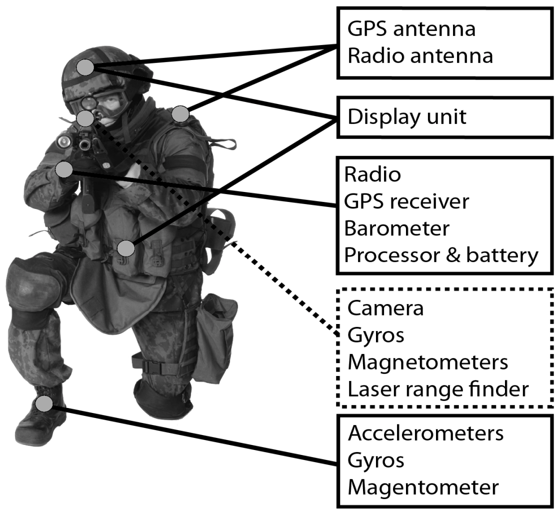

Figure 5. An example of a fully integrated Warrior for location purposes outdoors, indoors and in MOUT for contemporary warfare [18].

The destruction power of a chosen weapon system has to be optimized according to the enemy location (forest, open area, Urban Territory) state of movement on-the Move (OTM) or at-the-halt (ATH) and the protection-level (mounted, dismounted, dig). Aside, the commanding officer has to keep in mind that operations are executed with improper SA, COP and with lack of precise real- time CID.

The cruel reality remains that an executive commander is always aware of fact the there is always the possibility of fratricide and collateral damage. The commander who is not employing the firepower in his possession will have his troops killed by the actions of the enemy as presented in Figure 2 earlier.

To enhance improved SA and COP, Geographical Based Situational Awareness (GBSA) can be utilized [9]. The system utilizes the VHF-frequency operated Combat Net Radios (CNRs). When the CNRs are on the connectivity range, they recognize and identify radios in the system. Once

 ISBN: 978-1-61208-127-4

the radios are at the same channel and the clock (hopping sequency) of CNRs are in a correct time, a reliable SA-tool [9]. The main problems related to this system have to do with the clock and hopping sequence. This is one possibility to avoid fratricide and collateral damage. At the moment, the main benefit of this concept is in preventing from being fired at by own weapon systems, BoB, by means of improved SA-information.

Figure 6 below emphasizes the importance of both CID and BFT in a battlefield environment. The end-user of the weapon system, the one opening fire, has to be aware of the locations and status of both own troops and the enemy. Before employing the deadly force, the impact of the given weapon system needs to be in proportion to the chosen target and its perimeters in order to avoid unnecessary collateral damage caused by possibly choosing too effective weapon systems to destroy a particular target.

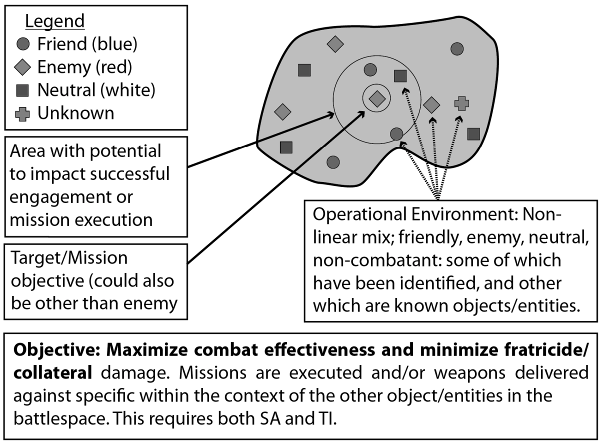

Figure 6. Military problems of CID-BFT identified from the perspective of collateral damage and fratricide assets.

VI. CHALLENGES INVOLVED IN DISTRIBUTING SITUATIONAL AWARENESS DATA

The amount of gathered data via sensors and tracking systems is vast. To distribute the location information filtered and fused through various systems remains a challenge. A warrior has to fight, not to monitor his palm, wrist computer or lap-top. Besides, the disturbances in electromagnetic spectrum, quality of service (QoS) and transmitting power along with the limited bandwidth set limitations to the communication systems. As indicated in Figure 7, the possibilities of communication are vast, since almost all the sensors are somehow linked together to maximize BFT, CID, COP and SA.

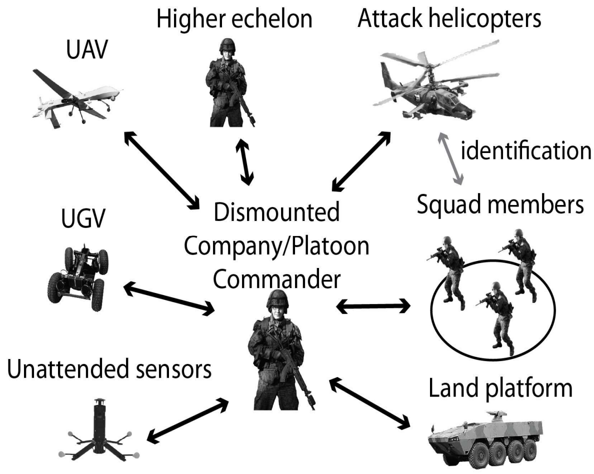

Figure 7. The types of possible platforms serving as sensors and network nodes.

The problems in data distribution are linked to various devices and data in interfaces. BML can be seen as a common language enabler between machines and interfaces [5] along with almost ubiquitous swarms of UAVs described in [6]. Limitations in energy and bandwidth play an important role. Locating instruments of various types consumes reasonable amounts of energy, not to mention the increase in weight and number of devices in warrior gear and required maintenance. Due to the lack of accessible wire line infrastructures, unmanned systems have to be powered through a combination of batteries, solar power, and power scavenging [15]. When FSO-technology is adopted in backbone networks and between selected ground stations, an intelligent, dynamic and secure data transmission with high data rates can be offered to mobile end-user [7]. FSO-technology offers high-speed, 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 [8]. It has been demonstrated in tests that the advanced DWDM RoFSO offers a viable solution to provide broadband wireless connectivity. Radio over Fiber (RoF) technology will most likely offer a reliable data transmission rate of 10 Gbps in the next generation FSO-systems [8].

Furthermore, older existing systems are available for distributing data gathered by various types of sensors in various types of military and humanitarian crises environments. These technologies are based on WPSNs described in [1] and Wireless Sensor Networks (WSNs) described in [10][16]. The former is passive, so it will remain hidden once the latter is active, representing an easier detected system. Both systems are applicable to be used in transmitting constant data from a sensor to a node, for example, to a vehicle or an Unmanned Vehicle (UV).

To maximize the possibility of devices communicating in a proper and planned manner, the topology of network

 ISBN: 978-1-61208-127-4

systems has to be correctly coordinated (manage spectrum usage with group mobility patterns) [24]. Also the hierarchy of a network has to support and enable this. Both the goals can be achieved by hierarchical design where devices are only to interact with their peers from the same group [11]. In addition, the transmit antenna selection is a practical technique for achieving significant power gain, even with commodity hardware and without changes to different waveform protocols [12].

VII. Location Possibilities in Urban Areas

An Army tactical warfighter needs network services both OTM and ATH [3]. One of the lessons learned from Iraq and Afghanistan was the need for a more robust Beyond-Line-Of-Sight (BLOS) communication capacity between the lower Army echelon Land Warriors, from Squad Leaders to Battalion Commanders [3].

The proposed and described solutions have to be based on novel, generic and robust battlefield-proven solutions in order to meet the given needs, and this in turn involves addressing the topology of the network system carefully. In MOUT transmitting and receiving signals of different waveforms simultaneously is challenging due to the nature of the combat environment [17].

Since the power production and power consumption will remain as a challenge, certain issues need to be addressed. Thus when defining the network design, it has to be emphasized that network coding enables a more efficient, scalable and reliable wireless network [14].

The MOUT environment features no GNSS indoors and indoors propagation poses a serious problem. The placement of an antenna platform is challenging. One solution can be the installing of a high-bandwidth conformal antenna in the soldier's helmet with the coverage of over 750 MHz through a 2,7 GHz frequency band [13]. The combat-critical solutions involve improving communicating, SA and transmitting C2 information among highly dispersed battlefield units in dynamic environments, such as MOUT [14] [17].

Next, let us assume that there is a WPSN-system available for positioning and location services. If the capability of GPS-Pseudolite, better known as the Self-Calibrating Pseudolite Array (SCPA), is attached into the satellite-based Carrier-phase Differential GPS-type (CDGPS), it is possible to determine positioning in locations without access to the GPS satellite constellation [16] [1] [20]. This in turn will improve locating own troops inside buildings dramatically, thereby significantly improving CID, TID and SA. The particular challenges set by the MOUT environments are presented in Figure 8.

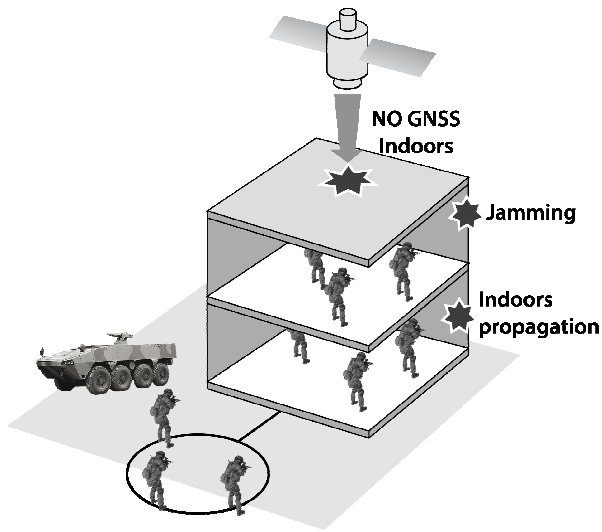

Figure 8. The challenging environment of MOUT.

VIII. Bold Quest Exercise

The Bold Quest is a name of exercises which have been executed as a series of exercises since 2007. One purpose of these exercises is to enhance SA, TID and minimize collateral damage and fratricide. The exercises are planned to be executed biannually. Between the exercises there is an evaluation period, where collected data are analyzed. Damage control in operations can be minimized by adopting advanced combat identification technologies via executing series of experiments. In Bold Quest 2009 (BQ09), organized by the US Joint Forces Command at Camp Lejeune and Marine Corps Air Station Cherry Point, North Carolina, Coalition Combat Identification – Advanced Concept Technology Demonstration (CCID – ACTD), various systems were tested. Ten partner nations participated, and the objective of the exercise was to demonstrate and assess air-to ground CID technologies in a stressful and challenging operational environment [18].

In BQ09, technical initiatives included prototype-level systems to enable aircrew and controllers to exchange position information digitally among friendly ground elements relative to their proximity to potential ground targets [4][25]. The results improve the capabilities in target acquisition and minimize the risk and level of fratricide.

One of the most promising technologies demonstrated during BQ09 was the Smart-Pull Warfighter Information for Targeting (SWIFT) Combat Identification Server (CIDS) [17]. SWIFT provides the fighter pilot of a combat aircraft with on-demand request capability for friendly forces location information. Information is forwarded via a secure transmission from the ground located CIDS as request based service. This is the process for the fighter pilot to verify the known friendly locations according to the ground commanders close air-support request. Figure 9 portrays the CCID-ACTD system.

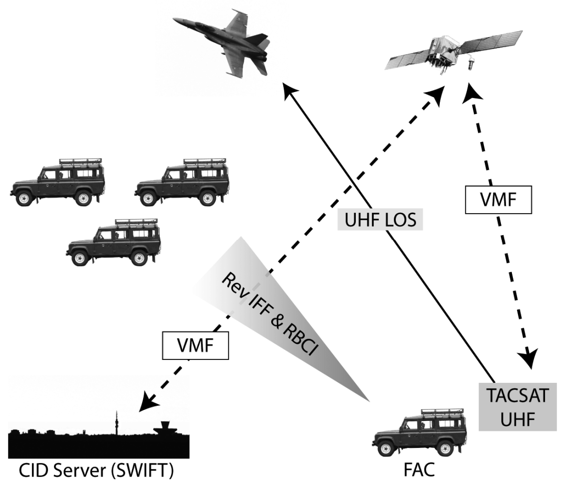

Figure 9. The CCID-ACTD system of collateral damage and fratricide assets.

When it comes to CIDS, the requirement is to contribute to improving Tactical Situational Awareness (TSA) for allied forces involved in the delivery and control of indirect and direct fires to land operations. The CIDS is about to correlate BFT information from 15 different sources, including LINK-16, BOWMAN [25]. Besides, the CIDS will enable the joint fires assets and Close Air Support (CAS)/Close Combat Air (CCA) aircraft on request. The CIDS will utilize Link-16, Variable Message Format (VMF) and other tactical networks to redistribute BFT information [17].

Once the next Bold Quest series exercise is arranged in June 2011 (BQ11), the focus will be on Fires on Dismounts. The CIDS technical demonstrator will be ready for the exercise for the extensive testing of the planned concept [17].

The air-to-air and ground-to-air systems utilize the IFF as a method to define entities in their battle space. In the near future, ground-to-ground systems may start using Battlefield Target Identification Device (BTID), CTI systems. As demonstrated in Figure 10 below, Radio-Based Combat Identification (RBCI), along with different types of IFF-systems available, can be utilized.

A key factor is the efficiency of a warrior, which can be gained via improved SA, BFT and Command, Control, Computers, Communication, Information, Intelligence, Surveillance and Reconnaissance (C^4I^2SR). However, since supplementary gear can never fully substitute human intelligence, a warrior must remain active and alert maintain in the battlefield.

The constant objective of military forces is to gain the initiative and turn this into success – to maximize performance in military operations with minimized casualties in minimal recovery times. Operational time spent in the battlefield can be minimized by careful mission analysis and thorough evaluation of Courses of Actions (COAs).

These presented technologies expand the possibilities to carry out the set missions in the future with ever increasing performance capabilities. On a practical level, this involves, for instance, minimizing fratricide and collateral damage by detecting roadside bombs early and precisely enough. One of the most promising Combat Identification systems is introduced in Figure 10 below. The collected CID data can be forwarded via different means of communication to everyone requiring these CID data.

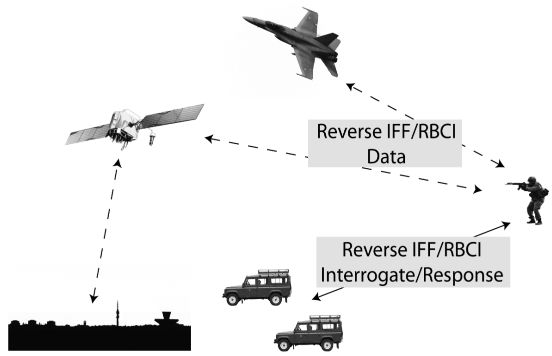

Figure 10. Radio-Based Combat Identification (RBCI).

To facilitate capability development, the Finnish Defence Forces plans to participate in the BQ11 in to increase combat effectiveness in national defence and coalition combat operations. This constant and continuing process enhances the capability to avoid BoB along with the capability to avoid collateral damage by tracking the WF.

The battle can be won only by careful mission planning and comparing different COAs, whereas winning wars presupposes winning the hearts and minds as well. Avoiding collateral damage, minimizing fratricide and increasing SA among the coalition forces enables performing maximally in minimum time, and enhances the probability to succeed in this complex challenge. The adoption of existing technologies and their viable solutions offers a key to constant success when appropriately applied.

IX. CONLUSIONS

This paper is a synthesis of recent research work in the Finnish Defence Forces and elsewhere on Combat Identification, and many of the proposed components in this synthesis are based on the author's research on the networking of the future warfighter. Since accurate and timely identification in the battlefield is life-preserving for each warrior, a careful analysis of the performance and capabilities of chosen systems needs to be executed before introducing any of these systems in the battlespace. CID equals the process that warriors and sensors go through in order to identify battlefield objects prior to deciding whether or not to open fire. Warfighters are trained to employ all available means at their disposal to define and assess potential targets in the battlespace prior to employing combat power. CID can be viewed as a complex series of networked systems, procedures and doctrine as presented in Figures 1 –

4. These systems also include the definitions of TTP, COP, SA, ROE and DIDEA.

More specifically, problems can arise in particular in commanding and being commanded, as indicated in Figures 5 – 7. Moreover, the functioning capacities of a chosen network are relevant, as demonstrated in Figures 8 and 9. CIDS offers military commanders and fighter pilots access to accurate and near real-time BFT and WFT systems. Besides this, CIDS offers commanders a tool which can foster improved mission planning resulting in increased accuracy and tempo of missions. To sum up, CIDS aids commanders to reduce the number of unexpected incidents and minimize collateral damage.

Once the TTP, CID, COP, and SA systems discussed in this paper (cf. Figure 1) are designed, tested and become fully implemented as part of the combat gear, some progress may be discernible in minimizing fratricide and collateral damage. The reality is that for as long as human actors remain part of any decision-making processes, incidents of fratricide and collateral damage are bound to occur. All efforts to minimize the human error factor by improving existing technologies, TTP, CID, COP and SA together with defining explicitly the formulations in ROE, are to be saluted. The efforts to minimize unwanted phenomena are to be applied, for example, in the ongoing series of Bold Quest exercises.

So far, all the decision-making processes in battlespace settings have culminated in a human being making the final decision to apply combat power. In the future, this decision maker's position may be manned by Artificial Intelligence (AI). And, needless to say, detailed planning, testing and implementation are necessary prerequisites for all future warrior systems to be successfully deployed by any robotic militaries of the future.

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