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DECISION SUPPORT FOR DISMOUNTED SOLDIER SYSTEMS

FINAL REPORT

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ABSTRACT

Combat Identification is a state of knowledge attained by a participant on the battlefield as a result of combining Situation Awareness (SA), Target Identification (TI), and Tactics, Techniques and Procedures (TTPs). Combat Identification is essential to the effective achievement of mission objectives and mitigates damage, casualties, and other negative consequences among friendly forces and non-combatants. This document presents the results of a review of currently available Combat Identification technologies that purport to be of use to the dismounted soldier (as opposed to aircraft, ships, or other military vehicles). These technologies are assessed against a descriptive model of the dismounted soldier and their task.

Six categories of Combat Identification technology are identified. For each category an evaluation is made regarding the most suitable product for the dismounted soldier and recommendations are made for research and development work that could address limitations with the products in the category. This document concludes by summarizing the likely impacts on the soldier and making recommendations regarding the most fruitful areas for research and development for Combat Identification.

RESUME

L'identification au combat représente les connaissances acquises par un individu sur le champ de bataille en combinant la connaissance de la situation (CS), l'identification de la cible (IC), ainsi que les tactiques, les techniques et les procédures (TTP). Elle est essentielle pour atteindre efficacement les objectifs de mission et pour réduire les dommages, les pertes et les autres conséquences négatives entre les forces alliées et les non-combattants. Ce document présente les résultats d'un examen des technologies d'identification au combat que peuvent actuellement utiliser les soldats débarqués (par opposition aux aéronefs, aux navires et aux autres véhicules militaires). Ces technologies sont évaluées par rapport à un modèle descriptif des soldats débarqués et de leurs tâches.

Il y a six catégories de technologies d'identification au combat. Pour chaque catégorie, une évaluation est faite relativement au meilleur produit pour les soldats débarqués. Des recommandations de recherche et de développement sont présentées afin que les produits de la catégorie puissent éliminer les lacunes. Enfin, ce document résume les répercussions possibles pour les soldats. Des recommandations sont formulées concernant les meilleurs domaines de recherche et de développement pour l'identification au combat.

EXECUTIVE SUMMARY

Introduction: Combat Identification is a state of knowledge attained by a participant on the battlefield as a result of combining Situation Awareness (SA), Target Identification (TI), and Training, Tactics and Procedures (TTPs). Combat Identification is essential to the effective achievement of mission objectives and mitigates damage, casualties, and other negative consequences. This document presents the results of a review of currently available Combat Identification technologies for use by the dismounted soldier (as opposed to aircraft, ships, or other military vehicles). These technologies are assessed against a descriptive model of the dismounted soldier and their task.

Results: Six categories of Combat Identification technology are identified. For each category an evaluation is made regarding the most suitable product for the dismounted soldier and recommendations are made for research and development work that could address limitations with the products in the category.

Several issues with current Combat Identification technologies emerged. Since most military missions involved coalitions, Combat Identification must accommodate the least well-equipped force. This would typically mean adopting the cheapest and least sophisticated solution (e.g. some sort of passive signalling device). Any solution is only likely to provide information about friendly entities on the battlefield, leaving a large number of potential targets as 'unknown' for the purposes of the technology. A technological solution is also likely to interfere with the activities in which the soldier must engage when moving to or in contact with an enemy, assuming data can be shared in battlefield conditions with limited or fallible network infrastructure. Finally, it is not known how to present Combat Identification to a soldier when moving to or in contact, so as not to hinder critical decision making by the soldier.

Significance: This review has considered available and emerging technologies from the perspective of the dismounted soldier, who has received scant attention to date. Notably, this review has used a model of dismounted soldier Combat Identification to make evaluations of available and emerging technologies, rather than focusing exclusively on the soldier or the technology. This has enabled the identification of likely impacts on the soldier and recommendations regarding the most fruitful areas for research and development for Combat Identification. In particular, research and development should not merely answer what forms of decision support are most effective, but also how, where, and when they should be presented, and what additional information is required by the soldier to appropriately calibrate their level of trust. Recommendations for research under this Applied Research Program (ARP) are made in a variety of areas.

Future Plans: This work will be carried forward in the next phase of the Defence Research and Development Canada (DRDC) ARP by investigating some of the questions raised in laboratory experimentations. Ultimately, it is expected that the results and insights from the ARP will assist the Department of National Defence (DND) in the development and acquisition of effective Combat Identification solutions.

SOMMAIRE

Introduction : L'identification au combat représente les connaissances acquises par un individu sur le champ de bataille en combinant la connaissance de la situation (CS), l'identification de la cible (IC), ainsi que les tactiques, les techniques et les procédures (TTP). Elle est essentielle pour atteindre efficacement les objectifs de mission et pour réduire les dommages, les pertes et les autres conséquences négatives entre les forces alliées et les non-combattants. Ce document présente les résultats d'un examen des technologies d'identification au combat que peuvent actuellement utiliser les soldats débarqués (par opposition aux aéronefs, aux navires et aux autres véhicules militaires). Ces technologies sont évaluées par rapport à un modèle descriptif des soldats débarqués et de leurs tâches.

Résultats : Il y a six catégories de technologies d'identification au combat. Pour chaque catégorie, une évaluation est faite relativement au meilleur produit pour les soldats débarqués. Des recommandations de recherche et de développement sont présentées afin que les produits de la catégorie puissent éliminer les lacunes.

Divers problèmes avec les technologies d'identification au combat actuelles sont ressortis. Puisque la majorité des missions militaires comportent des coalitions, l'identification au combat doit convenir à la force la moins bien équipée. Cela signifie généralement l'adoption de la solution la plus simple et la plus économique (p. ex., un certain type de dispositif de signalisation passif). Chaque solution risque de fournir uniquement l'information sur les entités amies sur le champ de bataille, laissant ainsi un grand nombre de cibles éventuelles inconnues de la technologie. Une solution technologique pourrait également perturber les activités auxquelles participent les soldats lorsqu'ils se dirigent vers l'ennemi ou entrent en contact avec celui-ci, en supposant que les données peuvent être partagées dans les conditions du champ de bataille avec une infrastructure de réseau limitée ou faillible. Enfin, on ignore comment présenter l'identification au combat à un soldat qui se déplace vers l'ennemi ou qui est en contact avec celui-ci de manière à ne pas nuire à sa prise de décision cruciale.

Importance : Ayant reçu peu d'attention jusqu'à maintenant, les technologies actuelles et nouvelles ont été examinées du point de vue des soldats débarqués. Un modèle d'identification au combat des soldats débarqués a servi à évaluer ces technologies plutôt qu'à mettre l'accent sur les soldats ou la technologie. Cela a permis d'identifier les répercussions possibles pour les soldats. Des recommandations sont formulées concernant les meilleurs domaines de recherche et de développement pour l'identification au combat. Les travaux de recherche et de développement ne devraient pas seulement identifier les types les plus efficaces d'aide à la décision, mais également comment, où et quand ils devraient être présentés. Cela permettra aussi de savoir quels renseignements supplémentaires les soldats ont besoin pour établir le bon niveau de confiance. Des recommandations de recherche sont faites concernant divers domaines dans le cadre du Programme de recherches appliquées (PRA).

Futurs plans : Le présent travail sera effectué durant la prochaine phase du PRA de Recherche et développement pour la défense Canada (RDDC). Certaines questions soulevées lors d'essais en laboratoire seront examinées. Au bout du compte, on s'attend à ce que les résultats et les observations issus du PRA aident le ministère de la Défense nationale (MDN) à élaborer et adopter des solutions d'identification au combat efficaces.

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1 INTRODUCTION

1.1 Background

On the battlefield it is often difficult to distinguish friend from foe. With the increasingly asymmetric nature of military operations, as epitomized by the recent Canadian Forces (CF) mission to Afghanistan, this has become more difficult. A variety of technological solutions to issue of Combat Identification (CID) have been deployed, ranging from simple patterns on vehicles to elaborate encrypted interrogation-response systems carried onboard aircraft, ships, and some armoured vehicles. To date, the range of CID options for the dismounted soldier has been limited. Where CID systems have been introduced, their effectiveness relies on effective application of Tactics, Techniques, and Procedures (TTPs), with technological means serving as the "second line of defence" (Webb and Hewitt, 2010). This approach has been successful, but relies heavily on the soldier's execution of their TTPs, leaving open the possibility of human error.

Defence Research and Development Canada (DRDC) Toronto and DRDC Valcartier have carried out Research and Development (R&D) programs for CID in the past (e.g. Vilhena, Zobarich, and Lamoureux, 2007), and the Department of National Defence (DND) has been involved in the Urgent Quest and Bold Quest series of multinational CID experiments. The current DRDC research effort builds on the earlier work by DRDC Toronto in the form of a three-year Applied Research Program (ARP) under Project 14dq. This project pursues the following objectives:

- To examine the impact of temporal and spatial uncertainty on the effectiveness of Blue Force Tracking (BFT) and target designation support tools;
- To develop models of soldier Situation Awareness (SA) and decision making; and,
- To develop validated performance specifications and decision support design concepts through laboratory- and field-based experimentation of handheld and rifle-mounted systems.

This project has mapped out their approach to achieving these objectives. The contract fulfills one of the activities in the first year of the ARP. Specifically, this work presents a review of BFT and target designation systems.

1.2 Objective and Tasks

The stated objective of this work, as stated in the Statement of Work (SOW; received via email dated 17th May, 2011), is as follows:

"...to survey the current state of technologies pertinent to decision support for combat identification (CID) for the dismounted soldier. In addition to assessing the potential of different technologies to serve as decision support for dismounted soldiers, this project will identify potential technical limitations and environmental effects that could affect the effectiveness and efficiency of such systems in real-world operational settings."

There were three main deliverables to this work:

1. Provide a partially annotated bibliography containing full references of all literature identified and summary notes of the most significant literature;

2. Provide copies of all literature reviewed; and,

3. Provide a report of the results of the literature review.

1.3 This Document

To address the objective, this work has defined CID and described the CID process, as laid out in doctrine and training, and identified the standards that apply to the CF. Additionally, this work has described CID in 'real terms'; that is, the nature of the people who would use CID technology, the environment in which it would be used, and the tasks into which CID technology would need to be integrated. This understanding helped in the development of a model against which CID technology could be evaluated.

With this information, different types of CID technology are described and specific products are listed. The various impacts of the technologies on the dismounted soldier are then discussed, as well as gaps in what is known about CID technology and its impact on the dismounted soldier.

This document is structured as follows:

Section 2: Method – This section describes how the search for literature was carried out, how CID technologies were categorized, and how CID technologies were evaluated;

Section 3: Combat Identification – This section defines CID, describes the process according to doctrine, and identifies relevant standards. This section also describes a model of CID with respect to the people carrying out CID, the environment in which CID takes place, and the tasks being carried out concurrently with CID;

Section 4: Review of Combat Identification Technologies – This section describes six different categories of CID technology and lists current products that fall into each category. The main implications for the dismounted soldier and the most likely successful technological approach is discussed for each category;

Section 5: CID Technology Impact on the Dismounted Soldier – This section discusses the specific implications of the identified CID technologies on the dismounted soldier, divided into physical impacts and cognitive impacts. Recommendations are made for the DRDC Toronto research program, focusing on current gaps in capability and knowledge; and,

Section 6: Conclusions or Next Steps: This section summarizes the work performed under this contract and maps the way forward for CID R&D at DRDC Toronto.

2 METHOD

The evaluation of CID technology for use by the dismounted soldier comprised three major activities:

1. Literature review;

2. Characterization of technologies and,

3. Evaluation of technologies in the context of the dismounted soldier.

Each step in this method is described in greater detail below.

2.1 Review of Available information

The team undertook a review of available information including a range of primary and secondary source publications such as technical and academic writings, patents, journal and news articles as well as interviews with members of the operational community. The search also included consultations with Subject Matter Experts (SMEs) who were able to provide additional resources as well as insight and guidance into the search.

The Contract Scientific Authority (CSA) provided over 450 references, which were reviewed to varying degrees according to their relevance to CID technologies and the information they contained concerning the impact of CID technology on the dismounted soldier.

The team also conducted database searches and targeted investigations for specific systems and vendors, as well as general searches for academic and scientific literature concerning CID. The databases searched included:

Google Scholar (http://scholar.google.ca); and

Janes suite of products (www.janes.com);

Google Patents (www.google.com/patents);

World Intellectual Property Organization (WIPO) Patent database (http://www.wipo.int/).

The team applied the following search terms:

Table 1 : Database Search Terms

Topic Search Words
Fratricide
"Combat Identification" (CID)
"Target Identification" (TI)
"Identify Friend Foe" (IFF)
"Blue Force Track(er/ing)" (BFT)
Neutricide
"Radio Based Combat Identification" (RBCI)
"Force XXI Battle Command Brigade (and) Below" (FBCB2)
"Battlefield Target Identification Device" (BTID)

In general, the literature reviewed fell into two broad categories: Combat ID Systems and the Application of Combat ID Systems.

As a part of the information review process, the team contacted and interviewed a number of SMEs. As this is a mature field of study, it was desirable to build on the efforts of other groups with similar research objectives. The team focused their attention on Canadian and Allied government representatives that have either been working to research, develop or deploy CID systems, including representatives from:

- DRDC Toronto;
- Canadian Forces Warfare Centre (CFWC);
- Canadian Integrated Soldier Systems Program (ISSP);
- Directorate of Land Requirements 5 (DLR 5);
- Chief of Force Development Combat Identification Project Management Office;
- "Diggerworks", an Australian army soldier systems program; and
- UK Defence Science and Technology Lab (DSTL).

Most of the interviews resulted in either the delivery of follow-on references or assistance in determining areas for additional targeted searches.

Each reference within the report was characterized with specific tags or keywords to facilitate filtering and navigation. Tags were organized into three characterization areas: "Source"; "Technology Type" and "Cognitive". Neither the areas nor the tags are mutually exclusive. The organization of areas and tags is shown graphically in Figure 1 below. Tags were developed iteratively with the information review; that is, as an organizational structure for the field became clear, appropriate tags were developed.

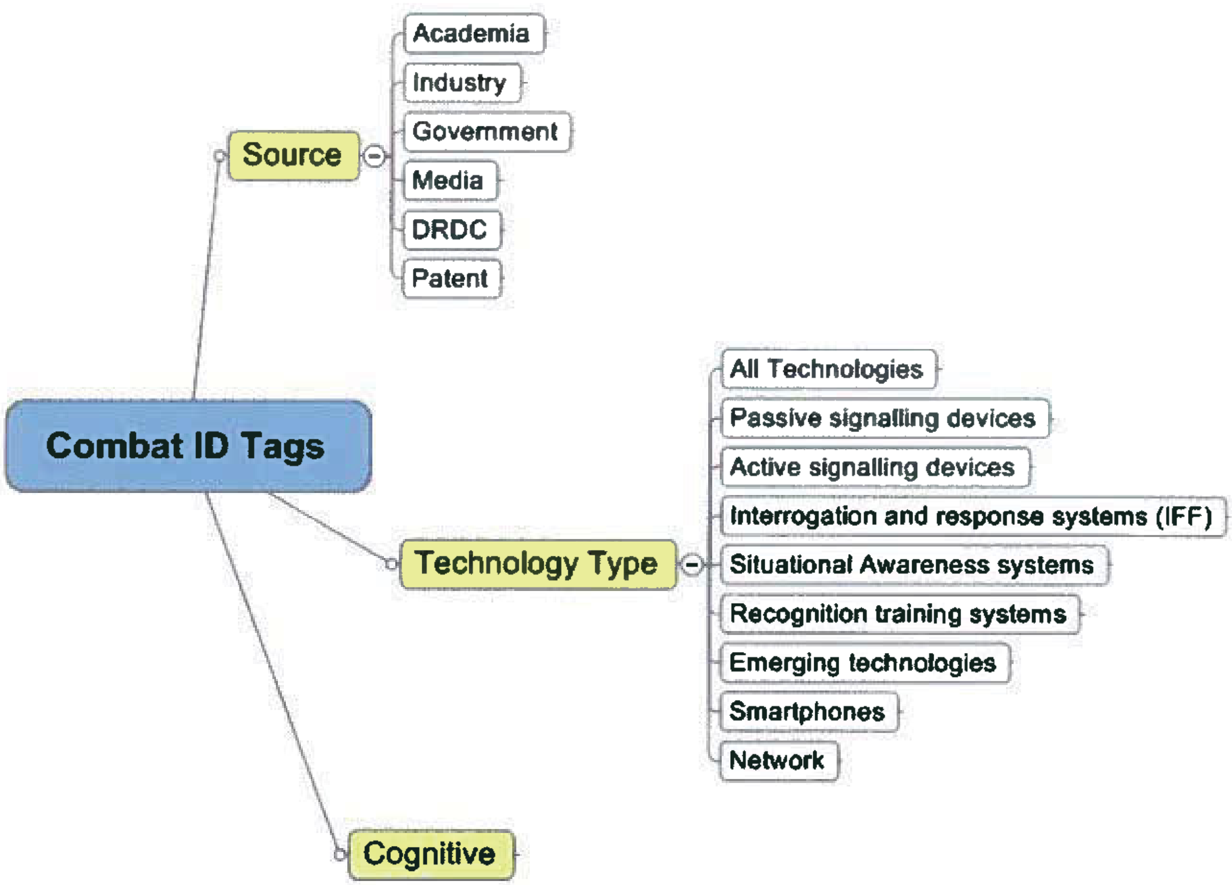

Figure 1: Combat ID Tags

The information reviewed allowed the project team to develop a summary of the current state of the art in CID technology by characterizing the technologies. The project team also developed a detailed model of the CID task carried out by the dismounted soldier. A Mission, Function and Task Analysis (MFTA) was developed to describe CID from the perspective of the dismounted soldier.

2.2 Characterization of Technologies

Boyd, Collyer, Skinner, Smeaton, Wilson, Krause, Dexter, Perry and Godfrey (2005) identified six technology areas associated with combat identification:

Group 1 – Passive signalling devices: enables CID of friendly units without any action or response by the person or platform carrying the device.

Group 2 – Active signalling devices: such devices emit electromagnetic energy to facilitate SA.

Group 3 – Interrogation / response systems: enable positive identification through the process of query and response. The tag used for this area was "IFF" for "Identify Friend or Foe".

Group 4 – Situation[1] Awareness (SA) systems: ensure timely dissemination of the 'operating picture', including combat identification systems of systems using a variety of information, across the combat force.

Group 5 – Recognition training systems: aim to increase the ability of soldiers to recognise potential targets through visible, thermal, and other observation systems. These systems are most often used for training of personnel before battle; however, some are now being adapted for use in the field.

Group 6 – Emerging technologies: technologies are those still emerging from the laboratory that, later rather than sooner, could have a role to play in CID. The most notable example is the introduction of smartphones as a SA system.

Through the process of the literature review, the team added to these tags technology areas:

All technologies: broad-based discussion of CID technologies as a whole.

Smartphones: originally included in "emerging technologies", sufficient developments were found in this area to warrant a separate classification.

Network: as an enabler for many other CID related technologies, references specifically related to network configurations and transmission were categorized separately from the other technology types.

The Australian Defence Science and Technology Organisation (DSTO) team (i.e. Boyd et al, 2005) delineate these technology areas according to "target cooperation, warning method, operating spectrum, effective range, power consumption, life-span, applicable platforms, employed role, environmental constraints, and costing data."

2.3 Evaluation of Technologies in the Context of the Dismounted

[1] Note that the noun form, "*situation* awareness" is used over the adjective form, "*situational* awareness", in keeping with Endsley's (1988) use of the term.

Soldier

Based on the information reviewed and the resultant understanding of the state of technology for CID, as well as an understanding of the missions, functions, and tasks of the soldier engaged in CID, the current project team developed a set of criteria for understanding the different technology types. These criteria were grouped into physical, technical and operational sets.

Each technology was described and evaluated against the different criteria contained within sets. This permitted the comparison of the different technologies on the basis of their impact on the dismounted solider, and facilitated the identification of areas where further research would be required.

To aid the reader's comprehension, this report proceeds as follows:

- Combat Identification is defined;
- The MFTA for CID by the dismounted soldier is presented;
- The criteria and sets are described;
- The technologies are described generally and in terms of the criteria; and,
- Conclusions and recommendations are made.

3 COMBAT IDENTIFICATION

3.1 Definition

Combat ID has been defined in the literature and by SMEs interviewed for this work as the outcome of the combination of SA, and TTPs. The US Army defines CID as follows:

> "*The process of combining situation awareness, target identification, specific tactics, techniques and procedures to increase operational effectiveness of weapons systems and reduce the incidence of casualties by friendly fire.*" (U.S. Army Headquarters, 2009)

SA is defined as "the understanding of the operational environment in the context of the Commander's (or Staff Officer's) mission (or task)." (JWP 0-01.1). Another definition is offered by the US Army: The US Army defines SA as providing "the immediate knowledge of operation conditions, constrained geographically and in time." (U.S. Army Headquarters, 2009) This includes the up-to-date identification and positions of all entities on the battlefield (friend, foe, neutral and unknown), which should agree with information being provided by weapons and sensor systems. Typically the best SA that can be attained is a knowledge of all friendly forces, and a clear delineation between foe and neutral. However, because a contact that is not friendly may not be cooperative (i.e. tell the soldier who they are) SA of significant proportions of foe and neutral contacts may not be possible.

The past 20 years have seen a decline in conventional warfare, making positive identification of adversarial forces, and differentiation of enemy forces from non-combatants, increasingly difficult. In the face of such ambiguity, it becomes necessary to divine the intent of nearby actors and groups, which is likely to be the critical difference between foe and neutral. For this reason, the military definition of SA must be contrasted with that of Endsley (1988) in which SA is "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future." Endsley's definition permits the soldier to include what s/he thinks the contact will do into their determination of friend, foe or neutral. This is very important given the asymmetric nature of modern warfare.

TI is defined as "the process that allows the immediate determination of a contact's identity by friendly, discrete platforms or individuals" (JWP 0-01.1). TI can be considered the final step in a CID process, in which the observer knows exactly who and what the contact is. TI is specifically addressed by IFF systems, therefore TI includes IFF and the two terms may be used together in this report.

CID technology that supports SA will most likely do so by externalizing SA, probably through some sort of display of entity positions. Such CID technology could be said to provide the soldier with information about "my world around me". CID technology that supports TI (such as IFF systems) will most likely do so by providing a direct response to a direct question. In other words, the soldier will be provided with specific information (i.e. "friend" or "not friend/unknown") about the contact under deliberate consideration. Because of the likely beamwidth (i.e. field of view) of TI systems (most likely laser-based), TI information is likely to be presented in a serial manner; that is, one TI interrogator will be provided information about 1 target per interrogation. Multiple targets will need to be interrogated singly, one after another. Such CID technology could be said to provide the soldier with information about "what I'm looking at right now".

TTPs can be defined separately as follows:

- *Tactics* are based on doctrinal concepts which units apply in combat and include the ordered placement and manoeuvre of units in relation to each other, the enemy, and terrain to obtain decisive results;
- *Techniques* are based on tactics which small units, crews, or individuals apply to a given set of circumstances (such as battle drills and crew drills); and
- *Procedures* are courses or modes of action that describe how to perform certain tasks (this is the lowest level of detail, at which task-level performance requires one or more procedures[2]).

The impact of TTPs on CID is significant. They affect the likelihood of a soldier coming into contact with a potential threat, how the soldier searches for that threat, how the soldier aggregates information to arrive at a decision, and what further action the soldier will take (e.g. Rules Of Engagement (ROEs) for an operation).

The consideration of TTPs will remain important for the CF. SMEs interviewed for this contract highlighted the inclusion of TTPs as a significant differentiator between the Canadian and US approaches to CID. Most attempts by industry to develop CID technology propose the technology as wholly sufficient to address CID, and are not designed to complement or integrate with TTPs. The exclusion of TTPs from industry CID technology operating concepts has been formalized in recent work by Ospital and Wojack (2007) who have defined CID as: "SA + TI = CID". This exclusion is unlikely to facilitate improvements in CID; any solution must recognize the human role and the need for TTPs to guide the soldier.

At its simplest, the CID process is a three-stage input-output circuit (see Figure 2) in which the stimulus consists of what the soldier senses, the decision is what the soldier decides, and the response in the action taken based on the decision.

[2] U.S. Army Command and General Staff College (1996). Student Text 101-5, Command and Staff Decision Processes, Fort Leavenworth, KS: CGSC Press.

Figure 2: Simplified CID Process

This model of the CID process is elaborated in the following section.

3.2 Process

CID is elaborated in the Detect, Classify, Recognise, Identify (DCRI) process, which describes the systematic increases in discriminability of a contact based on consideration of additional information at each stage. The process progresses from a coarse level of detail to a fine level of detail. This process may be discontinued at any stage (i.e. any level of detail, coarse or fine). However, a lack of detail does not imply that a decision cannot be made. Other knowledge held by the observer may facilitate decision-making at initial stages in the process. For example, in Afghanistan, the detection of something in the sky and classification of it as an aircraft would immediately lead to the decision that is a friendly unit, given the lack of any known enemy air assets.

The four stages of a decision are described in Table 2. As indicated in the table, the levels of discrimination have been refined to apply to both technological systems and humans.

Table 2: Definitions of Discrimination Levels – Technological (Holst, 2000) and Revised (CERDEC NVESD, 2005)

Discrimination Levels	Technological Definitions	Revised Definitions
Detection	The contact has a reasonable probability of being an object being sought.	The determination that an object or location in the field of view may be of military interest such that the military observer takes an action to look closer: alters search in progress, changes magnification, selects a different sensor, or cues a different sensor.
Classification	The broad class of object types to which the object belongs may be determined.	The object is distinguished or discriminated by class.
Recognition	Object discerned with sufficient clarity that its specific class can be differentiated.	For military vehicles and weapons platforms, the object can be distinguished by category within a class. For humans, the perception of individual elements, a combination, or a lack of, equipment, hand-held objects, and/or posture that can be distinguished to the extent that the human is determined to be of special military interest.
Identification	Object discerned with sufficient clarity to specify the type within the class.	For military vehicles and weapons systems, the object is distinguished by model. For commercial vehicles, the object is distinguished by typically known model types. For humans, the perception of individual elements or a combination of elements that can be distinguished to the extent that the human is determined to be armed or potentially combatant.

An alternative view of the DCRI model is provided by the Detection, Classification, Identify, Act (DCIA) process (Dean et al, 2005). This process more closely matches the simple model of CID (see Figure 2) with stimulus, decision and response stages defined as follows:

- Detection: An initial detection will allow the observer to decide whether the entity is a target or background clutter and also involves a degree of localization.
- Classification: Assuming that the decision maker is confident that something has been detected, this process will determine what it is. This could be based on physical identifying features (topology) or behaviour (size and speed).
- Identification: Determination of the allegiance of the entity.
- Action: Determination of whether the decision maker needs to close on the target to get more information and/or take some other action.

These actions may not be sequential. For instance, it may be possible to identify the allegiance of a contact (e.g. based on intercepted communication) before its classification (e.g. size, speed and location) are known. Also, the classification of an object may go through varying levels of refinement. For instance, the soldier may classify a contact as a vehicle, then a tracked vehicle, then T-72 (Russian Tank). This is similar to the different steps in the DCRI process.

Neither the DCRI nor the DCIA models of CID do much to enhance one's understanding of how other tasks performed by the soldier affect, or are affected by, the CID process. The next section provides a task analysis of the soldier's task while carrying out CID, which places the DCRI and DCIA models in context.

The dismounted soldier carries out CID as a critical part of any activity. CID can be considered both a process and an outcome. The process of CID involves the building and maintaining of SA for the soldier's environment, while the outcome of CID allows them to accurately identify targets, hostile entities, non-combatants, neutrals, and friendly entities. The range of possible CID outcomes is shown in Figure 3. Those cells filled in green are the desired outcomes, while those filled in red are not desired. Note that in the case of 'unknown' soldiers are likely to gather more information, but will be prepared to engage.

	Ground Truth: Friend, Non-Combatant, Neutral	Ground Truth: Hostile, Unknown
Identification: Friend, Non-Combatant, Neutral	Don't shoot	Don't shoot
Identification: Hostile, Unknown	Shoot	Shoot

Figure 3: CID Decisions vs Ground Truth

3.3 Standards

There are several North Atlantic Treaty Organization (NATO) Standardization Agreements (STANAGs) concerning CID. These common requirements are intended to support coalition interoperability for CID, allowing NATO members to operate effectively with each other. These STANAGs will not be dealt with in detail in this review, since there is less direct relevance to the human issues surrounding CID, beyond the fact that they deal with CID. The NATO STANAGs are:

- NATO STANAG 2129 Edition 8 (Draft): Identification of Land Forces on the Battlefield and in an Area of Operations;
- NATO STANAG 4579 C3: Battlefield Target Identification Devices (BTID);

- NATO STANAG 4630: Dismounted Soldier Identification Device (DSID); and,

- NATO NISCO (NATO Identification System Coordination Office) Update Report – NHQC3S (NISCO) 0011-2008: 19 December 2008.

There are a number of CID standards that are also published for use by a select group of allies. These include:

- ABCA (United States [America], Britain, Canada, and Australia) Standard 2076: Combat Identification (Target ID) Draft 2008; and,

- NATO/ISAF (International Security Assistance Force) IFF Standard Operating Procedure (SOP) 3500 Dated 16 June 2007.

3.4 Context

Much of the operational context and the factors influencing CID decision making have been described in detail by previous reports (Vilhena, Zobarich, & Lamoureux, 2007). At a coarse level of description, CID technology must integrate with a system comprising people, the environment, and the task. This section builds upon the earlier work to describe factors that will be involved in a multi-dimensional interaction between the technology/equipment provided and the CID process.

3.4.1 People

Introduction of a new soldier system should not adversely affect the soldier's ability to perform any required tasks. The new system should enhance cognition through support for perception, development and maintenance of SA, optimization of workload associated with concurrent tasks (i.e., CID and whatever else needs to be done) decision making (e.g. friend or foe) and selection of an appropriate response (e.g. search for more information, exercise force). The new system should also not impose significant physical stresses to the soldier. These physical stresses can take a number of forms, including excessive weight, uncomfortable postures, hindrance to movement of limbs and/or the whole body, heat, vibration, and noise.

External to the body of the soldier are other factors falling into the 'people' domain. These include organizational and interactional factors. The dismounted soldier typically operates as part of a team ('section') of 10 people, including the driver and gunner of the Light Armoured Vehicle (LAV) in which they travel. The soldier is considered 'dismounted' once they exit the LAV The section is organized such that different individuals have different responsibilities, and they move in a coordinated fashion to maintain continual awareness of their surroundings. Through a variety of communications means, the section seeks to maintain a single, shared understanding of their own disposition, the enemy's disposition and any changes to their environment.

Soldiers in the CF are highly trained and have sophisticated tactics that they employ on their operations. At the lowest level, all soldiers follow procedures that help manage expectations and facilitate soldiers' ability to work together with minimal time spent planning and coordinating. The CF also employs strict Rules of Engagement (ROEs) that govern the interaction of soldiers with others in the environment, including the use and escalation of force.

Finally, the dismounted soldier operates in concert with other military, paramilitary, and non-military entities, including many which will not share the same equipment or be otherwise interoperable with equipment used by the CF. These other groups may not speak English and, indeed, communications may need to go through a translator, adding further possible errors in communications.

With reference to CID, the key factor is the ability to share information on a one-to-one and one-to-many basis. This communication may be verbal, gestural, or symbolic (e.g. text or maps) and may be incoming or outgoing for the soldier. CID technology should fit within current organizational and communication paradigms or provide a demonstrable and quantifiable improvement when compared to current performance. A similar observation can be made with respect to TTPs; a CID system should not contradict or otherwise interfere with the application of the training received, the tactics used, the techniques applied, or the procedures adopted (including ROEs) by the soldier.

Other factors, such as clothing and protective equipment, are described under the 'task' domain.

3.4.2 Environment

The environment can make the effective use of new technology difficult. A CID system may be used in all weather, at all times of the day and night. Therefore it must be equally usable and operable regardless of temperature extremes, humidity, fog, or precipitation, in darkness or extremely bright conditions due to the moon or the sun, regardless of the angle of the light. The system should be rugged since the soldier is unlikely to focus on protecting the system, and it should not be susceptible to electromagnetic or other types of interference.

The CID system should also work regardless of the terrain, the cover, the presence or absence of large or small buildings. The dismounted soldier will typically be interested in the area that is within the range of their weapon, or the range of the adversary's weapon (whichever is greater). Although any weapon is unlikely to be effective at maximum range, the area assumed to be of interest to a dismounted soldier during this study has a radius of 5km (to accommodate the LAV 27mm cannon).

3.4.3 Task

The task domain includes the tools and equipment the soldier uses, the technology behind the equipment, the process to be followed, the application of automation, as well as the actual performance of tasks, as measured by speed, accuracy, etc. It is the point where the impact of the people and the environment is felt. Consequently, the task domain is described in more detail than the people and environment domains.

The Commander of a section maintains communications with the higher commands, using a radio carried by another member of the section. All members of the section carry a Personal Role Radio (PRR) that includes an earpiece and microphone to enable intra-section communication (including the LAV). Members of the section may carry a light or heavy machine gun, as well as a sidearm and a combat knife. Each member will also wear boots, camouflaged fatigues, a scarf, gloves, goggles and/or sunglasses, an armour plated fragmentation vest, and a helmet with or without Night Vision Goggles (NVG) mounted. The soldier will also wear Infra Red (IR) reflective patches and possibly IR strobes for the purposes of identifying him- or herself to suitably equipped (and presumably friendly) observers.

Finally, each member of the team will carry spare ammunition, batteries, water, food, basic medical supplies, and other items needed by the individual. Batteries alone may weigh up to 35 pounds, and the total weight of equipment carried by a dismounted soldier is up to 130 pounds.

The LAV can carry additional supplies for the soldiers and contains some technological assistance for studying maps and sharing information with higher commands (i.e. command and control applications) The LAV can also supply power for more intensive applications, such as preparing food, using IR or Image Intensification systems, or transmitting radio signals over longer distances.

The soldier is required to perform CID when stationary and when moving, whether mounted or dismounted. Hostile entities, especially in asymmetric environments, can be difficult to identify. They may not wear distinctive clothing or carry distinctive equipment and may use crowds for cover, as well as buildings, market stalls, vegetation, and other terrain. When under fire, the soldier is still required to exercise full CID to minimize the likelihood of casualties among non-combatants. The soldier will typically hold his/her rifle in two hands. The soldier will frequently visually inspect individuals in the immediate vicinity through the sight on the rifle. This augments the soldier's natural visual capabilities as well as reduces the time needed to raise the rifle to firing position in the event of some hostile action. This process implies that any technological CID system must be complementary to the process of raising the weapon and looking through the sight.

A soldier must be able to run and jump while wearing all the equipment described above, as well as continue moving for prolonged durations. The soldier may also fall on any side, and any equipment will be subject to significant physical shocks from running, jumping and falling. Any equipment must be operable by the soldier while wearing protective gloves, which may be thick if operating in cold climates. The display should also be visible while the user is wearing tinted eyewear, although it should not emit sufficient light to render the soldier detectable when in cover or in darkness. Systems should not require the soldier to interrupt a task in progress (such as movement, firing a weapon, talking on a radio) in order to make a requested input, or to silence an alert, or darken a display. Thus, based on the assumption that the current tasks performed by the soldier have been optimized, any CID system should fit seamlessly into the performance of current tasks.

The soldier's movement may be sufficiently abrupt that any weight being carried can unbalance the individual. The Integrated Soldier System Program (ISSP) recognizes these physical demands upon the soldier and has stated specifically that bidder systems (which must include CID technology components) with the lowest weight and volume (i.e. size) would be rated highly in the corresponding criteria (ISSP Industry Day, 31 May 2011). The ISSP includes a significant element of user trials in order to test the weight and volume of proffered solutions. These practical and project requirements imply that any technological CID system must not add so much weight, nor be so cumbersome, to offset or eliminate the benefits of the SA and TI/IFF capabilities afforded by the CID technology. This restriction on weight also affects the power requirements of a technological CID system. In particular, the soldier must not be required to carry extra batteries or power sources, since these are almost invariably heavy.

Given the demands of combat, it is unlikely that the soldier will want a system that impedes their ability to visually consider a scene. Any system must be convenient to look at, but must not be in the way. The system should also not generate heat so as not to create discomfort for the soldier. Heat is also detectable by an adversary. Any technological CID system should not increase the likelihood of detection of the soldier by an adversary, whether they are using thermal sights, IR sights, or more advanced Electronic Warfare (EW) equipment.

The advent of technological CID systems also raises the issue of soldier trust and reliance in the system. An improperly-designed system is, at best, ignored or discarded by the soldier. However, it is possible that the system is designed well for many situations such that the soldier begins to rely heavily on the system, without realizing the limits of the system to provide reliable advice. In this situation the soldier could persevere in using the system's advice, leading to poor performance (as defined in Figure 3). A good system helps the user understand the validity and reliability of the advice it is providing, allowing the user to calibrate their use of that advice accordingly (Wang, Jamieson, & Hollands, 2009).

Soldiers often have plenty of time to consult decision support and other information tools, such as when planning or rehearsing an upcoming action. There are, however, times of intense activity, such as advancing to contact or engagement with an enemy, that make it difficult to use any such tool Figure 4 illustrates a timeline of contact with a hostile force that indicates the times when use of CID tools is convenient and the times when it is most difficult. It seems CID technology will be useful at the beginning and end of the timeline but much less useful during contact when support for CID is required. Furthermore, a soldier's SA is likely to degrade when in contact (and possibly when moving to contact) as they focus exclusively[3] on their assigned area or arc of responsibility. This challenge is exacerbated when in urban environments, where there can be objects that obscure vision, potential non-combatants, and significant reductions in the distance to a possible target. Thus, a significant challenge for the design of CID technology is to provide support and help the soldier maintain good SA at precisely those times when it is most cognitively difficult for the soldier to take in new information.

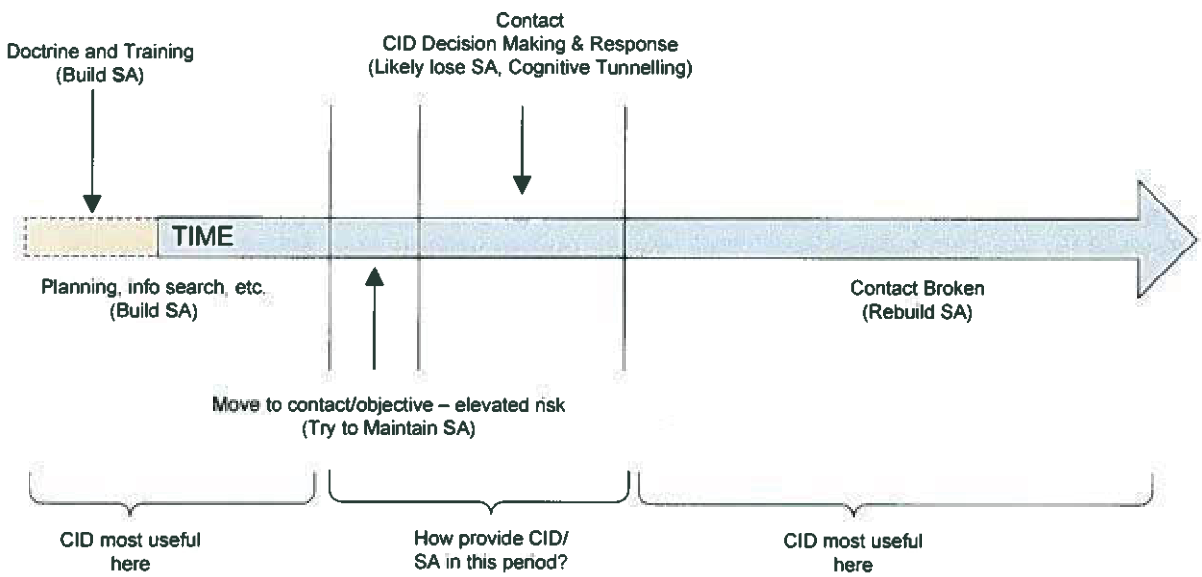

Figure 4: CID and SA against Time

3.4.4 Context Summary

Considering the descriptions of the people, environment, and task above it is possible to summarize the likely impact (positive or negative) of a CID system on the dismounted soldier. These impacts fall into two categories: Physical and Cognitive. Table 3 lists

[3] Cognitive tunneling refers to the effect where observers focus attention on information from specific areas to the exclusion of information presented outside these areas (Thomas and Wickens, 2006). For a soldier, this may mean they cease to see or hear anything that does not add to their search for an enemy. These areas may be physical locations, information, or stimuli.

the impacts in their respective categories. Note that this list is necessarily high level, and the specific nature of the impact is dependent on the specific circumstances.

Table 3: Physical and cognitive impacts of CID systems on dismounted soldier

Physical Impacts	Cognitive Impacts
Load carriage	Trust/confidence in system
Locomotion (e.g. walking, jumping)	Reliability
Movement (e.g. raising arm, moving head)	Perception
Endurance/fatigue	Situation Awareness (including cognitive tunnelling)
Posture	Workload
Operation of equipment	Human Error
Injury	Decision Making
Response execution	Response selection

These individual-level impacts can have a net effect on a mission with respect to safety (i.e., the danger to which own forces are exposed), efficiency (i.e., the economy of time and resources associated with goal achievement), and performance (i.e., the process and associated metrics followed to achieve the goal).

3.5 Model for CID System Evaluation

Based on the soldier model described in Sections 3.2 and 3.4, a set of criteria have been developed for evaluating the CID technology included in this review. As well as comparing functionality and performance, all criteria have an impact on the task, either directly or mediated via the soldier or the environment. Additionally, the cost and maturity of a given CID technology is evaluated. The evaluation criteria are displayed in Figure 5 below.

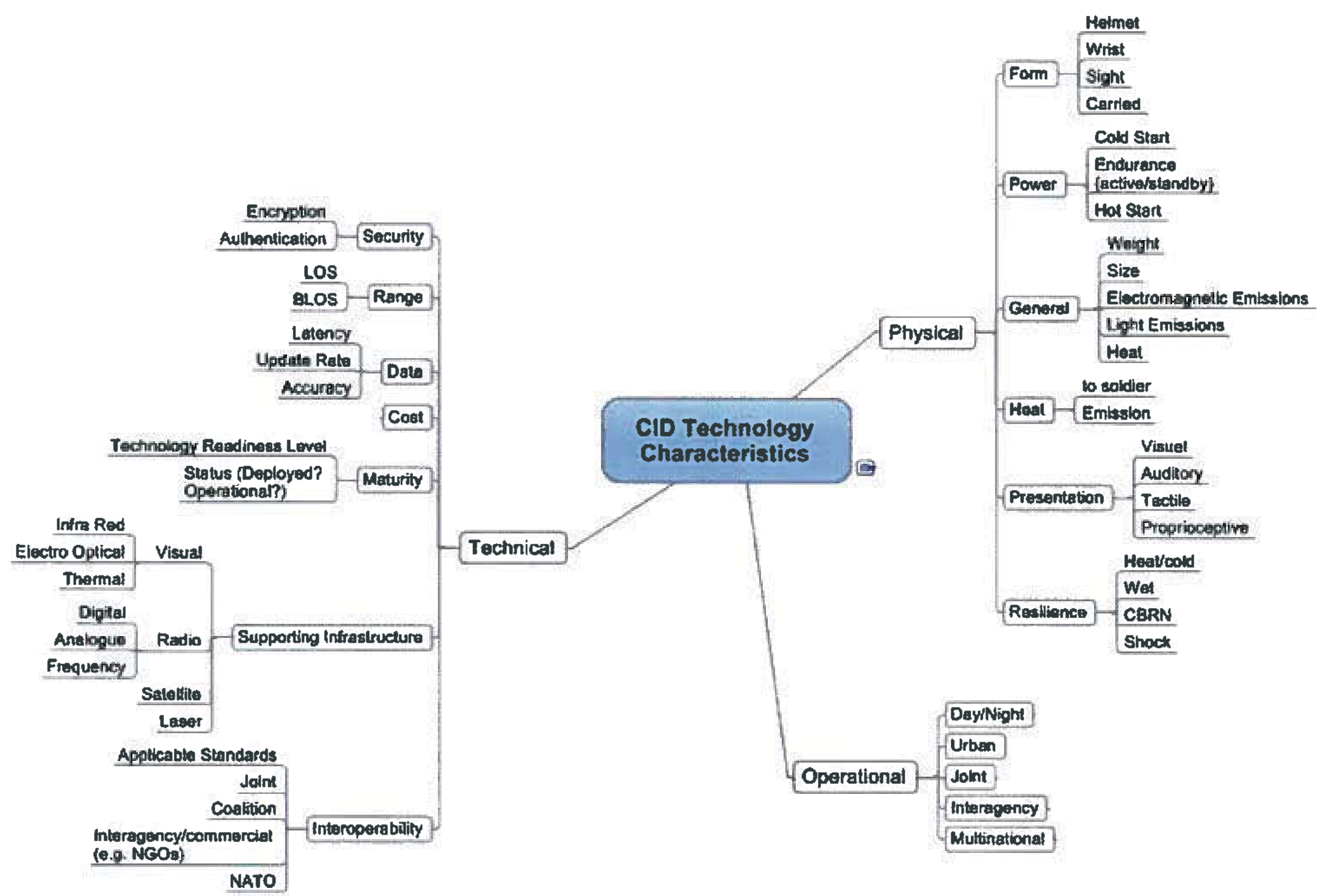

Figure 5: CID Technology Characteristics

4 REVIEW OF COMBAT IDENTIFICATION TECHNOLOGIES

This section describes the results of an extensive review of documentation provided and information found through internet searches. This documentation and information was reviewed and relevant data was categorized according to the groups described in section 2.2.

Each section below provides a general overview of the technology type, noting any significant deviations to the norm, before listing individual systems. Based on the evaluation, the likely impact on the soldier of CID technology is described and a gap analysis of where capability research and development would be beneficial is performed (section 5).

4.1 Group 1 – Passive signalling devices

4.1.1 Technology Review

Boyd, Collyer, Skinner, Smeaton, Wilson, Krause, Dexter, Perry, & Godfrey (2005) define passive signalling devices as enabling "CID of friendly units without any action or response by the person or platform carrying the device". The technologies in this group include: infrared paint and tape; identification panels (CIPs); and smoke markers. Most passive signalling devices fall under the Joint Combat Identification Marking System (JCIMS), including CIPs, Thermal Identification Panels (TIPs), Near IR (NIR) markers, thermal tape and fluorescent markers. (Team UK, 2006) Table 4 provides a general description of passive signalling devices against the evaluation criteria.

Table 4 : Passive Signalling Device Characteristics

CID Technology Characteristics			Passive Signalling*
Physical	General	Size	variable (1/2" - 2')
		Weight	Negligible (<100 g)
		Electromagnetic Emissions	None
		Light Emissions	Fluorescent tape visible to all; Thermal/IR visible by any with thermal/NV optical aids)
		Heat	None (NB - thermal tape visible with thermal imaging devices)
	Form	Helmet	Y
		Wrist	Y
		Sight	N (NB - enhanced sights used for viewing IR tape)
		Carried	Y
	Power	Cold Start	N/A
		Endurance (active/standby)	Unlimited, except fluorescent tape (requires exposure to

CID Technology Characteristics			Passive Signalling*
			light)
		Hot Start	N/A
	Presentation	Visual	Y (NB - many, including thermal and IR, require visual aids such as NVGs)
		Auditory	N
		Tactile	N
		Proprioceptive	N
	Heat	to soldier	Nil
		Emission	Nil
	Resilience	Heat/cold	No effect unless the ambient temperature obscures a thermal panel.
		Wet	No effect
		CBRN	Can possibly affect IR patch observation
		Shock	No effect
Operational	General	Day/Night	Night only
		Urban	Y
		Joint	Y
		Interagency	Y
		Multinational	Y
Technical	Other	Range (LOS/BLOS)	Line-of-sight (disrupted by foliage or other obstacles)
		Cost (est.)	Most options < $100/pp
	Security	Encryption	N/A
		Authentication	N/A
	Data	Latency	Immediate
		Update Rate	Persistent (given LOS)
		Accuracy	No loss/gain in accuracy
	Maturity	TRL	Variable
		Status (Deployed? Operational?)	Deployed
	Supporting Infrastructure	IR	Y
		EO	N
		Thermal	Y
		Radio	N
		Satellite	N
		Laser	N
	Interoperability	Applicable Standards	N/A
		Joint	Y
		Coalition	Y

CID Technology Characteristics			Passive Signalling*
		Interagency/commercial (e.g. NGOs)	Y
		NATO	Y

** Note: Y = yes; N = No, N/A = Not Applicable*

The common theme of these signalling devices are that they provide a unique identifier that is low-cost, easily implemented and has little to no impact on the dismounted soldier. All these technologies provide an enhanced ability to visually identify a friendly unit in conditions of poor light (night operations) or at a distance. They are already in use in the CF (e.g. IR markers, "cat's eyes" fluorescent tape).

There are a few disadvantages to passive signalling devices. The common IR and thermal tags require special viewing equipment, either through enhanced scopes, eyepieces (NVGs) or other enhanced displays (e.g. Forward-looking Infrared (FLIR) cameras). They also require line of sight identification. The possibility of detection/interception is mixed as there are no EM emissions, but passive signals can easily be viewed by properly equipped adversaries.

The "cat's eyes" fluorescent tape worn on the back of helmets is one of the only passive signalling devices that augment CID without the use of additional viewers such as NVGs. These are a cheap and easy fix which add no weight and help during reduced visibility, but are easily and inexpensively purchased and are only useful in identifying friendly forces from behind. These are also visible to anyone on the battlefield.

IR tape is already in use in the CF as passive markers:

- Helmet IR Marker on the back of the helmet (instead of fluorescent tape) for dismounted soldier; and
- Canadian Flag IR Marker on the shoulder of the combat uniform for dismounted soldier.

Again, IR tape requires the use of NVGs or similar to be effective (Vilhena, Zobarich, & Lamoureux, 2007).

Table 5: Passive Signalling Devices

Technology	Description	Vendor	Type	Reference
Glo-Tape	IR tape visible using NVGs.	US NightVision	Passive signalling	(Boyd et al., 2005)
Athena Tag	Radar-detectable tag for vehicles	Sandia	Passive signalling	
Combat Identification Panels	Aluminum panels covered with thermal tape that allows ID of vehicles from a distance using thermal imaging devices.	Crossroads Industrial Services	Passive signalling	(Suttie, 2004)
Cat's Eyes Tape	Fluorescent markers worn on the rear of helmets and generate visible light for several hours.	Various (e.g., Rothco, BCB)	Passive signalling	(Team UK, 2006)

Passive signalling devices are of most use in ground-ground CID, owing to the limited range at which they can be detected and identified by friendly forces.

4.1.2 Implications of Passive Signalling for Dismounted Soldier

Passive signalling devices have limited implications for the dismounted soldier with respect to mobility or task execution, or in terms of information presentation. However, they can only augment SA if the soldier uses an appropriate viewing device (e.g. a flashlight, NVGs). They also require line-of-sight, making them an imperfect situation at best. Finally, whatever SA they do provide is limited to the area being observed, rather than providing all-round SA at the range desired by the dismounted soldier (i.e. 5km).

Passive signalling devices can be detected and mimicked by a suitably-equipped adversary. Since night vision technology and IR patches are becoming more common, it is reasonable to assume such devices will be used by an opponent. For this reason, there has been some work on 'frequency-coding' passive signalling devices, as well as creating devices with a discernable pattern (e.g. a Canadian flag), making them difficult to mimic. Frequency-coded passive signalling devices are only observable by observers with equipment that can detect the specific frequency of light reflected by the passive signalling device. Patterns can be easily copied by an adversary.

4.1.3 System Recommendations

To guard against detection by adversaries who have access to night vision or other IR emitting technologies, only passive signalling devices that can be frequency-coded should be under continued development and provided to soldiers.

4.2 Group 2 – Active signalling devices

4.2.1 Technology Review

Unlike passive signalling devices, active signalling devices emit 'electromagnetic energy to facilitate SA'. (Boyd et al., 2005). The most common technology is the IR beacon, which uses infrared light to emit a signal that can be viewed through night vision equipment at ranges of 10 kilometres or more. (Boyd et al., 2005)

As seen in section 4.1, active signalling devices exhibit many of the same characteristics as passive signalling devices. In many cases, these "quick fix" CID solutions are grouped with passive signalling devices as cheap, low-signature, high-impact solutions for reducing fratricide.

Table 6: Active Signalling Device Characteristics

CID Technology Characteristics			Active Signalling
Physical	General	Size	variable (1/2" - 3")
		Weight	Negligible (<100g), however spare batteries add weight
		Electromagnetic Emissions	(NB - RF tags detectable by radar)
		Light Emissions	IR lights visible to any with NVGs/FLIR
		Heat	
	Form	Helmet	Y
		Wrist	N
		Sight	N
		Carried	Y
	Power	Cold Start	Immediate (exception - programmable modes)
		Endurance (active/standby)	
		Hot Start	Immediate

CID Technology Characteristics			Active Signalling
Operational	Presentation	Visual	Y
		Auditory	N
		Tactile	N
		Proprioceptive	N
	Heat	to soldier	Nil
		Emission	Negligible
	Resilience	Heat/cold	N/A
		Wet	N/A
		CBRN	N/A
		Shock	N/A
	General	Day/Night	Night only
		Urban	Y
		Joint	Y
		Interagency	Y
		Multinational	Y
Technical	Other	Range (LOS/BLOS)	Line-of-sight (disrupted by foliage or other obstacles)
		Cost (est.)	Most options < $100/pp (~$30)
	Security	Encryption	N/A
		Authentication	N/A
	Data	Latency	Immediate
		Update Rate	Persistent (given LOS)
		Accuracy	No loss/gain in accuracy
	Maturity	TRL	Variable
		Status (Deployed? Operational?)	Deployed
	Supporting Infrastructure	IR	Y
		EO	N
		Thermal	N
		Radio	Y
		Satellite	N
		Laser	N
	Interoperability	Applicable Standards	N/A
		Joint	Y
		Coalition	Y
		Interagency/commercial (e.g. NGOs)	Y
		NATO	Y

Just as active and passive signalling devices share many of the same characteristics, their advantages and disadvantages are very similar. The major exception of note is the increased range of detection of an IR beacon over an IR patch on a uniform. This is particularly beneficial in reducing air-ground fratricide but potentially advantageous to an adversary with NVGs or FLIR. The flashing lights typical of an IR beacon can be confused as gunfire as well, which could cause confusion if units are not properly trained in what to expect. (Anecdotally, the flashing Budd Light IR beacon was so common for a short period of time that soldiers could not use NVGs when units were using them). However, ROEs and training can prevent this from becoming an issue.

Another disadvantage is that IR beacons require batteries that must be replaced frequently. Many IR beacons, such as the Phoenix light, take an attached 9-volt battery. Though a small issue, this can require additional logistical considerations and means that there needs to be a battery replacement scheme in place.

Table 7: Active Signalling Devices

Technology	Description	Vendor	Type	Reference
Black Blitz	Long-range high-intensity IR strobe	Survival Strategies	Active signalling	(Survival Strategies International, 2003)
Individual Force Protection System	Personal radio beacon (tag) capable of providing location and position information	DARPA; SAIC	Active signalling	(Boyd et al., 2005)
Budd Light	IR beacon visible through NVGs	Insight Technologies	Active signalling	(Office of Technology Assessment, 1993)
Phoenix Light	IR beacon visible through NVGs	Phoenix Products	Active signalling	(Ospital & Wojack, 2007)
DARPA Light	IR beacon visible through NVGs	DARPA	Active signalling	(Wahl, 2004)

Technology	Description	Vendor	Type	Reference
CORAL-CR	Coral handheld thermal imaging binoculars with target acquisition capabilities.	Coral	Active signalling	(Ebbutt & Gething, 2011)
Lily	Rifle-mounted thermal sight capable of connecting to Personal Data Unit (PDU) via Ethernet.	Elbit Systems	Active signalling	(Ebbutt & Gething, 2011)
MARS	Handheld thermal imager with camera.	MARS	Active signalling	(Ebbutt & Gething, 2011)

4.2.2 Implications of Active Signalling for Dismounted Soldier

Active signalling devices require line-of-sight to be detected, which limits their contribution to SA and target identification. This, additionally, makes them observable to adversaries. Active signalling devices have also been considered an aggravation when there are many such devices in the field of view, because of the uncoordinated flashing (Vilhena, Zobarich, & Lamoureux, 2007). However, their advantage lies in being light and, therefore, not affecting movement or tasks.

To mitigate, somewhat, the problems associated with active signalling devices, they can be designed to use specific sequences of flashes to clearly identify a friend. The pattern of flashes can be set precisely by the emitting system and measured precisely by the receiving system. The emitting system can also be tuned with regard to the wavelength and frequency of the emission. The degree of precision offered, as well as the ability to control the wavelength and frequency of the emission, results in a simple system that can be successful in evading interception by an enemy.

4.2.3 System Recommendations

The active signalling devices most likely to be useful to the soldier are the IR strobes (i.e. the Black Blitz, BUDD, DARPA and Phoenix Lights in Table 7) which can be observed using NVGs (which are issued to all deployed soldiers and are mounted on the helmet). Research should focus on systems that control the sequence, wavelength and frequency of the emissions. Further, because these devices require a power source, any research should focus on minimizing the size of battery required for maximum endurance, as well as defining the mounting location that is maximally observable in the most situations.

4.3 Group 3 – Interrogation/Response Systems

4.3.1 Technology Review

Interrogation/response systems enable positive identification through the process of query and response. Interrogation/response CID systems are designed to focus on a narrow field of view such as the 0.1° azimuth accuracy of the United Kingdom's Battlefield Target Identification Device (BTID) (Austin, 2006). In addition to BTID, the German Army proposes a Dismounted Soldier Identification Device (DSID) as a solution to CID.

Based on industry offerings and reports, the emphasis of CID technology development appears to have shifted away from the use of IFF interrogators and transponders for US dismounted units (as opposed to aircraft and ships, and some land vehicles). Although STANAG 4630 (Dismounted Soldier Identification Device [DSID]) has yet to be ratified by all NATO nations and the Coalition Combat Identification (CCID) Military Utility Assessment (MUA) is still awaited, the US Army has already downplayed the utility of dismounted soldier IFF systems in close combat situations, primarily because of the reaction delays their use potentially imposes. (Pellingley, 2006) According to one article, the UK Ministry of Defence (MoD) has also shown "reservations over the prospective diminution of 'killer instinct' their use would engender in a fire fight, leading to greater own-force losses in close combat" (Pengelley, 2006). This is a realization of one of the critical potential limitations posed by CID technologies: the introduction of a decision aid into CID may pose a problem for soldiers in the long term who may seek to use it in situations where time constraints make it imprudent to make use of a CID system. Further, many of the interrogators are rifle-mounted and require the rifle to be pointed at a target in order for the device to be used, which makes interrogating a source a hostile act. (Pellingley, 2006) On the other hand both the UK and US militaries and user communities seem to concur that such systems have utility in the build-up phase, before contact with the enemy, for situational awareness purposes.

There is still a desire for Radio Based Combat Identification (RBCI) by the world's militaries as implied by the requirement for such a capability in many soldier modernization programs, which could form part of an interrogation/response system, as a part of ground systems.

Table 8: Interrogation/Response System Characteristics

CID Technology Characteristics			IFF
Physical	General	Size	Interrogators ~6"x2"; transponders ~4"x4"
		Weight	Interrogators ~500g; Transponders ~350g
		Electromagnetic Emissions	Variable (RF v. laser)
		Light Emissions	None
		Heat	Negligible
	Form	Helmet	Transponder
		Wrist	N
		Sight	Interrogator/transponder
		Carried	N
	Power	Cold Start	Unknown
		Endurance (active/standby)	30 days
		Hot Start	Unknown
	Presentation	Visual	Y
		Auditory	Y (encoded radio signal)
		Tactile	N
		Proprioceptive	N
	Heat	to soldier	Negligible
		Emission	Negligible
	Resilience	Heat/cold	Yes
		Wet	Yes
		CBRN	Yes
		Shock	Yes
Operational	General	Day/Night	Y
		Urban	Y (reduced benefits in close quarters, esp. laser)
		Joint	Y
		Interagency	N
		Multinational	Y (capable)
Technical	Other	Range (LOS/BLOS)	LOS (> 1100 m)
		Cost (est.)	Can be cheap with commercial encrypted transmitters
	Security	Encryption	Y
		Authentication	Y
	Data	Latency	Immediate (< 1 s)

CID Technology Characteristics			IFF
		Update Rate	N/A
		Accuracy	No loss/gain in accuracy
	Maturity	TRL	Variable
		Status (Deployed? Operational?)	Deployed
	Supporting Infrastructure	IR	N
		EO	N
		Thermal	N
		Radio	Y
		Satellite	Y
		Laser	Y
	Interoperability	Applicable Standards	STANAG 4579
		Joint	Y
		Coalition	Y
		Interagency/commercial (e.g. NGOs)	N
		NATO	Y

IFF is subject to the same electromagnetic considerations as other CID technology, that is, an interrogation or response may be intercepted and exploited by an adversary. IFF is also susceptible to error due to the wide beamwidth typically used. As illustrated in Figure 5, an IFF device pointed at one target may have other targets within its beamwidth which can receive the interrogation signal sent by the device. In this event, that other target, which is not the target of interest, may send a reply that the IFF user mistakenly attributes to the target he/she is pointing at. This permits the possibility of incorrect attribution of a friendly response to a hostile contact (UK Ministry of Defence, 2004).

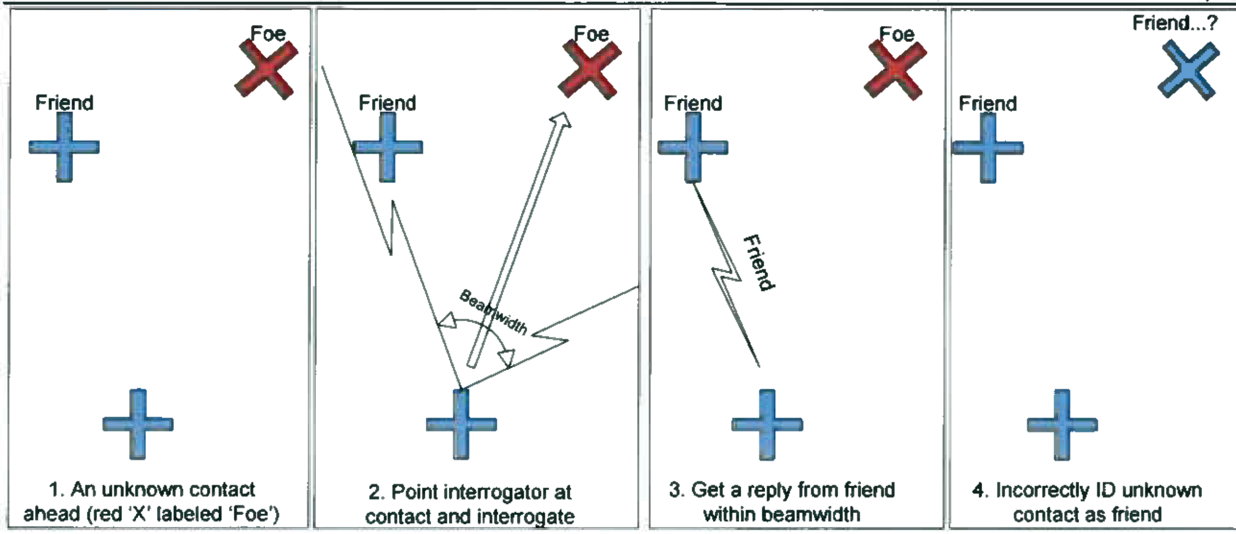

Figure 6: Graphical explanation of IFF error

For their part British forces are said to have a policy objection which may be interpreted as "any delay during a firefight is bad." (Hewish & Pengelley, 2003) The belief is that while an Individual Combat Identification System (ICIDS) or DSID (as distinct from a vehicle-mounted BTID system) might be made to work in peace support scenarios, it would not be appropriate in all war situations. Accordingly it is felt that shoot/don't shoot decisions should continue to be reached intuitively. To that end the British Army's Future Integrated Soldier Technology (FIST) program is focusing on SA sytems, the service introduction of personal role radios having meanwhile begun to help considerably by improving voice contact between affiliated troops in close combat. (Hewish & Pengelley, 2003)

Table 9: Interrogation/Response Systems

Technology	Description	Vendor	Type	Reference
Dismounted Soldier Identification Device (DSID)	IFF system for dismounted soldiers	Rheinmetall	IFF	(Petersen, Glikerdas, Mckean, & Kuehl, 2009)
Battlefield Identify Friend or Foe (BIFF)	Vehicle-mounted IFF	Thales	IFF	(Guichemerre, 2004)
Optical Combat Identification System (O-ICDS)	Laser-based IFF.	Cubic	IFF	(Cubic Corporation, 2004)

Technology	Description	Vendor	Type	Reference
Battlefield Target Identification Device (BTID)	Millimetre Wave (mmW) IFF system for vehicles.	Raytheon	IFF	(Raytheon Systems, 2006)
Individual Combat Identification System (ICIDS)	IFF system designed for the dismounted soldier		IFF	(Kogler, 2003)
Radio Based Combat Identification (RBCI)	Radio-based (Single Channel Ground and Airborne Radio System - SINCGARS) IFF, predominantly vehicle-based (only interrogation response from dismounted platforms).	ITT	IFF	(ITT, 2010)
SIMLAS	Laser-based training system that can be used for combat identification.	Oerlikon Contraves/ Rheinmetall	IFF/Trg	(Gaughan, 2005)

4.3.2 Implications of Interrogation/Response Systems for Dismounted Soldier

Interrogation/response systems are direct interrogations of single (potential) targets, meaning that SA is significantly reduced for the time of interrogation, since the soldier's focus is only on one target. The act of interrogation is also time consuming since the soldier must somehow direct the interrogator onto the target and wait for a response (which, although transmit and receive times are almost imperceptible, may take in excess of a second to process and display a response to the soldier). Finally, the act of interrogation may also impose additional tasks on the soldier, reducing their combat effectiveness briefly.

Similarly to Passive and Active signalling devices, interrogation/response systems also only provide part of the soldier's SA. In order for IFF to be successful, an interrogation must trigger a response, which means that the target must be suitably equipped to make a response. Since it is likely that only friendly forces will be equipped, no interrogation response will be received from enemies and non-combatants alike, leaving the soldier only certain that they are not engaging an equipped friend. Modern warfare requires equal consideration for non-combatants and friendly solders, so such a restriction on the SA information provided by an IFF system is clearly not sufficient.

Interrogation/response systems may also impose weight penalties on the soldier. Although an interrogation/reception unit may weigh as little as 500g, and be powered by a battery weighing about 250g, they are likely to be mounted on a rifle, which is distal to the soldier's centre of mass, and exert disproportionate force on the soldier. Other systems, such as radio-based systems, will be mounted on the soldier, but any display will be either mounted on the rifle (ideally integrated with the rifle sight), or will be implemented as a separate unit which is unlikely to compatible with concurrent rifle use.

4.3.3 System Recommendations

As much as possible, any IFF system must be complementary to the soldier's task. This entails pointing the rifle at a target and sighting the target through the rifle sight. Thus, the interrogator must be bore-sighted with the rifle barrel, and the response must be presented to the soldier, clearly and unambiguously, in the vicinity of the rifle sight.

With these caveats to implementation of an interrogation/response system, the solution most likely to be successful is a rifle-mounted laser interrogator with TI information presented through or close to the rifle sight.

4.4 Group 4 – Situation Awareness (SA) systems

4.4.1 Technology Review

SA systems support CID judgments by presenting positional information about friendly units. These systems include a human interface of some sort, a processing unit and a means to share information between networked users. From a CID perspective, the most critical function of an SA system is to identify the position and movements of other "blue" or friendly forces (hence SA systems are also called 'Blue Force Tracking', or BFT, systems). Another function available on many SA systems is the sharing of data on the locations of sighted or engaged enemy forces. Some systems have additional capabilities including shared planning and intelligence information that augment underlying SA and enhance CID.

One of the most prevalent BFT systems is the US-developed FBCB2. FBCB2 has line-of-sight capability with the FBCB2-Enhanced Positioning Location and Reporting System (FBCB2-EPLRS) and beyond line of sight capability with FBCB2-Blue Force Tracking (FBCB2-BFT) commercial satellite transceiver. FBCB2-EPLRS is accredited for secret information while FBCB2-BFT is currently unclassified because its data travels over commercial satellite systems (Austin, 2006). While it is a US system, it has been deployed in support of coalition operations to other allies, including Canada. Similar BFT systems are being developed by other nations, while the NATO Friendly Force Tracker (FFT) was designed to be deployed as a coalition system with the capacity to operate with participating nations' native BFT systems through common standards.

BFT system designers face two common problems when fielding any communications system; coverage and bandwidth. (Austin, 2006) In Operation Iraqi Freedom tactical users stated "the biggest problem with FBCB2 (Force XXI Battle Command Brigade and Below) was that our digital pipe was too small." (Austin, 2006). Coverage and bandwidth constraints depend on the type of exchange technology (e.g., radio, satellite, tactical intranet) employed. Thus, BFT systems are constrained, to some extent, with respect to the types and amounts of information exchanged. The choice of exchange technology will also affect the system's accuracy, latency or refresh rate, interoperability with other systems, and effective range.

BFT system designers must also incorporate security measures to prevent the enemy from gaining friendly position information. The enemy may accomplish this through electromagnetic detection, "hacking" into the BFT network, or simply capturing an active terminal. Theoretically, if BFT systems transmit long enough, the enemy could locate friendly forces by radio frequency direction finding. Efforts to thwart this include levels of emissions control (EMCON), spread spectrum, and rapid frequency hopping (Austin, 2006)

Another factor to be considered with respect to SA/BFT systems is the challenge of "time to first fix" (TTFF), which is the period of time from when a receiver is deployed to location data being received. For vehicle systems this can be upwards of 5 minutes (Paul, 2010). Factoring in the reduction in transmitter power and smaller antennas that are likely for a man-portable SA/BFT system, it is reasonable to expect even longer TTFF for the dismounted soldier.

Table 10: SA System Characteristics

CID Technology Characteristics			SA
Physical	General	Size	Variable (7.12 x 10.25 x 2.25 in)
		Weight	As low as ~250g for lighter options such as the GD 300, with weights varying up to 5.4 lbs approx with internal battery ("Commanders Digital Assistant," 2008);
		Electromagnetic Emissions	Likely, but SME opinion is that encryption and other methods of deception make any such emissions safe for operations.
		Light Emissions	Depends upon the manifestation of the system. Some use touchscreen displays which may be quite bright. Others might use monocular displays that use mechanical approaches to ensuring that the display is not illuminated until the user has pressed the display securely to their face.
		Heat	Likely to emit some heat, but unlikely to be detectable by enemy.
	Form	Helmet	Y
		Wrist	Y
		Sight	Y

CID Technology Characteristics			SA
		Carried	Y
	Power	Cold Start	Unsure
	Power	Endurance (active/standby)	Probably no more than 24 hours on a full charge, depending upon the intensity of use intentionally by the user, and automatically by sending and receiving position information.
	Power	Hot Start	Unknown
	Presentation	Visual	Y
	Presentation	Auditory	Y
	Presentation	Tactile	N
	Presentation	Proprioceptive	N
	Heat	to soldier	Possibly, depending upon the nature of the power supply, processing unit, and display.
	Heat	Emission	As above.
	Resilience	Heat/cold	Limited range of operating conditions – probably not extreme cold or extreme heat, especially when subjected to prolonged exposure to either.
	Resilience	Wet	Not currently, but ruggedized versions are in development.
	Resilience	CBRN	Subject to the same considerations as other electronic systems.
	Resilience	Shock	As above, ruggedized versions are under development.
Operational	General	Day/Night	Y
Operational	General	Urban	Y
Operational	General	Joint	Y
Operational	General	Interagency	N
Operational	General	Multinational	Y (depending on pre-planning, common data exchange standards or common systems)
Technical	Other	Range (LOS/BLOS)	Variable - can be up to BLOS
Technical	Other	Cost (est.)	Unknown
Technical	Security	Encryption	Yes
Technical	Security	Authentication	Yes
Technical	Data	Latency	Depending on infrastructure, can be < 2 s but typically in the region of minutes currently. Standards call for 8 – 15 s.
Technical	Data	Update Rate	100 pkts/sec against a specification of 83 and a latency rate of one second (for BFT-HC). ("Force XXI Battle Command Brigade-and-Below - Blue Force Tracking (FBCB2-BFT)," 2011)
Technical	Data	Accuracy	Variable based on environment; can include adjustments for altitude and motion inside buildings. Standards call for 50m.
Technical	Maturity	TRL	Variable
Technical	Maturity	Status (Deployed? Operational?)	Deployed
Technical	ing Infrastr	IR	N
Technical	ing Infrastr	EO	N

CID Technology Characteristics			SA
		Thermal	N
		Radio	Y
		Satellite	Y
		Laser	N
	Interoperability	Applicable Standards	
		Joint	Y
		Coalition	Y
		Interagency/commercial (e.g. NGOs)	Yes
		NATO	Yes

The ability to receive persistent and accurate data of all friendly forces within range of the dismounted soldier is the primary technological challenge for BFT. Any lack of persistence, loss in accuracy or incomplete picture can cause the user to distrust the system as a reliable CID aid. Persistence and accuracy, however, have not been objectively defined in the literature on BFT systems The ideal update is real-time, as a short lag (e.g. 2 sec) can lead to a 2-3m discrepancy in position accuracy (based on average speed of movement of soldiers and/or vehicles). Most systems do not exhibit this degree of real-time accuracy, instead meeting threshold (i.e. minimum acceptable) parameters. (Pengelley, 2011) For example, the threshold Joint Battle Command-Platform (JBC-P) Key Performance Parameters (KPP) requirement is that all operational terminals should be able to instantaneously present to their users 75% of available joint Position Location Information (PLI) in the 'immediate' battlespace (i.e., 2.5 km radius of the dismounted soldier using the system), and 65% within the 'extended' battlespace (i.e., 5 km of the dismounted soldier using the system). The ultimate requirement (i.e. 'objective' requirement) that systems should be attempting to meet is 95% of available PLI in the immediate battlespace and 85% in the extended battlespace (Pengelley, 2011). Further, as a threshold requirement, the position information needs to be accurate to within 50m in the case of all friendly dismounted callsigns (Pengelley, 2011). While this threshold may be satisfactory for some BFT activities, it is unlikely to be acceptable for CID.

Closely related to persistence and accuracy is the latency (or position update rate) requirement for alerting friendly callsigns to those battlefield dangers that might affect them. The US Army has set the latency requirements for JBC-P at a threshold requirement of eight seconds and an objective requirement of four seconds for networks based on terrestrial (SINCGARS/EPLRS) links, or 15 and eight seconds respectively for satellite-based networks (Pengelley, 2011). Again, a 15 second delay in dismounted unit PLI data could lead to confusion at best. In close quarters scenarios, any latency can render an SA/BFT system for CID useless (Pengelley, 2011). Latency for current ground platforms is typically 5 minutes and up to 2 minutes for aviation platforms using FBCB2 (Austin, 2006). Increasing the report rate of BFT systems, however, will saturate the already stressed bandwidth of current communications systems (Austin, 2006). Additionally, increased report rates will intensify electronic emissions and may increase the potential for enemy exploitation of BFT transmissions (Austin, 2006). Previous SA/BFT systems using a celestial L-band satellite network have provided a 2.6 kbit/s data throughput, now increased to 26.6 kbit/s using the newer L-band BFT 2 Next Generation Transceiver (Pengelley, 2011). This translates into an update rate of just under two seconds, which is nonetheless likely to be inadequate for CID. Pengelley (2011) has argued that "considerably higher throughputs will be needed if the shared blue-force situational awareness (SA) and shared survivability key performance parameters (KPPs) laid down for JBC-P are to have any prospect of being fulfilled". One option is the introduction of commercial off-the-shelf (COTS) 3G/4G networks, 802.11 Wi-Fi and 802.16/21 WiMAX 'hot spots', which provide ubiquitous wireless network coverage, to even the most remote dismounted soldier, thus providing coverage to "the forward edge and the last tactical mile" (Pengelley, 2011).

As fielding of SA/BFT systems has expanded, so too has the perception these systems provide complete knowledge of friendly forces. During Operation Iraqi Freedom, one battalion commander stated he "knew the location of all adjacent units and command posts" by using FBCB2 (Austin, 2006). If users believe that these systems provide complete, error-free positional information at all times, then training about the systems being received is inadequate. SA/BFT systems may also lead a user to erroneous conclusions about the identities of displayed and non-displayed entities. A soldier may, for example, encounter an entity for which the SA/BFT device presents no corresponding blue force indicator and assume that the entity must therefore be hostile. This is not necessarily the case as the entity could be a non-hostile who has no transponder or even a friend whose transponder or communications have failed. Operators and commanders must still accomplish positive enemy identification, probably through visual confirmation (Austin, 2006).

One final issue surrounds the motivating effect SA/BFT systems might have on an enemy. Potential exploitation of SA/BFT offers the enemy a high pay off. An adversary that has access to or exploits a SA/BFT system will have knowledge of a soldier's position and movements which can be used to defeat the soldier (Austin, 2006). FBCB2-EPLRS is accredited for secret information while FBCB2-BFT is currently unclassified because its data travels over commercial satellite systems (Austin, 2006). Adding encryption increases the size of the data package, potentially increasing latency. Further challenges occur because existing COTS technologies do not have software-based Type 1 (secret-and-below) encryption approved and accredited for application to generic classes of COTS equipment, which would allow ubiquitous exploitation of handheld smartphones and other commercial terminals (Pengelley, 2011). A keen understanding of security requirements and available options should be exercised when selecting a SA system.

Table 11: SA Systems

Technology	Description	Vendor	Type	Reference
Infantry Soldier Situational Awareness Tool	SA/BFT connected to BOWMAN PRR	Selex Communications	SA	Selex, 2008
xMax Radio	Cognitive radio system.	xG Technology	IFF/SA	(xG Technology, 2011)
Joint Battle Command-Platform (JBC-P) Handheld	Handheld means of operating FBCB2	US Army	SA	US Army, 2011
Target Recognition Operator Notification system (TRON)	Air recognition system	Lumitex Inc.	SA	Cooper, 2008
Miltrak	BFT system developed by Thales for UK.	Thales	SA	(Ebbutt, 2008)
FBCB2 BFT	Blue force tracking system	Northrup Grumman	SA	(Abejon, 2005); (Bitar & Felsman, 2005)
Commander's Digital Assistant (CDA)	Ruggedized PDA with L-Band antenna	Raytheon (other models by other vendors as well)	SA	(Ackerman, 2005)
Tacticomp 1.5	Ruggedized PDA, with satellite access via nearby vehicles; uses mesh network and has low probability-of-intercept (unlike CDA).	Sierra Nevada Corporation	SA	(Ackerman, 2005); (Sierra Nevada Corporation, 2009)
Tactisight HMD	Helmet-mounted display. Notable that units did not like the use of HMD during some user tests.	Sierra Nevada Corporation	SA	(Soldier Battle Lab, 2006)

Technology	Description	Vendor	Type	Reference
NATO Friendly Force Tracking System (FFTS)	Not a particular system but a group of national systems sharing interoperable friendly force information.	N/A	SA	(Porta, 2008)
Dominator	Integrated Soldier System includes BFT capability. Runs Elbit's TORC2H BMS. The S-NAV Soldier Navigation System provides 3-D inertial tracking in those places where the GPS signal is unavailable.	Elbit	SA	(Ebbutt & Gething, 2011)
Defense Advanced GPS Receiver (DAGR)	Handheld Global Positioning System (GPS) receiver, capable of overlaying maps. First fix in under 100 seconds (Wikipedia). SAASM-capable.	Rockwell Collins	SA	(Rockwell Collins, 2009)
Dismounted Intelligence Situational Mapboard (DISM)	Has BFT/BFSA ability and quick reports.	Trident Systems	SA	(Coffey, 2007)

Technology	Description	Vendor	Type	Reference
S-NAV	System provides infantry soldiers with continuous follow-up three-dimensional pinpointing, even in areas lacking GPS capability or when the mission requires particularly covert operations.	Elbit Systems	SA	(Cohen, 2011)
SPOT Satellite Messenger	Commercially-available satellite communications network	SPOT Technologies	SA	
GR 100	Firefrighter SA system	Harris	SA	
Common Battlefield Application Toolset (ComBAT)	UK SA suite that includes BFT capability	General Dynamics UK	SA	(Ebbutt, 2008)
International Security Assistance Force Friendly Force Tracking (ISAF FTS)	NATO FFT system with two types of terminals, one of which can be dismounted and remoted from a vehicle.	NATO C3 Agency / Globecomm Systems	SA	(Ebbutt, 2008)
RF-6920 Situational Awareness Application	PDA-type SA application that runs C2CE. Designed to work with FALCON II radios.	Harris	SA	(Ebbutt, 2008)
Infantry Soldier Situational Awareness Tool (ISSAT)	Italian SA tool with built-in modified BOWMAN radio	Selex	SA	(Selex Communications, 2008)

Technology	Description	Vendor	Type	Reference
Honeywell Dead Reckoning Module (DRM-5/DRM-4000)	Miniature, self-contained, electronic navigation unit that provides the user's position relative to an initialisation point (usually provided by GPS) by using a tilt-compensated magnetic compass, electronic pedometer and barometric altimeter.	Honeywell	SA	(Ebbutt, 2008)
Pedestrian Navigation Module	A pedometer that detects steps and changes in acceleration, linked to a digital compass, a barometer (to detect changes in height), and a gyro.	Vectronix	SA	(Ebbutt, 2008)
RO Tactical Radio	Provides on-the-move, over-the-horizon secure voice and global position information in a handheld Push-To-Talk (PTT) communications device.	ITT Electronic Systems	SA	("RO Tactical Radio," 2011)

4.4.2 Implications of SA Systems for Dismounted Soldier

The precise information requirements of soldiers using a BFT device have not been established. For example, should positional information be given in three-dimensions?

What frame of reference should be used and what orientation should be presented? How should the display vary with the soldier's orientation? How accurate should the representation be? Given the distances involved in close-quarters contacts, the 50m threshold accuracy referred to in Pengelley (2011) is likely to be too imprecise to be of use. Likewise, how up-to-date must the information be to be of use? The times noted above, ranging from 4 to 15 seconds, may not be adequate in an urban environment.

Research is needed to better understand how information should be presented to soldiers for the purposes of maximizing SA for CID. Standards for the amount of information and the speed of information transfer could be used as benchmarks for effective CID technology. Research is also needed to explore the issue of trust in CID systems and determine how to properly calibrate trust of users of SA systems.

SA systems will, depending upon the implementation, still impose burdens on the soldier. In particular, the weight of the system and its associated power source may hinder movement and performance of tasks. Also, the manner in which the information is presented to the soldier may adversely affect task performance (for instance, if the soldier has to stop to consult a graphical display that is stowed in a pocket or pouch, or mounted on the wrist or chest). Again, further research should consider the manner of display (e.g. wrist, weapon, chest, eyewear, monocle, etc.). Other research may consider novel strategies for transmitting and collating SA information. For instance, a hub-and-spoke approach, with the supporting vehicle (e.g. a LAV) as the hub may reduce the requirement to over long distances and thus reduce the power consumption of SA devices.

4.4.3 System Recommendations

There are a variety of systems that present SA information. It is expected that the ability to gather positional information from each soldier will become ubiquitous through the integration of GPS and digital radio as standard, even if the individual soldiers are not presented with this SA information. Using a hub and spoke approach currently, the Sierra Nevada Corporation Tacticomp 1.5 ruggedized PDA with helmet mounted display may represent the most 'soldier friendly' SA system currently fielded in that it interferes minimally with soldiers' tasks when compared with the other technology systems reviewed here. However, it is clear that substantial detailed work is required to develop a SA system that addresses the needs of the dismounted soldier and integrates seamlessly with other levels of command.

4.5 Group 5 – Recognition training systems

4.5.1 Technology Review

Recognition training systems can increase CID accuracy and decrease decision-making time by improving situation assessment skills, especially with respect to Endsley's (1988) second level of SA , identifying and classifying what has been observed in the environment. Training systems educate the soldier in the appearance and discriminating features of different entities on the battlefield. These features can include vehicle features, weapon features, uniform features, helmet features, etc. that can assist in identifying friendly forces from adversary forces. Based on discussions with soldiers returning from Afghanistan, a period of approximately two weeks is required in theatre to be able to apply such training in operations. Recognition training systems may accelerate or even eliminate this learning curve.

Recognition training systems, such as the Recognition of Combat Vehicles (ROC-V) and the Combat Identification Training System (CITS), are used only in training environments and are not the focus of this study. Rather, this report focuses on CID technologies that are expected to be used in operations and no recognition training systems are deployed in operations. However, it is important to note that any CID technology should have an associated recognition training system to promote their effectiveness in operational scenarios. This goes beyond system familiarization, where the user becomes familiar with the functions and operation of the CID system. Recognition training allows the user to be aware of the information the system provides with respect to friendly, enemy and other units while using the system. This reduces the time required to interpret the information in real-life operational scenarios and improves CID decision-making.

Because recognition training systems would be used prior to deployment, rather than by a dismounted soldier under operational conditions, no evaluation table or technology table is provided for recognition training systems.

4.5.2 Implications of Recognition Training Systems for Dismounted Soldier

Since recognition training systems are used prior to deployment and rely on developing long-term skill and knowledge in recognizing different battlefield participants, rather than provision of CID information when deployed, there are few implications for the dismounted soldier. However, it should be borne in mind that CID, even with effective training, is difficult in operations because of environmental conditions and the actions of the actor or object being observed. Therefore, effective CID technology will prove to be an effective adjunct to recognition training systems applied prior to deployment.

4.5.3 System Recommendations

Since recognition training systems rely on developing long-term skill and knowledge in recognizing different battlefield participants, there are no recommendations regarding which system should be considered the state of the art. However, improved recognition training systems, especially those that 'immerse' the soldier in the environment in order to shorten the in-country acclimatization period, may represent important advances in training for asymmetric operations.

4.6 Group 6 – Emerging technologies

This section reviews technologies that were not developed specifically to assist CID but which could conceivably be used to augment or enhance other CID technologies. It should also be noted that attempts to miniaturize the technologies associated with CID, as well as developing more effective power sources, are also ongoing but serve a great many technologies, not just CID. Miniaturization must also be balanced with the device's ability to present information intelligibly to the user (refer to section 4.6.9 for a commercially-available miniaturized display that would complement soldier's equipment and tasks).

4.6.1 Smartphones

The exploitation of smartphone potential is being aggressively pursued by the US Army, with a number of ongoing initiatives (Herringer, 2011), although the use of smartphones for BFT and SA is still in the exploratory phase. Smartphone technology has the potential to overtake other technologies under development, partly by making greater use of Commercial-Off-The-Shelf (COTS) systems and converting them for military use. The use of smartphone technologies is being promoted by the US Army program "Connecting Soldiers through Digital Applications" (CSDA), based out of Fort Gordon, Georgia (http://www.arcic.army.mil/csda.html and http://www.benning.army.mil/mcoe/cdid/aewe/content/pdf/20110928_AEWE%282%29.pdf). The use of these COTS smartphones is limited by their access to a network, and would thus require the user to be within range of a military-hosted base station. However, developers are currently working to provide network services up to 35 kilometers from the base station, based on a hub and spoke concept in which successive hubs link up as a mesh to the base station.

Another recent addition to the consumer marketplace overcomes the difficulties associated with networks. The SPOT satellite messaging service is based on the very limited capability of GPS satellites to receive data (GPS satellites are typically only used to transmit a geo-locating message, which a GPS receiver combines with other GPS satellite signals in order to triangulate a position). SPOT provides three messages as standard: "OK" (and time and position report); "HELP" (and time and position report); and "EMERGENCY" (and time and position report). The "HELP" message is delivered to those who subscribe to the message (typically family and friends) whereas the "EMERGENCY" message is delivered immediately to local emergency services. The SPOT device has recently been augmented to connect with a smartphone. The smartphone is used to compose a more elaborate message which is then transmitted by the SPOT device, via the GPS satellite network, to an addressee. The ease of producing SPOT reports to contribute SA information that could help inform CID decisions is analogous to readily-available applications that provide social media updates. The integration of specific BFT functions shown by current systems (e.g., applications on iPhone or Android phones such as BattleTac, Family Tracker, FourSquare, Loopt, and Find My Friends) could be developed to support CID as well as be integrated with devices such as JBC-P Handheld. While only in its nascent phase, the use of Android-based smartphones as the delivery mechanism for JBC-P functions could be possible by 2013. (Cox, 2011)

Most work in this field has focused on Android phones, rather than Apple iPhones, due to their open source code and ease of access to the battery compartment (Pengelley, 2011). However, this is changing as Apple releases developer's kits and enhances the encryption on the iPhone. Regardless, however, all COTS phones are vulnerable to being hacked.

4.6.2 Power

The US Marine Corps is involved in the development of new power sources (http://online.wsj.com/article/SB10001424052748704810504576307563280615054.html). In particular, they use the Ground-Renewable Expeditionary Energy System (GREENS) which consists of four portable modules that fold out into two large solar panels each, all connected to a power cell to store energy overnight. GREENS is only suitable at the base of operations. When on patrol, each Marine carries a Solar Portable Alternative Communications Energy System (SPACES), an eight-square-inch flexible solar panel that can be rolled up and stored in a pack. Where normally a patrol carries enough batteries to last three or four days, weighing 20 – 35 pounds, SPACES weighs 2.5 pounds. Carrying SPACES also eliminates the dangers associated with replenishment in space.

4.6.3 Miniature Antenna

Raytheon Company has developed a miniaturized interrogation antenna capability to extend use of its Cooperative Target ID technology to soldiers and unmanned aircraft. This effort builds upon an existing Raytheon antenna design and additional enhancements performed in concert with the U.S. Army CERDEC Intelligence & Information Warfare Directorate (I2WD) (http://blogs.ottawacitizen.com/2011/08/01/new-efforts-to-reduce-friendly-fire-%E2%80%93-a-miniature-antenna-helps-pilots-track-friendly-forces-on-the-ground/).

Figure 7: Miniature Antenna

The new miniature antenna is approximately the size of an ice cube and weighs only a fraction of an ounce. It capitalizes on proven cooperative millimeter wave technology, which has been certified at technical readiness level seven by the military for use on combat vehicles. Although designed primarily for air-ground CID, it is conceivable that such a system can be directed toward ground-ground CID.

4.6.4 Wideband Tactical Radios and Broadband Satellite

Harris is currently providing Falcon III® wideband tactical radios and broadband satellite terminals to Canada's armed forces (http://blogs.ottawacitizen.com/2011/08/16/harris-supplying-falcon-iii-wideband-tactical-radios-and-broadband-satellite-terminals-to-canadian-forces/). These terminals form a system that allows personnel to transmit voice and high-bandwidth data over wide areas, including beyond line-of-sight. These systems could be leveraged to provide a component of a CID system.

The radio enables applications such as streaming video, simultaneous voice and data feeds, collaborative chat, and connectivity to secure networks in real-time.

4.6.5 Kraken

The US Army is evaluating a cutting-edge force-protection system which combines radar, surveillance cameras, unmanned sensors, gunshot detection and remote-controlled weapons (http://blogs.ottawacitizen.com/2011/09/01/%E2%80%9Ckraken%E2%80%9D-system-combines-radar-surveillance-cameras-unmanned-sensors-gunshot-detection-and-remote-controlled-weapons/). The Combat Outpost Surveillance and Force Protection System, or COSFPS, nicknamed "Kraken," includes sensors and weapons that are combined into a single, integrated system that can scan surrounding terrain for threats, alert soldiers of potential imminent danger, and provide them the information necessary to respond.

Figure 8: Kraken

The individual technologies assembled for the Kraken are integrated through government-owned, scalable and open architecture software called Joint Force Protection Advanced Security System (JFPASS). The JFPASS software enables data from all of Kraken's system components to be integrated via a standard protocol, fused and conditionally automated (i.e. automated under specific operating conditions). The information is displayed on screens showing a Common Operating Picture (COP).

For assessment and identification, a series of 11 cameras are strategically aligned to cover a 360° view, including electro-optical/infra-red, low-light perimeter and all-weather day and night thermal cameras. Two of the cameras, a laser rangefinder and a GSR are rotatable atop a 10-meter mast. Eight white and infra-red perimeter lights are included for night operations and two laptops with two larger displays are included for command and control. The radar on top of the mast can detect people at distances up to 10 kilometers and vehicles out to 20 kilometers. Also, Kraken has a second mid-range ground surveillance radar (GSR) which scans a full 360 degrees every second and is engineered to interface with video cameras, ground sensors and remote weapons applications. Kraken also contains a laser pointer/illuminator. The cameras, radar and lights are augmented by seismic/acoustic sensors, infra-red or magnetic sensors engineered with sophisticated algorithms designed to identify targets such as enemy personnel or vehicles based on combined seismic and acoustic signatures.

4.6.6 Tactical Mobile Networks

General Dynamics Canada offers Tactical Mobile Routers (TMR), which .provide reliable data delivery where Internet standards fail due to low bandwidth availability or a disrupted tactical- edge network (http://blogs.ottawacitizen.com/2011/09/13/general-dynamics-canada-introduces-new-tactical-mobile-routers-to-provide-reliable-data-delivery/). The routers ensure that mission-critical personnel who rely on tactical internet connections to accomplish their mission can communicate using off-the-shelf applications, including email, chat messages and multimedia-rich shared information resources.

For military and other personnel who rely on the continuous availability of applications residing on a tactical internet, TMRs seamlessly create ad hoc networks that automatically form, reconfigure and operate even when network infrastructure is overloaded, damaged or unavailable due to mountainous or remote terrain, urban environments or other conditions.

Tactical Mobile Routers comprise advanced networking technologies and communications engineering that enable 'store and forward' capabilities that ensure vital information is sent and received. Available in a range of sizes and capabilities, TMRs simplify system integration into military platforms where size, weight, power and cost are important considerations.

4.6.7 Throwbots

Although not directly related to CID, small, easily transportable "throwable" robots equipped with surveillance cameras designed to beam back video from confined spaces, buildings, tunnels and other potentially dangerous locations could represent another source of SA information,.

The Recon Scout XT Throwbot (Figure 9; http://www.recon-scout.com/products/recon-scout_XT.cfm) is a small, barbell-shaped robot with wheels at each end of a titanium tube along with forward-positioned cameras able to capture images from dangerous locations, antenna and an illuminator. It weighs 1.2 pounds. and is designed to withstand a 30-foot vertical drop. The Recon Scout also includes an operator control unit with a small viewing screen and joystick.

Figure 9: Recon Scout XT Throwbot

QinetiQ's Dragon Runner, originally developed for the U.S. Marine Corps, weighs about 14-pounds and includes cameras, motion-detectors and an optional small manipulator arm able lift about 10-pounds (http://www.qinetiq.com/what/capabilities/land/Documents/Dragon-Runner-SUGV.pdf).

iRobot's First Look (http://www.irobot.com/gi/ground/110_FirstLook/) is about 10-inches long and weighs less than five pounds. The robot has four built-in cameras facing different directions and is engineered to withstand a 15-foot drop. It is waterproof to a depth of three feet and is designed to climb steps as high as eight inches. The robot is configured like a miniature model of the widely used PackBot robot (Figure 10; http://www.irobot.com/gi/ground/510_PackBot/). The First Look's sensor payload includes cameras, thermal imagers and chem-bio radiation sensors.

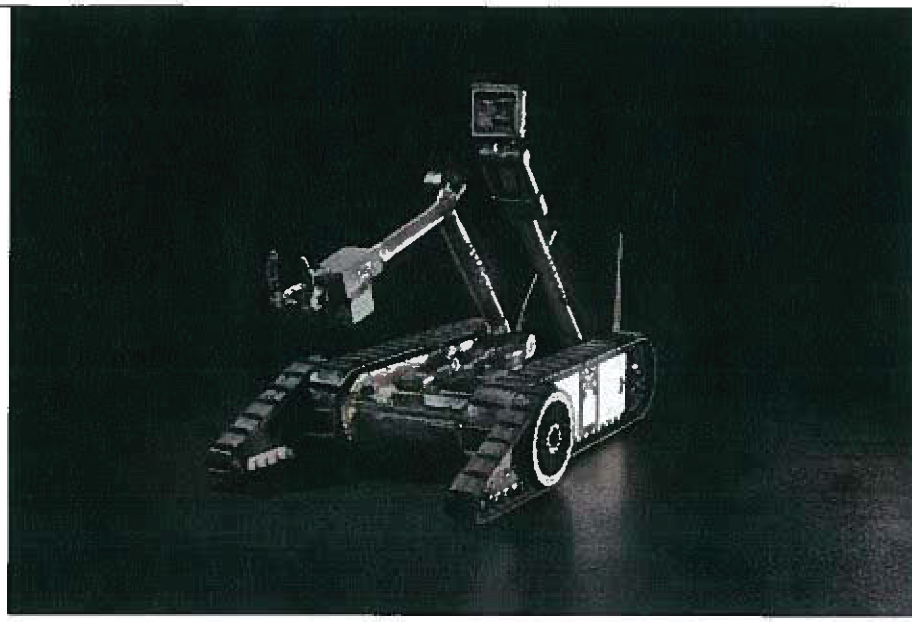

Figure 10: PackBot

The Armadillo V2 also weighs about 5-pounds. It has four small wheels, is built to withstand eight-meter "throws" and also includes multiple cameras and thermal imaging (http://www.macrousa.com/pdf/armadillo.pdf).

4.6.8 Tethered Aerostats

Lockheed-Martin's tethered aerostat provides real-time, around-the-clock reconnaissance and surveillance of broad geographic areas for warfighters in Iraq and Afghanistan (http://blogs.ottawacitizen.com/2011/11/15/lockheed-martin-tethered-aerostat-to-provide-surveillance-for-troops-in-iraq-and-afghanistan-383-million-contract/).

Figure 11: Tethered Aerostat

Equipped with multiple sensors, the Persistent Threat Detection System (PTDS) is an aerostat-based system that delivers constant day and night, 360° detection, surveillance, monitoring and force protection.

4.6.9 Ubiquitous Displays

Although not an acknowledged 'category' of displays, we have chosen the term 'ubiquitous displays' to represent those that do not require the soldier to deliberately access the display. IFF information displayed through the rifle sight could fall into this category. However, with increasing demand from consumers for information about the world around them and the ability to document what they are doing, some technologies are providing ubiquitous displays.

The Recon Instruments MOD and MOD Live systems (http://www.reconinstruments.com/products/mod) are micro-optical displays presented through ski goggles (MOD Live is the same as MOD, except that data is exchanged with other users and social media applications). Many human factors issues have been considered and addressed in the development of these systems. For instance, although presented at a distance of less than an inch, the projection mimics a focal distance of 5 feet, allowing the user's eye to be relaxed. The display presents a great many parameters unobtrusively in the corner of the goggles. The system can present navigational information, including maps, 'buddy tracking' PLI, communications, and camera feeds. The device is controlled by a Bluetooth-connected remote that can be mounted wherever preferred by the individual. To take advantage of all the features, the system must be connected to an Android smartphone. However, the infrastructure afforded by Android could presumably be exploited by a ruggedized digital communications device for use with soldiers on the battlefield.

Another opportunity to present ubiquitous displays is through the new generation of headware. Revision Military offers the Batlskin Head Protection System (Figure 12; http://www.revisionmilitary.com/batlskin/) which provides a ballistic helmet shell, trauma liner, front mount, retention system, mandible guard and visor. The result is a single, fully integrated system that provides excellent protection from blunt force, blast and ballistic threats, with a lightweight wearability for peak performance.

Figure 12: Batlskin Helmet

4.6.10 User-Centred Test and Evaluation

Much development of military technology focuses on the technology itself and problems associated directly with it. The user, and the environment in which the technology will be used, are rarely considered until the technology is deployed,. In an effort to address these issues, the U.S. Army has committed 2nd Brigade Combat Team, 1st Armored Division, to evaluate new technologies and network capabilities that are shaping the Army's evolving tactical network (http://blogs.ottawacitizen.com/2011/11/19/u-s-army-tests-network-capabilities-as-it-deals-with-an-evolving-tactical-network/). This Combat Team consists of 3,800 soldiers and is tasked, organized and equipped to replicate heavy, light, and Stryker (i.e. mounted [LAV] infantry) formations. The Combat Team is based at White Sands Missile Range in New Mexico. The Combat Team adopts a user-centred test and evaluation approach, ensuring that scenarios and tasks reflect the system purpose, the user objectives and activities, and the operational environment, before evaluating whether or not the technology adequately performs its intended function. Accurate and frank feedback is sought from soldiers who are briefed that, without accurate feedback, inadequate or useless equipment may be given to soldiers on the battlefield.

The development and evaluation of CID technologies can benefit from advances in live, virtual and constructive simulation. Simulations involving real soldiers on instrumented ranges, such as those at White Sands or Fort Benning, are live simulations (as opposed to live exercises). Simulations involving real soldiers in simulated environments are considered virtual (simulations involving no live actors are considered constructive). There are several competing applications for developing virtual simulations that could be used to extensively test CID technologies. Recently, Presagis announced an update to the STAGE product that enables the user to simulate IFF and create additional IFF modes (http://blogs.ottawacitizen.com/2011/11/22/presagis-releases-new-software-for-virtual-forces-simulation/). Stage also includes artificial intelligence that can be used to simulate realistic behavior on the part of constructive entities reacting to the actions of live entities (e.g. participating soldiers).

5 CID TECHNOLOGY IMPACT ON THE DISMOUNTED SOLDIER

The preceding discussions of different CID technologies have also covered the likely impact of these technologies on the dismounted soldier. This section presents a more detailed discussion of these impacts, grouped according to user-centred rather than technology-centred characteristics. Following Table 3 in section 0, this section organizes the discussion into discrete elements of physical and cognitive impacts.

5.1 Physical Impacts

5.1.1 Load Carriage

The primary concern for load carriage of CID technology is the addition of weight to the existing heavy load of the soldier. It is not expected that any CID display technology will be heavy, although the location of such technology may be sufficiently far from the user's centre of gravity as to make carriage of the weight uncomfortable and fatiguing. Of more concern is the power supply (i.e. batteries and replacement batteries) and any cabling required (for power or connectivity) since both can be very heavy. Additional weight can fatigue the solder, make it difficult to initiate, cease, or change direction of movement, cause the adoption of awkward postures, and ultimately lead to injury through constant or repetitive physical stress, unexpected shifts in weight, or impacts with the weight. A well-designed CID solution will place any significant weight close to the soldier's centre of gravity (i.e. on the body rather than arms, head, or weapon) and will minimize cabling (perhaps using a local wireless communications solution such as Bluetooth). A CID solution will also find ways to maximize system endurance, possibly through using solar power or kinetic power generation (as used in wind-up radios, 'shakeable' flashlights, and watches that are powered by natural arm swinging motions) which are complementary to the natural movements of the soldier.

5.1.2 Locomotion

As noted above, additional weight can make it difficult to initiate, cease, or change direction of movement. The addition of CID technology to the soldier's load may impede walking, running or jumping through its placement or its weight. If there are trailing cables, these may also represent a trip hazard to the soldier. Again, a well-designed CID solution will be compact and located close to the soldier's centre of gravity, with minimal cabling.

5.1.3 Movement

Movement can be impeded by the weight and/or placement of CID technology. Further, placement of CID components distal to the soldier's body may make it difficult or fatiguing to stop, initiate, or change direction of movements due to the greater inertia afforded by the CID technology. This may be critical when a soldier is in contact as they have to rapidly move their rifle from target to target.

Use of CID technology itself may cause problems for movement, depending on where. the system is mounted. Based on the task of the soldier, if this display is not mounted on the rifle then the CID technology will interrupt the soldier raising their weapon by requiring him to look at a PDA mounted on their chest or stowed in a pocket. Conversely, if CID information is presented through the rifle sight, they may be required to raise their weapon more frequently than they do currently, increasing fatigue. As indicated in section 3.4.3 and Figure 4, CID technology may be challenging to implement usefully for troops in contact because of the additional cognitive and physical tasks it imposes.

5.1.4 Endurance/Fatigue

It is unlikely that the provision of CID technology for decision support will result in any mental fatigue (i.e. reduction in vigilance, concentration). However, the additional weight, particularly if spare batteries are carried, may increase the rate of fatigue and reduce the endurance of the soldier. Additional tasks may also contribute to the fatigue felt by the soldier. As noted above, CID systems should attempt to maximize power endurance through means that are complementary to the normal activities of the soldier (i.e. solar power, movement), as well as integrating CID information displays with the soldier's normal equipment, activities, and posture.

5.1.5 Posture

The weight of the CID device may force the soldier to adopt awkward postures in order to view or use the device. These postures may include holding weight that is located distal to the centre of gravity, or repeatedly bending the neck in order to view a display that is positioned on the chest or wrist. The adoption of awkward postures can lead to fatigue or repetitive strain injury, and may be impossible in situations such as lying prone to minimize the target area an enemy can exploit.

5.1.6 Operation of Equipment

Soldiers are required to carry many different items of equipment, and increasingly these are becoming more technological. The operation of any CID system should be simple and should adopt the same operation and display principles as other equipment they need to use. Further CID systems should not impede the operation of any other equipment that the soldier uses. For instance, CID systems should not impede the soldier's ability to use their weapon, binoculars, or NVGs.

Some experimentation and evaluation also has to be performed on the methods by which information is input into the CID system. It is expected that an SA system will permit manual entry of contacts, which will require a data entry system which allows rapid entry of such information. How will the soldier enter this information quickly and efficiently? If the process is not quick and efficient the data fields that might be available will not be filled in. Also, how will the soldier navigate around the system and what type of control(s) will be provided? An R&D program will need to investigate a number of solutions, ranging from joystick and trackpad, to keypads, to voice entry and remote data entry (i.e. dictated over the radio and transcribed by someone else to the system).

5.1.7 Injury/Detection

Although the opportunity for soldiers to be injured due to the weight and physical location of CID systems has been mentioned several times it is probably an unlikely outcome. Nevertheless, the systems should be designed to minimize the weight and hazards to the soldier.

CID technology may also create opportunities for the soldier to be injured by the enemy. In particular, CID technology may radiate or emit a signal that the enemy can detect and triangulate in order to locate the soldier. Alternatively, if the CID technology sends position reports, the enemy may be able to precisely locate the solder and input this information into sophisticated targeting systems for artillery or missiles. Further challenges are brought because existing COTS technologies do not have software-based Type 1 (secret-and-below) encryption approved and accredited for application to generic classes of COTS equipment, which would allow ubiquitous exploitation of handheld smartphones and other commercial terminals (Pengelley, 2011).

An additional potential hazard of CID devices comes from the displays used. Many displays will emit light which can be detected by an enemy, particularly at night. Night settings on displays still emit light. Attempts should be made to occlude any light sources from observers. Some systems, such as Elbit's Dominator have a mechanical device to only power the display once the eye has been pressed against an occluding eyepiece. Others, such as Recon's MOD, are such small displays located so close to the eye that observable light is probably minimal. A well-designed CID system will minimize the likelihood of detection by an enemy and, if detected, will not allow the enemy to determine the location of the soldier.

5.1.8 Response Execution

In common with section 5.1.6 above, response execution concerns the effect of CID on the soldier's ability to carry out their task. However, instead of focusing on the physical ability to operate equipment, response execution refers to the impact the CID technology has on the end-to-end process of reacting to a target in the area of interest.

In this respect, response execution is concerned with the addition of tasks required to use CID technology that may delay or even interrupt the appropriate response to a potential target. These may include the use of a display that is not rifle- or helmet-mounted, or the requirement to make an input to 'confirm' the advice being provided by the CID system. Response execution may also be adversely affected by poor information presentation. For instance, information that is ambiguous, unclear, or otherwise requires the soldier to store, process and transform the information may insert delays in response execution and may create conditions where human error is more likely. A well-designed CID system should not impose any delay on the soldier's ability to affect an immediate response of their own choosing to the unfolding situation.

5.2 Cognitive Impacts

5.2.1 Trust/Confidence

Proper calibration of trust in the system is important to the success of a CID system. Given the high potential cost of poor system performance the system will need to prove itself extremely reliable in order to be trusted by operators. However, with good performance the trust may become inappropriately absolute. For instance, a soldier may be issued with a CID system while in pre-deployment work ups. During this time, they may be predominantly operating amongst others also equipped with CID systems (including ancillary personnel acting as enemies). Even once arrived in the operational theatre, the soldier may find himself amongst others with interoperable CID systems. Because the soldier's experience of the CID system to this point has been benign, the soldier may have developed significant levels of trust and confidence in the system. Indeed, the soldier may have begun to exercise less of their own discretion in the CID decision making process. If the soldier then finds himself in a situation with ambiguous, missing, or deceptive data, but is not alerted to this fact and continues to trust and have confidence in the system, the soldier may make errors that lead to serious consequences. Thus, it is important for any CID system to present some indication of the reliability of its output to the user. Where some degree of uncertainty is associated with displayed information, such as the identity or position of entities, the system must have some way to convey the level of uncertainty. Research should consider what the different sources of uncertainty could be, and how they can be presented elegantly on a small display such that they do not require much thought or resolution by the user. Research should also consider how a user in the field, with limited means to enter data, can easily enter this uncertainty data. Evaluations of resulting systems might focus on measuring soldier's levels of trust against the 'ground truth' level of trust that should be exhibited.

5.2.2 Reliability

Related to trust and confidence, reliability refers to how often the system provides CID information. For instance, the system may always be correct in its identification, but only provide identifications occasionally. This may be due to interruptions in network availability, or line-of-sight issues, or the robustness of equipment. Some of these interruptions may be due to intentional tampering or sabotage. Poor reliability for whatever reason will affect a soldier's trust in a system and their desire to use it. Without reliability a system becomes merely weight and will be therefore discarded by the soldier. Any system must be proven to be reliable and available to the same standards as, for example, cell telephone services before it is deployed to operational forces and be resistant to tampering or sabotage.

5.2.3 Perception

As the first stage in cognition, perception is key to CID. A CID system must present its information to the soldier in a clear and timely manner, in particular if the entities in the environment have changed in some way. To adequately deal with this, a CID system must address two issues: notification to the soldier that a new entity has appeared in the environment, and highlighting changes in the environment to the soldier. Based on the systems seen for this review, there has been limited development of display representations for dismounted soldiers, irrespective of whether they are IFF or SA systems. A notification for appearance or change may be external to the display, so the soldier can be alerted to the information, or it can be contained within the display, such that the soldier is only informed when they choose to consult the display. In the latter case, appearance and change can use the same display approach. However, in the case of a change, the soldier will probably also need to be reminded of what the target was before it changed. The presentation of these two information elements (i.e. before and after change) needs to be considered alongside how the soldier will be cued to the new or changed elements in the display.

5.2.4 Situation Awareness

Regardless of the type of the CID technology (passive, active, IFF, SA training or other) the ultimate objective of the system is to augment an element of the soldier's SA for the purposes of better decision making. A CID system, however, can have a detrimental effect reducing 'global' SA (i.e. SA across the whole environment) in favour of increasing SA for a specific area or task. Passive signalling devices, for instance, could lead an observer to focus exclusively on detecting the passive signalling device on targets to the exclusion of other aspects of the environment. Active signalling devices are less disruptive to global SA since they emit an identifiable signal that can be noted during a scan of the environment. IFF systems require a focus on the target as the interrogation is made, which may also reduce global SA. Even an SA system, which provides information on as many entities in the environment as possible, can reduce global SA but forcing the soldier to remain 'head-down' and focused on the display (wherever this is mounted). This cognitive tunnelling effect can be extremely dangerous for the soldier, who must maintain global SA at the highest level possible so he or she can make the best decisions to maintain safety and achieve the goals of the mission.

All of the systems reviewed provide only limited descriptions of targets.. Passive and active signalling systems simply indicate the presence of friendly units. For these systems, position is already known through the initial observation. However, these systems can be co-opted by the enemy, potentially leaving the soldier with a false confidence in their own SA. IFF provides a more sophisticated knowledge of friend-or-not-friend, in that it is less likely to be interfered with by an adversary and can provide additional target information. However, passive, active and IFF systems are line-of-sight and one-to-one, meaning that they cannot, by definition, provide global SA. The soldier must remember the positions and identities of all contacts in the environment in order to use these systems to build SA (note that maintaining SA is specifically excluded from this claim). This puts an additional burden on the soldier and can be a source of error.

The SA systems have the potential to go beyond line-of-sight and present the one-to-many relationship required by the soldier, but none have established the information required by the soldier to build and maintain SA. Given Endsley's (1988) definition of SA, the system must provide information to perceive, comprehend, and predict the target. Perception has been dealt with above, in particular the indication that something about the target has changed. Comprehension is more difficult; is it enough to say that the target is a friend, or that it is military or police or Other Government Department (OGD), or that it is 'A' company, 1st battalion, Royal Canadian Regiment (for example), or even the name or zip number of the target? Should positional information, altitude, speed, stop time, etc. be provided with the target information? What is the ideal range scale for the soldier? Will they want to zoom in and out? How should they access more or less information about a target? What level of granularity is appropriate for an individual soldier, for a section commander, platoon commander, company, battalion, or brigade commander? Typically planning is done for 'one up, one down'; that is, the planner considers the actions of their immediate superior formation and their immediate subordinate formation, and this approach may be appropriate for the presentation of SA information. Specifically, a user is presented with detailed information for the unit immediately subordinate to their own formation. The units comprising the subordinate formation are aggregated and not presented to the user in detail.

To address Endsley's third level of SA (prediction), the user may need dynamic information, historical information, and trend information. For instance, the user may need speed and direction information, or moving time and stopped time. If navigational plans are held, the user may want the route plotted on the display, including waypoints.

Information latency and accuracy will also be important for SA. In particular, how long has it been since a new entry for a target has been recorded? This applies to network latency times, but is particularly relevant for those targets that have been manually plotted. When was the target manually entered? Who entered the information? Was the target observed and identified by the individual who entered the information? How reliable is the source? How reliable is the information? Where was the target going? How fast? With whom? Manually plotted information has the potential to hinder SA and thereby profoundly affect good decision making. The duration for which information remains useful and contributes something to SA and decision making will be important to establish through a CID research program.

5.2.5 Workload

The requirement to consult and, particularly, interact and update CID systems may impose additional workload on soldiers. While this workload may be acceptable if imposed during 'down' periods (see Figure 4) it is unlikely to be acceptable when the soldier is gathering the most relevant information i.e., during a contact. Studies of CID technology should ensure to collect data on workload in the baseline condition (i.e., current system without CID technology) as well as the CID technology condition. These studies should also attempt to isolate the main contributor(s) to workload in order to refine the R&D work being done. Virtual and constructive (e.g. Integrated Performance Modelling Environment [IPME], Dahn and Laughery, 1997) simulation may provide preliminary answers at relatively low cost before significant design, build and deployment decisions are made.

5.2.6 Human Error

As noted throughout this discussion, CID technology has the ability to create conditions in which human errors are more likely. These errors can arise through over-reliance, misinterpretation, cognitive tunnelling, workload, and confusion. As with workload, studies of CID technology should collect data on human error in the baseline condition before moving to CID technology conditions. As well as being a useful performance metric by themself, errors can also be analysed based on commonly-used models of human error to further identify facets of CID technology that require further R&D, and to establish what aspects of CID should remain the purview of TTPs.

5.2.7 Decision Making

Poor CID information may lead the soldier to make incorrect decisions regarding the most appropriate course of action (see Figure 3). However, equally dangerous is the soldier who makes the right decision for the wrong reason. The soldier may continue to persevere with an incorrect strategy if it seems to be correct. For this reason, CID systems must make clear to the user the level of uncertainty in any friend-or-foe decision, and this information must be clear and easily assimilated by the user. Furnished with this insight into the system and how it provides decision support, the user will be better able to calibrate their trust in the system and will make more accurate decisions.

There are two potential decisions that should be considered with respect to CID systems: friend-or-foe, and what response should be made (e.g. do nothing, employ escalating force as permitted by ROEs). The first decision is clearly intended to be supported by CID systems. The second decision is more likely to be reliant on the soldier's knowledge and experience with the application of TTPs. Experimental study of the second decision will be difficult in the laboratory or live exercise and conclusions regarding CID technology's impact on what the soldier actually does may need to be based on operational experience.

The decision regarding friend-or-foe will be significantly affected by the relative proportions of known (friend), unknown (enemy), and unknown (neutral) in the environment. Research and experimentation may usefully investigate what those proportions are. For instance, is there a percentage of CID system-equipped entities in the battlespace below which the CID system ceases to provide any advantage?

5.2.8 Response Selection

As noted above, the decision regarding what to do about the resultant identification will be the natural consequence of a CID system, but will not be specifically reliant on the CID system. In escalating force the soldier's decision will be mediated by many additional factors, some of which will not be encompassed by the TTPs. From this review it is not clear the degree to which decision support is provided for course of action selection. This may be a useful addition to a SA system, although additional R&D would be required, as well as experimentation, to determine how to deliver the decision support and to establish its performance benefits.

5.3 Measures of Performance and Measures of Effectiveness

A CID system must be shown to be better than the status quo in order to be worthy of investment. This determination is not a simple yes or no decision; it will depend upon the weighted judgments of users in which they trade-off the benefits of having the technology against the negative impact associated with workload, weight, and training. Frequently, these judgments will be disproportionately affected by the emotions of the soldier, and will place less emphasis on performance data. To objectively establish the relative performance of CID technologies (or discrete components of CID, as described in this report), the ARP should ensure the advance development of reliable and valid measures, as well as controlled scenarios to ensure that comparisons made between competing options are also valid and reliable.

Any program of experimentation for CID technology should use scenarios that are controlled for complexity or difficulty, but avoid a learning effect amongst participants.

Assuming a repeated measures design, scenarios should be presented to participants in a random order. However, the same measures should be collected in each experiment. The measures should be subject to a focused development effort in advance of the trial.

Two types of measures should be developed: measures of performance and measures of effectiveness. Measures of performance are targeted at a fine level of detail, predominantly addressing discrete activities performed in pursuit of the system objective. Measures of effectiveness reflect aggregated or overall system performance. Measures of performance may include input errors, number of times the display is viewed, number of zoom operations, observation of probe elements (constructed and inserted in the scenario specifically to test discrete elements), time to complete certain tasks, periodic measures of SA, etc. Measures of effectiveness may include overall correct identification rate, overall workload, average time to identify a contact, overall trust in the system, average time to detect a contact, etc.

6 CONCLUSIONS OR NEXT STEPS

This review has considered the current CID technologies deployed or available to the dismounted soldier, as well as technologies that could potentially be used for CID. These technologies were characterized according to a standard table and evaluated against a descriptive model of the dismounted soldier, their environment, and their tasks. The clearest conclusion that can be drawn from this review is that a CID system is unlikely to provide a dismounted soldier with absolute awareness of all entities, friendly, hostile, or neutral, in their immediate and extended battlespaces. It is unlikely that all friendly forces will be suitably equipped to share this information, and even less likely that neutrals or hostile forces would participate. For this reason, it is likely that passive signalling will continue to be employed for CID for the foreseeable future. Passive signalling devices are cheap enough to be purchased by poor but friendly military nations, or distributed to friendly forces as and when required.

However, the growing ubiquity of personal electronics devices with the ability to transmit a signal means that future CID technology may be able to take advantage of 'ambient' emissions to build up a picture of the local environment. Even before this capability is attained, the development of active, IFF, and SA systems for CID will continue and these systems will be offered to DND for purchase. To make the best decisions about whether to purchase such systems and, if so, which system to purchase, a number of questions need to be answered through focused R&D. Without the answers to these questions, the dismounted soldier stands to be issued with equipment that, at best, is not used and, at worst, puts them and others at risk.

This review has evaluated the current state of CID technology against a descriptive model of the dismounted soldier performing CID. The key conclusions and recommendations for the CID research program at DRDC Toronto are as follows:

Physical form: A CID device needs power, connectivity, and should be mounted conveniently for the soldier to use. However, a CID device may add weight, impede movement, or obstruct tasks. Research should investigate minimizing the size and cabling requirements to the greatest extent possible (without reducing usability), as well as maximizing the endurance of power sources. These should be evaluated in realistic task scenarios. The mounting location of the CID device should also be investigated such that any device is viewable and operable by the soldier without interrupting tasks or adopting awkward postures. This may require the investigation of different forms of display, for instance monocles, smartphone-type displays, rifle-sights, and goggles. In the case of passive devices, they should be mounted on the soldier for maximum visibility by friendly forces.

Input Tasks: The ideal CID device would require no input from the soldier; all information would be fed automatically. This is possible with respect to passive and active signalling devices and IFF devices. With SA systems, however, input is going to be required since the SA systems should provide complete entity information for up to

5km. If the SA system did not report contacts that the soldier could directly observe, trust in the system would be non-existent. Therefore soldiers will be expected to manually enter contacts they observe. Without presupposing the nature of the information to be entered, it is assumed the system will be small with limited scope for a full keyboard. Therefore other ways of navigating the interface, selecting items, and entering information will need to be investigated. This may require the consideration of a variety of input methods such as speech input, chord keyboards, multi-function keypads, touch devices, eye movement tracking, etc. Guidance should be developed through this investigation that assists in minimizing the data inputs required by the soldier.

Information Presentation: Another significant area of research should be on information presentation; i.e., what is presented and how it is presented. Although much is known about the information used by soldiers to build and maintain SA, less is known about the minimum amount of information required. Also, work should answer questions surrounding how best to display different types of information and how this presentation would vary as a function of the other tasks/roles that soldiers have to perform concurrently with CID. It is unlikely that the presentation of every information item as a discrete element would be efficiently interpreted by the soldier. A composite display of integrated information items is more likely a match to the soldier's mental model of the world. Some information may be better suited to graphical renderings, others to text or numeric representations, and others to sound, vibration, colour, etc. To address information presentation, detailed cognitive task analysis of CID and other concurrent tasks should be carried out and used for the purposes of design and experimentation. Elements of the design should be traceable back to the task analysis. These designs should then be the subject of laboratory experiments with clear hypotheses based on the task analysis and design rationale.

Alerting and Cueing: Different methods should be developed of alerting CID system users to the appearance of new or changed data, and cueing users to the location to find this new or changed information. These methods should not compromise the safety of the soldier, nor should they necessarily interrupt tasks in which the soldier is currently engaged. Experimental studies of these methods should also establish whether alerts or cues should be cancelled automatically after a certain period of time.

Situation Awareness: Related to issues of information presentation and alerting and cueing discussed above, methods of presenting information should be developed that support perception, comprehension, and prediction, and guard against cognitive tunnelling. SA is presented separately in this list to reflect the criticality of SA to successful CID. However, SA will also need to be supported at different levels of command, probably through different representations of battlefield entities at different levels of granularity. To support SA, displays will also likely need to display dynamic information and trend information to support pattern identification for the purposes of prediction by the soldier.

Workload: A CID system should not adversely affect workload. Excessive workload will contribute to errors but too little workload can lead to user complacency (i.e. over-reliance, over-confidence). Experimental studies should establish a baseline workload for soldiers and establish that the introduction of CID technology has a net positive effect on workload. Preliminary studies could be conducted with IPME in order to generate hypotheses for later virtual and live simulations.

Decision Support: Although CID systems are intended to support decision making, there may be opportunities to provide even more sophisticated decision support, for instance in choosing the most appropriate course of action given the identification and the ROEs. A cognitive task analysis should be performed to identify opportunities for decision support systems beyond the mere provision of CID information.

Trust, Confidence, Reliance, and Uncertainty: Trust is a judgement based on a variety of information beyond the merely cognitive, occurs in situations when something is at stake, and can require extrapolation beyond the information that is immediately available for use in a broader set of inferences (Adams, 2005). Confidence is a discrete reason-based judgement related to the probability of a specific event occurring that often occurs in situations without risks (Adams, 2005). Reliance is the tendency of the user to let the system carry out some activity that the user could carry out manually. Uncertainty in the data, assuming the system performs as designed and the design is fit for purpose, will be the main reason why levels of trust, confidence, and reliance should change. Inappropriate levels of trust, confidence, and reliance in a system should not be attributed entirely to the user; system design may hide data (i.e. uncertainty) that would help the user to calibrate their trust and reliance in the system. A study should identify the different types of uncertainty that could affect CID system performance. With this information, different methods should be developed for presenting uncertainty information that would help the soldier gauge how reliable the system is and whether they should trust it. With several different options, an experimental investigation should be pursued to establish how best to present uncertainty information and when the task of trusting, being confident, and relying should be taken from the soldier (i.e. the system should automatically suspend decision support).

Experimental Design: A strong program of R&D should develop a challenging scenario that represents as many elements of spectrum of missions as possible. This scenario should be run as a baseline (i.e. 'as is') condition with specific measures of performance and measures of effectiveness. These measures of performance and effectiveness should be defined a priori and address all areas of interest, for instance SA, workload, human error, speed, accuracy, etc. When developments are introduced, these should be tested in the same scenario as the baseline to allow direct comparisons to be made.

Latency: the likelihood is that any CID system will be subject to some delay between the 'observation' of the scene and the display of the results at the soldier. Although some threshold and objective requirements are published, empirical evidence to support these requirements was not found. It is recommended that an experimental investigation establish the latency at which point significant decrements in decision speed and accuracy are observed. Another concern is the 'age' of manually entered contacts. Since these are not automatically updated they will become progressively more distracting and misleading as they age. Again, an experimental investigation should establish the 'age' at which these manual tracks cause significant decrements in decision speed and accuracy.

Availability and Resilience: Engineering studies should ensure that any CID system meets the most stringent standards for system and network availability and resilience to interference and sabotage.

Level of Equippage to be Useful: Using data from experimental investigations into human performance aspects of CID, constructive simulations should be developed and executive to establish the level of CID system equipage that must be observed on the battlefield before tangible benefits in human performance are realized.

Detectability: Although an engineering study rather than a human systems integration study, efforts should be taken to ensure that CID devices minimize the chances of detection, whether through transmission or direct observation by an adversary. This latter point refers to the light emitted by any display. These issues may be usefully addressed during live simulations where soldiers intentionally use the device to give away their position, with performance measured by the number of detections by enemy actors.

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8 LIST OF ACRONYMS AND ABBREVIATIONS

ABCA	United States [America], Britain, Canada, and Australia
ARP	Applied Research Program
BFT	Blue Force Tracking
BIFF	Battlefield Identify Friend or Foe
BTID	Battlefield Target Identification Device
CCID	Coalition Combat Identification
CDA	Commander's Digital Assistant
CF	Canadian Forces
CFWC	Canadian Forces Warfare Centre
CID	Combat Identification
CITS	Combat Identification Training System
ComBAT	Common Battlefield Application Toolset (UK)
COP	Common Operating Picture
COSFPS	Combat Outpost Surveillance and Force Protection System
COTS	commercial off-the-shelf
CSA	Contract Scientific Authority
DAGR	Defense Advanced GPS Receiver
DARPA	Defense Advanced Research Projects Agency
DCIA	Detection, Classification, Identify, Act
DCRI	Detect, Classify, Recognise and Identify
DLR	Directorate of Land Requirements
DND	Department of National Defence
DRDC	Defence Research and Development Canada
DSID	Dismounted Soldier Identification Device
DSTL	Defence Science and Technology Lab
DSTO	Defence Science and Technology Organisation
EMCON	emissions control
EPLRS	Enhanced Positioning Location and Reporting System
EW	Electronic Warfare
FBCB2	Force XXI Battle Command Brigade (and) Below
FFT	Friendly Force Tracker
FFTS	Friendly Force Tracking System
FIST	Future Integrated Soldier Technology (UK)
FLIR	Forward-looking Infrared
GPS	Global Positioning System
GREENS	Ground-Renewable Expeditionary Energy System
GSR	Ground Surveillance Radar
HMD	Helmet-mounted display
ICIDS	Individual Combat Identification System
IFF	Identify Friend Foe
IPME	Integrated Performance Modelling Environment
IR	Infra Red

ISAF	International Security Assistance Force
ISSAT	Infantry Soldier Situational Awareness Tool
ISSP	Integrated Soldier Systems Program
JBC-P	Joint Battle Command-Platform
JCIMS	Joint Combat Identification Marking System
JFPASS	Joint Force Protection Advanced Security System
KPP	Key Performance Parameters
LAV	Light Armoured Vehicle
MFTA	Mission, Function and Task Analysis
mmW	Millimetre Wave
MUA	Military Utility Assessment
NATO	North Atlantic Treaty Organization
NIR	Near Infrared
NISCO	NATO Identification System Coordination Office
NVG	Night Vision Goggles
OGD	Other Government Department
O-ICDS	Optical Combat Identification System
PLI	Position Location Information
PRR	Personal Role Radio
PTDS	Persistent Threat Detection System
PTT	Push-To-Talk
R&D	Research and Development
RBCI	Radio Based Combat Identification
ROC-V	Recognition of Combat Vehicles
ROEs	Rules of Engagement
SA	Situation Awareness
SINCGARS	Single Channel Ground and Airborne Radio System
SMEs	Subject Matter Experts
SOP	Standard Operating Procedure
SOW	Statement of Work
SPACES	Solar Portable Alternative Communications Energy System
STANAG	Standardization Agreement
TI	Target Identification
TIP	Thermal Identification Panel
TMR	Tactical Mobile Router
TRON	Target Recognition Operator Notification
TTFF	time to first fix
TTPs	Tactics, Techniques and Procedures
WIPO	World Intellectual Property Organization

APPENDIX A LIST OF TECHNOLOGIES

Technology	Description	Vendor	Type	Reference
Glo-Tape	IR tape visible using NVDs.	US NightVision	Passive signalling	(Boyd et al., 2005)
Athena Tag	Radar-detectable tag for vehicles	Sandia	Passive signalling	
Combat Identification Panels	Aluminum panels covered with thermal tape that allows ID of vehicles from a distance using thermal imaging devices.	Crossroads Industrial Services	Passive signalling	(Suttie, 2004)
Cat's Eyes Tape	Fluorescent markers worn on the rear of helmets and generate visible light for several hours.	Various (e.g., Rothco, BCB)	Passive signalling	(Team UK, 2006)
Black Blitz	Long-range high-intensity IR strobe	Survival Strategies	Active signalling	(Survival Strategies International, 2003)
Individual Force Protection System	Personal radio beacon (tag) capable of providing location and position information	DARPA; SAIC	Active signalling	(Boyd et al., 2005)
Budd Light	IR beacon visible through NVGs	Insight Technologies	Active signalling	(Office of Technology Assessment, 1993)
Phoenix Light	IR beacon visible through	Phoenix Products	Active signalling	(Ospital & Wojack, 2007)

Technology	Description	Vendor	Type	Reference
	NVGs			
DARPA Light	IR beacon visible through NVGs	DARPA	Active signalling	(Wahl, 2004)
CORAL-CR	Coral handheld thermal imaging binoculars with target acquisition capabilities.	Coral	Active signalling	(Ebbutt & Gething, 2011)
Lily	Rifle-mounted thermal sight capable of connecting to Personal Data Unit (PDU) via Ethernet.	Elbit Systems	Active signalling	(Ebbutt & Gething, 2011)
MARS	Handheld thermal imager with camera.	MARS	Active signalling	(Ebbutt & Gething, 2011)
Dismounted Soldier Identification Device (DSID)	IFF system for dismounted soldiers	Rheinmetall	IFF	(Petersen et al., 2009)
Battlefield Identify Friend or Foe (BIFF)	Vehicle-mounted IFF	Thales	IFF	(Guichemerre, 2004)
Optical Combat Identification System (O-ICDS)	Laser-based IFF.	Cubic	IFF	(Cubic Corporation, 2004)
Battlefield Target Identification Device (BTID)	Millimetre Wave (mmW) IFF system for vehicles.	Raytheon	IFF	(Raytheon Systems, 2006)
Individual Combat Identification	IFF system designed for the dismounted		IFF	(Kogler, 2003)

Technology	Description	Vendor	Type	Reference
System (ICIDS)	soldier			
Radio Based Combat Identification (RBCI)	Radio-based (Single Channel Ground and Airborne Radio System - SINCGARS) IFF, predominantly vehicle-based (only interrogation response from dismounted platforms).	ITT	IFF	(ITT, 2010)
SIMLAS	Laser-based training system that can be used for combat identification.	Oerlikon Contraves/ Rheinmetall	IFF/Training	(Gaughan, 2005)
xMax Radio	Cognitive radio system.	xG Technology	IFF/SA	(xG Technology, 2011)
Infantry Soldier Situational Awareness Tool	SA/BFT connected to BOWMAN PRR	Selex Communications	SA	(Selex Communications, 2008)
Joint Battle Command-Platform (JBC-P) Handheld	Handheld means of operating FBCB2	US Army	SA	(U.S. Army Headquarters, 2009)
Target Recognition Operator Notification system (TRON)	Air recognition system	Lumitex Inc.	SA	(Cooper, 2008)
Miltrak	BFT system developed by Thales for UK.	Thales	SA	(Ebbutt, 2008)
FBCB2 BFT	Blue force	Northrup	SA	(Abejon, 2005; Bitar &

Technology	Description	Vendor	Type	Reference
	tracking system	Grumman		Felsman, 2005)
Commander's Digital Assistant (CDA)[1]	Ruggedized PDA with L-Band antenna	Raytheon (other models by other vendors as well)	SA	(Ackerman, 2005)
Tacticomp 1.5	Ruggedized PDA, with satellite access via nearby vehicles; uses mesh network and has low probability-of-intercept (unlike CDA).	Sierra Nevada Corporation	SA	(Ackerman, 2005; Sierra Nevada Corporation, 2009)
Tactisight Helmet-mounted display (HMD)	Helmet-mounted display. Notable that units did not like the use of HMD during some user tests.	Sierra Nevada Corporation	SA	(Soldier Battle Lab, 2006)
NATO Friendly Force Tracking System (FFTS)	Not a particular system but a group of national systems sharing interoperable friendly force information.	N/A	SA	(Porta, 2008)
Dominator	Integrated Soldier System includes BFT capability. Runs Elbit's TORC2H BMS. The S-NAV Soldier Navigation System	Elbit	SA	(Ebbutt & Gething, 2011)

Technology	Description	Vendor	Type	Reference
	provides 3-D inertial tracking in those places where the GPS signal is unavailable.			
Defense Advanced GPS Receiver (DAGR)	Handheld GPS receiver, callable of overlaying maps. First fix in under 100 seconds (Wikipedia). SAASM-capable.	Rockwell Collins	SA	(Rockwell Collins, 2009)
Dismounted Intelligence Situational Mapboard (DISM)	Has BFT/BFSA ability and quick reports.	Trident Systems	SA	(Coffey, 2007)
S-NAV	System provides infantry soldiers with continuous follow-up three-dimensional pinpointing, even in areas lacking GPS capability or when the mission requires particularly covert operations.	Elbit Systems	SA	(Cohen, 2011)
SPOT Satellite Messenger	Commercially-available satellite communications network	SPOT Technologies	SA	http://international.findmespot.com/

Technology	Description	Vendor	Type	Reference
GR 100	Firefighter SA system	Harris	SA	http://www.harris.com/view_pressrelease.asp?act=lookup&pr_id=3058
Common Battlefield Application Toolset (ComBAT)	UK SA suite that includes BFT capability	General Dynamics UK	SA	(Ebbutt, 2008)
International Security Assistance Force Friendly Force Tracking (ISAF FTS)	NATO FFT system with two types of terminals, one of which can be dismounted and remoted from a vehicle.	NATO C3 Agency / Globecomm Systems	SA	(Ebbutt, 2008)
RF-6920 Situational Awareness Application	PDA-type SA application that runs C2CE. Designed to work with FALCON II radios.	Harris	SA	(Ebbutt, 2008)
Infantry Soldier Situational Awareness Tool (ISSAT)	Italian SA tool with built-in modified BOWMAN radio	Selex	SA	(Selex Communications, 2008)
Honeywell Dead Reckoning Module (DRM-5/DRM-4000)	Miniature, self-contained, electronic navigation unit that provides the user's position relative to an initialisation point (usually provided by GPS) by using a tilt-compensated magnetic compass,	Honeywell	SA	(Ebbutt, 2008)

Technology	Description	Vendor	Type	Reference
	electronic pedometer and barometric altimeter.			
Pedestrian Navigation Module	A pedometer that detects steps and changes in acceleration, linked to a digital compass, a barometer (to detect changes in height), and a gyro.	Vectronix	SA	(Ebbutt, 2008)
RO Tactical Radio	Provides on-the-move, over-the-horizon secure voice and global position information in a handheld Push-To-Talk (PTT) communications device.	ITT Electronic Systems	SA	("RO Tactical Radio," 2011)
SINCGARS	Combat net radio platform for US.	ITT	Network	(Soldier Battle Lab, 2006)
Recognition of Combat Vehicles (ROC-V)	Training system to identify military vehicles	US Army	Recognition Training	(Compton & Giunta, 2004)
Combat Identification Training System (CITS)	Training system to identify military personnel and equipment	DT Media Ltd	Recognition Training	(TeamUK, 2006)

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Combat Identification is a state of knowledge attained by a participant on the battlefield as a result of combining Situation Awareness (SA), Target Identification (TI), and Tactics, Techniques and Procedures (TTPs). Combat Identification is essential to the effective achievement of mission objectives and mitigates damage, casualties, and other negative consequences among friendly forces and non-combatants. This document presents the results of a review of currently available Combat Identification technologies that purport to be of use to the dismounted soldier (as opposed to aircraft, ships, or other military vehicles). These technologies are assessed against a descriptive model of the dismounted soldier and their task.

Six categories of Combat Identification technology are identified. For each category an evaluation is made regarding the most suitable product for the dismounted soldier and recommendations are made for research and development work that could address limitations with the products in the category. This document concludes by summarizing the likely impacts on the soldier and making recommendations regarding the most fruitful areas for research and development for Combat Identification.

L’identification au combat représente les connaissances acquises par un individu sur le champ de bataille en combinant la connaissance de la situation (CS), l’identification de la cible (IC), ainsi que les tactiques, les techniques et les procédures (TTP). Elle est essentielle pour atteindre efficacement les objectifs de mission et pour réduire les dommages, les pertes et les autres conséquences négatives entre les forces alliées et les non-combattants. Ce document présente les résultats d’un examen des technologies d’identification au combat que peuvent actuellement utiliser les soldats débarqués (par opposition aux aéronefs, aux navires et aux autres véhicules militaires). Ces technologies sont évaluées par rapport à un modèle descriptif des soldats débarqués et de leurs tâches.

Il y a six catégories de technologies d’identification au combat. Pour chaque catégorie, une évaluation est faite relativement au meilleur produit pour les soldats débarqués. Des recommandations de recherche et de développement sont présentées afin que les produits de la catégorie puissent éliminer les lacunes. Enfin, ce document résume les répercussions possibles pour les soldats. Des recommandations sont formulées concernant les meilleurs domaines de recherche et de développement pour l’identification au combat.

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Soldier Systems; combat identification; situation awareness; target identification