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EVALUATION OF OVERLAY TECHNOLOGY IN MOBILE GEOGRAPHIC INFORMATION SYSTEMS FOR THE DISMOUNTED SOLDIER

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Abstract

The design of location-based technology systems is expected to play an important role in future military mission success. Accordingly, Defence Research and Development Canada (DRDC) has initiated an Applied Research Project (ARP) (14dk) on the evaluation of human factors issues associated with geospatial data visualization in a mobile Geographic Information System (GIS) environment.

The first phase of this project involved a review of the potential utility of mobile GIS devices for the dismounted infantry soldier and the capabilities and functionality of current technology with the goal of identifying human factors research questions. This tasking investigated the types of map data that would be required by dismounted infantry soldiers to carry out operational tasks. Since all of the required data would be too complex to display on a small, portable device, options for grouping the data into separately, callable overlays were explored. These composite overlays were then simulated using geo-mapping software and presented for evaluation by Infantry Subject Matter Experts (SMEs), using scenario simulations.

The results showed that the required data for overlays depended upon both the command position (Section or Platoon) and the type of operation. Accordingly, recommendations were made for a base map (composite overlay consisting of all essential information required by the dismounted infantry commander) that would always be available and for three additional composite overlays containing information that could be called up depending upon the operational situation.

Résumé

On prévoit que la conception de systèmes à technologie de géolocalisation jouera un rôle important dans la réussite des futures missions militaires. En conséquence, Recherche et développement pour la défense Canada (RDDC) a lancé un projet de recherches appliquées (PRA) (14dk) sur l'évaluation des facteurs humains associés à la visualisation de données géospatiales avec un système d'information géographique (SIG) mobile.

La première phase du projet était un examen de l'utilité potentielle d'appareils SIG mobiles pour un soldat débarqué, ainsi que des capacités et des fonctionnalités de la technologie actuelle afin de cerner des questions de recherche sur les facteurs humains. Cette tâche a permis d'étudier les types de données cartographiques dont un soldat débarqué aurait besoin pour accomplir des tâches opérationnelles. Étant donné que toutes les données nécessaires seraient trop complexes pour être affichées sur un petit appareil portatif, on a examiné des façons de grouper les données en couches pouvant être affichées individuellement. Ces affichages composites ont ensuite été simulés grâce à des logiciels géocartographiques et soumis à l'évaluation d'experts en la matière (EM) de l'infanterie, à l'aide de simulations de scénarios.

Les résultats ont montré que les données requises pour les couches d'affichage dépendent du commandement (section ou peloton) et du type d'opération. En conséquence, on a recommandé d'adopter une carte de base (affichage composite constitué de toute l'information essentielle dont le commandant d'infanterie débarquée a besoin) qui serait affichée en permanence et trois couches composites additionnelles contenant de l'information pouvant être consultée en fonction de la situation opérationnelle.

Executive Summary

The design of location-based technology systems is expected to play an important role in future military mission success. Accordingly, Defence Research and Development Canada (DRDC) has initiated an Applied Research Project (ARP) (14dk) on the evaluation of human factors issues associated with geospatial data visualization in a mobile Geographic Information System (GIS) environment.

The first phase of this project involved a review of the potential utility of mobile GIS devices for the dismounted infantry soldier and the capabilities and functionality of current technology, with the goal of identifying human factors research questions. This tasking investigated the types of data that would be required by dismounted infantry soldiers to carry out operational tasks and how to organize the data in a manner that would provide effective access in the field.

An inventory of 49 information/data types required by dismounted infantry soldiers to carry out infantry tasks was compiled based on literature that described detailed dismounted infantry missions. This literature was also reviewed to refine two tactical scenarios that were used to evaluate the data type overlays during a Subject Matter Expert (SME) workshop.

Additional data types and functionality for accessing data currently available in commercial GIS packages were reviewed in order to better understand possible application to a mobile device and assist in the development and validation of the data types inventory. This validation was conducted by two Combat Arms SMEs.

Since the entire data inventory would be impossible to render with any clarity on a small, mobile device, one of the major goals of the project was to identify data elements that would comprise a base map and those that could be aggregated into optional composite data overlays.

The validated inventory of data types was then used during a SME evaluation to determine appropriate combination of data types that could be grouped into composite overlays (base map and additional composite overlays) that would be most useful to dismounted infantry commanders at the Platoon and Section level. This SME evaluation was conducted in the form of a workshop with six infantry SMEs, who were divided into two groups, Platoon Commanders and Section Commanders, based on their experience and rank.

Two dismounted infantry scenarios were used to facilitate the SME evaluation of composite overlays of the data types. The first was an attack-based scenario in a rural environment, and the second was a patrol-based scenario in an urban environment. After a walk-through of the attack scenario, each data type was evaluated individually and then re-evaluated and discussed within the designated groups. Data types were evaluated based on 1) whether the information was required for the individual during a specific phase of the mission and 2) whether the data needed to be available all of the time or whether it could be accessed on demand. Each group then presented their choices, which was followed by a discussion centred on differences in perceived requirements. A similar process was followed for the patrol scenario. A final focus group was conducted to discuss the overall workshop outcome, composition of overlays, issues of access functionality, and any other general issues or concerns about the implementation of the mobile GIS system for dismounted infantry soldiers.

The quantitative and qualitative data were then compiled. Quantitative group ratings were produced through group discussion and averaging individual rankings. The quantitative group ratings were

then used as an overall rating to guide the final overlay groupings. Qualitative data gathered during the group sessions as well as in a final focus group discussion were used to guide functionality and identify additional data types not previously considered by the research team. Results indicated that in general, Platoon Commanders required more information than Section Commanders in both scenarios. Both groups indicated that on a base map there were only six or seven critical data types that were required. Platoon Commanders had very similar base map requirements in both scenarios whereas the Section Commanders required very different information in each scenario. SMEs also identified data that could be grouped into optional composite overlays, accessible to complement the base map. The data type content for these optional overlays varied highly between scenarios. The main factor influencing this variance was the type of environment in which the mission took place; rural versus urban.

This report provides some initial recommendations for the data types that should be represented in a base map and in three optional composite overlays. Different data contents are suggested for different commanders and mission situations. Interface designs for accessing the optional composite overlays are suggested and discussed. The report concludes with suggestions for future research that would be necessary in order to enable the present findings to be further expressed as operational design requirements.

Sommaire

On prévoit que la conception de systèmes à technologie de géolocalisation jouera un rôle important dans la réussite des futures missions militaires. En conséquence, Recherche et développement pour la défense Canada (RDDC) a lancé un projet de recherches appliquées (PRA) (14dk) sur l'évaluation des facteurs humains associés à la visualisation de données géospatiales avec un système d'information géographique (SIG) mobile.

La première phase du projet était un examen de l'utilité potentielle d'appareils SIG mobiles pour un soldat débarqué, ainsi que des capacités et des fonctionnalités de la technologie actuelle afin de cerner des questions de recherche sur les facteurs humains. Cette tâche a permis d'étudier les types de données dont un soldat débarqué aurait besoin pour accomplir des tâches opérationnelles et la façon d'organiser ces données de façon à offrir un accès efficace sur le terrain.

On a compilé un inventaire de 49 types d'information/de données permettant aux soldats débarqués d'accomplir des tâches d'infanterie. Pour ce faire, on a consulté de la documentation décrivant en détail des missions d'infanterie débarquée. On a également examiné cette documentation pour raffiner deux scénarios tactiques qui ont servi à évaluer les couches d'affichage des types de données lors d'un atelier avec des experts en la matière (EM).

De plus, on a examiné d'autres types de données et d'autres fonctionnalités permettant d'accéder aux données disponibles dans des produits SIG commerciaux afin de mieux comprendre les applications possibles dans un appareil mobile et de faciliter le développement et la validation des inventaires de types de données. Cette validation a été effectuée par deux EM d'armes de combat.

Étant donné qu'il serait impossible d'afficher la totalité de l'inventaire de données de façon lisible dans un petit appareil mobile, un des principaux défis à relever dans le cadre de ce projet était de cerner les éléments de données qui constitueraient la carte de base et ceux qui seraient combinés dans les couches d'affichage facultatives. Lors d'une évaluation par des EM, l'inventaire validé des types de données a ensuite servi à déterminer des combinaisons appropriées de types de données pouvant être regroupées dans les couches d'affichage composites (la carte de base et les couches additionnelles) qui seraient les plus utiles pour les commandants d'infanterie débarquée au niveau des pelotons et des sections. Cette évaluation par des EM a été menée sous forme d'atelier avec six EM d'infanterie, qui ont été répartis en deux groupes, les commandants de peloton et les commandants de section, en fonction de leur expérience et de leur grade.

Deux scénarios d'infanterie débarquée ont été utilisés pour faciliter l'évaluation par les EM des couches d'affichage composites des types de données. Le premier était un scénario d'attaque dans un environnement rural, et le deuxième un scénario de patrouille dans un environnement urbain. Après un examen détaillé du scénario d'attaque, chaque type de données a été évalué individuellement, puis réévalué et examiné dans le cadre des discussions des groupes désignés. Les types de données ont été évalués selon que 1) l'utilisateur avait besoin de cette information pendant une phase particulière de la mission et que 2) les données devaient être disponibles en tout temps ou si l'on pouvait y accéder au besoin. Par la suite, il y a eu présentation des choix par chacun des groupes et une discussion axée sur les différences dans les exigences perçues. Un processus similaire a ensuite été suivi pour le scénario de patrouille. Un dernier groupe de discussion a été constitué pour discuter des résultats de l'atelier, de la composition des couches d'affichage, des problèmes de fonctionnalité d'accès et de tout autre problème ou de toute autre préoccupation concernant la mise en œuvre du SIG mobile pour les soldats débarqués.

Les données quantitatives et qualitatives ont ensuite été compilées. Les notes quantitatives ont été créées dans le cadre de discussions de groupe en calculant la moyenne des notes individuelles. Les notes quantitatives de la page iv, Evaluation of Overlay Technology - Mobile GIS Humansystems®, ont ensuite été utilisées comme note globale pour orienter les regroupements finaux des données dans les différentes couches d'affichage. Les données qualitatives recueillies au cours des séances en groupe et lors de la rencontre du groupe de discussion final ont servi à orienter des fonctionnalités et à cerner des types de données supplémentaires auxquels l'équipe de recherche n'avait pas encore songé. Les résultats ont indiqué que, de façon générale, les commandants de peloton avaient besoin de plus d'information que les commandants de section dans les deux scénarios. Les deux groupes ont indiqué que seuls six ou sept types de données critiques étaient nécessaires sur la carte de base. Les commandants de peloton avaient des exigences très semblables pour la carte de base dans les deux scénarios, alors que les commandants de section avaient besoin d'informations très différentes dans chaque scénario. Les EM ont aussi relevé des données qui pouvaient être groupées dans des couches d'affichage composites facultatives, auxquelles on peut accéder afin de complémenter la carte de base. Les types de données inclus dans ces couches d'affichage facultatives variaient considérablement d'un scénario à l'autre. Le facteur principal ayant une incidence sur cette différence était le type d'environnement où l'on menait la mission : rural ou urbain.

Ce rapport contient des recommandations initiales sur les types de données qui devraient être présentées dans une carte de base et dans trois couches d'affichage composites facultatives. On suggère différents contenus de données selon les commandants et les situations de mission. On discute aussi de conceptions suggérées de l'interface pour permettre à l'utilisateur d'accéder aux couches d'affichage composites facultatives. Enfin, le rapport contient des suggestions de travaux de recherche qui seraient nécessaires pour permettre d'exprimer de façon plus approfondie les présentes constatations sous forme d'exigences de conception opérationnelles.

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List of Acronyms

3D	Three-dimensional
AO	Area of Operation
ARP	Applied Research Project
COTS	Commercial-off-the-shelf
CSA	Contract Scientific Authority
DAGR	Defense Advanced GPS Receiver
DND	Department of National Defence
DoD	(United States) Department of Defense
DRDC	Defence Research and Development Canada
ESRI	Environmental Systems Research Institute
FBCB2	Force XXI Battle Command Brigade and Below
GIS	Geographic Information System
GPS	Global Positioning System
HSI®	HumanSystems Incorporated
ISSP	Integrated Soldier System Project
JBC-P	Joint Battle Command – Platform
LFCA	Land Force Central Area
LRF	Laser Range Finder
MET	Meteorological
MIL-STD	Military Standards
na	Not applicable
OMI	Operator Machine Interface
SALUTE	Size, Activity, Location, Unit Identification, Time, and Equipment
SAASM	Selective Availability Anti-spoofing Module -
SIREQ TDP	Soldier Information Requirements Technology Demonstration Project
SITREP	Situation Report
SME	Subject Matter Expert
SOPs	Standard Operating Procedures
TC	Training Centre

UAV	Unmanned Aerial Vehicle
USMC	United States Marine Corps

1. Introduction

1.1 Background

The design of location-based technology systems is expected to play an important role in future military mission success. Accordingly, Defence Research and Development Canada (DRDC) has initiated an Applied Research Project (ARP) (14dk) on the evaluation of human factors issues associated with geospatial data visualization in a mobile Geographic Information System (GIS) environment. GIS is a tool used for understanding geographical relationships which potentially could lead to more intelligent decision making. By organizing geospatial data in a unique fashion, GIS affords an operator reading a map the ability to access information pertinent to a specific project or task (ESRI, 2007). GIS can help soldiers achieve enhanced situation awareness to plan, brief, explain, rehearse and/or visualize steps or expected action of the operation as well as monitor the execution of missions.

In the near future, infantry soldiers will be outfitted with a handheld system that will incorporate some form of GIS technology. For example, the Department of National Defence of Canada - Integrated Soldier System Project (ISSP), is acquiring an integrated suite of equipment that includes a hardware and software solution for GIS applications such as navigation and wayfinding, target designation, and blue force tracking. This initial operating capability is scheduled for 2014. In contrast to paper maps with hand-drawn overlays, which limit the complexity and range of information that can be presented, mobile GIS devices can make available a wide range of digital data. This will create the need to manage the potential information overload and ensure discriminability of critical information. Thus, there is a requirement to develop human factors guidelines to ensure the suitability, usability, and effectiveness of future mobile GIS devices for the dismounted infantry soldier.

The first phase of this project involved a review of the potential utility of mobile GIS devices for the dismounted infantry solider and the capabilities and functionality of current technology, with the goal of identifying human factors research questions. As a result, one of the important issues identified was that geographic data overlays were a key functional component of the mobile GIS and their effective management was critical (Rehak, McKee, Matthews, 2010). To address this concern, the current phase of this project investigated the types of data that would be required by dismounted infantry soldiers to carry out operational tasks and the appropriate functionality and suitability of these overlays when used on mobile GIS devices.

This contract report outlines the tasks that were undertaken and the analyses that were conducted. Section 2 discusses the GIS information requirements of the dismounted infantry soldier and summarizes the tactical scenarios that were implemented during SME workshop. Section 3 reviews the functionality currently available in commercial GIS packages and GIS information that is currently used by dismounted infantry. Section 4 presents the findings from the SME workshop, while Section 5 reviews interaction options for accessing overlays. The report concludes with a summary and provides recommendations for future work.

1.2 Overall Project Objectives and Scope

Two primary objectives were pursued for this tasking:

1. Critically evaluate currently available overlay data in commercial GIS systems and tools for their use on mobile devices for dismounted soldiers.

2. Develop and evaluate groupings of data to form composite overlays that would support current and proposed tasks carried out by dismounted soldiers using GIS software on mobile electronic devices.

The scope was limited to the potential use of a mobile GIS by dismounted infantry commanders at the Section and Platoon level and their needs for mission execution rather than initial mission planning. However, re-planning in reaction to unexpected changes in the operational context during execution (e.g., developing a plan for a hasty attack) was included.

2. GIS Information Requirements

This section discusses the GIS information requirements of the dismounted infantry soldier and summarizes the tactical scenarios that were implemented during the SME evaluations.

2.1 Goals

The following goals were pursued for this phase of the tasking:

1. Document information/data types required by the dismounted infantry soldier to carry out infantry tasks
2. Select tactical scenarios to be implemented during the conduct of the SME evaluations

2.2 Method

In fulfilment of Task 1 of the Statement of Work, previous reports by Rehak, McKee and Matthews (2010) and Huber (2011) were reviewed to document information/data types required by dismounted infantry soldiers to carry out infantry tasks and to select tactical scenarios to be implemented during the conduct of the SME evaluations (hereafter referred to as the SME workshop).

In carrying out the above task, several gaps were identified in both reports with respect to the information required for this tasking. A higher level of detail was required to identify discrete dismounted infantry tasks and associated data requirements, and a more detailed and relevant tactical scenario was required for the SME workshop than was provided in the above reports. This task was therefore re-scoped and additional documents and information resources were sourced and reviewed. These included Soldier Information Requirements Technology Demonstration Project (SIREQ TDP) studies (Adams, Tack, and Thomson, 2005; Colbert, Tack, and Bos, 2005; Tack and Nakaza, 2005; Colbert, Kumagai, and Hawes, 2005; Tack, D. W., and Angel, H., 2005), Integrated Soldier System Project (ISSP) Technical Performance Specifications (National Defence website, 2011a), Standing Operating Procedures (SOP) For Land Operations (B-GL-334-001/FP-001), and the United States Marine Corps (USMC) Handheld Requirements Generation Workshop (Tack and Nakaza, 2011).

2.3 Scope

For this tasking the information/data types required by dismounted infantry soldiers were constrained to geo-referenced information that could be represented as overlays, such as raster and vector layers, environmental features, contour lines, blue force tracking, and defensive arcs of fire. Information/data types such as planning tools, administrative tools (e.g., clock, calendar, timer, calculator, stopwatch), and status indicators (battery, radio and satellite signal strength) were deemed to be out of scope by the Contract Scientific Authority (CSA).

2.4 Results

2.4.1 Information/Data Type Requirements

Based upon the analysis of the above reports and information resources, the following list of 49 fundamental data types was selected as meeting the information requirements of dismounted infantry soldiers to carry out infantry tasks. These fundamental data types were categorized based on the type of information and are presented, in no particular order, in Table 1. It should be noted that the data types are not unique, that is a given dataset may be classified by multiple data types (e.g., environmental features and nature of area). Annex A provides a definition of these data types. Furthermore, a sub-set of this list was previously validated on a separate effort by 35 Subject Matter Experts (SMEs) from 2nd Battalion 1st Marines, 3rd Battalion 5th Marines, 1st Light Armoured Reconnaissance Battalion, 2nd Marine Division, and the Mountain Warfare Training Centre. This validation effort was conducted during the USMC Handheld SME Conference that was held at Marine Corps Base Pendleton in 2011 (Tack and Nakaza, 2011).

Table 1: Data Types

Item No.	Data Type Category	Data Types
1	Tactical Digital Map	Vector Map
2		Raster Background Map
3		Distance Measurement (range bands, ruler)
4		Grid Reference / Different Coordinate Systems
5		Compass
6		Tactical Graphics Unit Icons Equipment Icons Irregular Warfare
7		Weapon Arcs of Fire
8		Effective Weapon Ranges
9		Optimum Observation Point and Dead Ground Indicator
10	Environment	Environmental Features
11		Key Landmarks
12		Weather
13		Nature of Area
14		Terrain Type
15		Contour Lines
16		Vegetation Coverage (from seasonal information)
17		Elevation
18		Altitude
19		Impact of Ambient Lighting on Terrain

Item No.	Data Type Category	Data Types
20		Details of Underground, Underwater, sky (e.g., sewer system)
21	**Situation Awareness**	Own Location
22		Blue Force Tracking
23		Enemy Location
24		Unknown Entity
25		Neutral Entity
26		Snail Trails
27		Situation Projection
28		Location of Previous Enemy Engagements
29	**Reporting/ Messaging**	Reports (e.g., SALUTE, Medevac, SITREP)
30		Messaging (chat, email) Geo-referenced
31	**Navigation**	Terrain Appreciation
32		Intervisibility Tool
33		Wayfinding Cues
34		Current Heading
35		Direction of Current Movement
36		Bearing Tool to / from POI
37		Planned Route
38	**Planning Tools**	Route Planner
39		Orders Template
40		Time Appreciation Tool
41		Combat Estimate Tool
42		Mission Trace (operational plan)
43	**Display Images**	Photographs - geo-tagged (e.g., recce of building)
44		Video (location , viewing angle of video)
45		Graphics (annotation layer)
46	**Target Designation**	Manual Designation
47		LRF-Assisted Designation
48	**Miscellaneous**	Notepad
49		Labels

2.4.2 Scenario Selection

Two scenarios were selected as being representative of general tasks executed during dismounted infantry operations. These scenarios were planned to be used during the SME workshop to set the

stage, and provide a narrative, for the concept of use of a mobile GIS system for the dismounted infantry soldier. The attack scenario was based on a modified attack vignette set in a temperate wooded environment created for the SIREQ-TDP (Tack and Angel, 2005). The patrol scenario was based on a modified dismounted infantry patrol set in a more densely populated urban environment (than compared with the attack scenario) created for the ISSP (National Defence web site, 2011b). In developing these scenarios, some artificial elements were included, such as an increased operational tempo and stringing together a series of discrete temporal events that would not usually occur concurrently during an operation. This was done in order to include representative infantry tasks and to ensure that participants considered all situations in which the mobile GIS system could be employed. These scenarios are outlined in Annex B.

3. Review of Functionality and Suitability of Data Types in Commercial GIS Systems

This section reviews both the GIS information types and functionality currently available in commercial GIS packages. A process for checking and validating the suitability of these packages as a mobile GIS for dismounted infantry is described.

3.1 Goals

The following goals were pursued for this phase of the tasking:

1. Review the functionality available in commercial GIS packages
2. Gather information from SMEs about mobile GIS information types and functionality (both current and potential) that might be beneficial in the dismounted infantry context.
3. Validate the data types as outlined in the section above.

3.2 Method

3.2.1 Functionality in Commercial GIS Packages

A trade study and review of the functionality of several commercial-off-the-shelf (COTS) GIS products, pre-selected by the CSA, were carried out. The products were: Google Earth, Google Map, Bing Map, and ArcGIS 9.3. The research team systematically explored each of the products and reviewed technical documents such as the user manual in order to organize a list of functions into the following categories: Data, Application, Data access, Annotate, Print, Save & store, Organize, Compatibility, Feature, Tool, Collaboration, Application (navigation), Analyses, Views, Search, Alert.

This list was then reviewed within the context of mobile GIS devices in dismounted infantry operations and a matrix was created to compare the different GIS packages. Functions that were considered necessary or required, in the opinion of HSI®, were identified. If the function was not essential but was deemed to afford additional or supplementary capability to the operator, then the function was categorized as "blue-sky". That is, these functions were not seen to be required or necessary, but were envisioned to aid the operator with additional capability. Notably, these "blue-sky" functions included features such as a history slide bar, three dimensional visualization of buildings and terrain, ability to animate routes, ability to "fly through" environments, and the ability to provide a 360° horizontal view of the environment. The final list of functionality is provided in Annex C.

3.2.2 Combat Arms SME Knowledge Elicitation

The objective of the interview with two Combat Arms SMEs was to gather information about mobile GIS data types and functionality (both current and potential) that could be of use to dismounted infantry soldiers. Another objective was to identify any appropriate tools that may be

of value for accessing and using overlays in mobile GIS systems. Two soldiers with the rank of Sergeant participated in the interviews.

3.2.2.1 Interview Protocol and Findings:

The interview consisted of three phases:

Phase 1: Introduction

Phase 2: Question and Answer

Phase 3: Validation

The interview began with a brief introduction during which the SMEs were introduced to the research team and informed of the goal of the overarching research project as well as the specific objectives of the interview. The substance of the interview then followed. The goal of the interview was to establish current practices within the Geomatics Technician trade and to establish the GIS tools currently employed by dismounted infantry soldiers (training and in theatre). The third phase was structured so that the SMEs were able to provide feedback and validate the preliminary list of data types and associated categories intended for infantry operations.

According to the Geomatics Technician, the current practice requires them to create maps for each mission depending on what is mandated by the Commander, and also based on Training and Doctrine Command Pamphlet which outlines Standard Operating Procedures (SOPs) for creating different overlay-groupings and categories in different mission requirements. Typically these maps are vector based and data types such as topography, elevation, contour lines; chokepoints, highpoints; vegetation; and anything that is an obstacle such as roads, tracks, caves, houses, swamps, waterways are included. Raster based maps, such as satellite and aerial photographs are also provided if it is available. Overlay groupings within these maps are created by the Geomatics Technicians, but is not manipulated by the end user. 3D mapping can also be created, however it is currently not used due to computer hardware and software limitations. Three different types of software programs are employed by the Geomatics Technicians to create and display these maps. These include ArcGIS, Global mapper, and FalconView (MS Windows based mapping application widely used by DND and U.S. DoD). Force XXI Battle Command Brigade and Below (FBCB2) software is also used, but predominantly by the U.S. DoD.

For Mission Planning, the Geomatics Technician stated that both electronic and paper maps are used. For dismounted operations an electronic map may be used with an appropriate handheld device, but a paper map is always required and is more commonly used by soldiers. Presently the DAGR (Defense Advanced GPS Receiver) is the most prevalent military approved handheld GIS device. The technology is rugged, secure and encrypted (Selective Availability Anti-spoofing Module - SAASM chip), unfortunately the device has many limitations: technology is dated, the device is large and clunky, the display is low in resolution and is monochrome, the user interface is difficult to use, and the system is difficult to learn. In addition the DAGR is a Platoon level asset, and is not used at the Section or individual soldier level. Depending on the Unit, some will therefore purchase commercial off-the-shelf (COTS) GPS handheld devices for the Sections, while individual soldiers will often purchase their own GPS devices and use them in theatre. The SMEs mentioned that typical devices include the Garmin eTrex, but it was also stated that these devices were not approved as it utilizes civilian GPS signals, is not secure, and the signal can be jammed/spoofed.

Following this discussion, both SMEs were presented with a list of data types (as outlined in Table 1), and asked to provide a ranking based on their knowledge of and expertise in infantry operations.

For each data type they provided a rating as follows:

1. Data type never required
2. Data type seldom required
3. Data type sometimes required
4. Data type generally required
5. Data type always required

Results from this exercise showed that all of the data types were required (a requirement rating of 3 (sometimes required) or higher), except for three; Weapon Arcs of Fire, Effective Weapon Ranges, and Impact of Ambient Lighting on Terrain. Weapon Arcs of Fire and Effective Weapon Ranges were rated low by the SMEs, as these data types were originally explained as pertaining to friendly weapons. It was later discussed, however, that these data types would be rated as always being required (i.e. 5), if they pertained to enemy weapons as this information would be very valuable. In terms of Ambient Lighting on Terrain, the SMEs were unsure as to the utility of this data type.

3.2.3 Potentially Useful Overlays and Functionality

Using the information collected during the knowledge elicitation exercise, as well as from the documentation of information/data types required by the dismounted infantry soldier, selection of tactical scenarios, and review of functionality in commercial GIS packages, the next step was to identify combinations of data types that could be aggregated into potentially useful composite overlays. Prototype map overlays for each of the data types as defined in Section 2, Table 1, were developed for each of the mission scenarios and are shown in Annex D. The prototype overlays were prepared using Environmental Systems Research Institute (ESRI) ArcGIS 9.3 and Adobe Photoshop CS5 software. These illustrations were created for use during the subsequent SME review of overlays. An example screen shot for the attack and patrol scenarios can be seen in the figures below.

Figure 1: Example of a Composite Map using ArcGIS 9.3 for Attack Scenario

In Figure 1, the following data types were represented using ArcGIS 9.3; vector map, raster image, distance measurement (range ring), grid reference, compass rose (north indicator), tactical graphics, key landmarks, contour lines, own location, blue force tracking, enemy location, location of unknown entity, breadcrumb trail, location of previous enemy engagements, planned route, mission trace, labels, photographs, mail, notepad, and drawing and annotation tool. Each of these individual overlays contributes to a composite overlay (or overlay grouping) as represented above.

Figure 2: Example of a Composite Map using Photoshop CS5 for Patrol Scenario

In Figure 2, the following data types were represented using Adobe Photoshop CS5; raster image, distance measurement (range rings and ruler), compass rose (north indicator), tactical graphics, own location, blue force tracking, enemy location, location of unknown entity, breadcrumb trail, location of previous enemy engagements, and labels. As in Figure 1, Figure 2 represents a composite map created through the combination of individual overlays.

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4. SME Evaluation of Overlays

This section presents findings from the scenario-based evaluation of prototype overlays that were carried out by Infantry SMEs. The term 'base map' is used when referring to the composite overlay consisting of all essential information required by the dismounted infantry commander. The term 'additional/optional composite overlay' is used when referring to the secondary overlay groupings that can be toggled on/off by the Commander.

4.1 Background

A one-day SME workshop was conducted on 30 November 2011 at DRDC Toronto. The workshop aimed at identifying the information required by Platoon and Section Commanders during dismounted infantry operations. Two tactical scenarios were used to provide context and examples of the mission-specific tasks performed by dismounted infantry soldiers. Participants rated the importance of each data type during each phase of operations and indicated whether the information was required continuously or on demand. Following the rating exercise a focus group discussion was conducted after each scenario. The workshop agenda can be found in Annex E.

4.2 Goals

The following goals were pursued during the one-day SME workshop:

1. Determine the essential information (primary data types) required by the dismounted infantry commander to be always visible on a mobile GIS system for dismounted operations (i.e., base map).
2. Define secondary data types and ways that they may be combined to form additional/optional composite overlays to be turned on or off on demand with "one click" access.
3. Determine any variations in the data types selected for the above that would be applicable to Section or Platoon Commanders.

4.3 Subject Matter Experts (SMEs)

Four dismounted light Infantry soldiers (Captain, Warrant Officer, two Sergeants) with operational experience in the role of a 2IC (second in command) or higher, a Geomatics Technician and an Intelligence operator were recruited from Land Forces Central Area (LFCA) headquarters, and from the LFCA Training Centre (TC) Meaford to participate in this study. The participants had operational experience (i.e., ≥2 previous tours), experience in planning (e.g., employing software with geo-location capabilities and experience in blue-force tracking, position and situation awareness) and were technology savvy (e.g., smartphone users).

4.4 Method

The workshop began with a briefing, which included the concept of net-centric and net-enabled warfare, allied programs that have looked at past, current and future mobile GIS concepts and devices, and an introduction to the current project.

Demographic information including military experience was collected from participants. They were then provided with an overview of the data types, definitions, and map-based examples developed in ArcGIS and Photoshop. Participants were given a list of the data types that they would use in the working sessions for each scenario (see Table 1). Once participants were familiar with the data types and overlays, the first scenario, an attack scenario developed as part of the SIREQ TD, was presented. The HSI® presenter walked through the scenario and asked the participants if they understood the details of the operation. The HSI® presenter then showed a prototype electronic composite map for the SIREQ attack scenario using ArcGIS (as outlined in Section 3, Figure 1). This map provided participants with a series of overlays that served as a visual demonstration of how scenario relevant data types could potentially look on the base map. These prototype overlays were created based on the feedback received from SMEs as described in Section 3.2.

Participants were then asked to provide an importance rating based on the information they would want to have available if they were executing the scenario. The questionnaire completed by SMEs is presented in Annex F. For each data type they provided a rating as follows:

1. Data type never required
2. Data type seldom required
3. Data type sometimes required
4. Data type generally required
5. Data type always required

Participants were given approximately 15-20 minutes to complete these ratings individually. All participants had access to the list of data types and definitions as well as to the HSI® team to provide clarification during this time. The participants were also asked to indicate any other data types that they felt would be required or desired that were not included in the list provided.

Once the individual ratings were completed, participants were divided into two groups. The Captain, Warrant Officer, and Intelligence specialist provided insight with respect to the role of Platoon Commander. The two Sergeants and Geomatics Technician provided insight with respects to the role of the Section Commander. The participants then averaged and /or negotiated ratings as a group and discussed the reasoning behind their individual rating choices. During this group session participants also provided an assessment of whether the particular data type is required to be constantly displayed or could be accessed and removed on demand through a one-step system (e.g., via a virtual screen button). Participants were instructed to select “1” if the information should be available on the map at all times, or “2” if the information should be available to display on demand, or left blank if the information is not required to be displayed.

The final step was a group discussion on how contextual considerations in an operation might influence the information that is critical and optional. The output of this discussion was a list of data types required for each event during the attack scenario and a visual demonstration of the selected data types on ArcGIS. Each group then presented their data selections and supported their choices. This lead to a discussion on how these could be grouped into mission relevant combinations of data types to form composite overlays that could be quickly selectable.

Figure 3: Attack Scenario Composite Map Displayed on a Tablet Device

The entire process for the attack scenario was then repeated for the second scenario, ISSP: patrol and assault scenario. Adobe Photoshop CS5 was used as an alternative to ArcGIS to demonstrate how data types could be represented differently using the two software programs. Due to time limitations the third scenario SIREQ Patrol was not completed.

Additional ranking activities were planned if time allowed for data type subcategories such as Tactical Graphics, and Environmental Features, however, there was insufficient time to carry out this task.

4.5 Results

Results gathered from the final group rankings were compiled to produce an overall indication of the degree of importance of each data type in terms of its requirement (as indicated in Section 4.3) and the appropriate level of accessibility. The results are presented in the tables below.

The criteria for a data type to be included as part of the base map were a requirement rating of 5 “always required” and an availability rating of 1 (always available).

The criteria for a data type to be considered in an optional overlay (an overlay in addition to the base map) were a requirement rating of 3 (sometimes required) or higher and an availability rating of 2, or not rated (note some data types rated 3 and above for the requirement ratings were not given an accessibility rating, this was interpreted as an oversight and thus were considered to have an availability rating of 2).

4.5.1 Platoon Commander SIREQ Attack Scenario

Platoon Commanders identified all data types as being required during the attack scenario (Table 2). A subset of seven data types met the criteria for inclusion in the base map.

Table 2: Platoon Commander Priority Data Types for the SIREQ Attack

Data Type Category	Data Types	Group rating of Data Requirements	Overall rating for information accessibility
Tactical Digital Map	Vector Map	5	1
Tactical Digital Map	Grid Reference / Different Coordinate Systems	5	1
Environment	Key Landmarks	5	1
Environment	Contour Lines	5	1
Situation Awareness	Own Location	5	1
Situation Awareness	Blue Force Tracking	5	1
Situation Awareness	Enemy Location	5	1
Environment	Environmental Features	5	2
Tactical Digital Map	Raster Background Map	4	2
Tactical Digital Map	Distance Measurement (range bands, ruler)	4	2
Tactical Digital Map	Compass	4	2
Tactical Digital Map	Tactical Graphics	4	2
Tactical Digital Map	Unit Icons	4	2
Tactical Digital Map	Weapon Arcs of Fire	4	2
Tactical Digital Map	Optimum Observation Point and Dead Ground Indicator	4	2
Environment	Nature of Area	4	2
Environment	Terrain Type	4	2
Environment	Vegetation Coverage (from seasonal information)	4	2
Environment	Elevation	4	2
Situation Awareness	Unknown Entity	4	2
Situation Awareness	Neutral Entity	4	2
Situation Awareness	Breadcrumb Trail (Snail Trail)	4	2
Situation Awareness	Situation Projection	4	2
Situation Awareness	Location of Previous Enemy Engagements	4	2

Data Type Category	Data Types	Group rating of Data Requirements	Overall rating for information accessibility
Navigation	Terrain Appreciation	4	2
Navigation	Intervisibility Tool	4	2
Navigation	Wayfinding Cues	4	2
Navigation	Current Heading	4	2
Navigation	Direction of Current Movement	4	2
Navigation	Bearing Tool to / from POI	4	2
Navigation	Planned Route	4	2
Planning Tools	Route Planner	4	2
Planning Tools	Time Appreciation Tool	4	2
Planning Tools	Combat Estimate Tool	4	2
Planning Tools	Mission Trace (operational plan)	4	2
Display Images	Photographs - geotagged (e.g., recce of building)	4	2
Display Images	Video (location , viewing angle of video)	4	2
Display Images	Graphics (annotation layer)	4	2
Target Designation	Manual Designation	4	2
Target Designation	LRF-Assisted Designation	4	2
Miscellaneous	Notepad	4	2
Miscellaneous	Labels	4	2
Tactical Digital Map	Equipment Icons	3	2
Tactical Digital Map	Irregular Warfare Symbols	3	2
Tactical Digital Map	Effective Weapon Ranges	3	2
Environment	Weather	3	2
Environment	Altitude	3	2
Environment	Impact of Ambient Lighting on Terrain	3	2
Environment	Details of Underground, Underwater, sky (e.g., sewer system)	3	2
Reporting/ Messaging	Reports (e.g., SALUTE, Medevac, SITREP)	3	2
Reporting/ Messaging	Messaging (chat, email) Georeferenced	3	2
Planning Tools	Orders Template	3	2

Thus, a base map to support the Platoon Commanders during an attack scenario should include: a Vector Map, Grid Reference / Different Coordinate Systems, Key Landmarks (e.g., airport), Contour Lines, Own Location, Blue Force Tracking, and Enemy Location. A visual representation of this base map created in ArcGIS is presented in Figure 4.

Figure 4: Representation of a Base Map to Support Platoon Commanders During an Attack Scenario

4.5.2 Section Commander SIREQ Attack Scenario

Section Commanders identified 35 data types (see Table 3) that were required in the attack scenario. Seven data types were identified as meeting the criteria for inclusion in the base map. These were: a Vector Map, Grid Reference / Different Coordinate Systems, Compass, Own Location, Enemy Location, Current Heading, and Direction of Current Movement. Figure 5 is a representation of this base map. Comparing Figures 4 and 5 we can see that the data types selected by Section Commanders are quite different from those selected by Platoon Commanders for the attack scenario despite both groups selecting seven base map data types.

Table 3: Section Commander Priority Data Types for the SIREQ Attack

Data Type Category	Data Types	Group rating of Data Requirements	Overall rating for information accessibility
Tactical Digital Map	Vector Map	5	1
Tactical Digital Map	Grid Reference / Different Coordinate Systems	5	1
Tactical Digital Map	Compass	5	1
Situation Awareness	Own Location	5	1
Situation Awareness	Enemy Location	5	1
Navigation	Current Heading	5	1
Navigation	Direction of Current Movement	5	1
Tactical Digital Map	Raster Background Map	5	2
Tactical Digital Map	Distance Measurement (range bands, ruler)	5	2
Environment	Environmental Features	5	2
Environment	Key Landmarks	5	2
Environment	Nature of Area	5	2
Environment	Terrain Type	5	2
Environment	Contour Lines	5	2
Environment	Elevation	5	2
Environment	Details of Underground, Underwater, sky (e.g., sewer system)	5	2
Situation Awareness	Blue Force Tracking	5	2
Situation Awareness	Location of Previous Enemy Engagements	5	2
Reporting/ Messaging	Reports (e.g., SALUTE, Medevac, SITREP)	5	2
Navigation	Terrain Appreciation	5	2
Navigation	Planned Route	5	2
Display Images	Photographs - geotagged (e.g., recce of building)	5	2
Display Images	Video (location , viewing angle of video)	5	2
Display Images	Graphics (annotation layer)	5	2
Target Designation	Manual Designation	5	2
Target Designation	LRF-Assisted Designation	5	2
Miscellaneous	Notepad	5	2
Miscellaneous	Labels	5	2

Data Type Category	Data Types	Group rating of Data Requirements	Overall rating for information accessibility
Situation Awareness	Breadcrumb Trail (Snail Trail)	4	2
Navigation	Wayfinding Cues	4	2
Environment	Weather	3	2
Navigation	Bearing Tool to / from POI	3	2
Tactical Digital Map	Weapon Arcs of Fire	3	na
Tactical Digital Map	Effective Weapon Ranges	3	na
Situation Awareness	Situation Projection	3	na

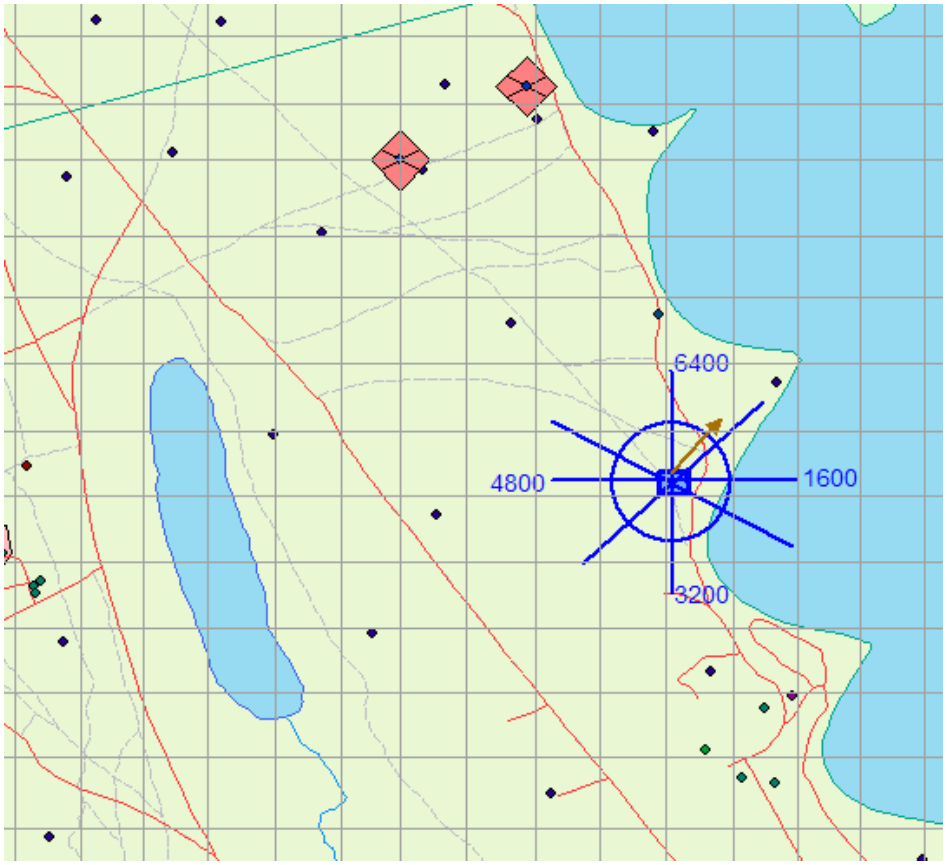

Figure 5: Representation of a Base Map to Support Section Commanders During an Attack Scenario

Table 4 provides the seventeen data types identified as not required during the attack scenario by Section Commanders:

Table 4: Data Types Not Required by Section Commanders During an Attack Operation

Data Type Category	Data Types
Tactical Digital Map	Tactical Graphics
	Unit Icons
	Equipment Icons
	Irregular Warfare Symbols
	Optimum Observation Point and Dead Ground Indicator
Environment	Vegetation Coverage (from seasonal information)
	Altitude
	Impact of Ambient Lighting on Terrain
Situation Awareness	Unknown Entity
	Neutral Entity
Reporting/ Messaging	Messaging (chat, email) Georeferenced
Navigation	Intervisibility Tool
Planning Tools	Route Planner
	Orders Template
	Time Appreciation Tool
	Combat Estimate Tool
	Mission Trace (operational plan)

4.5.3 Platoon Commander ISSP Dismounted Platoon Patrol Scenario

Using the same criteria as previously described, Platoon Commanders again identified seven data types that should comprise a base map for the ISSP Dismounted Platoon Patrol (Table 5). These data types are identical to those chosen during the attack scenario with the exception that the preferred format for the background map was raster rather than vector. The selections were: a Raster Background Map, Grid Reference / Different Coordinate Systems, Key Landmarks, Contour Lines, Own Location, Blue Force Tracking, Enemy Location.

Table 5: Platoon Commander Priority Data Types for the ISSP Dismounted Platoon Patrol

Data Type Category	Data Types	Group rating of Data Requirements	Overall rating for information accessibility
Tactical Digital Map	Raster Background Map	5	1
Tactical Digital Map	Grid Reference / Different Coordinate Systems	5	1
Environment	Key Landmarks	5	1
Environment	Contour Lines	5	1
Situation Awareness	Own Location	5	1
Situation Awareness	Blue Force Tracking	5	1
Situation Awareness	Enemy Location	5	1
Tactical Digital Map	Vector Map	5	2
Tactical Digital Map	Compass	5	2
Tactical Digital Map	Effective Weapon Ranges	5	2
Environment	Details of Underground, Underwater, sky (e.g., sewer system)	5	2
Reporting/ Messaging	Reports (e.g., SALUTE, Medevac, SITREP)	5	2
Navigation	Intervisibility Tool	5	2
Navigation	Planned Route	5	2
Planning Tools	Route Planner	5	2
Planning Tools	Orders Template	5	2
Target Designation	Manual Designation	5	2
Target Designation	LRF-Assisted Designation	5	2
Tactical Digital Map	Distance Measurement (range bands, ruler)	4	2
Tactical Digital Map	Tactical Graphics	4	2
Tactical Digital Map	Unit Icons	4	2
Tactical Digital Map	Equipment Icons	4	2
Tactical Digital Map	Weapon Arcs of Fire	4	2
Tactical Digital Map	Optimum Observation Point and Dead Ground Indicator	4	2
Environment	Environmental Features	4	2
Environment	Vegetation Coverage (from seasonal information)	4	2
Situation Awareness	Unknown Entity	4	2

Data Type Category	Data Types	Group rating of Data Requirements	Overall rating for information accessibility
Situation Awareness	Neutral Entity	4	2
Situation Awareness	Breadcrumb Trail (Snail Trail)	4	2
Situation Awareness	Location of Previous Enemy Engagements	4	2
Reporting/ Messaging	Messaging (chat, email) Georeferenced	4	2
Navigation	Terrain Appreciation	4	2
Navigation	Current Heading	4	2
Navigation	Direction of Current Movement	4	2
Display Images	Photographs - geotagged (e.g., recce of building)	4	2
Display Images	Video (location , viewing angle of video)	4	2
Display Images	Graphics (annotation layer)	4	2
Miscellaneous	Notepad	4	2
Miscellaneous	Labels	4	2
Tactical Digital Map	Irregular Warfare Symbols	3	2
Environment	Weather	3	2
Environment	Nature of Area	3	2
Environment	Terrain Type	3	2
Environment	Elevation	3	2
Environment	Altitude	3	2
Environment	Impact of Ambient Lighting on Terrain	3	2
Situation Awareness	Situation Projection	3	2
Navigation	Wayfinding Cues	3	2
Navigation	Bearing Tool to / from POI	3	2
Planning Tools	Time Appreciation Tool	3	2
Planning Tools	Combat Estimate Tool	3	2
Planning Tools	Mission Trace (operational plan)	3	2

Figure 6 provides a representation of these data types; this is shown with the bird's eye view Raster image that was preferred by the Platoon Commanders. This image was created in Photoshop and looks very different from the base map created in ArcGIS for Platoon Commanders in the attack scenario. However, there were only two differences noted between the two base maps. Firstly, the selection of a raster map during the patrol scenario (see Figure 6) compared with a vector map during the attack scenario (see Figure 4). Secondly, the zoom level of blue force tracking in the

attack scenario was selected to be at the Platoon level, and for the patrol scenario was selected to be at the individual level. The Platoon commanders expressed requirements for the increased zoom in the urban environment in order to better monitor soldiers at the individual level.

Figure 6: Representation of a Base Map to Support Platoon Commanders During a Patrol Based Operation

4.5.4 Section Commander ISSP Dismounted Platoon Patrol Scenario

Section Commanders identified 34 required data types in the patrol scenario (Table 6). Six data types met the criteria for inclusion in the base map. These were: Raster Background Map, Own Location, Blue Force Tracking, Enemy Location, Breadcrumb Trail (Snail Trail), and Location of Previous Enemy Engagements. Figure 7 provides a representation of this base map.

Table 6: Section Commander Priority Data Types for the ISSP Dismounted Platoon Patrol

Data Type Category	Data Types	Group rating of Data Requirements	Overall rating for information accessibility
Tactical Digital Map	Raster Background Map	5	1
Situation Awareness	Own Location	5	1
Situation Awareness	Blue Force Tracking	5	1
Situation Awareness	Enemy Location	5	1
Situation Awareness	Breadcrumb Trail (Snail Trail)	5	1
Situation Awareness	Location of Previous Enemy Engagements	5	1
Tactical Digital Map	Distance Measurement (range bands, ruler)	5	2
Tactical Digital Map	Grid Reference / Different Coordinate Systems	5	2
Tactical Digital Map	Weapon Arcs of Fire	5	2
Environment	Environmental Features	5	2
Environment	Key Landmarks	5	2
Environment	Details of Underground, Underwater, sky (e.g., sewer system)	5	2
Reporting/ Messaging	Reports (e.g., SALUTE, Medevac, SITREP)	5	2
Display Images	Photographs - geotagged (e.g., recce of building)	5	2
Display Images	Video (location , viewing angle of video)	5	2
Target Designation	Manual Designation	5	2
Target Designation	LRF-Assisted Designation	5	2
Miscellaneous	Notepad	5	2
Miscellaneous	Labels	5	2
Tactical Digital Map	Compass	4	2
Display Images	Graphics (annotation layer)	4	2
Tactical Digital Map	Unit Icons	4	.
Environment	Weather	4	.
Reporting/ Messaging	Messaging (chat, email) Georeferenced	4	.
Navigation	Terrain Appreciation	4	.
Navigation	Current Heading	4	.
Navigation	Direction of Current Movement	4	.

Data Type Category	Data Types	Group rating of Data Requirements	Overall rating for information accessibility
Navigation	Bearing Tool to / from POI	4	.
Navigation	Planned Route	4	.
Tactical Digital Map	Tactical Graphics	3	.
Environment	Nature of Area	3	.
Environment	Terrain Type	3	.
Situation Awareness	Situation Projection	3	.
Navigation	Intervisibility Tool	3	.

Figure 7: Representation of a Base Map to Support Section Commanders During a Patrol Scenario

The eighteen data types identified as not required during the patrol scenario by Section Commanders are shown in the table below:

Table 7: Data Types Not Required by Section Commanders During a Patrol Operation

Tactical Digital Map	Vector Map
	Equipment Icons
	Irregular Warfare Symbols
	Effective Weapon Ranges
	Optimum Observation Point and Dead Ground Indicator
Environment	Contour Lines
	Vegetation Coverage (from seasonal information)
	Elevation
	Altitude
	Impact of Ambient Lighting on Terrain
Situation Awareness	Unknown Entity
	Neutral Entity
Navigation	Wayfinding Cues
Planning Tools	Route Planner
	Orders Template
	Time Appreciation Tool
	Combat Estimate Tool
	Mission Trace (operational plan)

4.6 Additional data types

Additional data types that were not part of the original list provided were suggested by the Platoon Commanders for both scenarios; these include,

- Live UAV feed
- Weather tracking and meteorological (MET) data (similar to that put out by environment Canada)
- All historical data of the AO (specifically war related, or anything that may require additional caution in working in the AO e.g., old mine fields)
- Danger areas
- Enemy weapon effects

4.7 Summary

In general, Platoon Commanders require access to more information than Section Commanders regardless of the scenario. Platoon Commanders wanted seven data types to be constantly present on a base map for both the attack and patrol scenarios and all other data types accessible via a one click access. Section Commanders required seven data types constantly present for the attack scenario and six constantly present on a base map for the patrol scenario. Section Commanders indicated 17 and 18 data types that were not required at all for the attack and patrol scenarios respectively.

4.7.1 The Base Map

In both scenarios the Platoon Commanders' base map included identical data types, except for the type of map imagery. For the attack scenario Platoon Commanders wanted a vector map, and for the patrol scenario a raster map. Based on observation during the workshop this difference is likely attributable to the environment in which these missions occur. Detail of the landscape is not required in a rural environment in the attack scenario, thus a vector map suffices. On the other hand, a raster image provides the high level of detail required and in urban operations increases situation awareness of critical features via pictorial and color representations of the area of operation. Note that the raster imager for the patrol scenario was a birds-eye view raster image, which was selected as the preferred image option by both Platoon Commanders and Section Commanders (see below). Note that the particular format employed is just one example of how raster image data may be displayed; other examples of raster type images include a top down satellite view, a street view, or various other angled birds-eye views.

Similar to the Platoon Commanders, the Section Commanders also requested a vector map during the rural attack and a raster map during the urban patrol. Two data types, own location, and enemy location were the only consistencies between scenarios for the Section Commanders.

In summary, the data types for a base map to support Platoon and Section Commanders across scenarios are shown Table 8. The base map is proposed as a primary composite overlay that provides the user with the essential information that is always required during the mission.

Table 8: Data Types for Base Maps for Platoon and Section Commanders

Platoon Commander (attack and patrol)	Section Commander (attack)	Section Commander (patrol)
Vector Map or Raster Map	Vector Map	Raster Background Map
Grid Reference / Different Coordinate Systems	Grid Reference / Different Coordinate Systems	Own Location
Key Landmarks	Compass	Blue Force Tracking
Contour Lines	Own Location	Enemy Location
Own Location	Enemy Location	Breadcrumb Trail (Snail Trail)
Blue Force Tracking	Current Heading	Location of Previous Enemy Engagements
Enemy Location	Direction of Current Movement,	

4.7.2 Optional overlays

From the large number of data types that met the criteria for inclusion in an optional overlay, additional filtering was conducted in order to segregate the data types into three categories. This was done in order to limit the amount of information in an optional selection to a level that would be informative but not overwhelming,

The groupings of the data types into three optional composite overlays were based upon the following criteria. SME data requirement ratings were first organized by value, then the overall information accessibility ratings were considered. All data types given a data requirement rating of 5 and an information accessibility rating of 2 were grouped into a secondary composite overlay (Table 9). Likewise, data types with a rating of 4 were grouped into tertiary composite overlay (Table 10), and data types with a rating of 3 were grouped into a quaternary composite overlay (Table 11). It is noted that not all these data types were given an information accessibility rating by Section Commanders. In these cases, the data requirements were still considered important based on a requirement rating of 3 or 4. The remaining data types not required by the Section Commanders can be found in Table 12.

Table 9: Secondary composite overlay (Importance rating of 5 & Accessibility requirement 2).

SIREQ Attack : Platoon Commander	ISSP Patrol & Assault: Platoon Commander
Environmental Features	Compass
	Details of Underground, Underwater, sky (e.g., sewer system)
	Effective Weapon Ranges
	Intervisibility Tool
	LRF-Assisted Designation
	Manual Designation
	Orders Template
	Planned Route
	Reports (e.g., SALUTE, Medevac, SITREP)
	Route Planner
	Vector Map
SIREQ Attack : Section Commander	**ISSP Patrol & Assault: Section Commander**
Blue Force Tracking	**Details of Underground, Underwater, sky (e.g., sewer system)**
Contour Lines	**Distance Measurement (range bands, ruler)**
Details of Underground, Underwater, sky (e.g., sewer system)	**Environmental Features**
Distance Measurement (range bands, ruler)	Grid Reference / Different Coordinate Systems

Elevation	**Key Landmarks**
Environmental Features	**Labels**
Graphics (annotation layer)	**LRF-Assisted Designation**
Key Landmarks	**Manual Designation**
Labels	**Notepad**
Location of Previous Enemy Engagements	**Photographs - geotagged (e.g., recce of building)**
LRF-Assisted Designation	**Reports (e.g., SALUTE, Medevac, SITREP)**
Manual Designation	**Video (location , viewing angle of video)**
Nature of Area	Weapon Arcs of Fire
Notepad	
Photographs - geotagged (e.g., recce of building)	
Planned Route	
Raster Background Map	
Reports (e.g., SALUTE, Medevac, SITREP)	
Terrain Appreciation	
Terrain Type	
Video (location , viewing angle of video)	

Bold font indicates data types that were given the same evaluation (importance rating and accessibility requirement) in both scenarios.

Table 10: Tertiary composite overlay (Importance rating of 4 & Accessibility requirement 2 or not rated)

SIREQ Attack : Platoon Commander	*ISSP Patrol & Assault: Platoon Commander*
Bearing Tool to / from POI	***Breadcrumb Trail (Snail Trail)***
Breadcrumb Trail (Snail Trail)	***Current Heading***
Combat Estimate Tool	***Direction of Current Movement***
Compass	***Distance Measurement (range bands, ruler)***
Current Heading	*Environmental Features*
Direction of Current Movement	*Equipment Icons*
Distance Measurement (range bands, ruler)	***Graphics (annotation layer)***
Elevation	***Labels***

Graphics (annotation layer)	***Location of Previous Enemy Engagements***
Intervisibility Tool	*Messaging (chat, email) Georeferenced*
Labels	***Neutral Entity***
Location of Previous Enemy Engagements	***Notepad***
LRF-Assisted Designation	***Optimum Observation Point and Dead Ground Indicator***
Manual Designation	***Photographs - geotagged (e.g., recce of building)***
Mission Trace (operational plan)	***Tactical Graphics***
Nature of Area	***Terrain Appreciation***
Neutral Entity	***Unit Icons***
Notepad	***Unknown Entity***
Optimum Observation Point and Dead Ground Indicator	***Vegetation Coverage (from seasonal information)***
Photographs - geotagged (e.g., recce of building)	***Video (location , viewing angle of video)***
Planned Route	***Weapon Arcs of Fire***
Raster Background Map	
Route Planner	
Situation Projection	
Tactical Graphics	
Terrain Appreciation	
Terrain Type	
Time Appreciation Tool	
Unit Icons	
Unknown Entity	
Vegetation Coverage (from seasonal information)	
Video (location , viewing angle of video)	
Wayfinding Cues	
Weapon Arcs of Fire	
SIREQ Attack : Section Commander	***ISSP Patrol & Assault: Section Commander***
Breadcrumb Trail (Snail Trail)	*Bearing Tool to / from POI*

Wayfinding Cues	*Compass*
	Current Heading
	Direction of Current Movement
	Graphics (annotation layer)
	Messaging (chat, email) Georeferenced
	Planned Route
	Terrain Appreciation
	Unit Icons
	Weather

Bold font indicates data types that were given the same evaluation (importance rating and accessibility requirement) in both scenarios.

Table 11: Quaternary overlay grouping (Importance rating of 3 & Accessibility requirement 2 or not rated)

SIREQ Attack : Platoon Commander	ISSP Patrol & Assault: Platoon Commander
Altitude	**Altitude**
Details of Underground, Underwater, sky (e.g., sewer system)	Bearing Tool to / from POI
Effective Weapon Ranges	Combat Estimate Tool
Equipment Icons	Elevation
Impact of Ambient Lighting on Terrain	**Impact of Ambient Lighting on Terrain**
Irregular Warfare Symbols	**Irregular Warfare Symbols**
Messaging (chat, email) Georeferenced	Mission Trace (operational plan)
Orders Template	Nature of Area
Reports (e.g., SALUTE, Medevac, SITREP)	Situation Projection
Weather	Terrain Type
	Time Appreciation Tool
	Wayfinding Cues
	Weather

SIREQ Attack : Section Commander	ISSP Patrol & Assault: Section Commander
Bearing Tool to / from POI	Nature of Area
Effective Weapon Ranges	**Situation Projection**
Situation Projection	Tactical Graphics
Weapon Arcs of Fire	Terrain Type
Weather	Altitude

Bold font indicates data types that were given the same evaluation (importance rating and accessibility requirement) in both scenarios.

Table 12: Summary of Data Types Not Required by Section Commanders by Scenario

Data Type Category	Data types not required by Section Commanders during a patrol based scenario	Data types not required by Section Commanders during an attack based scenario
Tactical Digital Map	na	Tactical Graphics
	Vector Map	na
	na	Unit Icons
	Equipment Icons	Equipment Icons
	Irregular Warfare Symbols	Irregular Warfare Symbols
	Effective Weapon Ranges	na
	Optimum Observation Point and Dead Ground Indicator	Optimum Observation Point and Dead Ground Indicator
Environment	Contour Lines	na
	Vegetation Coverage (from seasonal information)	Vegetation Coverage (from seasonal information)
	Elevation	na
	Altitude	Altitude
	Impact of Ambient Lighting on Terrain	Impact of Ambient Lighting on Terrain
Situation Awareness	Unknown Entity	Unknown Entity
	Neutral Entity	Neutral Entity
Reporting/ Messaging	na	Messaging (chat, email) Georeferenced
Planning Tools	Route Planner	Route Planner

Data Type Category	Data types not required by Section Commanders during a patrol based scenario	Data types not required by Section Commanders during an attack based scenario
	Orders Template	Orders Template
	Time Appreciation Tool	Time Appreciation Tool
	Combat Estimate Tool	Combat Estimate Tool
	Mission Trace (operational plan)	Mission Trace (operational plan)
Navigation	Wayfinding Cues	na
	na	Intervisibility Tool

Section Commanders had a total of 13 data type requirements that were not needed in either scenario, as demonstrated in the table above.

It should be noted that the Section Commanders discussed the data requirements taking into account the typical base map that they are used to seeing in operations. Keeping this in mind, some data elements that were excluded based on the ratings (i.e., tactical graphics, contour lines, unit icons) may in fact be more important than initially recognized by the participants who role played the Section Commanders.

Additional data types suggested during the workshop, such as live UAV feed, MET data, historical data, danger areas, and enemy weapon effects, have not been included in the suggested composite overlays pending appropriate validation.

Differences in the amount and type of information required by the Platoon Commanders versus the Section Commanders may reflect the difference in responsibility between dismounted Platoon and Section Commanders, and supports our initial approach to separate the participant groups based on the two types of command.

It should be noted that given the small sample size of SMEs participating in the workshop the results and recommendation should be regarded as preliminary and subject to more rigorous future validation. Further, another caution concerning the small sample size is the possibility that one person may have influenced the group ratings.

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5. Functionality for Accessing Overlays

5.1 Goals

The purpose of this section is to discuss methods by which operationally relevant overlays could be accessed on a mobile GIS by dismounted infantry commanders. The analysis does not extend to a review of existing tools and technology in commercially available devices (see Rehak, McKee, Matthews, 2010), nor does it look at the physical requirements for accessing the display (e.g., size and location of touch area, use of stylus). Instead, we concentrate on the issue of how the required overlay information could be organized for rapid access under changing mission phases.

5.2 Assumptions

1. The required information is grouped into composite overlays comprising a base set (base map) and options for augmenting the base map with additional overlays containing information only relevant to different mission contexts, or commander information requirements.
2. The results of the analysis in Section 4 show that in addition to a base map, there are **three** categories of optional information as determined by user ratings of importance and the criteria used for inclusion.
3. Each optional composite overlay needs to be independently turned on and off.
4. Given the variance among the types of optional information required for different missions, mission phases and commanders (as outlined in Section 4), it is expected that a capability will exist in a fielded system that will allow for customizable pre-configuration of the contents of each optional composite overlay. Such functionality falls outside of the scope of the present project, and the approach to implementing such will require future analysis of options.
5. Our recommendations assume that the user is on the "map page" and is ready to use the base map and overlays. Considerations for the higher level system Operator Machine Interface (OMI) that enables the user to select the base map are out of scope for this project. That is, we are not responsible for designing the generic OMI in which the overlay selection resides.
6. The user needs rapid and unambiguous access to the optional composite overlay information. This requirement means that certain interface options are not suitable as follows:
    - hierarchical menu: requires too many steps; requires too much visual and cognitive processing
    - drag and drop: since the user will likely be using drag operations to pan and scroll the screen, using a similar functionality for accessing overlays could result in errors and increased workload. To differentiate the mode for accessing the overlays from pan/scrolling actions, it would be possible to require a two finger approach for the former. This possibility should be empirically investigated, especially

under high tempo situations to ensure that each mode can be accurately performed without errors of commission. Further, the ability of operators to use this mode with gloved hands may present some ergonomic challenges and should be investigated.

7. The "design space" for the "access function" assumes that the user is displaying the base map and that the means of selecting optional composite overlays must be available on the display.
8. The requirement for rapid access to the overlay information can be best met by some form of "rapid access buttons" that are associated with a discrete touch areas on the display screen.

5.3 Options for representation and access

In considering options for access, the following factors have been considered

- Number of steps required
- Potential for error
- Semantic representation
- Learnability
- Population stereotypes

5.3.1 Representation

Each of the options described below assumes that the base map required for a mission will always be displayed and that there will be three separately selectable composite overlays that are accessed through touch areas or "buttons." For each area, there is a need to represent:

1. the semantic information (a means of describing the layer properties),
2. the interface widget that allows selection,
3. the state of selection, that is on or off
4. the functionality of the selection and information content

5.3.2 Semantic Information

Semantic information provides the user with knowledge as to the data types within an overlay. In the present case, we have seen that the actual data types selected by the SMEs vary widely across mission types, phases and commanders. Because of this variability, there is no simple aggregation label that will describe the overlay contents uniquely, for example, "environmental" or "weather." This means that the semantic information cannot easily be represented by a meaningful descriptive label.

Options that could be considered for the semantic representation are color, location on the display, icons and text.

We do not recommend color coding as an option in this context, since there are no "natural" relationships or pre-existing population stereotypes for this type of semantic information. Further,

one would want to avoid using colors that are already coded for different information types, as MIL-STD1472F. This would mean coming up with a color set that is unique, in which the alternate selections are clearly distinguishable under all lighting conditions, are easily learned and remembered with accuracy under adverse battle conditions. Given the difficulty in ensuring that such criteria can be met, we would recommend against the use of color in this regard.

Location would therefore appear to be a better option. It has the advantage that once the user has learned the configuration and, if the access "buttons" are well separated in position on the display, then the different overlays may be accessed without the user having to actually look at the display. However, given that the point of accessing the overlay is to get the information, for which the operator has to look at the display anyway, this seeming advantage on non-visual access may be irrelevant. Further, it must be considered that when the wider functionality of the display as a whole is considered, having dedicated input areas for the overlay function may constrain other requirements for display interaction with other functions. In addition, it may be the case that the user would change the orientation of the device under some circumstances, thus the remembered, dedicated location would not be in the expected location.

This leaves the option of *text* or *iconic* representation of the information content of the overlay. Since there are no existing standards or guidelines for a mobile GIS for this type of operation using either a text or graphic label, we recommend that the appropriate method for conveying the semantic information *be evaluated experimentally in future work*.

While a descriptive text label could be used for the three additional composite overlays, because the content of each overlay may vary according to who is using the display and the operational circumstances, no simple, single text descriptor can capture this diversity. Therefore, as an *interim* working solution, we recommend that the three overlay selection options be labeled numerically **"1", "2", "3**" which corresponds semantically with the importance rating provided by the SMEs.

5.3.3 Touch area size

The size of the touch area for accessing an overlay will be dependent upon a number of physical considerations that are beyond the scope of this project and will be guided by defined military standards for gloved use and other operationally relevant variables.

5.3.4 Touch area shape

The two most commonly used shapes are circle and square. A square that has the same length side as the equivalent diameter of a circle but, provides a slightly greater receptive touch area. Therefore, for working purposes we propose that the selection area shape be square.

5.3.5 Selection status

For representing the state of the selection, several options are possible. The first is not to represent selection state at all, leaving the user to recognize by the actual content of the displayed map, which additional composite overlays are currently being displayed. This option would seem to place an unnecessary cognitive burden on a commander under already stressful and cognitively demanding operational conditions. Therefore, we recommend that this option not be adopted but alternate methods be considered of conveying the state of selection that is less mentally demanding.

Several graphical options are available for representing a selection status, including the following, for example (assuming that there will be either a circular or square soft button).

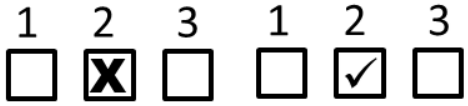

Figure 8: Overlay Selection Interface: Empty Versus Checked (two options shown)

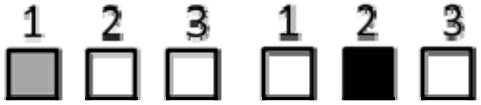

Figure 9: Overlay Selection Interface: Empty Versus Checked (two options shown)

We would recommend against using "3D" representations that attempt to show a "depressed" button state, since the graphical rendition of this will not only be difficult to implement in a small display area and may also result in some ambiguity and a longer time for the operator to mentally process the state.

However, the disadvantage of the above options shown in Figure 8 and Figure 9 is that extra space on the screen is required for the numeric labels. If this is a concern an alternate approach is to contain the label within the selection button, as shown below: (note the color selected for the "selected state" is for illustration only). However, it should be recognized that operators probably do not have learned stereotypes for which state of contrast represents which state of selection. Therefore, it is likely that there would be some initial ambiguity concerning which option is selected until the contrast mapping had been learned through training and usage.

Figure 10: Overlay Selection Interface: Colour Select State

There are two competing options for representing the background color in either state of selection. If it is opaque the background color for the unselected state will insure that the number within the box remains discriminable from any of the underlying map elements. This has the disadvantage that it could obscure critical map features beneath the selection area. The other approach is to use a transparent (as in the Land Warrior OMI), or semi-transparent background that retains a "see through" capability for the map, but runs the risk that the semantic information for the selection button is less discriminable. In addition, there is a possibility that under some circumstances the button label could be confused with underlying map data.

This design approach means that the selected state would have to be rendered with a suitable background to allow reverse contrast of the text. Two disadvantages of this approach are (i) when the user is making a selection choice, the finger occludes the semantic label and (ii) there is no population stereotype which corresponds to whether positive or negative contrast indicates the "selected" or "on" state. For example, can we be sure that the user will interpret in the above example that "2" is selected, and that "1" and "2" are de-selected. The counter-argument to the first objection is that the user can still see the labels for the other section areas, so the user knows by elimination which overlay is being selected. Again, we suggest that the final decision concerning the specific selection mode be based upon a future user trial in a scenario simulation, although the final option presented above seems to offer the most promising approach.

5.3.6 Location on the screen of selection buttons

This will depend to a great degree on the overall OMI design and where other interactive menus and selections are placed. In general, no matter the placement, the long axis of the selection area should be aligned with the orientation of the closest edge of the display to avoid greater intrusion of the buttons into the more central areas of the map.

Some options with advantages and disadvantages are outlined below:

- Place at top: recommended location for important information, but user's hand could occlude map during selection
- Place at left or right edge: minimizes obscuring map data in central area of display but left accessing buttons on left hand edge may obscure the display for right handed users
- Place at bottom: disadvantage is that user may position map to be "route up" so that the user's current position is always at bottom and may be obscured by buttons – unless they were located left or right of center
- Position off the map: there is no chance that the buttons will obscure map or be confused with map entities, but requires extra area on display and reduces amount of map data that can be displayed
- Allow user to reposition as required (e.g., dragging buttons to preferred location): allows user to match location to current information needs for the map, but lack of consistency in location could lead to some confusion under stressful and quick response field conditions.

In the absence of any contextual information about constraints that may be imposed by the device overall OMI, we recommend that user-reposition option be implemented as a first and evaluated under appropriate operational conditions, real or simulated.

5.3.7 Graphic Examples of input options

The following figure shows some options for the representation and positioning of input buttons with some comments. The actual sizes and location of the input buttons are for illustrative purposes only and do not necessarily represent the final design.

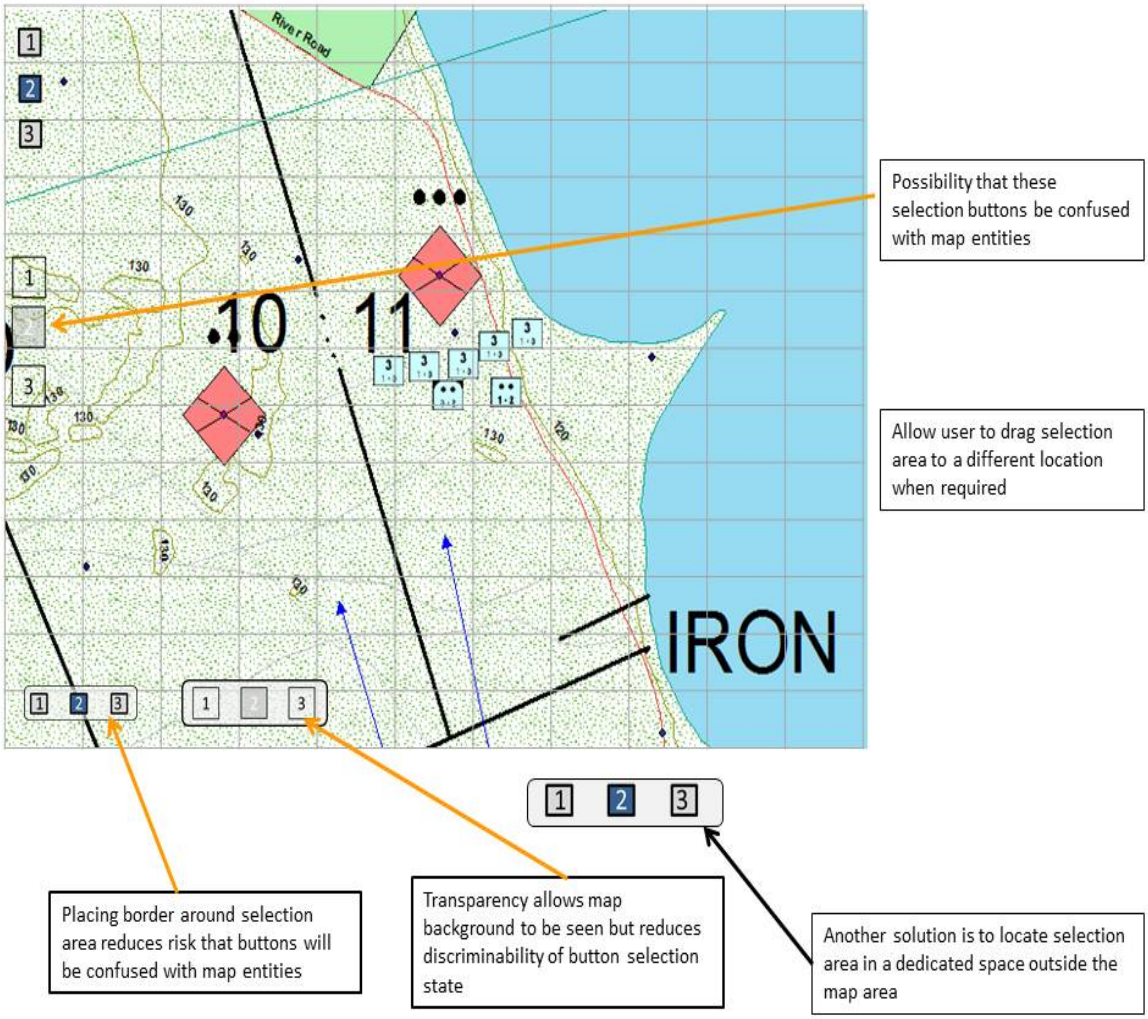

Figure 11: Examples of Overlay Selection Buttons

6. Discussion

The goals of this project were to critically evaluate the currently available overlay data and tools for their suitability for use on mobile devices in a military setting; and develop and evaluate composite overlays that would support current and proposed tasks carried out by dismounted soldiers using GIS software on mobile electronic devices. The scope was limited to the potential use of a mobile GIS by dismounted infantry commanders at the Platoon and Section level and their needs for mission execution rather than initial mission planning.

Forty-nine (49) fundamental data types, which were validated by a panel of SMEs, were deemed necessary for the dismounted infantry soldier to carry out infantry tasks. Based on a trade study of several COTS products, a list of GIS functionality was also identified as having potential for being incorporated into overlays.

Based on the SME review of the fundamental data types, a series of composite overlays was conceived to support Platoon and Section Commanders during dismounted infantry operations. These composite overlays were further differentiated as primary (base map) or optional overlays based on the data requirement ratings and accessibility ratings of the data types (see Section 4.7 for details).

For Platoon Commanders, the only variability in data type identified on the primary composite overlay (base map) was the vector map or raster background map. A vector map was preferred for the attack scenario, which took place in a temperate wooded environment, verses a raster background map for the dismounted patrol scenario which was set in a more densely populated urban environment. That is, the participants did not require very fine detail of the wooded environment. Conversely, the patrol scenario occurred in a more densely populated urban environment, therefore participants required a more detailed image (raster background map) of the buildings and roadways. To accommodate for this single variability on the base map, it is suggested that an option to toggle the image from vector to raster be provided for the primary composite overlay. Similar functionality can be found on many COTS software, such as Google Maps, where the overlay can be toggled from a vector map ("Map") to a raster map ("Satellite") with a single on-screen 'click'.

In contrast, results from the Section Commanders indicated that there was large variability in the data types required on the primary composite overlay (base map) between the two scenarios (see Table 8). Similar to the Platoon Commanders, Section Commanders also preferred a vector map for the attack scenario and a raster background map for the dismounted patrol scenario.

In terms of the secondary composite overlays (additional composite overlays), three sub-sets of overlay groupings of relative importance were specified by both Platoon and Section Commanders. Results, however, showed that there was large variability in the data types required between the two scenarios for both Commander levels. One of two approaches is therefore suggested to allow for the organization of these data types into tactically relevant products;

1. As outlined in the results section, the data types that comprise the secondary composite overlays (additional composite overlays) could be organized based on similarity of the ratings for importance and accessibility requirement in both scenarios (i.e., as represented in bold face font in the summary tables in Annex G). This approach, however, has disadvantages as selection of only the common data types (bold face font) and exclusion of

the others may not be appropriate for all scenarios as the data types were mission and context dependent.

2. Alternatively and preferably, configuration of the data types should be customizable prior to stepping off on a mission. Depending on the mission and personal preference, Platoon Commanders would pre-select the relevant data types to be included in each of the three secondary composite overlays. Once configured, these additional composite overlays would be readily accessible through a "one-click" access from the primary screen as discussed in Section 5.

Future studies should validate the feasibility of these two approaches as the findings from this effort were inconclusive.

7. Recommendations for Future Work

7.1 Validation

The primary limitation in the current work is the small sample size involved in generating the data requirements. Therefore, future validation should be conducted prior to the current recommendations being accepted as definitive requirements for an operational mobile GIS. Further, the additional data type requirements that emerged during the SME workshop, and were not part of the original set that was rated, should also be validated by other SMEs.

In addition, time was not available during the SME workshop for participants to indicate which data sub-types (Unit Icon, Equipment Icon, Irregular Warfare, and Environmental Feature) would be required by the dismounted infantry commander (Platoon or Section) for a mobile GIS. It is recommended that future studies be conducted so that SMEs can review and validate these data sub-types.

In general, we recommend that validation proceed with a laboratory based, high resolution scenario in which infantry commanders proceed in real time through a simulated operation using a prototype mobile GIS device to preselect and call-up additional composite overlays. Metrics on utility (does the device provide the correct information) and usability (does the device allow for rapid and accurate access) should be collected under a high information demand context that is potentially stressful and occasionally high tempo.

7.2 Base map format

Note that within the SME workshop, one optional display format for the base map was bird's eye view raster image. This turned out to be the preferred format for both Platoon Commanders and Section Commanders (as opposed to the vector map). The format of this raster image was a "bird's-eye ¾ perspective view." Since this is only one mode by which a raster image data type may be configured, it is important that the appropriate representation of this raster image should be examined in future research. For optimum validity this evaluation should be done by SMEs on the appropriate mobile device in a laboratory or field setting.

7.3 Data elements comprising the composite overlays

The selection of which data elements should be assigned to three optional overlays was based solely on the ratings provided. No consideration was given as to whether 3 was the correct number or whether 2 or 4 would be better. Thus, this categorization was based upon utility (what information was perceived to be needed) and not usability (could the information selected be usefully accessed). It is possible that the suggested groupings contain too many data elements which may lead to more "noise" on the map than is desirable for rapid information extraction. Thus, there is a possible trade-off between the number of elements within the additional composite overlays and the number of composite overlay options. Fewer options provide more information at a selection, but possibly compromise the ability to find, extract and interpret information. More overlays with fewer data elements reduce the potential for "noise" but at the same time could create additional workload by the need for more activity in selecting/deselecting the pages.

Therefore, we suggest that an experimental investigation be conducted to determine the optimal balance between data content of the overlays and the number of overlays that are selectable.

7.4 Implementation of optional composite overlays

Two approaches to the implementation of the optional composite overlays are possible. First, the data types could be grouped in the manner we have documented in this report, based upon ratings of importance. These could then be selected on or off as a mission proceeds and circumstances demand. This further assumes that the actual final selection of the data types for the three categories would be done in the field prior to operation zero hour. A second approach would be to have commanders in the field select data groupings into composite overlays based upon the planned phases of the battle. Thus, there could be a grouping of data that would be pre-configured, for example, for “advance to contact” etc. This would ensure that the appropriate data is always available at the right phase of the mission and ensure that all of the individual commanders have the same information. However, the downside of such an approach is that it allows no flexibility in the field for unexpected events that may require different information to be available than has been pre-configured. The more flexible arrangement of option 1 would allow such information to be drawn in as required, at the cost that not all commanders may actually do this when it is appropriate.

These two options provide a basis for some scenario focused future research.

7.5 Detailed interface design for overlay selection

We have presented in Section 5 some broad indications as to how commanders in the field could access optional overlay information. However, these recommendations need to be considered in the wider context of the overall mobile GIS OMI as well as other human factors issues. Some of these issues include implementation of appropriate human factors guidelines once the final device hardware options have been constrained, considerations for gloved use, design for day and night use and other ambient illumination situations, and general usability of the interface by an individual who is moving over terrain and must be situationally aware while at the same time consulting the map information.

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Annex A: Data Type Definitions

The following definition of Data Types were provided to and reviewed with the participants at the beginning of the SME Workshop.

Item No.	Data Type Category	Data Types	Descriptions / Definitions
1	**Tactical Digital Map**	Vector Map	Similar to Google Maps "map" view. Different geographical features are expressed by different types of geometry: Points (e.g., single point reference such as features of interest, peaks), Lines or polylines (e.g., linear features such as rivers, roads, railroads, trails), Polygons (e.g., lakes, city and provincial boundaries, buildings)
2		Raster Background Map	Similar to Google Maps "satellite" view. Any type of digital image such as an aerial photo, satellite image
3		Distance Measurement (range bands, ruler)	Used to calculate distances between points
4		Grid Reference / Different Coordinate Systems	Display own grid and grid at cursor (e.g., MGRS or Latitude and Longitude lines)
5		Compass	Traditional (cardinal points or mils) / rolling compass, or arrow directing soldier to points of interest (i.e., target, waypoint). Including reference to declination, reference from true north to magnetic north, and age of map.
6		Tactical Graphics	Icon based images representing common warfighting symbology Tactical Graphics (e.g., POI, AOO), Unit Icons (e.g., Air Assault, Outpost), Equipment Icons (e.g., Air Defence Missile Launcher, Intermediate Range Air Defense Missile Launcher), Irregular Warfare (e.g., Arson/Fire, Artillery/Artillery Fire)
7		Weapon Arcs of Fire	Effective arcs of fire from a given location based on weapon, terrain and foliage
8		Effective Weapon Ranges	Range fire fans based on the weapon, terrain, and foliage (direct fire support weapons)
9		Optimum Observation Point and Dead Ground Indicator	Areas in the environment where the enemy cannot be attacked by defenders or may be used for concealment
10	**Environment**	Environmental Features	Aspects such as roadways, black track, waterways, sewers, and vegetation
11		Key Landmarks	Features such as civilian buildings, radio towers
12		Weather	Past, current, future weather or dynamic weather pattern displayed over the area of interest

Item No.	Data Type Category	Data Types	Descriptions / Definitions
13		Nature of Area	Urban, forest, desert, arctic
14		Terrain Type	Rock, sand, snow
15		Contour Lines	Topographical lines representing elevation
16		Vegetation Coverage (from seasonal information)	Displays expected thickness and location of vegitation
17		Elevation	Spot elevation data such as Canadian digital elevation data; American digital terrain elevation data
18		Altitude	Display altitude
19		Impact of Ambient Lighting on Terrain	Display expected shadow areas according to a selected time of day
20		Details of Underground, Underwater, sky (e.g., sewer system)	e.g., details of sewer systems, mines
21	**Situation Awareness**	Own Location	Your location is indicated on the digital map (i.e., knowing where you are)
22		Blue Force Tracking	Knowing where 'friendlies' are (i.e., knowing where your buddies are)
23		Enemy Location	Knowing where your enemies are
24		Unknown Entity	Knowing the location of unidentified entities
25		Neutral Entity	Knowing the location of neutral entities
26		Breadcrumb trail	History of route taken
27		Situation Projection	Future "tactical picture"
28		Location of Previous Enemy Engagements	E.g., IED, fire fights
29	**Reporting/ Messaging**	Reports (e.g., SALUTE, Medevac, SITREP)	Geo-referenced reports represented on the map as an icon and called up when required
30		Messaging (chat, email) Georeferenced	Geo-referenced messages represented on the map as an icon and called up when required
31	**Navigation**	Terrain Appreciation	Assess the type of terrain, foliage, cover etc. (e.g., if an area is swamp in the spring, then the trace will indicate that heavy vehicles will not be able to traverse that particular terrain).

Item No.	Data Type Category	Data Types	Descriptions / Definitions
32		Intervisibility Tool	Tool to indicate what area of terrain can see a specific location or a route (i.e., capacity to determine and display a full 360 degrees Line of Sight assessment from a selected point or series of points on a map).
33		Wayfinding Cues	Key points on the map representing navigation route
34		Current Heading	Direction soldier is facing
35		Direction of Current Movement	Direction soldier is moving
36		Bearing Tool to / from POI	
37		Planned Route	Navigation course
38	**Planning Tools**	Route Planner	Geo-referenced tool represented on the map as an icon and called up when required. Supports planning a navigation course
39		Orders Template	Geo-referenced tool represented on the map as an icon and called up when required. Supports giving orders
40		Time Appreciation Tool	Geo-referenced tool represented on the map as an icon and called up when required. Supports time appreciation estimates (e.g., time to execute tasks)
41		Combat Estimate Tool	Geo-referenced tool represented on the map as an icon and called up when required. Supports the development of a combat estimate (e.g., evaluate own team, assets, strengths, numbers etc.)
42		Mission Trace (operational plan)	Overlay of the intended mission
43	**Display Images**	Photographs - geo-tagged (e.g., recce of building)	Geo-referenced picture represented on the map as an icon and called up when required. Similar function to Google Maps
44		Video (location , viewing angle of video)	Geo-referenced video represented on the map as an icon and called up when required.
45		Graphics (annotation layer)	Annotate the map using hand drawings
46	**Target Designation**	Manual Designation	Pointing on the map to designate an entity
47		LRF-Assisted Designation	Entity is designated via a laser range finder and the location is plotted on the map as an icon
48	**Miscellaneous**	Notepad	Annotate the map using text (e.g., post it note)
49		Labels	e.g., road names, cities, rivers

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Annex B: Scenario

The following two scenarios were used during the SME workshop to set the stage for and provide a narrative for the concept of operations for a mobile GIS system for the dismounted infantry soldier. An attack scenario was developed based on a modified attack vignette that was created for the Soldier Information Requirements Technology Demonstration Project (SIREQ-TDP). A patrol scenario was developed based on a modified dismounted infantry patrol that was created for the Integrated Soldier System Project (ISSP).

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SIREQ Attack Scenario

Mission Brief	
SITUATION	2 Canadian Mechanized Brigade Group (CMBG) has secured the Mattawa Airstrip and two plains (Gust and Jorgens) through a combined water and air assault. Defence of the airfeld is being provided by 3 RCR with elements of the Royal Canadian Dragoons. 1 RCR Battle Group has been tasked to clear the remainder of the Mattawa Plain (MP) in order to support the Brigade assault on objective PEACH.
EN Forces	Strength – Isolated pockets of EN up to section strength throughout MP and up to Coy strength along TransCanada Hwy. Location – Known EN concentrations centered at GR 181951, possible EN OP at GR 197933
FRIENDLY Forces	1 RCR is tasked with clearing the majority of the MP in order to support the Brigade assault on objective PEACH. 1 RCR to advance two Coy up, A Coy left forward, D Coy right forward, 11 Pl right forward, 12 Pl reserve.
	Outline of D Coy plan: D Coy will clear dismounted east half of MP with 2 Pls up and 1 in reserve. 10 Pl left, 11 Pl right, 12 Pl in reserve. D Coy will then secure LD for Brigade attack on obj PEACH. Outline of 11 Pl plan: 11 Pl to advance two sections up, 1 Section left, 2 Section right, 3 Section depth.
MISSION	2 Sect will clear east half of Pl trace within boundaries
EXECUTION	(1) Phase One – Participate in forward passage of lines through 3 RCR to phase line IRON (2) Phase Two – Advance to contact (3) Phase Three – Secure Line of Departure (LD) as part of D Coy plan

Event #	Event
1.	Move to Attack Position: D Coy 1RCR links up with 3RCR to guide the company to the AP. In the AP, 11 Pl shakes out into its advance to contact formation. 1 Section (LEFT fwd) and 2 Section (RIGHT fwd) shake out into extended line formation.
2.	Advance to Contact: 2 Section shakes out into the extended line formation: 1 Aslt Gp left, 2 Aslt Gp right and crosses the LD at H hour. Sect Comd christens the ground to indicate reference points (tree, burnt out vehicle, berm) and verbally identifies possible enemy positions. Positive control is maintained by Coy HQ to ensure 10 Pl and 11 Pl advance together.
3.	React to Effective EN Fire: The section is "bumped" and encounters effective EN fire, all members of the rifle section react. Section Comd reports "Contact wait out". Section members continue to observe enemy, return fire, move to new fire positions. They avoid bunching and pass information quickly and accurately.
4.	Locate EN: Speculative fire and changing fire positions are used to locate the EN. Sect Comd verbally requests members to indicate EN position. An isolated EN trench is located and EN strength is estimated. The Sect Comd radios a CONTACTREP to Pl Comd.
5.	Win the Fire Fight: The Sect Comd gives a fire control order (GRIT). The Sect Comd performs a hasty combat estimate and develops a plan. A SITREP is radioed up, and the Pl Comd confirms plans to destroy the enemy allowing the Coy advance to continue. The Sect Comd verbally issues orders. The plan is for a right flanking with fire support from the 2 i/c and Aslt Gp 2.
6.	Approach: Section 2 i/c and Aslt Gp 2 will act as the fire base while the remainder of Aslt Gp 1 moves off to the right flank to begin their approach. The Pl Comd adds his C6 to support the section fire base. Section Comd of Aslt Gr 1. approaches to grenade range of the enemy.

Event #	Event
7.	Assault: The aim is to destroy or capture the EN. Maintaining momentum, maximum fire is brought on the EN position by the fire base while the assault group prepares frag grenades or M72s. Fire teams rush the objective, one member assaults under the covering fire of his partner. Fire support base shifts fire to the rear of the EN position, cutting off any EN retreat and clears the EN trench. One casualty is suffered. A prisoner is disarmed and kept under guard. As the attack progresses, 11 Pl Comd positions his Platoon to continue the larger task and rejoin the advance.
8.	Consolidation: Following the assault, consolidation (ammo re-distribution, PW handling, administering first aid). The position is secure and Pl Comd rejoins the advance and leap-frogs 3rd section to take fwd position. 2 Section now becomes depth.

ISSP Dismounted Platoon Patrol Scenario

Mission Brief	
SITUATION	The purpose of the operation is to step up on going efforts by Coalition Forces to stop the flow of drugs and drug money used to acquire and transport IED making material by destroying or capturing them before they can be used against Coalition Soldiers. Task Force (TF) 1 Commander is focusing his resources on the intelligence gathering required to identify targets and generate Civil Military Cooperation (CIMIC) opportunities. This intelligence will allow him to select the best time and location to engage insurgents to deny them sources of supply and income required to assemble and deploy IEDs. Once identified, potential targets must be tracked and monitored until sufficient information is available to warrant offensive action. TF 1 is now engaged in an aggressive **presence patrol** program reaching all corners of the Area of Operations (AO)
MISSION	1 Platoon (Pl) will conduct a dismounted patrol sweep of DUMOINE in order to provide a presence in the area and confirm Friendly HUMINT source BUGLE is still present
EXECUTION	1 Pl will insert via helo at LZ COUGAR and insert by foot moving on SNAKE to DUMOINE. You will conduct a dismounted patrol sweep along route SNAKE and make contact with local Zefra National Police (ZNP). You will also locate HUMINT source BUGLE and gather intel. If any drugs, wpns, or IED caches are found they will be photographed and the items documented before being destroyed in place. Report lines: RAPIDS and WATERFALL. PZ is at TIGER (grid 1234 5678). Order of march is 11A left, 11B right, Pl Comd, Wpns Det, with G11, followed by Engr Sect left rear and 11C right rear.

Event #	Event
1.	Pl Move 1: Pl shakes out and commences movement on SNAKE from COUGAR to DUMOINE. Pl arrives at village edge
2.	11A Contact: SITREP 11A has made contact with local ZNP reps. CIMIC with interpreter are now having discussions. Indications are that there is no insurgents in the area as far as the ZNP are aware
3.	Mark Building: ZNP house (house no. 4) is marked as cleared with green electronic chem. light
4.	Pl Move 2: Pl continues sweep along SNAKE. At RAPIDS Pl Comd sends SITREP that a small market is set up in the main street.
5.	Sniper Engagement: Sniper engages CS 11 A. M203 gunner in Assault Group 1 of Sect is hit and seriously wounded (identified as Wounded in Action – WIA#1)
6.	Mark Sniper Location: 1 Sect Comd confirms sniper location (house no. 19) to all with Red NATO symbol. Sect 2 i/c with 1 other attempts to get wounded member under cover to administer First Aid but sniper prevents this. Sect is engaging
7.	Mark WIA #1: Sect 2i/c marks down man as a casualty (WIA #1) on BMS for Medics
8.	3 Sect Flank: Pl Comd directs 3 Sect that is not being engaged by the sniper to flank sniper while 1 and 2 plus Wpn Det and Engr Sect provide covering fire (left flanking)
9	EN Snatch: Sniper fire and confusion in street covers EN snatch of fire team partner of 1 Sect soldier who has moved wounded member (WIA #1) to cover
10	Mark Snatch Location: Sect Comd marks house (house no. 8) where snatched member disappears
11	Sniper Killed: Sniper is confirmed killed and 3 Sect takes up fire position in order to engage house where EN have Pl member

Event #	Event
12	Order for Pl Assault: Pl Comd issues order for Pl assault on EN bldg where Pl member is being held.
13	Pl Assault: 2 Sect entry followed by Pl HQ and Wpn Det. 3 Sect with 1 Sect and remaining attachments providing suppressive fire from current location
14	WIA #2 Recovered: Pl completes assault of bldg. 2 Sect with Wpn Det clears bldg room by room. All EN killed and snatched soldier recovered but severely wounded (becomes WIA#2)
15	MEDEVAC: Pl Comd request MEDEVAC from CS1 with extraction for 2 x WIA from with a pick up time of not before 13:30:00 Z as he must move from his current location and secure the Pick-up Zone (PZ).
16	Pl Move 3: Pl moves to PZ for MEDEVAC
17	All Round Defence: Pl Comd confirms all round defence while Pl WO takes recce party to HIDE in orchard southeast (SE) of TIGER
18	HIDE Sketch: Pl WO confirms acceptability of HIDE and sends sketch to Pl Comd for modified layout of Pl for its occupation
19	Sniper Engagement #2: Pl WO and guides receive sniper fire
20	Call For Fire: Pl WO does CALL FOR FIRE on sniper (using Laser Range Finder – LRF) and destroys target
21	Pl Move 4: Pl Comd issues movement order for occupation of HIDE in the orchard SE of TIGER to await arrival of vehicles
22	Range Card: Based on delay expected for pickup, Pl Comd requires range cards for all wpns for all-round defence

Annex C: Review of Functionality

The following list of 100 functions were derived based on the trade study and review of the COTS GIS products.

Function Category	Functionality for Military Mobile Device	Tactical Relevance	Bing maps	Google earth	Google maps	ArcGIS
Alert	Flag significant changes since last time viewed.					
Analyses	Perform statistical analyses	Blue sky				x
Annotate	Add marker by clicking on a point on the map	x	x	x	x	x
Annotate	Associate with marker: list / text /photos / links msg ,emails - scroll over pop-up functionality	x	x	x	x	x
Annotate	Drag to re-route	x	x		x	x
Annotate	Draw line	x		x	x	x
Annotate	Draw / edit route (line along road, nodes along route with supplementary information)	x	x	x	x	x
Annotate	Mark-up an area	Blue sky	x	x	x	x
Annotate	Create new features (sketching / drawing tools)	Blue sky				x
Annotate	Modify existing features (e.g., edit building structure)	x				x
Annotate	Make general notes (e.g., sticky note function may or may not be geo-referenced)	x			x	x
Annotate	Geo-tag with drag and click cursor	x		x		x
Annotate	Provide colour palette for edits (route, highlighted area, etc.)	x	x	x	x	x
Annotate	Provide an edit function for shapes or lines (e.g.,thickness of line, dashed/dotted etc.)	x	x	x	x	x
Annotate	Add, create symbols	Blue sky	x	x	x	x
Annotate	Means of interaction is always available (e.g., tool bar)	x	x	x	x	
Annotate	Add multiple destinations in route planning	Blue sky			x	x
Application	Historical information manipulate time slider in an area	Blue sky		x	x	x

Function Category	Functionality for Military Mobile Device	Tactical Relevance	Bing maps	Google earth	Google maps	ArcGIS
Application	Time-slider (e.g., adjust sun position / shadows, time of day, seasons)	x		x		x
Application	Taxi fare calculator	Blue sky				
Application (navigation)	Select mode specific routes based on method of travel	x	x		x	x
Application (navigation)	Suggest routes upon selected geo-referenced features, time, or distance		x		x	?
Application (navigation)	Automated route selection for operator criteria (e.g., avoiding counterdetection points)	Blue sky	x		x	x
Application (navigation)	Animate designated path. Adjust camera angle, speed, quality	x		x		?
Application (navigation)	Avoid highways, toll roads, round-trip	x	x		x	x
Application (navigation)	Click destination directions (right click from 'here' to 'there')	Blue sky			x	x
Application (navigation)	Situate drawn route into the air (hover at different altitude)	Blue sky		x		?
Application (navigation)	Route planner (Directions by business, address, landmark) via typing address / place	Blue sky	x		x	x
Collaboration	Collaborate with other cohorts in real-time	Blue sky			x	x
Collaboration	Transmit / receive map		x	x	x	x
Compatibility	Accessible from ArcGIS	x	x			N/A
Compatibility	Compatible with CAD (computer aided design) files	x (must be selectable)				x
Compatibility	Operating system is compatible with MAC or PC	Blue sky	?	x	?	x
Data	Click icon to access metadata	Blue sky		x	x	x
Data	Overlay maps	x		x		x

Function Category	Functionality for Military Mobile Device	Tactical Relevance	Bing maps	Google earth	Google maps	ArcGIS
Data	Select / deselect labels for data types					x
Data	Manage data, copy, rename, delete data within the map or overlay					x
Data	Automatically mark own location in real-time (e.g., provide a georeference marker for own location)	x				?
Data	Distance measurement calculator - quick access	Blue sky	x	x		x
Data	Select units of measurement				x	x
Data	Designate map scale	Blue sky				x
Data	Display specify properties of layers (e.g., population density)	x				x
Data	Customize maps with imported data		?	x	?	x
Data access	Add hyperlinks (e.g., to locally stored data) associated with map	Blue sky		?	x	x
Data access	Navigation windows always accessible	x		x		x
Data access	Easy access navigation tool bar	Blue sky		x		x
Feature	Build 3D models of buildings	x				
Feature	Animate 3D models	x		x		
Feature	Scalable map (switches to best map type as you zoom) e.g., simple road when far, satellite image when close	Blue sky	x	x	x	x
Feature	Create animated tour through selected map features. Adjust time between each.	Blue sky		x		x
Organize	Flexible GUI for layer selection (e.g., organize file view as a list, details, thumbnails)	Blue sky		x		x
Organize	Organize user created metadata (folders, save markers / snapshots), Organize user created metadata (folders, save markers / snapshots) unique names, descriptions, views, allow user to manipulate organization. ique names, descriptions, views.	x		x		x
Organize	Clutter reduction capabilities	x				x
Print	Easy to print directions, with added notes, lrg map & step by step maps	x	x		x	x

Function Category	Functionality for Military Mobile Device	Tactical Relevance	Bing maps	Google earth	Google maps	ArcGIS
Save & store	Record & save	x		x	x	x
Save & store	Save "screen grab"	x		x		x
Save & store	Bookmark user selected location	x				x
Save & store	Print		x		x	x
Save & store	Record mission details (e.g., route, timing, tasks) and play back , save and share	Blue sky		x		x
Search	"Corridor" search along route (e.g., IED locations, buildings)	Blue sky				x
Search	Associated news (in area) - easy access / pop-up	Blue sky	x			x
Search	Aggregate search results	Blue sky				x
Search	Search function for categories of georeferenced entitities, and specific attribute values	Blue sky	x	x	x	x
Search	Remember searches for future	x		x	x	x
Search	Search results automatically refresh onto map (with pan/zoom)					
Search	Utility for finding specific features based on attribute value	x	x	x	x	x
Search	Build unique query (used to select specific features within a layer, display only items that satisfy the condition)					x
Search	Utility for finding specific features based on location (coordinates)		x	x	x	x
Tool	Tool bar accessibility	Blue sky		x		x
Tool	Note distances between route points	Blue sky	?	x	x	x
Tool	Hide navigation bar					
Views	Angle tilt with zoom. From Birdseye to standing on street (streets view)	x		x		x
Views	Automatic center map on selected point	x	x	x	x	x
Views	Automatic zoom to pre-set levels region, city	x	x	x		x
Views	Grab and drag map	x	x	x	x	x
Views	User selectable map orientation (e.g., north not always top of screen, track-up)	x	x	x		x

Function Category	Functionality for Military Mobile Device	Tactical Relevance	Bing maps	Google earth	Google maps	ArcGIS
Views	Continuous pan and scroll		x	x	x	x
Views	Continuous zoom	Blue sky	x	x	x	x
Views	360 degree views (streets view)	x		x		x
Views	360 object rotations (e.g., rotate building)	x		x		x
Views	3D birds eye view			x		x
Views	3D birds eye view (angled)		x			x
Views	3D view			x		x
Views	Automatic labeling increases with zoom level (roads, waterways, features etc.)		x	x	x	x
Views	Birds eye view - "better angle of aerial photography" provides better depth perception for building geography (oblique, 45-deg angle)		x			x
Views	Explore underground, underwater, sky			x		?
Views	Keep zoom level with any map modifications (e.g., annotating map does not change selected view)	x		Search automatically zooms out to display top 10 locations	x	x
Views	Satellite view	x	x	x	x	x
Views	Street side view	x	x	x	x	x
Views	Use arrows to adjust in street side view			x	x	x
Views	Use arrows to adjust view perspective in street side view			x	x	?
Views	Use arrows to navigate through streets in street side view			x	x	?
Views	Rapid situation awareness (alternate quickly between different views e.g., multiple windows, configurable pictures with selected AOI)					

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Annex D: Prototype Overlay

For each of the prototype overlays that were created using ArcGIS and Adobe Photoshop, aside from those listed below under data type no. 1: 'Vector Map', and data type no. 2: 'Raster Background Map', all additional data types were layered on top of these images (data type no. 1 and 2.). In terms of hierarchy, Distance Measurement, Grid Reference, Compass, Own Location, Current Heading, Blue Force Tracking, Enemy Location, and Unknown Entity data types were organized to always comprise of the upper most layer.

With this in mind, the following table presents the 'example image(s)' (aka: prototype overlay) for each of the data types.

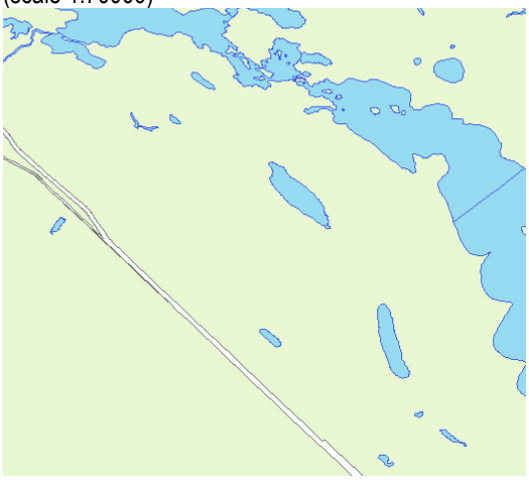
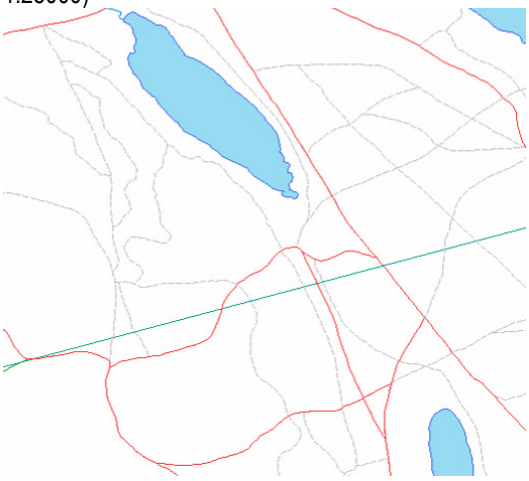
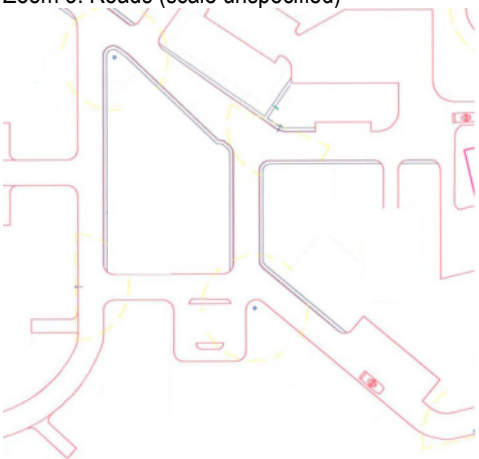
Limitations:

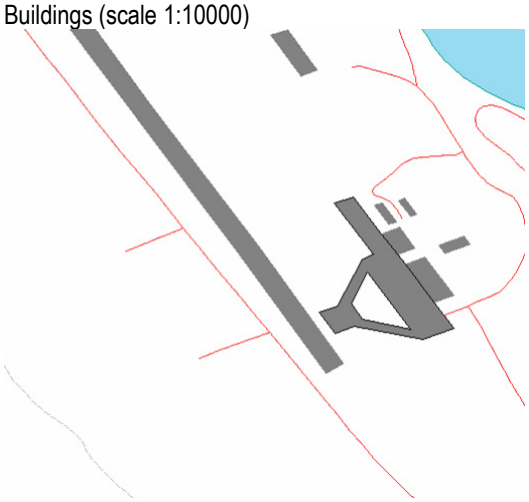
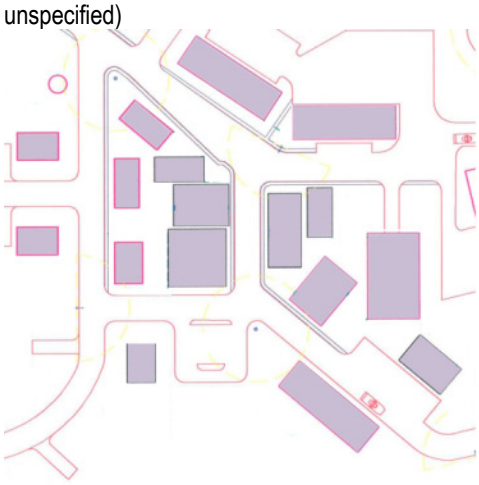
1. These example images were derived for the purposes of the SME workshop, and represent the data types that were specific to the scenarios but may also support proposed tasks carried out by dismounted soldiers. The data types as pictured below, however, do not necessarily depict all of the potential data types that may arise in other scenarios (e.g., Tactical Graphics, Equipment Icons), nor are they meant to dictate the characteristics of what the final overlay should look like (i.e., size, shape, colour, translucency, text, etc.).

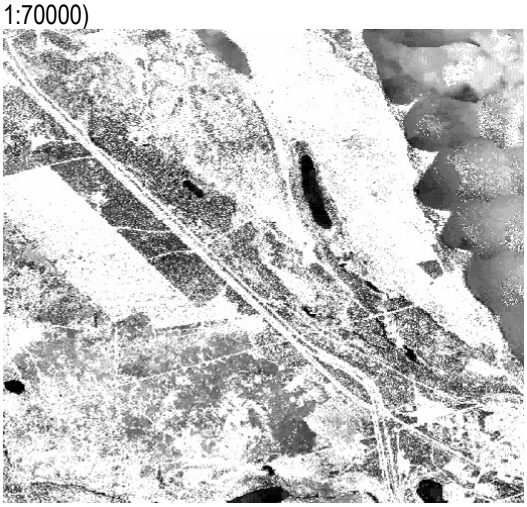
2. With the exception of data type no. 1: 'Vector Map', and data type no. 2: 'Raster Background Map', the following data types are not mutually exclusive. That is a data type may be represented by a combination of vector and/or raster type graphics and a data type may be layered on either a vector map or a raster background map. For example, the authors attempted to show this in Arc GIS for data type no. 6: 'Tactical Graphics', no. 13: 'Nature of Area', no. 49: 'Labels', and in Photoshop for data type no. 6: 'Tactical Graphics', no. 7: 'Weapon Arcs of Fire', no. 13: 'Nature of Area', no. 49: 'Labels'.

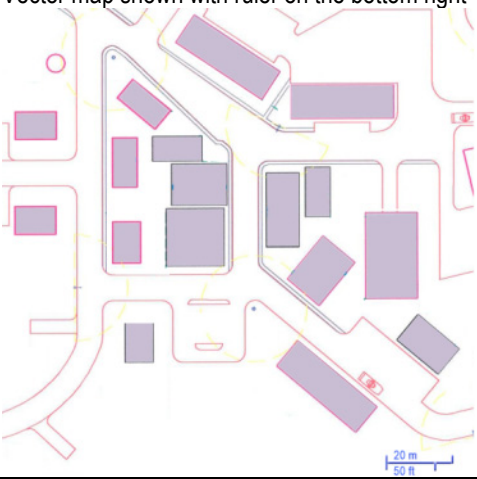
3. The transparency of each overlay and interaction between the overlays (i.e., how one overlay was layered on top of another), such as the potential for data types to occlude other data types (e.g., own location icon obscuring Blue Force Tracking icon) were not considered as it was beyond the scope of this project.

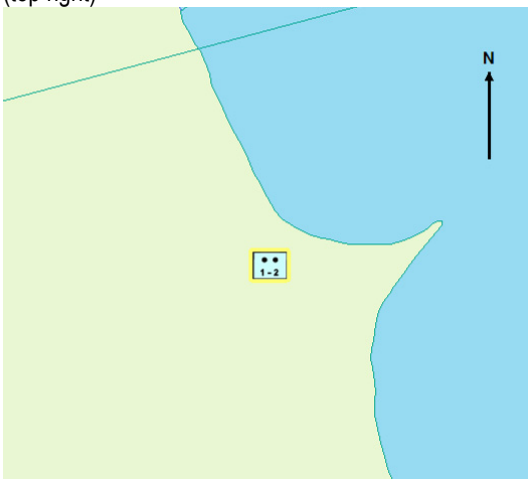
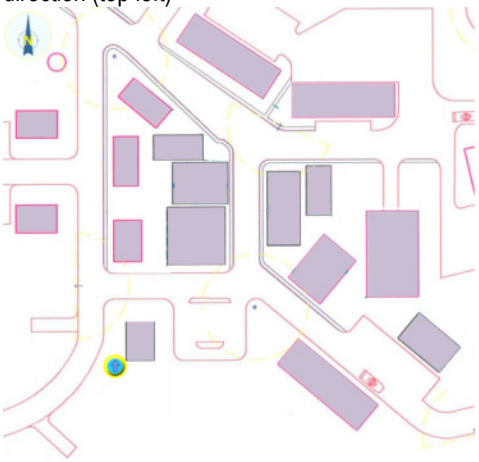
4. The Graphical User Interface and the management of clutter within and between the overlays was not addressed as it was beyond the scope of this project (e.g., 'zooming' in and out of a map and the effect on the size of icons and labels such as roads and buildings).

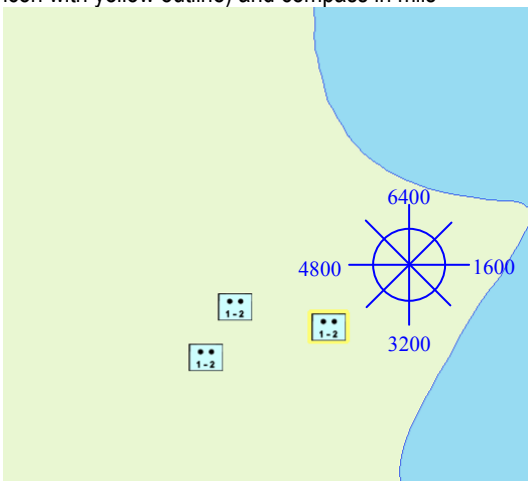
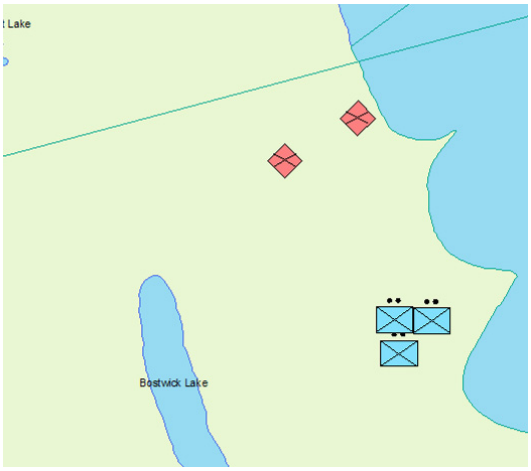
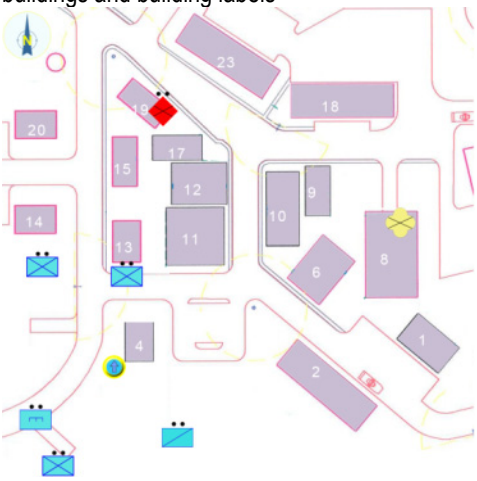
Item No.	Data type (name)	ArcGIS prototype overlay (example image)	Photoshop prototype overlay (example image)
1	Vector Map	Zoom 1: Land Mass, Bodies of Water, and Highway (scale 1:70000)  Zoom 2: Roads, Trails, and Bodies of Water (scale 1:25000) 	Zoom 2 (scale unspecified)  Zoom 3: Roads (scale unspecified) 

		Zoom 3: Roads, Trails, Bodies of Water, and Buildings (scale 1:10000) 	Zoom 3: Roads and Buildings (scale unspecified) 
2	Raster Background Map	Zoom 1: Overview Black and White Aerial Image (scale 1:70000) 	Zoom 1: Overview Aerial Image (scale 1:80000) 

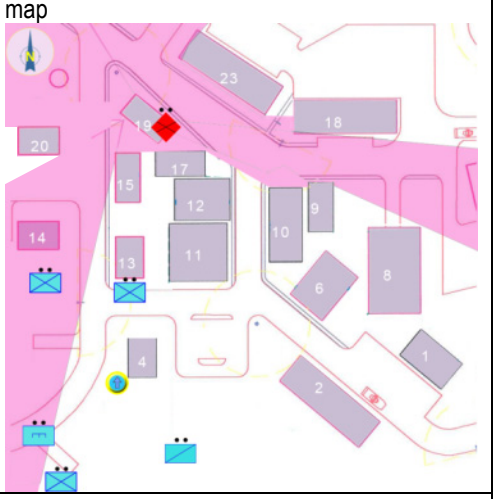
		Zoom 1: Overview Aerial Image of Elevation (scale 1:70000)  Zoom 2: Aerial Image (scale 1:25000)  Zoom 3: Aerial Image (scale 1:10000) 	Zoom 2: Aerial Image (scale unspecified)  Zoom 3: Aerial Image (scale unspecified)  Zoom 4: ¾ birds eye view shown with building labels 

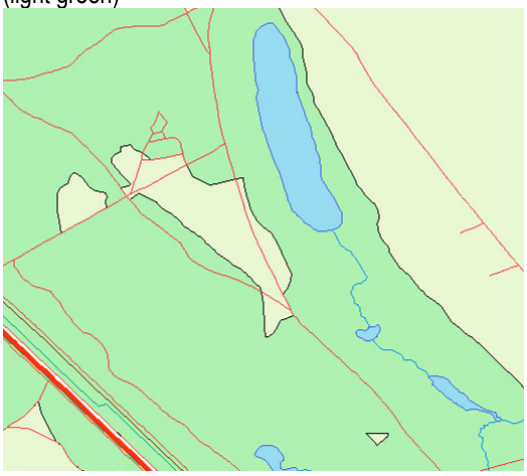
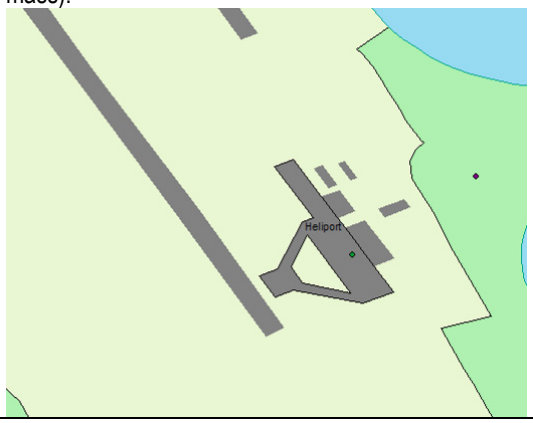
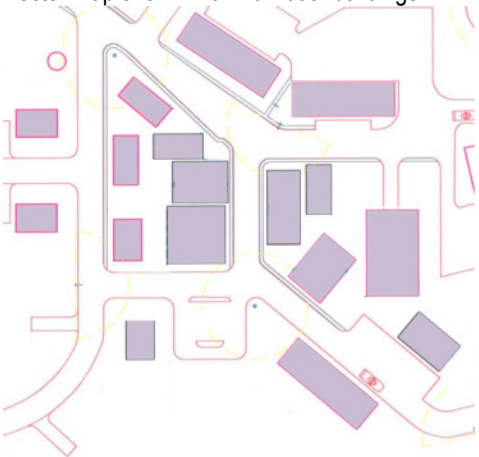
			"Street Level View" 
3	Distance Measurement (range bands, ruler)	Raster background map shown with own location and range bands (scale of range bands unspecified) 	Raster background map shown with own location (blue circle with embedded arrow) and range bands (scale of range bands unspecified)  Vector map shown with ruler on the bottom right 

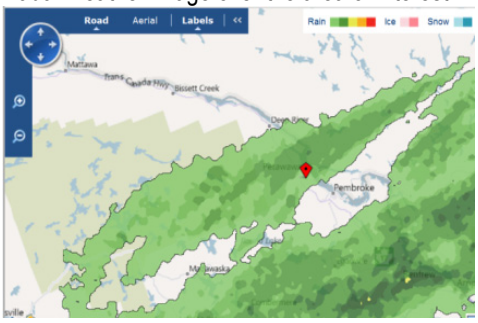
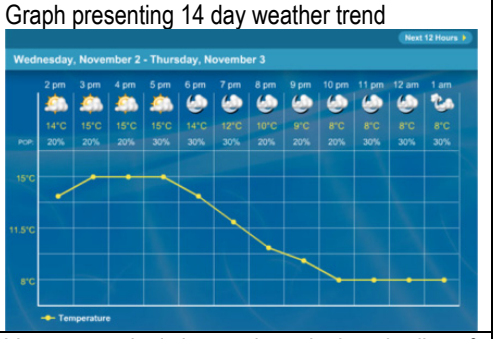
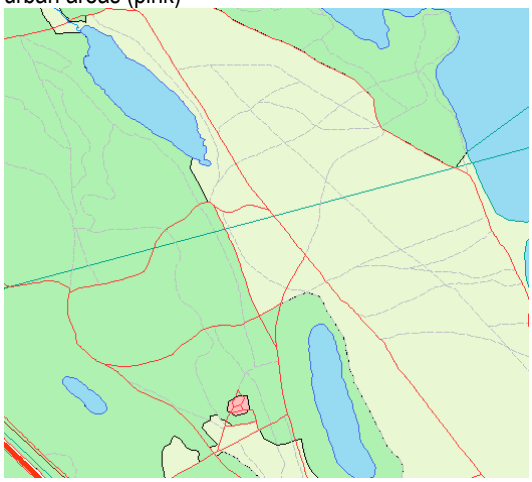
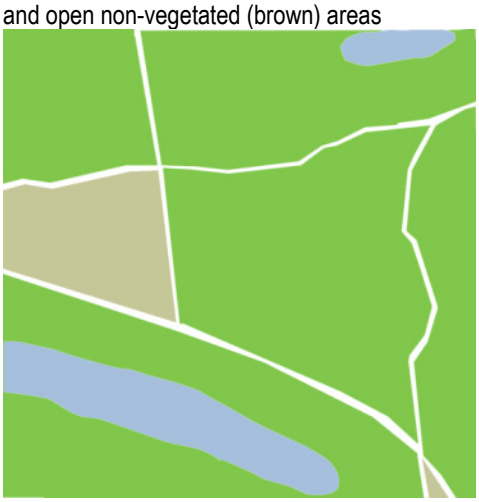
4	Grid Reference / Different Coordinate Systems	Raster background map shown with grid reference system 	Raster background map shown with grid reference system and grid labels 
5	Compass	Vector map shown with own location (blue rectangular icon with yellow outline) and north cardinal direction (top right) 	Vector map shown with own location (blue circle with embedded arrow) and north cardinal direction (top left) 

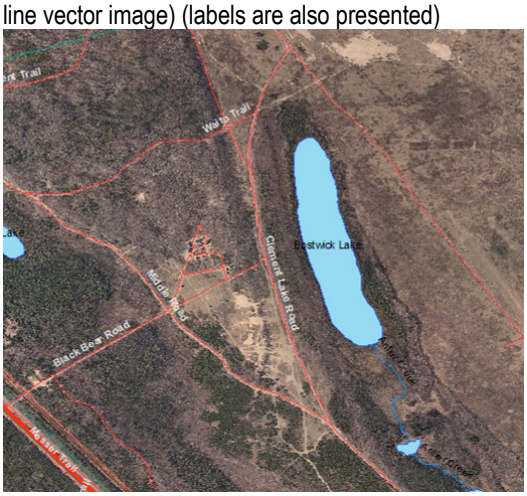
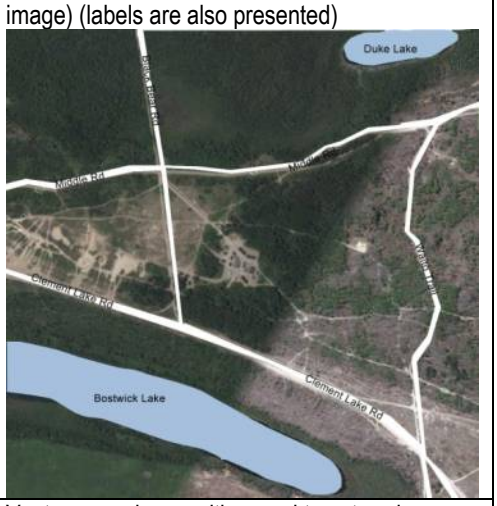
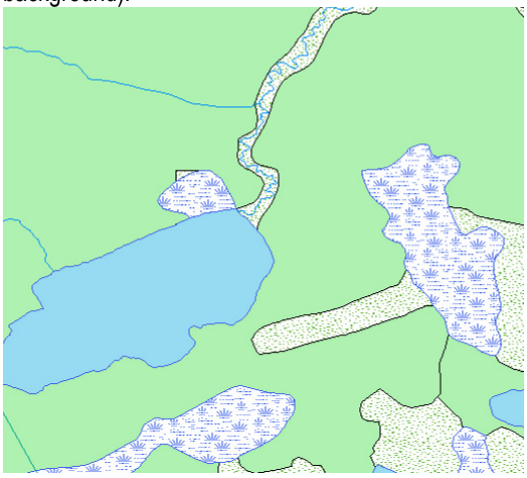
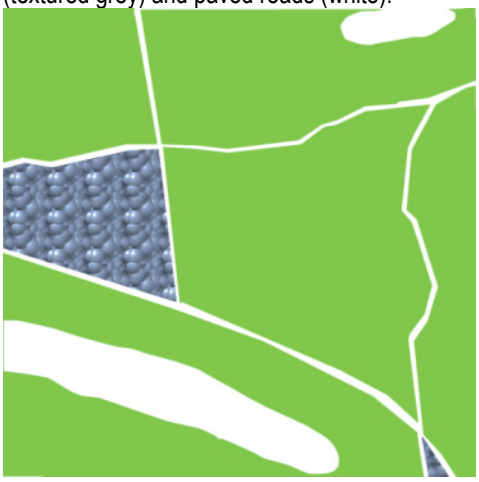
		Vector map shown with own location (blue rectangular icon with yellow outline) and compass in mils 	Raster background map shown with own location (blue circle with embedded arrow) and compass in mils 
6	Tactical Graphics	Vector map (land mass and bodies of water) shown with blue force tracking (blue rectangular icons), enemy (red diamond), and labels 	Vector map shown with own location (blue circle with embedded arrow), blue force tracking (blue rectangular icons), enemy (red diamond), unknown (yellow icon), north cardinal direction, buildings and building labels 

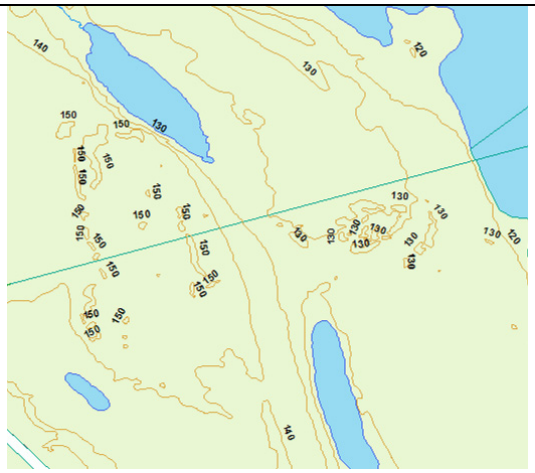
		Same image as above but shown on a raster background map  Note: Tactical Graphics also include icon based images representing common warfighting symbology such as Points Of Interest and Area Of Operations (POI and AOO), Unit Icons (e.g., Air Assault, Outpost), Equipment Icons (e.g., Air Defence Missile Launcher, Intermediate Range Air Defense Missile Launcher), and Irregular Warfare (e.g., Arson/Fire, Artillery/Artillery Fire). These are not shown.	Same image as above but shown on a raster background map  Note: Tactical Graphics also include icon based images representing common warfighting symbology such as Points Of Interest and Area Of Operations (POI and AOO), Unit Icons (e.g., Air Assault, Outpost), Equipment Icons (e.g., Air Defence Missile Launcher, Intermediate Range Air Defense Missile Launcher), and Irregular Warfare (e.g., Arson/Fire, Artillery/Artillery Fire). These are not shown.
7	Weapon Arcs of Fire	Not shown	Raster background map shown with own location (blue circle with embedded arrow), blue force tracking (blue rectangular icons), enemy (red diamond), north cardinal direction, building labels, enemy weapon arcs of fire and enemy effective weapon ranges (translucent pink), 

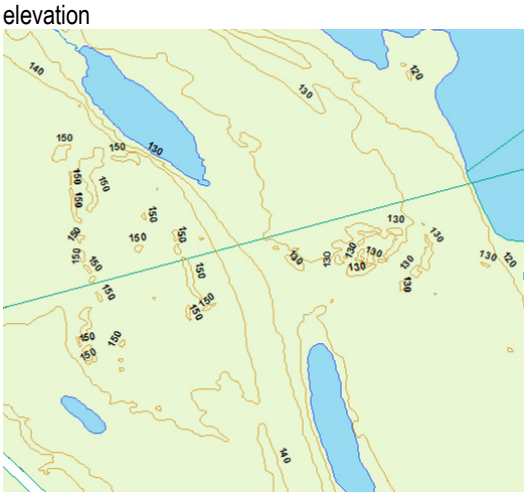
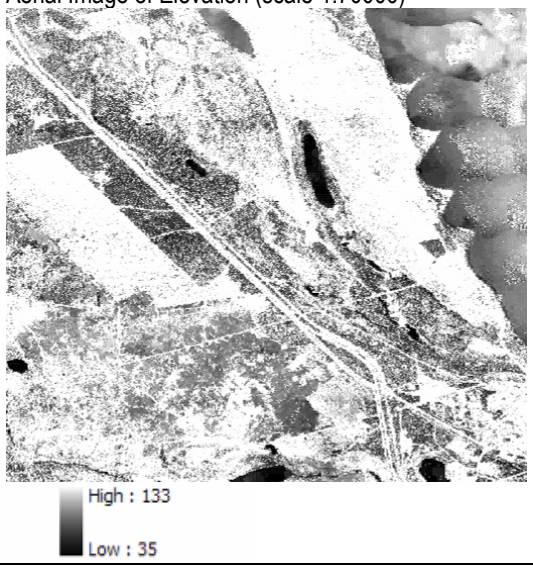
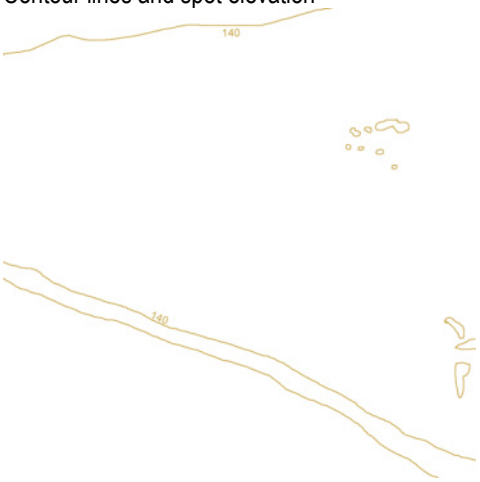
			Same image as above but shown on a raster ¾ birds eye view background map  Same image as above but shown on a vector map 
8	Effective Weapon Ranges	Not shown	See above
9	Optimum Observation Point and Dead Ground Indicator	Not shown	

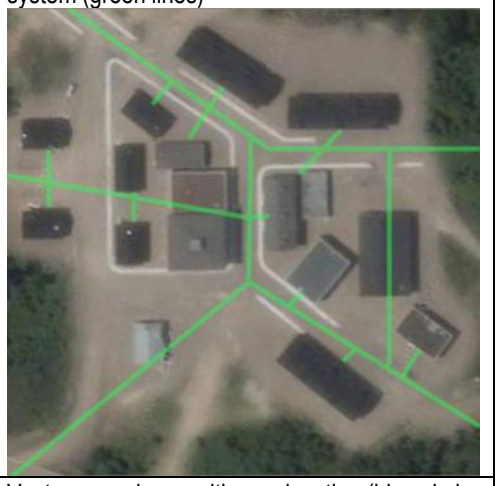
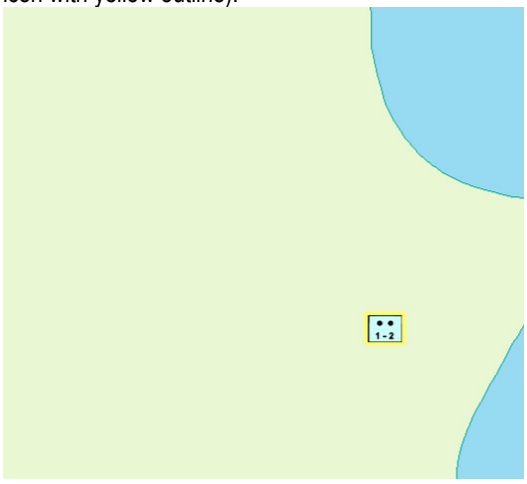
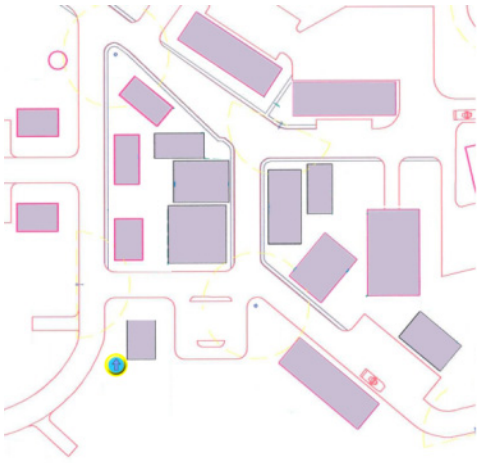
			Raster background map shown with own location (blue circle with embedded arrow) and dead ground indicator (black shaded area) 
10	Environmental Features	Vector map depicting water (blue), roads and highway (red), vegetation (green), and non-vegetated areas (light green) 	Vector map depicting water (blue), roads (white), vegetation (green), and non-vegetated areas (brown) 
11	Key Landmarks	Vector map shown with heliport, buildings, and historic site (demarcated with a dot on the green land mass). 	Vector map shown with individual buildings 

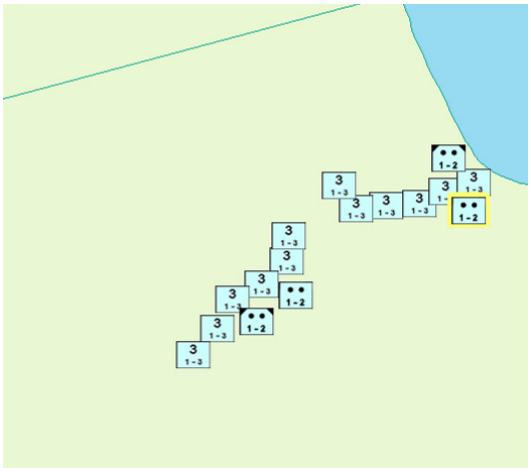
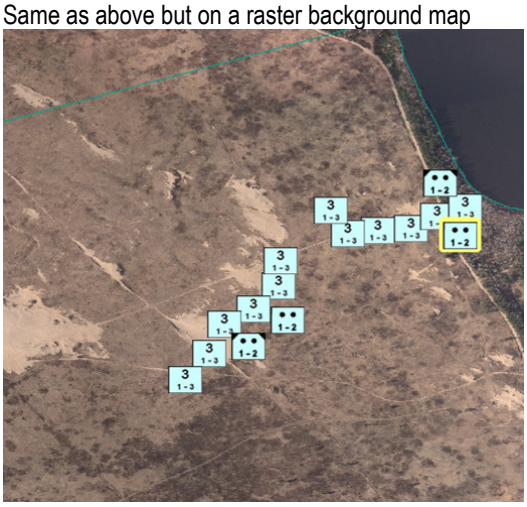
		Note: Key landmarks may also include other civilian buildings, installations, and infrastructure such as Christian places of worship, Muslim places of worship, schools, etc., radio towers, hydro towers and water towers.	Note: Key landmarks may also include other civilian buildings, installations, and infrastructure such as Christian places of worship, Muslim places of worship, schools, etc., radio towers, hydro towers and water towers.
12	Weather	Not shown	Radar weather image over the area of interest  Graph presenting 14 day weather trend 
13	Nature of Area	Vector map depicting moderately deep bodies of water (solid blue shape), shallow rivers (single thin blue lines), dual highway (thick red line), primary roads (thin red line), secondary roads (black line), trails (grey dashed line), dense wooded area (solid green), open non-vegetated area (light green), and urban areas (pink) 	Vector map depicting moderately deep bodies of water (solid blue shape), primary and secondary roads (white), dense wooded area (solid green), and open non-vegetated (brown) areas 

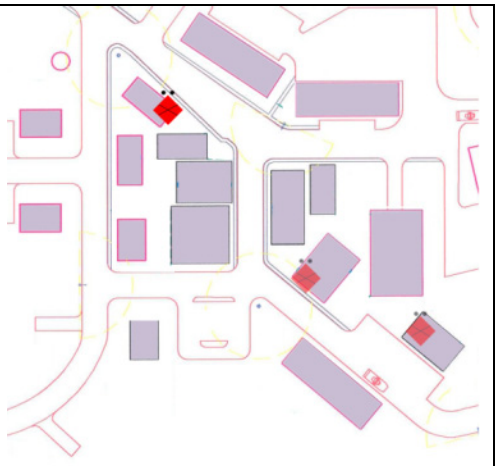
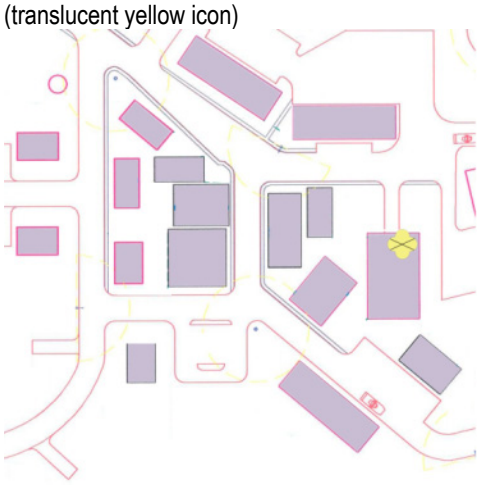
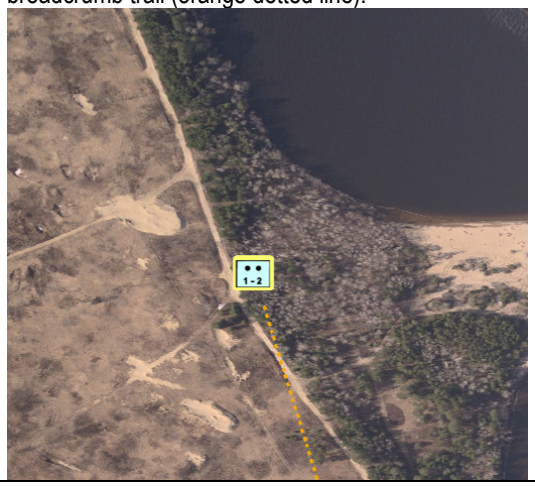
		Raster background map shown with moderately deep bodies of water (blue vector image), dual highway (thick red line vector image), primary roads (thin red line vector image) (labels are also presented) 	Raster background map shown with moderately deep bodies of water (blue vector image) and primary and secondary roadways (white vector image) (labels are also presented) 
14	Terrain Type	Vector map shown with scrub (stippled green), and swamp (blue dashes with vegetation on white background).  Note: Other terrain types may include areas such as, wetlands, mangrove, snow field/ice, and sand.	Vector map shown with gravel type terrain (textured grey) and paved roads (white).  Note: Other terrain types may include areas such as, wetlands, mangrove, snow field/ice, and sand.
15	Contour Lines	Vector map shown with contour lines and spot elevation	Vector map shown with contour lines and spot elevation

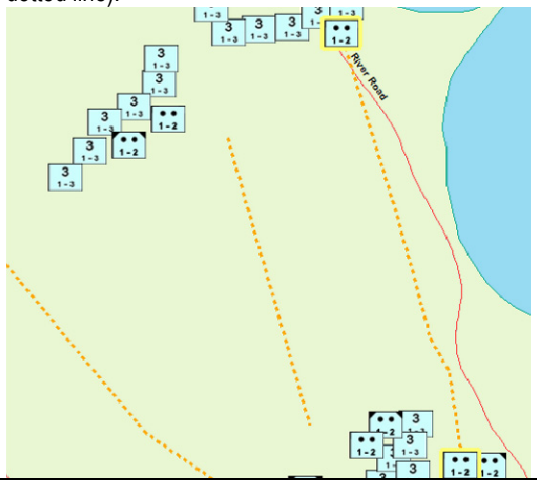
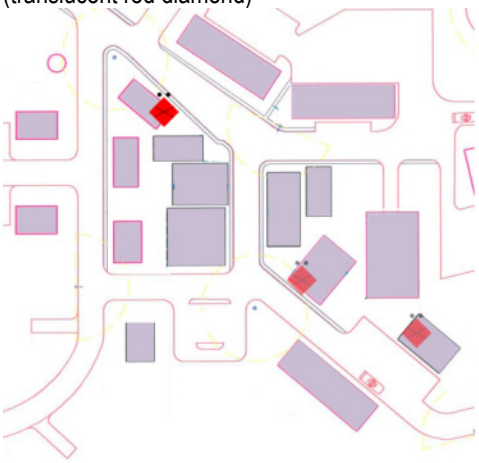
		 Raster background map shown with contour lines and spot elevation 	 Raster background map shown with contour lines and spot elevation 
16	Vegetation Coverage (from seasonal information)	Not shown	Vector map shown with vegetation coverage (seasonal small trees and bushes depicted by green jagged circles) 

17	Elevation	Vector map shown with contour lines and spot elevation  Aerial Image of Elevation (scale 1:70000)  High : 133 Low : 35	Contour lines and spot elevation 
18	Altitude	Not shown. The altitude could simply be shown as an alpha-numeric value on the map display	Not shown. The altitude could simply be shown as an alpha-numeric value on the map display
19	Impact of Ambient Lighting on Terrain	Not shown	Raster background map shown with own location (blue circle with embedded arrow) and the effect of ambient lighting on terrain (black shadows cast by buildings)

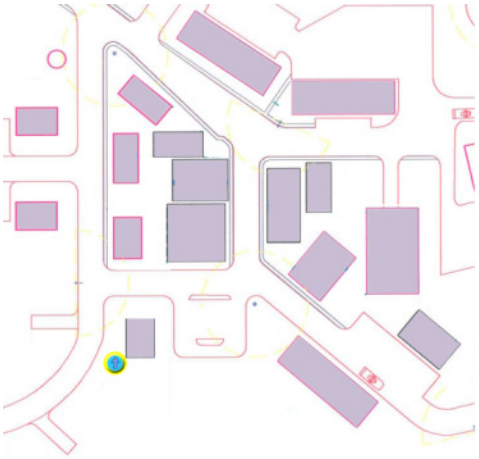
			
20	Details of Underground, Underwater, sky (e.g., sewer system)	Not shown	Raster background map shown with sewer system (green lines) 
21	Own Location	Vector map shown with own location (blue rectangular icon with yellow outline). 	Vector map shown with own location (blue circle with embedded arrow). 
22	Blue Force Tracking	Vector map shown with own location (blue rectangular icon with yellow outline) and blue force tracking. Each	Vector map shown with own location (blue circle with embedded arrow) and blue force tracking.

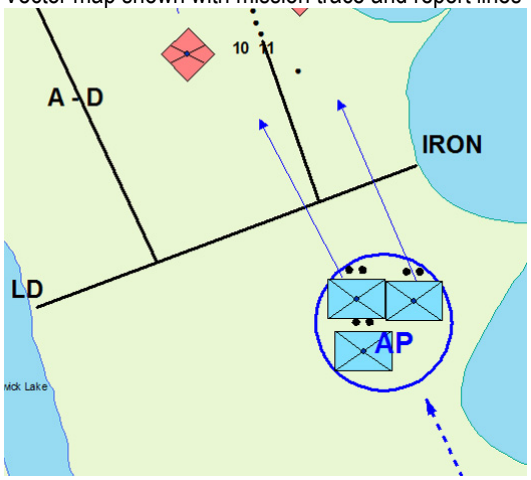
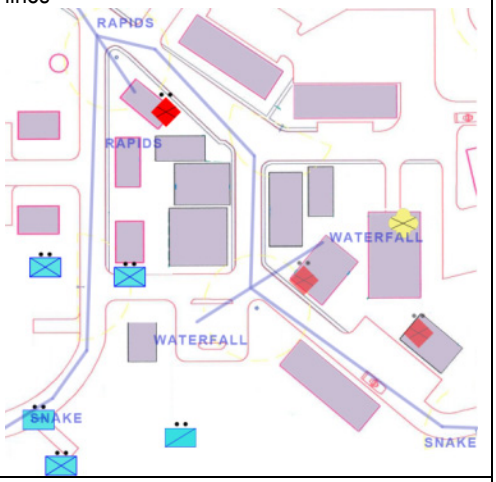
		individual soldier is represented as a blue rectangular icon with symbol modifiers for Platoon, Section, role, etc.  Same as above but on a raster background map 	Each individual soldier is represented as a blue circular entity.  Raster background map shown with own location (blue circle with embedded arrow) and blue force tracking. Each section centre of mass is represented as a blue rectangular icon. 
23	Enemy Location	Raster background map shown with enemy location and blue force tracking. For blue force tracking, each section centre of mass is represented as a blue rectangular icon.	Vector map shown with enemy location (solid red diamond) and previous enemy engagements (translucent red diamond)

			
24	Unknown Entity	Not shown	Vector map shown with unknown entity (translucent yellow icon) 
25	Neutral Entity	Not shown	Not shown
26	Breadcrumb trail	Raster background map shown with own location (blue rectangular icon with yellow outline) and breadcrumb trail (orange dotted line). 	Raster background map (3/4 birds eye view) shown with own location (blue circle with embedded arrow) and breadcrumb trail (green dotted line). For blue force tracking, each section is represented as a blue rectangular icon. Building labels are also shown.

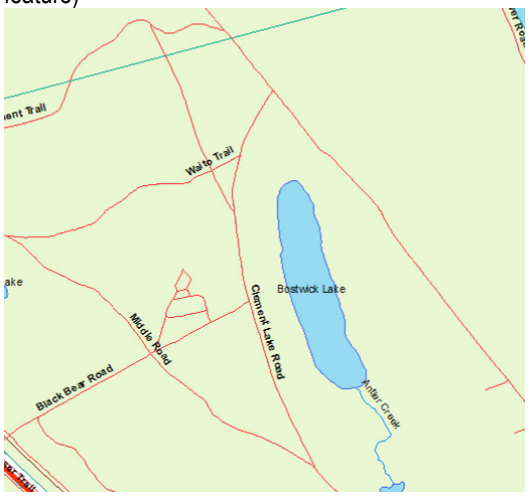
			
27	Situation Projection	Vector map (roads and bodies of water) shown with blue force tracking and situation projection (orange dotted line). 	Not shown
28	Location of Previous Enemy Engagements	Not shown	Vector map shown with enemy location (solid red diamond) and previous enemy engagements (translucent red diamond) 

29	Reports (e.g., SALUTE, Medevac, SITREP)	Not shown	Raster background map shown with geo-tagged report icons 
30	Messaging (chat, email) Georeferenced	Not shown	Raster background map shown with geo-tagged email icons 
31	Terrain Appreciation	Not shown	Not shown.
32	Intervisibility Tool	Not shown	Not shown. Data type representation is envisioned to be similar to data type no. 7: 'Weapon Arcs of Fire' and data type no 8. 'Effective Weapon Ranges
33	Wayfinding Cues	Not shown	Raster background map shown with waypoint markers

			
34	Current Heading	Not shown	Vector map shown with own location (blue circle with embedded arrow). The direction of the arrow represents the current heading. 
35	Direction of Current Movement	Not shown. As an example, direction of current movement may be shown as an arrow in the direction of travel.	Not shown. As an example, direction of current movement may be shown as an arrow in the direction of travel.
36	Bearing Tool to / from POI	Not shown	Not shown
37	Planned Route	Not shown	

			Raster background map showing planned route 
38	Route Planner	Not shown	Not shown. Data type representation is envisioned to be similar to data type no. 29: 'Reports'.
39	Orders Template	Not shown	Not shown. Data type representation is envisioned to be similar to data type no. 29: 'Reports'.
40	Time Appreciation Tool	Not shown	Not shown. Data type representation is envisioned to be similar to data type no. 29: 'Reports'.
41	Combat Estimate Tool	Not shown	Not shown. Data type representation is envisioned to be similar to data type no. 29: 'Reports'.
42	Mission Trace (operational plan)	Vector map shown with mission trace and report lines 	Vector map shown with mission trace and report lines 
43	Photographs - geo-tagged (e.g., recce of building)	Raster background map shown with geo-tagged photograph image	Raster background map (3/4 birds eye view) shown with labels and geo-tagged photograph image

			
44	Video (location , viewing angle of video)	Not shown. Data type representation is envisioned to be similar to data type no. 43: 'Photographs'.	Not shown. Data type representation is envisioned to be similar to data type no. 43: 'Photographs'.
45	Graphics (annotation layer)	Not shown	Raster background map shown with annotated graphics 
46	Manual Designation	Not shown	Not shown
47	LRF-Assisted Designation	Not shown	Not shown
48	Notepad	Not shown	Raster background map shown with notepad/sticky notes (x3 yellow squares on right side of the image)

			
49	Labels	Vector map shown with labels (roads and water feature)  Raster background map shown with waterway and roadway labels  	Vector map shown with labels (roads and water feature)  Raster background map (3/4 birds eye view) shown with building labels 

			Raster background map shown with building labels 

Annex E: SME Workshop Schedule

The following schedule was followed during the one day SME workshop that was conducted on 30 November 2011 at DRDC - Toronto. Six SMEs were recruited from Land Force Central Area (LFCA) headquarters, and from the LFCA Training Centre (TC) Meaford to participate.

Time	Event	Duration (min)
9:00	Welcome, introduction, background, and goals	0:20
9:20	Explanation of data types	0:30
9:50	BREAK	0:15
10:05	Attack scenario mission brief	0:20
10:25	Groups of 3 – 4 pers & familiarization	0:10
10:35	Group working session	0:45
11:20	Ranking data types	0:10
11:30	LUNCH	0:50
12:20	Focus group (attack scenario)	0:30
12:50	Patrol scenario mission brief	0:15
13:05	Group working session	0:45
13:50	BREAK	0:15
14:05	Ranking data types	0:10
14:15	Focus group (patrol scenario)	0:25
14:40	Focus group (consolidated overlay, roles + features)	0:45
15:25	Ranking of additional data types	0:10
15:35	Wash-up	0:10
15:45	Workshop End	

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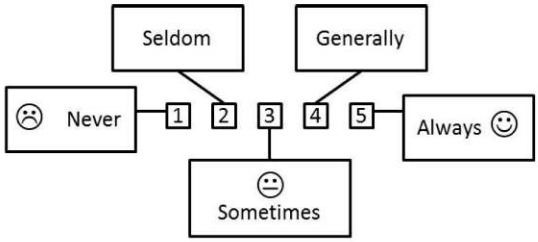
Annex F: Questionnaire on Data Requirements

Using the five point scale provided, participants were asked to indicate the degree to which each data type is required by a dismounted infantry commander (Platoon or Section). Definitions of the data types are provided in Annex A.

2 Questionnaire: Data types for mGIS Overlays

Name				Job Title	
Years of Experience		MOS		Rank	
Operational Experience	Nature of Mission (e.g., infantry)	Date	Duration	Tasks	
Workshop Role	Platoon Commander ○ Section Commander ○				

Degree to which data type is required for dismounted infantry commanders: Using the five point scale provided, please indicate the degree to which each data type is required by a dismounted infantry commander (platoon or section). Definitions of the data types are provided starting on page 4.



Availability of information: Ranks the criticality of displaying the information. Select 1 if the information *must* be available on the map at all times; 2 if the information should be available to display via one click access; leave blank if the information is not required to be displayed.

			Degree to which data type is required for dismounted infantry commanders						Availability of information	
Item No.	Data Type Category	Data Types	☹ 1	2	😐 3	4	☺ 5	N/A	1	2
1	**Tactical Digital Map**	Vector Map	○	○	○	○	○	○	○	○
2		Raster Background Map	○	○	○	○	○	○	○	○
3		Distance Measurement (range bands, ruler)	○	○	○	○	○	○	○	○
4		Grid Reference / Different Coordinate Systems	○	○	○	○	○	○	○	○
5		Compass	○	○	○	○	○	○	○	○

1

2 Questionnaire: Data types for mGIS Overlays

Item No.	Data Type Category	Data Types	Degree to which data type is required for dismounted infantry commanders						Availability of information	
			☹ 1	2	😐 3	4	☺ 5	N/A	1	2
6		Tactical Graphics	○	○	○	○	○	○	○	○
7		Unit Icons	○	○	○	○	○	○	○	○
8		Equipment Icons	○	○	○	○	○	○	○	○
9		Irregular Warfare Symbols	○	○	○	○	○	○	○	○
10		Weapon Arcs of Fire	○	○	○	○	○	○	○	○
11		Effective Weapon Ranges	○	○	○	○	○	○	○	○
12		Optimum Observation Point and Dead Ground Indicator	○	○	○	○	○	○	○	○
13	**Environment**	Environmental Features	○	○	○	○	○	○	○	○
14		Key Landmarks	○	○	○	○	○	○	○	○
15		Weather	○	○	○	○	○	○	○	○
16		Nature of Area	○	○	○	○	○	○	○	○
17		Terrain Type	○	○	○	○	○	○	○	○
18		Contour Lines	○	○	○	○	○	○	○	○
19		Vegetation Coverage (from seasonal information)	○	○	○	○	○	○	○	○
20		Elevation	○	○	○	○	○	○	○	○
21		Altitude	○	○	○	○	○	○	○	○
22		Impact of Ambient Lighting on Terrain	○	○	○	○	○	○	○	○
23		Details of Underground, Underwater, sky (e.g., sewer system)	○	○	○	○	○	○	○	○
24	**Situation Awareness**	Own Location	○	○	○	○	○	○	○	○
25		Blue Force Tracking	○	○	○	○	○	○	○	○
26		Enemy Location	○	○	○	○	○	○	○	○
27		Unknown Entity	○	○	○	○	○	○	○	○
28		Neutral Entity	○	○	○	○	○	○	○	○

2

2 Questionnaire: Data types for mGIS Overlays

			Degree to which data type is required for dismounted infantry commanders						Availability of information	
Item No.	Data Type Category	Data Types	☹ 1	2	😐 3	4	☺ 5	N/A	1	2
29		Breadcrumb Trail (Snail Trail)	○	○	○	○	○	○	○	○
30		Situation Projection	○	○	○	○	○	○	○	○
31		Location of Previous Enemy Engagements	○	○	○	○	○	○	○	○
32	**Reporting/ Messaging**	Reports (e.g., SALUTE, Medevac, SITREP)	○	○	○	○	○	○	○	○
33		Messaging (chat, email) Georeferenced	○	○	○	○	○	○	○	○
34	**Navigation**	Terrain Appreciation	○	○	○	○	○	○	○	○
35		Intervisibility Tool	○	○	○	○	○	○	○	○
36		Wayfinding Cues	○	○	○	○	○	○	○	○
37		Current Heading	○	○	○	○	○	○	○	○
38		Direction of Current Movement	○	○	○	○	○	○	○	○
39		Bearing Tool to / from POI	○	○	○	○	○	○	○	○
40		Planned Route	○	○	○	○	○	○	○	○
41	**Planning Tools**	Route Planner	○	○	○	○	○	○	○	○
42		Orders Template	○	○	○	○	○	○	○	○
43		Time Appreciation Tool	○	○	○	○	○	○	○	○
44		Combat Estimate Tool	○	○	○	○	○	○	○	○
45		Mission Trace (operational plan)	○	○	○	○	○	○	○	○
46	**Display Images**	Photographs - geotagged (e.g., recce of building)	○	○	○	○	○	○	○	○
47		Video (location , viewing angle of video)	○	○	○	○	○	○	○	○
48		Graphics (annotation layer)	○	○	○	○	○	○	○	○
49	**Target Designation**	Manual Designation	○	○	○	○	○	○	○	○
50		LRF-Assisted Designation	○	○	○	○	○	○	○	○
51	**Miscellaneous**	Notepad	○	○	○	○	○	○	○	○

3

2 Questionnaire: Data types for mGIS Overlays

			Degree to which data type is required for dismounted infantry commanders						Availability of information	
Item No.	Data Type Category	Data Types	☹ 1	2	😐 3	4	☺ 5	N/A	1	2
52		Labels	○	○	○	○	○	○	○	○

Please comment on required functionality and/or presentation of the data types:

Additional Comments:

4

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(U)

4. AUTHORS (First name, middle initial and last name. If military, show rank, e.g. Maj. John E. Doe.)

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(U) The design of location-based technology systems is expected to play an important role in future military mission success. Accordingly, Defence Research and Development Canada (DRDC) has initiated an Applied Research Project (ARP) (14dk) on the evaluation of human factors issues associated with geospatial data visualization in a mobile Geographic Information System (GIS) environment.
The first phase of this project involved a review of the potential utility of mobile GIS devices for the dismounted infantry solider and the capabilities and functionality of current technology, with the goal of identifying human factors research questions. This tasking investigated the types of map data that would be required by dismounted infantry soldiers to carry out operational tasks. Since all of the required data would be too complex to display on a small, portable device, options for grouping the data into separately, callable overlays were explored. These composite overlays were then simulated using geo-mapping software and presented for evaluation by Infantry Subject Matter Experts (SMEs), using scenario simulations.
The results showed that the required data for overlays depended upon both the command position (Section or Platoon) and the type of operation. Accordingly, recommendations were made for a base map (composite overlay consisting of all essential information required by the dismounted infantry Commander) that would always be available and for three additional composite overlays

(U) On prévoit que la conception de systèmes à technologie de géolocalisation jouera un rôle important dans la réussite des futures missions militaires. En conséquence, Recherche et développement pour la défense Canada (RDDC) a lancé un projet de recherches appliquées (PRA) (14dk) sur l™évaluation des facteurs humains associés à la visualisation de données géospatiales avec un système d™information géographique (SIG) mobile.
La première phase du projet était un examen de l™utilité potentielle d™appareils SIG mobiles pour un soldat débarqué, ainsi que des capacités et des fonctionnalités de la technologie actuelle afin de cerner des questions de recherche sur les facteurs humains. Cette tâche a permis d™étudier les types de données cartographiques dont un soldat débarqué aurait besoin pour accomplir des tâches opérationnelles. Étant donné que toutes les données nécessaires seraient trop complexes pour être affichées sur un petit appareil portatif, on a examiné des façons de grouper les données en couches pouvant être affichées individuellement. Ces affichages composites ont ensuite été simulés grâce à des logiciels géocartographiques et soumis à l™évaluation d™experts en la matière (EM) de l™infanterie, à l™aide de simulations de scénarios.
Les résultats ont montré que les données requises pour les couches d™affichage dépendent du commandement (section ou peloton) et du type d™opération. En conséquence, on a recommandé d™adopter une carte de base (affichage composite constitué de toute l™information essentielle dont le commandant d™infanterie débarquée a besoin) qui serait affichée en permanence et trois couches composites additionnelles contenant de l™information pouvant être consultée en fonction de la situation opérationnelle.

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Geographic Information System; GIS; mobile mapping; ISSP; geospatial data visualization; composite overlays