# Combat ID and Situational Awareness Technologies for the Protection of Disadvantaged Troops

**Recent developments in technology have allowed the introduction of numerous sensors and systems that enable fast information exchange within battlespace. Different users are faced with different requirements as dictated by the missions in which they are involved. To complicate matters further, the tempo of modern warfare has made conventional communication tactics inefficient and rendered them unable to provide up-to-date and precise information to the participating units over a wide area. As a result, even in the most advanced armies, blue-on-blue incidents are still occurring.**

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In this article, we explore the available technologies that could provide a near real-time tactical picture to disadvantaged troops (e.g. lacking Tactical Data Link (TDL) equipment, no access to military networks, operating in remote areas, etc), based on widely available COTS equipment without the need of specialised hardware. It is shown that it is possible to provide situational awareness and Blue Force Tracking (BFT) capabilities to ground troops with devices such as PDAs and UMPCs, as derived from TDL systems such as Link-16. Furthermore, the information can be geo-referenced to enhance the user's understanding of the environment in which he is asked to operate.

Server Awareness Lite Geospatial Tactical Info-centre (ServAL GTI) has been developed as a demonstration of what the new technologies can offer in the domain of situational awareness and combat ID. The users are given an up-to-date tactical picture as generated by a remote server. The picture is derived from various TDL and BFT systems, enhanced with additional data and real-time video feeds, if available, over low bandwidth. The users can interact with the server over a link-agnostic web service, and can also translate and promulgate data over TDL-specific systems. The system can also support input feed from civilian reporting systems such as maritime AIS (Automatic Identification System) and ADS-B (Automatic Dependent Surveillance-Broadcast).

## Introduction

In the past few years, there has been a constant growth of TDL implementation around the world. More and more countries have realised the need to operate in a network centric environment and the advantage of being able to share information between their platforms. As a result, systems like Link-11, Link-16, VMF (Variable Message Format) and the UK's Bowman, are now widely used to support operations around the world with different nations. The objective is to be able to provide up-to-date information to all the networked users, enabling them to coordinate their actions and offer an all-round picture of the battlespace. In addition to the command, control and surveillance operations, some of the systems can provide additional information such as fuel status, weapons status, mission type, etc.

The use of TDL systems showed that it is possible to link disparate units as long as they have the means of receiving and decoding the information. Unfortunately, as these TDL systems are not compatible with each other, multi-link operations are not straightforward, requiring specialised forwarders and gateways. Furthermore, due to different system requirements and architectures, the supporting hardware varies greatly in volume and characteristics. As a result, some of the systems cannot be used for smaller and mobile units due to the size and weight restrictions. Systems like Bowman and VMF have been developed for use by ground troops but do not provide the high level of functionality that is available to more advanced systems.

This paper focuses on the available technologies that can provide a tactical picture to disadvantaged troops who cannot carry large equipment, as in figure 1, and allow the tracking of their position by other friendly forces to minimise the probability of blue-on-blue incidents. Additionally, it demonstrates that it is possible to obtain TDL information without the need of TDL terminals but using simple handheld devices and a remote server and at the same time report back to the server. Furthermore, it will be shown that it is possible to have different level of services, depending on the available equipment and communication bearer available. Added capabilities that enhance the operational impact of the units are discussed and described, such as full motion video reception and transmission, interaction with other units and fusion with electro-optical sensors, always bearing in mind that only low bandwidth communication systems are available.

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## ServAL GTI: Providing situational awareness to disadvantaged users

Figure 2 illustrates a typical scenario for a Close Air Support mission. An aircraft is called in to provide support to a ground unit. A number of other friendly units are operating in the area, requiring to report their position back into the network, to avoid being accidently engaged by the friendly aircraft.

Additionally, information that is in the Link-16 network should be made available to the ground users to provide them a clear picture of the battlespace, identifying friendly and enemy positions. Currently, if the aircraft is equipped with VMF, it is possible to communicate directly with it when it approaches the area of interest. On the other hand, it is not possible to provide the Link-16 picture to the ground troops as they do not have the means of receiving and processing the Link-16 messages.

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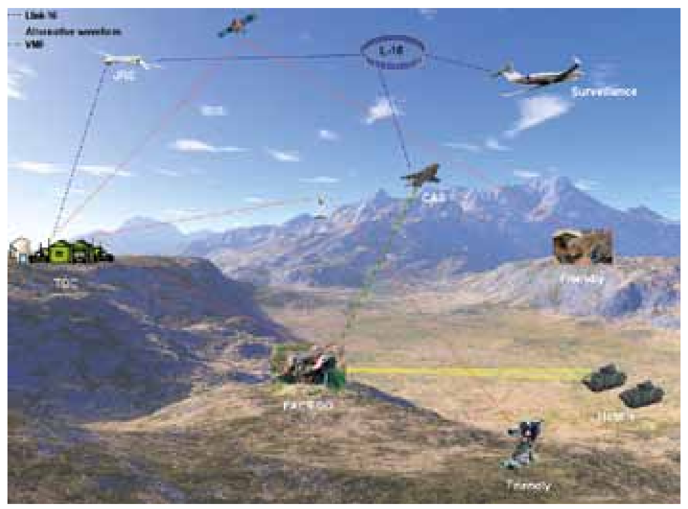

ServAL GTI was developed to investigate how modern technologies could address the above problem and provide the link between these users without the need of specialised equipment. Figure 3 illustrates the proposed architecture of the system and the links between the various users. The primary objective of this tool is to provide surveillance information to the users, therefore the analysis has been focused on the surveillance messages of the TDLs. Nevertheless, it is possible to re-program the databases to accept additional messages.

Assume that the platforms operating in the area under the Tactical Operational Centre (TOC) employ Link-16, VMF and BFT. The messages are collected in the ServAL Server, either from RF transmission or indirectly, e.g. from other web services. In the ServAL Server, the object reports are correlated and a common picture is built that populates a database. The database is then geo-referenced and is made available for the users to pull when required. The communication link between the users and the ServAL Server can be made over any commercial or dedicated network that can support IP-based services. Examples of networks that can be used are 3G, Satellite networks, WLAN, PAN, Ethernet, etc.

The user handheld equipment, such as PDA, Laptops, UMPC, and Mobile Phones, receives the reports and plots them on the map available in the cache of the device. If the area is not pre-cached or there is no high-resolution data available, a request can be sent to the server to transmit to that user the geo-spatial data. Furthermore, the user can select the refresh rate on their device to minimise its RF energy footprint. Additionally, the user can pull to the device the available data on the object and if there is a video-feed available, watch it on the handheld device. At the same time, the users on the ground can add object reports to the system that become available to all other users and can exchange free-text messages between them.

### System architecture

To understand the implemented architecture better, it is broken down into three major parts: TDL processor, ServAL Server, and ServAL client. The TDL processor segment is responsible for the translation of the TDL-specific messages to a link-agnostic format. The ServAL Server contains the databases and the algorithms required for the fusion of all the multi-media information, while the ServAL client allows the interaction of the user between them and with the server.

The ServAL Server can be physically situated away from the battlespace in a convenient location. Although one option would be to have it in a secure location as far away as possible, it must still be physically possible to receive the signals from the TDL networks of interest. Assume the scenario in figure 2. The ServAL Server is placed in the TOC and connected to a Link-16 network via JRE, if it is outside its Line Of Sight (LOS). Other connections may include VMF and Bowman which still rely on RF range. Other BFT systems can provide their inputs over satellite systems such as IRIDIUM. The TDL processor component of ServAL is responsible for receiving all the messages and translating into a common link-agnostic format. The server can also process input feeds from ADS-B hardware receivers and maritime AIS (hardware and internet feed).

In our demonstrator, a synthetic environment is used to generate the Link-16 messages. Two different TDL synthetic environments are used, Diginext TactX2 [1] and Northrop Grumman TIGER [2] (marketed in Europe by Lockheed Martin UK). The output is then connected to Combined Interoperability and Validation Evaluation Tool (CIVET), a Lockheed Martin UK IS & S developed tool. The primary function of CIVET is to monitor real time the messages from a Link-16 terminal or network and examine the implementation of the standards. CIVET can receive the messages through Standards Interface for Multi-link Platform Evaluation (SIMPLE), MIL-STD-1553, or pre-saved files. For the purposes of the demonstrations, the TDL synthetic environment is connected to CIVET through SIMPLE. CIVET is re-configured to output the selected messages, Precise Position Location Indicator (PPLIs) and Tracks Reports, in a link-agnostic setup with pre-selected attributes. The same can be done for the other data links. All the inputs can then go to the correlation and fusion algorithm in order to provide an accurate common tactical picture. The reports are then used to populate the database in the ServAL Server.

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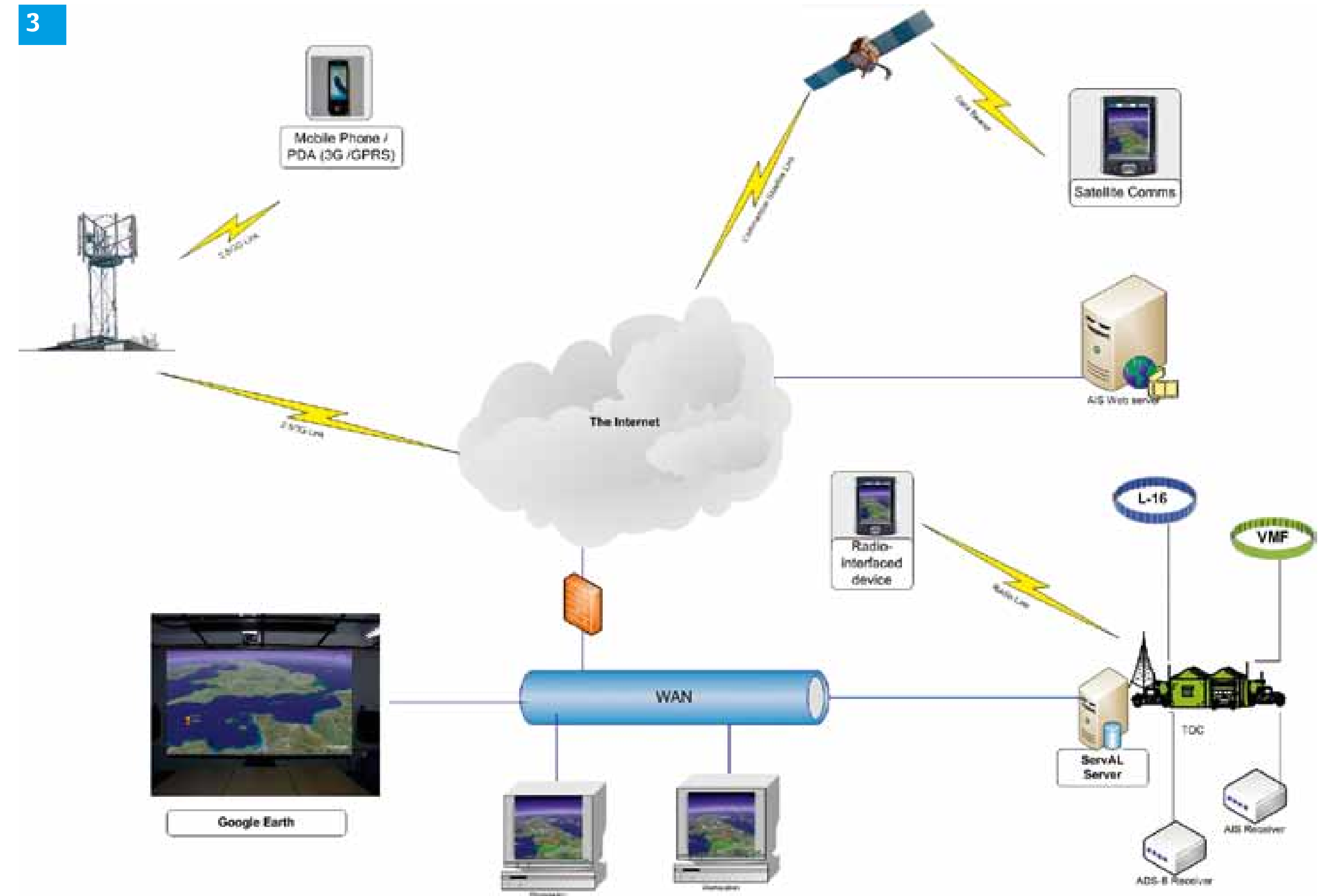


The database server used in this case is a standard Microsoft SQL server, designed to use the inputs from the attributes of the link-agnostic file that contains the track reports. The database is updated upon receipt of the reports which are made available to the users upon request on a client-server basis through a standard web service. Furthermore, the ServAL Server contains the GIS application that provides geo-referencing of the track reports. The maps can be built by the user, using different layers, with respect to the depth of detail required. In addition to that, the ServAL Server contains the video servers from platforms that are equipped with video cameras.

The video has to be transmitted over low bandwidth channels and Lockheed Martin's proprietary encoders were used, developed jointly with Essential Viewing [3]. This encoder is available in different models to address the needs of different users, from platform to individuals. The encoder can offer good quality full motion video over extremely low bandwidth implementing smart techniques for bandwidth utilisation. The video feeds on the server are associated with the specific track reports, and upon request from a user the video can be transmitted to him.

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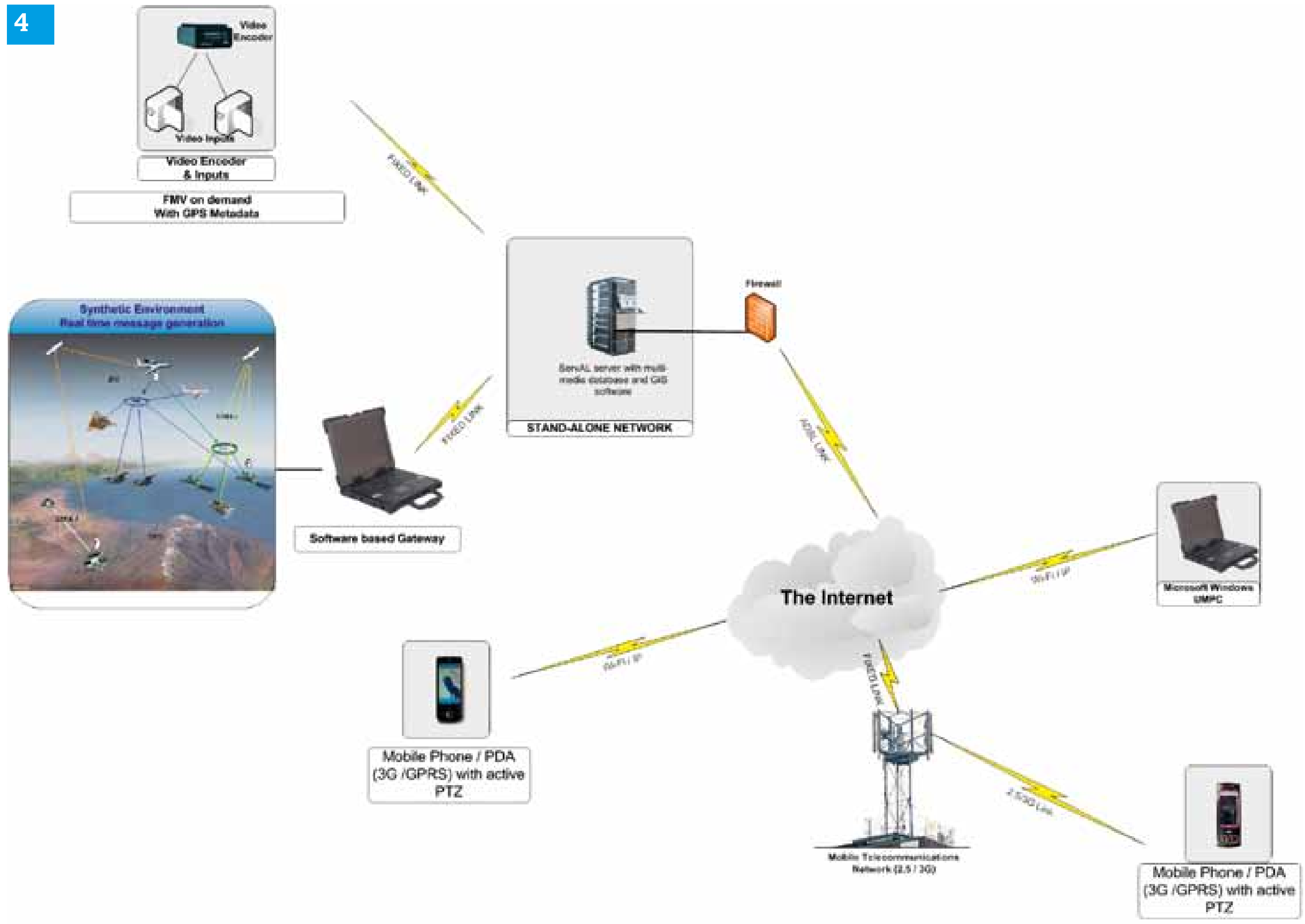


Furthermore, the ServAL Server can generate an image file of the current tactical picture. This is the lowest level service that can be provided to the user as this image file is uploaded to a secure web-page which does not require specialised software for viewing. The user can log-in to the website using any web browser available and view an up-to-date tactical picture. Of course, at this level of service there is no interaction with the server and no extra information can be retrieved except those appearing on the image file. For the purposes of this project, the selected format is JPEG, but it can be easily re-configured to accommodate specific needs.

As mentioned earlier, the end user is supplied with COTS devices that allow connectivity with IP-based networks. In this project we have experimented with a variety of handheld devices in order to investigate and assess the computational requirements and performance. In this sense, a selection of PDAs (HP214), Mobile phones (HP614 & Nokia N95) and UMPCs (General Dynamics Itronix MR1 & Samsung Q1 Ultra) were used offering a variety of test-beds and operating systems. The lightweight client installed on the handheld devices is using any available connection, as discussed above, to connect to the ServAL Server and pull the information. Upon receipt, the track reports are embedded on the available pre-cached maps. In the presence of a high-bandwidth connection, the device can request to download the additional layers of the maps.

The software interface allows the user to retrieve the information held on the object by selecting and requesting the data from the server. This way the traffic is minimised as only the required information is requested. Furthermore, these devices can use their embedded or external GPS receivers to report their position back to the server so that they can make their position available to the other users. Finally, it is possible to send text messages to the other users in the form of pre-defined or free format.



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### System demonstration

The test-bed demonstrator setup can be seen in figure 4, as described in the previous section. A generic scenario was developed, simulating a variety of units, equipped with Link-16 terminals. In addition to that, mobile phones were used to emulate Blue Force and Asset Tracking systems, by connecting to the server and transmitting positional information. Furthermore, the handheld devices equipped with the software providing the tactical picture can submit their position to the ServAL Server, visible to the rest of the users.

The synthetic environment, Northrop Grumman TIGER or Diginext's TactX2, is used to generate the Link-16 messages for the participating units. A number of different types of unit were simulated, including land, airborne and naval units that can be friendly, hostile and/or unknown. The Link-16 messages are transmitted to CIVET over SIMPLE. In a realistic case, CIVET would be installed on the server and connected to a terminal over MIL-STD-1553. CIVET applies the filter to the pre-selected messages and a report file is generated connecting all the new reports. The supported messages can be seen in Table 1. The filters can be re-configured to include additional messages.

The report file is then uploaded to the ServAL Server to populate the database. The attributes selected in this case are Track Number, Source ID, Message Type, Identity, Track Quality, Latitude, Longitude, Course, Speed, and Video Availability. The ADS-B and AIS feed is also processed and updates the database. When a platform or unit reports video availability, the video-associated attribute in the database allows the server to feed the track number and push it to the unit that sends the request. All the entities are geo-referenced so that it is possible for the client to embed the information on the map. The GIS tool used allows pre-caching the maps and only requesting extra geo-spatial information when required.

**Table 1**

| Message Number | Message Type |
|---|---|
| J2.2 | Air PPLI Message |
| J2.3 | Surface PPLI |
| J2.5 | Land Point PPLI Message |
| J2.6 | Land Track PPLI Message |
| J3.0 | Reference Point |
| J3.2 | Air Track Message |
| J3.3 | Surface Track Message |
| J3.5 | Land Point/Track Message |

TDL messages currently reported in ServAL.

As mentioned above, in order to emulate real life BFT systems, mobile phones are used to connect to the server over IP and transmit their positional information, as derived from their onboard or external GPS receivers. Applications were written in Symbian OS and Windows XP that allow activation of the GPS receiver and automatic population of the positional information fields. The user can select the ID and the refresh rate. The phone can then connect to the IP-address of the server and send the information. The ServAL Server then processes the received report and populates the database. The information becomes then available to the other users upon their next refresh.

Users with handheld devices that have the ServAL client install are provided with a geo-referenced tactical picture as seen in figure 5. The icons allow the user to see where the various entities are, what type of platform they are and of what identity. The user can select the area covered and zoom in/out the maps. Furthermore, the interface allows the user to retrieve all the tracks or the tracks in a specified radius around him or around a location of interest, selected by tapping on the screen. This is similar to the action of a J12.6 mark pointer in Link-16.

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Furthermore, the user can now click on the icon of interest and then pull the information available on that object. The advantage of this method is that it is not necessary to continuously send all the information on the objects but only that required to place it on the map. In this way usage of the bandwidth is optimised. If the platform is video-enabled, then the video icon allows the user to launch the viewer client and retrieve in real time the video feed from the ServAL Server.

A picture of the four video feeds on a mobile phone over 3G using Lockheed Martin – Essential Viewing encoder and viewer can be seen in figure 6.

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An additional capability recently added to the system is real-time target designation and reporting to the server. To perform this task, a Carl Zeiss TLS40 Range-finder is connected to the handheld device, as seen in figure 5 and provides the coordinates of a target using its internal GPS receiver, a Digital Magnetic Compass and a laser range-finder. The user can then check whether the targeted object is already reported on its ServAL client and verify its identity on the tactical picture. If it is not already reported, it can then send a report into the server so that it becomes available to other users. Furthermore, as the TLS40 has a video output, it can be connected to the Lockheed Martin – Essential Viewing encoder to send the video feed back to the server, providing a near real time video picture of the object, thereby providing further confirmation of target identity, and also battle-damage assessment.

Finally, as the device can be identified by an IP address, it is possible to exchange text messages between users, pre-formatted or free. This way, users can communicate directly between each other without the need for relay nodes, as long as they can both connect to the ServAL Server. In the pre-formatted text form, the system can report the coordinates of the user and the coordinates of a target or point of interest. The coordinate fields are populated automatically using the UMPC GPS receiver of the user unit and the calculated GPS coordinates of the target.

## Summary

In this paper, the current technology has been shown to be mature enough to provide a cost-efficient and readily deployable solution to the problem of disseminating tactical information to all the users in the battlespace without the need for bulky and expensive equipment.

It is possible to translate the picture derived from complicated and expensive systems such as Link-16 and Link-11, and by converting to a simple web service, forward it upon request to users on the battlespace for which a complete terminal solution would be inappropriate based on cost, weight, form factor and other consideration. COTS devices such as PDA and UMPC nowadays have powerful processors and a wide variety of built-in communication tools that enable them to connect to remote servers using standard commercial mechanisms and obtain a geo-referenced tactical picture. Furthermore, fusing the devices with EO sensors allows the user to feed back information to the server, increasing the networking between units and platforms.

This research is by no means complete and further investigations are required. One area that needs to be further considered is security. For military operations, preventing the enemy from accessing the information is as important as friendly forces accessing the information. Advances in encryption technology now make it possible to secure the transmitted information using fast and efficient software encoders, but these need to be proven in the military environment.

## Acknowledgments

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## Glossary

| | |
|---|---|
| 3G | Broadband mobile network |
| ADS-B | Automatic Dependent Surveillance-broadcast (air traffic) |
| AIS | Automatic Identification System. Maritime system used primarily for identifying and locating vessels. |
| BFT | Blue Force Tracking |
| Bowman | Secure digital radio (VHF and HF) |
| CAS | Close Air Support |
| CIVET | Combined Interoperability and Validation Evaluation Tool |
| COTS | Commercial Off-The-Shelf |
| DMC | Digital Magnetic Compass |
| GIS | Geographical Information System |
| GPS | Global Positioning System |
| IP | Internet Protocol |
| JRE | Joint Range Extension. A multi-Service concept for extending the range of networks exchanging tactical data beyond the range of tactical communications terminals used for these networks. |
| Link-11 | An automatic high speed HF/UHF data link exchanging picture compilation, command status, and control information. Also referred to as TADIL A. |
| Link-16 | A secure jam resistant data link that utilizes the Multifunctional Information Distribution System (MIDS) and the protocols, conventions, and fixed word message formats defined by STANAG 5516. Also referred to as TADIL J. |
| LOS | Line of sight |
| PAN | Private Area Network |
| PDA | Portable Digital Assistant |
| PPLI | Precise Position Location Indicator |
| RF | Radio Frequency |
| ServAL GTI | Server Awareness Lite Geospatial Tactical Info-centre |
| SIMPLE | Standards Interface for Multi-link Platform Evaluation |
| TDL | Tactical Data Link |
| TIGER | Tactical data link InteGration ExercisER |
| TLS40 | Carl Zeiss' Target Acquisition Binoculars product |
| TOC | Tactical Operating Centre |
| UMPC | Ultra Mobile PC |
| VMF | Variable Message Format. A message structure using predefined fields of fixed length employing internal syntax and a header extension. The internal syntax specifies the presence, absence, and recurrence of fields as selected by the user. |
| WLAN | Wireless Local Area Network |

## References

1. Diginext TDL Products, http://www.tdl-products.com/

2. Support website for TIGER tactical data link integration exerciser, http://www.tiger-link16.com/

3. Essential Viewing, http://www.essential-viewing.com/