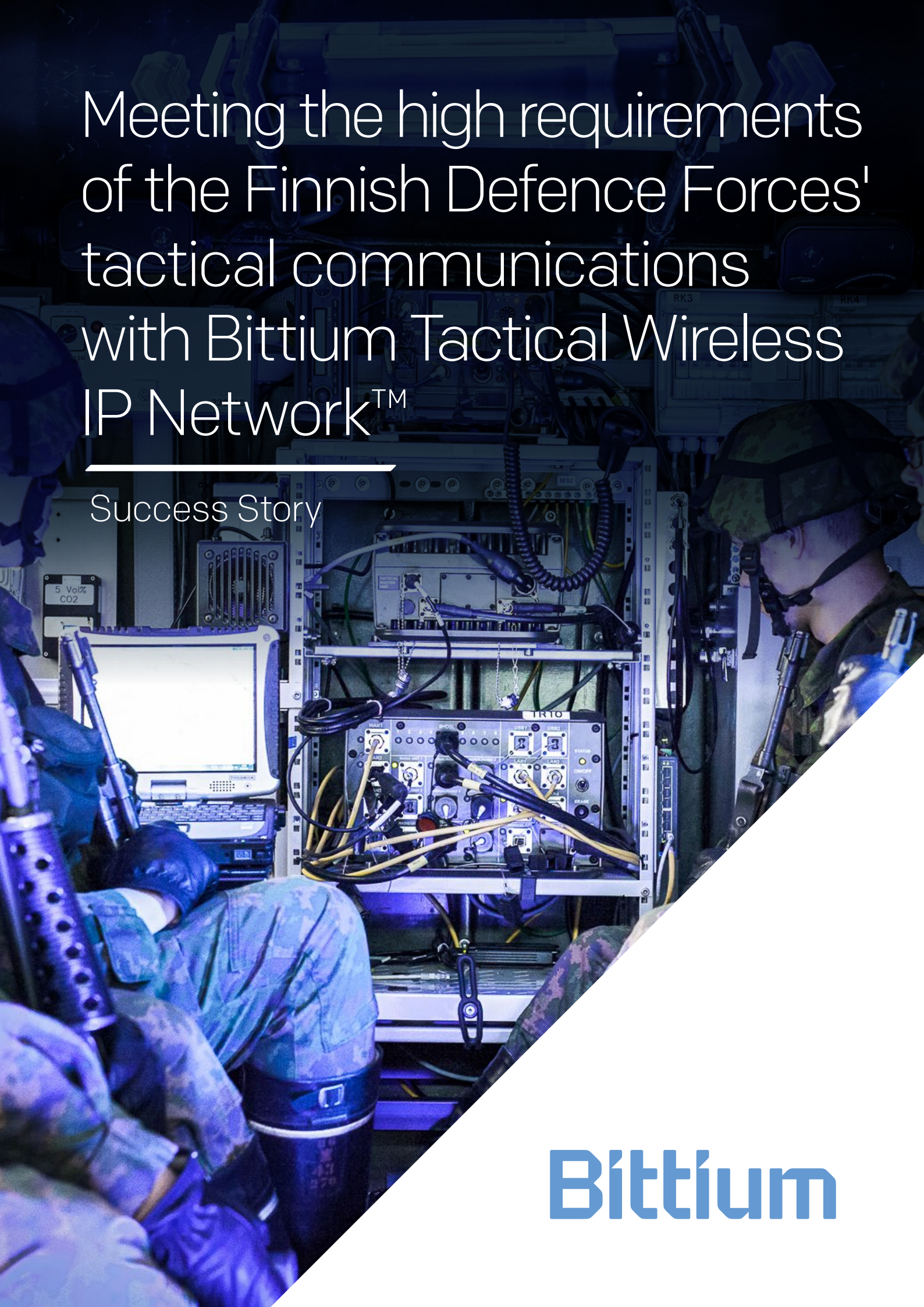
Meeting the high requirements of the Finnish Defence Forces' tactical communications with Bittium Tactical Wireless IP Network™

Success Story



Bittium

Rapid movement, situational awareness and initiative are the keywords of the reformed land warfare doctrine adopted by the Finnish Defense Forces (FDF). The backbone of the new doctrine is the command system that supports mobility with its modern wireless communications providing broadband services and access for the front line troops as well as for the command posts.

FDF is currently upgrading its tactical communications infrastructure with Bittium's (former Elektrobit) Tactical Wireless IP Network™ (TAC WIN) as the key technology. This article gives a brief introduction to the background of the Bittium TAC WIN and it's success with the FDF.

After the end of the cold war the trends in warfare have clearly changed. Instead of fighting the conventional enemy troops trying to overtake and occupy territory, today, the defense forces must fight new global threats such as terrorism, weapon of mass destruction, massacres and other catastrophies, side-by-side with other public safety agencies. With these new threats, the battlefield itself is becoming more and more complex and its traditional definition with a distinctive front line is gradually becoming obsolete. For many western military forces the international crisis management operations with small but well equipped troops represent the typical mode of operation nowadays [1].

To respond to the new challenges, as part of its organization reform, the FDF has introduced a new land warfare doctrine whereby smaller and better equipped troops can achieve better results. The doctrine emphasizes mobility of the troops, local defense and operations by distributed combat units. While in the past the defense was based on defending the area and keeping the selected geographical positions, the new system focuses on causing the enemy as much harm as possible while maintaining own ability to fight. Thus, the depth of the front line will be significantly increased, which requires the ability to move the troops rapidly and emphasizes the role of communications.

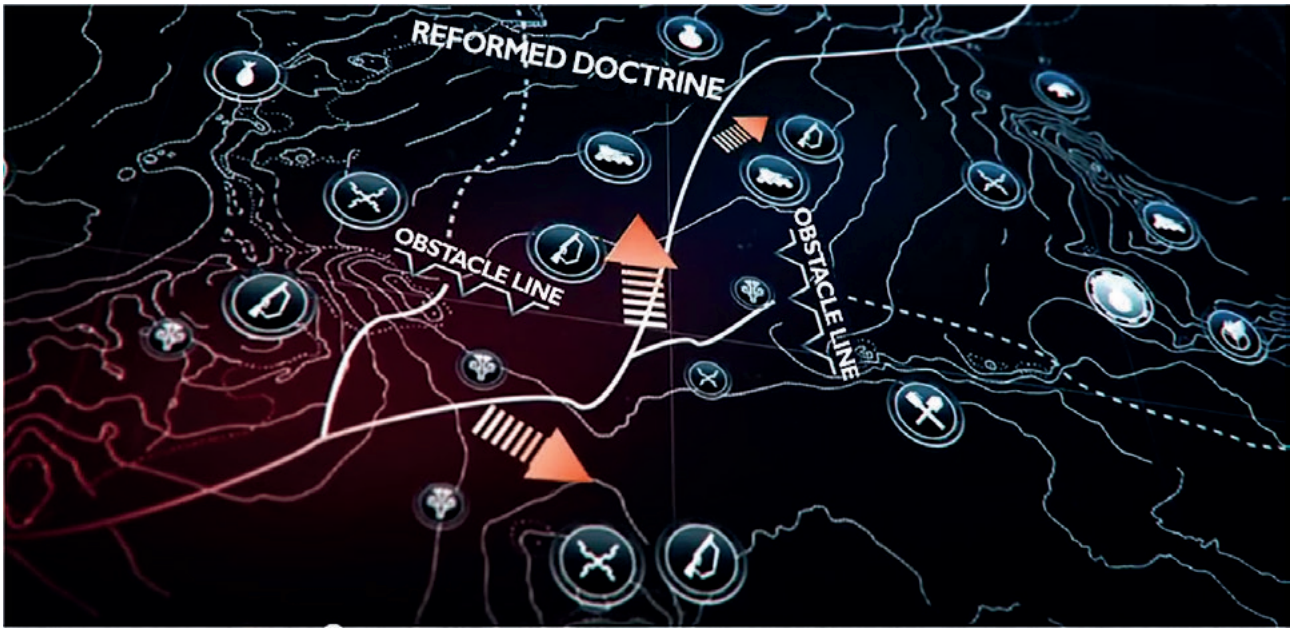


Figure 1: An example of the new tactics of FDF deploying distributed combat units (Copyright Finnish Defence Forces) [2]

The reformed warfare doctrine of the FDF created a need for a quick modernization of the command data communications system of the Finnish Army, which was mainly based on technology from the past decades. Examples of the used technology are Switched Telephone Network based link networks YVI 1 and 2 which had been deployed since the beginning of the 1990's [3],[4].

In a typical legacy tactical network (Figure 2) the link layer is based on independent microwave point-to-point links. IP-routers are deployed to provide IP-data transfer over the entire network. The connection to the mobile units is based on separate CNR (Combat Net Radio) providing voice and data services. In addition, field radio equipment operating either on VHF or sometimes HF frequencies from the 1970's are still used providing voice or low-speed data service with external data terminals using AFSK (Audio Frequency Shifted Keying) over the voice channel.

Although the CNR equipment support local mobility within the radio coverage, any larger movement of the troops will cause problems as the link network providing communications in between the battle units and command posts is still stationary. In addition, the lack of sufficient high-speed data services delivering the situational awareness across the combat units is clearly a major problem.

These issues could be partially solved by deploying new equipment providing specific functionality but at the same time the system would become more complex. A large number of different equipment and systems from various vendors make the system maintenance difficult and creates interoperability problems and is certainly not a cost-efficient approach when the entire life-cycle of such a system is taken into account.

As a conclusion, it is obvious that, in addition to the requirement for broadband access and mobility support, the troops are becoming more and more dependent on the reliable wireless communications. Thus, the network topology has to be robust and capable of standing extensive losses without loosing its data transfer capability. A conventional system based on stationary links with critical nodes provides not only limited support to mobility but is also an easy target for precision attacks. Therefore, it is evident that the conventional tactical communications solutions cannot fully meet the requirements of the modern battlefield operations.

In 2002 the FDF launched a program with the aim to develop a common platform to test and demonstrate different software-defined radio (SDR) functionalities like wideband waveforms, SDR architecture and adhoc networking. The Finnish SDR programme OHRA [5] was one of the first steps towards a modern all-digital, all-IP tactical communications system. The program focused on the SDR technology and wideband waveforms and it was able to prove that SDR was an efficient and also practical way to implement wireless

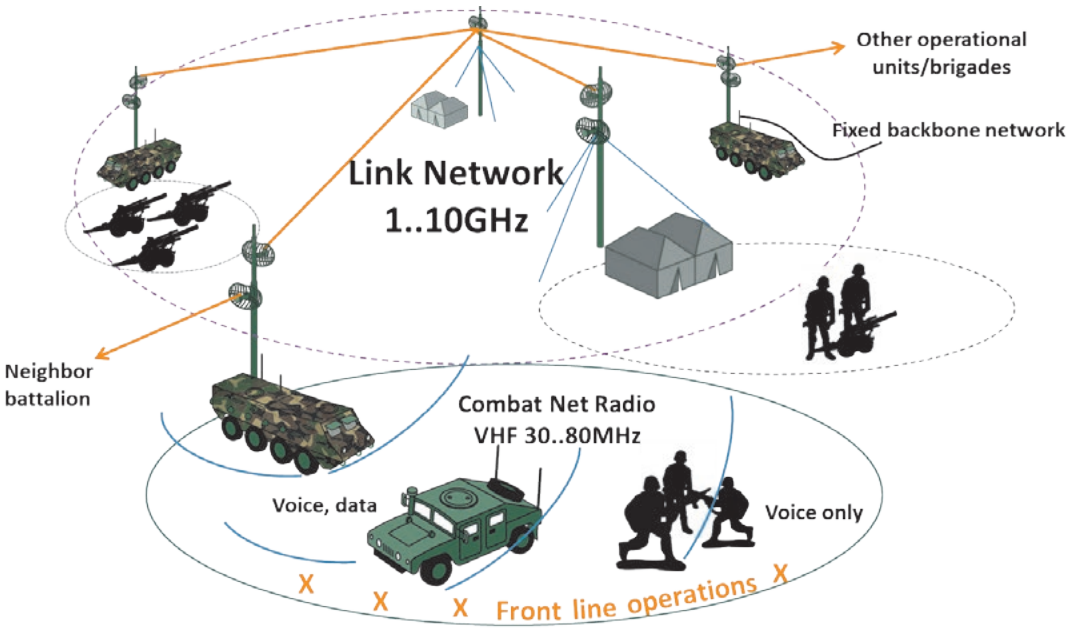


Figure 2: An example of a legacy tactical communications network

tactical communications. The programme developed a demonstration platform (Figure 3), which was used to evaluate and demonstrate various waveforms for communications and positioning purposes comprising, for example, LPD/LPI/AJ and high data rate modes and support for adaptive antennas.

OHRA was followed by other projects further developing the SDR concept, waveforms and also the high-layer functionality such as routing protocols. An example of such a project is the ESSOR (European Secure Software Defined Radio) [6], which is a major joint European activity involving 6 countries (Finland, France, Italy, Poland Spain, Sweden) with the goal of developing a joint base waveform and its national implementations in addition to national SDR hardware and software platforms.

In addition to SDR projects, several studies were carried out by the FDF and its partners to analyse the trends in wireless communications and the applicability of current technology and solutions to tactical communications. Cognitive radio, MESH -networks, adaptive antenna concepts and all IP digital networks were identified as key technologies for the next generation tactical communications system. In addition, a clear need to rapidly develop the systems deployed at that time was identified.

Figure 3: The Finnish SDR demonstrator OHRA in 2006

The development needs comprised, for example [1]:

- Support for increased mobility
- High data transfer capacity
- System compatibility
- Coverage
- All-IP principle

As a consolidation of all the development in tactical operations, trends in the warfare and the key enabling technologies becoming available, the Finnish Defence Forces' Army Signal Corps expressed the need to acquire a command system capable of delivering situational awareness and broadband data in addition to command messages across the entire operational area of the battle units.

The system requirements were, however, tough. The system should cover locations and situations where fixed network connections were not available, which required robust broadband wireless communications. In addition, the system would have to be IP-based, cost-efficient, support the new combat tactics with highly mobile troops and provide flexibility allowing connecting telephones, computers, special terminals and other equipment to the system. In addition, easy integration to legacy and future systems as well as support to incremental updates were mandatory requirements.

The budgetary issues were a major concern affecting the decision on the system procurement. The whole lifespan of the system, including planning, equipment, operation and maintenance was considered. A special concern was the anticipated high cost of the development of such a system as it soon became obvious that a cost-efficient and proven commercial solution that meets all the requirements could not be found.

To lower the development cost and risks, it was, however, concluded that the system should deploy commercial technology and follow the industrial standards whenever feasible. The radio equipment based on the SDR technology would allow incremental development and updates significantly lowering the R&D risk, as well as continuous upgrades throughout the entire life span of the system.

Colonel Juha Mattila from the C4IS Division of the Finnish Defence Forces described in September 2011 the facts behind the decision to start the procurement: "The defence forces require an even better situational awareness of the status in the field, forces need effective coordination and communication infrastructure, logistics needs to be planned online - this growing data flow requires the digitalization of command and control systems..." [7]

Once the need for the system and its initial requirements had been identified the process to find the suitable solution and its provider was started. The Army defined a concept of operations (CONOPS) complemented by preliminary system level requirements and provided the documentation to the industry to receive comments and the first indications of the system design and cost.

Based on the comments, the CONOPS and the requirements were then updated incrementally during several rounds of iterations. The evaluation process was lead by the Signals Corps' specialists supported by reviewers from the Navy, the Air Forces and the Joint Staff from the FDF, and industrial partners with specific competence in the corresponding technology areas.

The final concept of the system turned out to be very different from the first drafts. The number of units needed, performance requirements and interface definitions were modified several times before finally completing the specifications.

After completing the specifications, the next step was to send out an invitation to tender. Eventually, Bittium was contracted to develop and deliver the tactical IP network solution. Bittium's strengths were the successful history of collaboration with the FDF, world-class expertise in the software defined radio solutions and strong background in wireless communications. In addition to the company's competence, Bittium's solution was based on proven broadband wireless communications technology tailored to meet and exceed the customer's requirements with minimum development risk.

Due to the specific nature of the project comprising the entire product life-cycle starting from customer specific requirements to system specifications and from design engineering to manufacturing and maintenance, it was clear right from the beginning that it was not going to be a straightforward "sell-and-deliver" case, but a significant joint effort, in which Bittium and the Finnish Defence Forces were going to work together in close collaboration all the way to success.

The actual product development was started with Bittium's engineers designing the essential system components comprising both hardware and software functionality. The excessive testing supporting the system integration was carried out in parallel by three groups, each providing their valuable input to the development:

1. Bittium as the system provider, with both laboratory and field test facilities
2. Army Signal's integration team, with evaluation test environment both in the field and in a laboratory
3. Army Signal battalion, pilot units carrying out field testing

Today, the BIttium TAC WIN is in series delivery, operational ramp-up phase and training with the FDF as the lead customer.

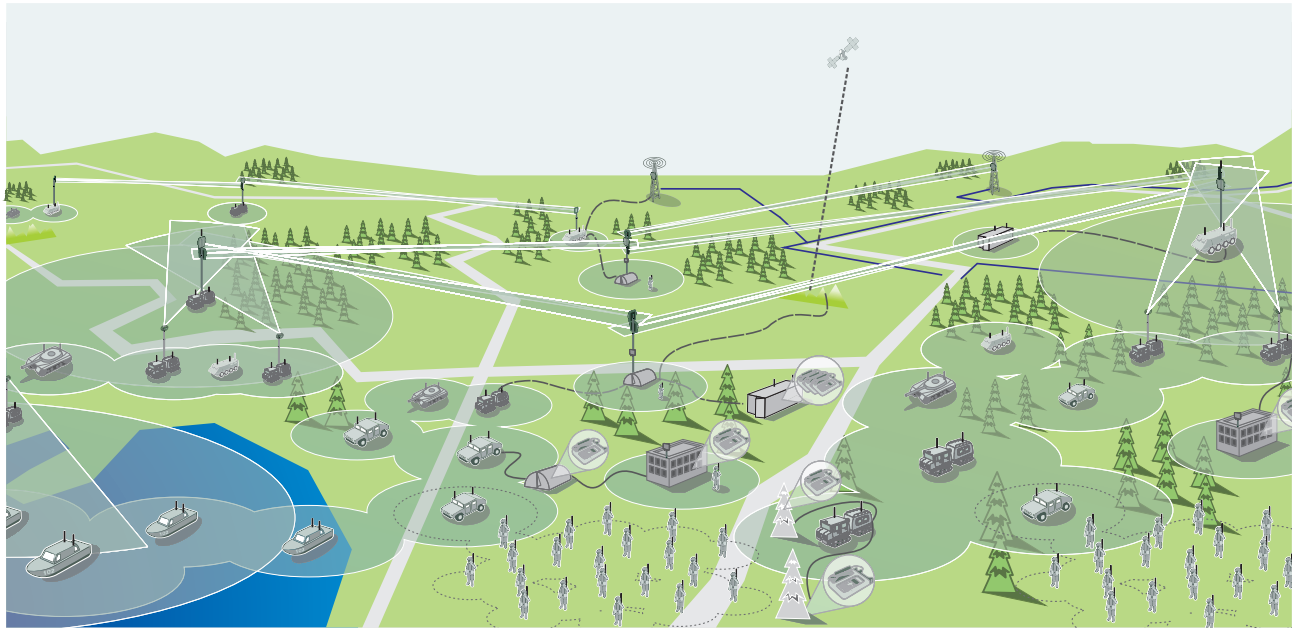


Figure 4: Bittium Tactical Wireless IP Network (TAC WIN)

The key factors to successful collaboration were a common goal, committed resources on both sides and flexibility to accept change requests and modifications to deliver the best possible product.

C4IS Division of the Finnish Defence Forces summarizes the advantages of Bittium TAC WIN:
"...High capacity wireless IP backbone solutions, like the Bittium Tactical Wireless IP Network, build the core of our digitalization and enables the creation of a tactical communications network... This compact Software Defined Radio based solution allows us to use less units, resulting in space savings and lower maintenance costs. It brings flexibility with multi-channel functionality and enables us to adapt to changes through the whole lifecycle." [7].

Satisfied customer representative, Colonel, Assistant Chief of Staff G6 Harri Virtanen summarized the advantages of BIttium TAC WIN:
"The purchased products represent the latest technology in tactical communication by enabling the use of Internet-like data networks when commanding mobile troops of the Army. The Tactical Wireless IP Network system is combat proof, independent from external data networks and highly automated. Software-based functionality enables cost-efficient development and adaptability during the whole lifespan of the system. It is a high-quality data transfer solution for both national and international operations." [8]

Bittium TAC WIN (Figure 4) is a novel solution providing outstanding performance for the tactical network communications among other applications. It replaces the traditional point-to-point link networks with a flexible high performance broadband network supporting quick automatic configuration and mobility.

With its ability to support multiple network topologies, including point-to-point (P2P), point-to-multipoint (P2mP) and more complex mobile ad-hoc network (MANET) configurations, Bittium TAC WIN allows more flexibility to adapt the network to the situation, which means higher tolerance to any threat that might block a

Figure 5: FDF Army signal vehicle.
Bittium TAC WIN Radio Head III connected to NATO band III antennas shown on the top of the mast (Photo copyright: FDF)

Figure 6: Bittium TAC WIN installation in an FDF Army signal vehicle.

link connection or disable network nodes.

The ability to establish and maintain connections to multiple nodes simultaneously using a single Bittium TAC WIN Tactical Router™ (Figure 7) simplifies the system configuration and allows quick changes in traffic routing. In addition to link network connections, the same Bittium TAC WIN Tactical Router supports connection to the Tactical Data Radio as well as legacy Combat Net Radio systems. For this purpose, Bittium TAC WIN Radio Heads I™ (Figure 7), III™ and IV™ providing access on NATO frequency bands I, III and IV are currently provided. As an SDR solution, Bittium TAC WIN supports running multiple waveforms simultaneously allowing versatile wireless performance optimized for each application. For example, while running TAC WIN high data rate waveform for the backbone IP network in one SDR core, wireless access to the IP network for the front-line troops can be provided by running ESSOR high data rate waveform in the second SDR core with no need for hardware re-configuration.

Bittium TAC WIN Tactical Router supports multiple simultaneous connections comprising both wired (e.g. LAN, SHDSL or 1Gb fiber optic) and wireless connections to build the tactical IP network. The wireless connections are established with TAC WIN Radio Heads I, III or IV with the waveform running in the SDR core of the Tactical Router. TAC WIN Radio Heads automatically select the optimal network topology; MANET, P2P or P2mP, case-by-case depending on the antennas deployed and the location of the nodes.

Bittium TAC WIN Radio Head I (frequency band 225 – 400 MHz) and III (frequency band 1350 – 2400MHz) support for example omnidirectional broadband antennas, adaptive mobile antenna solutions, sectorized fixed beam antennas or special high-gain directional antennas. In addition to network topology, the use of the different antennas is based on distance between the nodes, available masts, required setup time, required link performance and requirement to avoid interference and interception. Omnidirectional antennas are used when 360 degrees coverage is needed. This is typically applicable for Tactical Data Radio access operated at lower frequencies, such as 225–400MHz (NATO band I) requiring support to high mobility and ad-hoc routing.

Figure 8: The integrated NATO band IV Bittium TAC WIN Radio Head IV™

Figure 7: Bittium TAC WIN Tactical Router™ and the NATO band I Bittium TAC WIN Radio Head I™

Figure 9: Setting up the NATO band III antenna and Bittium TAC WIN Radio Head IV with integrated NATO band IV antenna.

Bittium TAC WIN Radio Head IV, operated on frequency band 4400–5000MHz (Figure 8) is especially designed for high-performance link applications and it combines the performance of an integrated directional high-gain antenna into the ability to provide service in a wider sector with its electronically controlled antenna beams. This makes setting up the connections easier and quicker as the antennas need no longer to be pointed precisely towards the other end. In addition, with adaptive beam control currently under field testing, it will be possible in the future to serve multiple users in different directions by switching the beams fully synchronized to the transmission according to where the other end is located.

In addition to supporting flexible network topologies and access to multiple network layers with the same equipment, Bittium TAC WIN supports IP-data transfer throughout the entire network. This forms a solid base for various end-user services including voice, data and multimedia information transfer.

Currently, alongside the product deliveries to FDF, Bittium is developing the waveform of the Bittium TAC WIN system. This further development enhances the system with additional features and optimized performance. Due to the software-based functionality of the system, it can be easily updated with additional performance cost-efficiently during the whole lifespan of the system. [9]

As a conclusion, in addition to Bittium TAC WIN having been developed in cooperation with the Finnish Defence Forces, it is a perfect solution also for all other defense forces requiring a modern way of delivering data across the battlefield. The routing capabilities of Bittium TAC WIN are optimized for highly mobile tactical use from 1Gb Ethernet fibers to MANET radios. It is a unique solution providing also seamless interoperability between different networks and easy integration with any existing or upcoming IP network.

References:

[1] Karsikas, Jarkko: Maavoimien verkostokeskeisen tiedonsiirtojärjestelmän arkkitehtuuri ja sen toteuttaminen Maanpuolustuskorkeakoulu, Tekniikan laitos, Julkaisusarja 1 n:o 28 (2007).

[2] Available at: https://www.youtube.com/watch?v=2crAx8kibis.

[3] Kosola, Jyri & Solante, Tero: Digitaalinen taistelukenttä, informaatioajan sotakoneen tekniikka. Maanpuolustuskorkeakoulu, Tekniikan laitos, Julkaisusarja 1 n:o 13 (2003).

[4] Puolustusvoimien Koulutuksen Kehittämiskeskus: Kenttäviestijärjestelmä 4, Yhtymän Viestijärjestelmä YVI 2 (2003).

[5] Tuukkanen, Topi; Pouttu, Ari & Leppänen, Pentti: Finnish software radio programme. Finnish Defence Forces & Telecommunication Laboratory and Centre for Wireless Communications (2003).

[6] Available at: http://www.occar.int/36.

[7] Available at: http://www.bittium.com/index.php?id=569&locate=201109%2F1544300.

[8] Available at: http://www.bittium.com/index.php?id=122&locate=201407%2F1825255.

[9] Available at: http://www.bittium.com/index.php?id=995&locate=201510%2F1958875.

Figure 10: FDF Army signal vehicle on the move in the Finnish forest. With its MANET capability Bittium TAC WIN allows maintaining the access to the tactical IP network also while moving. The NATO band I (225 – 400MHz) antennas connected to the Bittium TAC WIN Radio Head I shown on the roof of the rear wagon. (Photo copyright: FDF).