Tactical Communications for Ground-Based Air Defense (GBAD)

Application Note

Bittium

Tactical Communications for
Ground-Based Air Defense (GBAD)

Requirements and Challenges Set by Ground-Based Air Defense Systems and Their Operational Environment

Modern GBAD systems require a high performance IP (Internet Protocol) based tactical communication system in order to achieve real-time situational awareness and enable effective operations during missions.

Requirements for the communication system are complex and services have different priorities and needs. For example, radar or remote control data for unmanned vehicles requires low latency to be able to provide real-time response, and video service for target recognition requires high bitrate to be able to produce adequate image for reliable recognition. There can also be several sensors producing information and occupying their share of the bandwidth. Often the data is not targeted to a single recipient only and Quality of Service (QoS) is required to ensure the most critical communications will succeed. Examples of data and voice relayed in the network are presented in Figure 1.

Typically, there are other systems such as high power radars causing interference, and sensitive components like sensors can be impacted by it. Meeting the relevant military standards is a must for a communication system in order not to disturb the others, and vice versa itself, and to withstand the harsh battlefield conditions. Possible scenarios for enemy actions range from gathering intelligence information to jamming, or even destroying, the network elements. It is of utmost importance that all radio communications are secured with reliable methods and the tactical communication system adapts to different kinds of threat scenarios and remains operational to the highest extent that is possible under the stressed circumstances. This may require adaptation to poor channel conditions by sacrificing the maximum payload to secure the delivery of mission critical data, e.g. target coordinates, or complete re-routing of the traffic to avoid compromised sections of the communication network.

Finally, to be able to focus on the actual mission, the communication system must be as straightforward as possible to operate, and the system should adapt to changes automatically without any complex configuration changes.

As a conclusion, a good communication system must fulfill many requirements when considering weapon systems and platforms:

- High data throughput and low latency in demanding environments
- Easy to configure and operate
- High availability through self-healing and self-forming
- Reliable data transmission using QoS and electronic counter-countermeasures (ECCM) capabilities

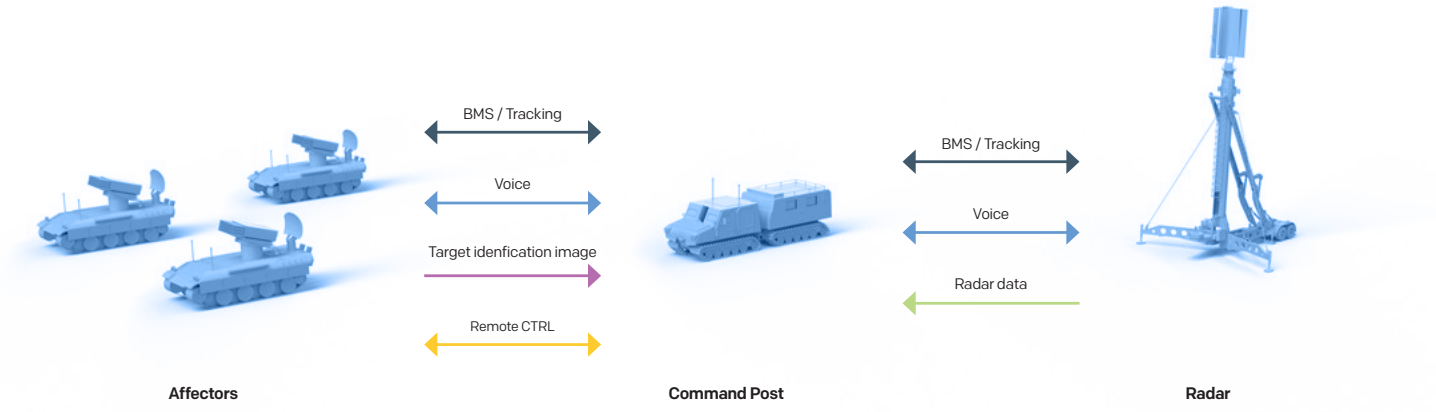

Figure 1: Examples of data and voice relayed in the tactical communications network

Single System for Optimal Performance

Bittium's tactical communications solutions meet all the aforementioned requirements with a single system. It is a native full IP system that supports Mobile Ad-hoc Network (MANET) topology for maximum availability. Therefore it is not necessary to have a direct connection between all system nodes, but the data can be automatically forwarded to reach its destination over multiple hops. Changes in the network topology or medium do not require configuration actions from the operator, i.e., it is self-configuring. The system can consists of Bittium Tough SDR Vehicular™ radios and Bittium Tactical Wireless IP Network™ (TAC WIN), including Tactical Router and Radio Heads. Both Tough SDR Vehicular and TAC WIN system use the low latency and wideband Bittium TAC WIN Waveform™ for networking. All elements are military-grade and enable system usage in harsh environments, offering resilient communications. See Table 1 for the typical performance characteristics of the system elements. An example of the node architecture including TAC WIN Tactical Routers and Radio Heads and Tough SDR Vehicular radios is presented in Figure 2. Learn more about the solutions by visiting Bittium website[1].

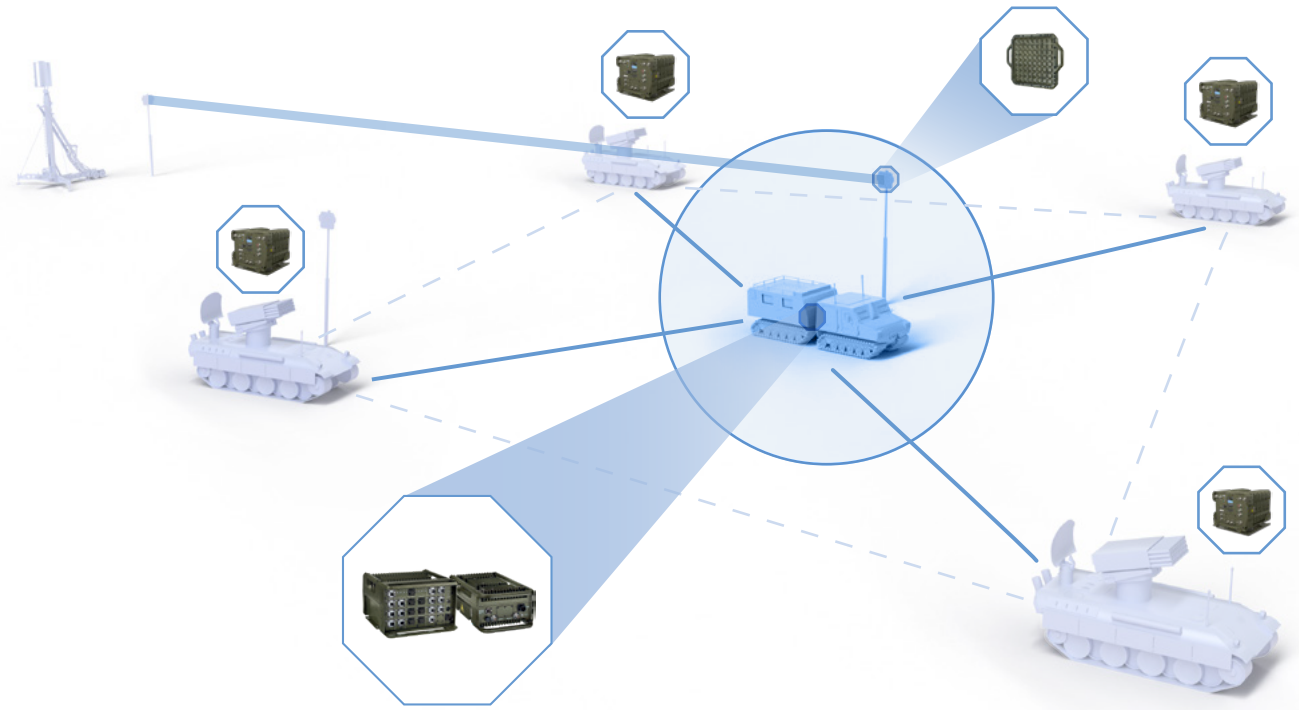

Figure 2: Example of node architecture of Bittium's communication system.

Capacity

The communication system can use multiple different mediums for communication. Radio connections are provided using different frequency bands, and wired connectivity using optical fiber and field wire. Typical performance characteristics and use cases of the system are presented in Table 1. The system has a very high throughput up to 12 Mbps – 72 Mbps depending on the used signal bandwidth.

1: https://www.bittium.com/defense-security/bittium-tactical-wireless-ip-network/ and https://www.bittium.com/defense-security/bittium-tough-sdr-vehicular/

Table 1: Typical performance characteristics of TAC WIN Waveform using different mediums

Medium	Frequency range and bandwidth	Typical scenario	Range	User data throughput	Antenna configuration
 **Tough SDR Vehicular**	30–2500 MHz BW 25 kHz to 10 MHz	NLOS / LOS MANET On-the-move	Up to 100 km+	Up to 36 Mbps	Omnidirectional or sector, external antenna
 **TAC WIN Radio Head I**	225 MHz – 400 MHz BW 5 MHz	NLOS / LOS MANET On-the-move	NLOS 2 – 5 km LOS typically up to 40 km, (max 100 km+)	Up to 12 Mbps	2x2 MIMO External antenna
 **TAC WIN Radio Head III**	1350 MHz – 2400 MHz BW 5/10 MHz	LOS MANET, point-to-multipoint, point-to-point	Typically up to 40 km (max 100 km+)	Up to 36 Mbps	External antenna
 **TAC WIN Radio Head IV** (RH-IV and RH-IV High Gain)	4400 MHz – 5000 MHz BW 5/10/20 MHz	LOS point-to-point	Typically up to 40 km, (max 100 km+)	Up to 72 Mbps	Internal beam steering antenna or external antenna
Field wire SHDSL	-	Low cost tactical cable	Typically 1 – 4 km Up to 10 km	Up to 5.6 Mbps	
Fiber optic field cable	-	High throughput tactical cable	Typically 1 – 5 km Up to 30 km	Up to 1000 Mbps	

TAC WIN Tactical Router

Interfaces:
- 3 x TACWIN Radio units
- 4 x WAN (2 x RJ45 1000BASE-T / 2 x Fiber 1000BASE-LX)
- 4 x LAN (1000BASE-T) with PoE (802.3af)
- 8 x ITU-T G991.2 (GSHDSL)
- 4 x serial/audio connector
- 2 x USB
- GPS in/out

Routing services:
- Custom OLSR in TACTICAL network
- Custom multicast in TACTICAL network
- OSPF / BGP routing for external connections
- Automatic IP address configuration
- VLANs and configurable bridges
- QoS: Traffic classifying and priority queues (8 queues)
- SNMP v3
- Radius server support
- AAA
- 802.1X port authentication
- Call admission control

TAC WIN Waveform
- Slow/fast frequency hopping
- Operation without GNSS
- Network time distribution via Air Interface
- Optimized interference cancellation algorithms
- Supported bandwidths: 5 / 10 / 20 MHz
- QoS based network radio resource management

Latency

Video service for target recognition sets bandwidth and latency requirements for the tactical communications system. Examples of such requirements are presented in Table 2.

All radio connections using TAC WIN Waveform have a typical per-hop latency down to 20 ms, and in star topology average is 30 ms.

QoS

When the available bitrate drops as the vehicle goes into an area of limited radio coverage, voice communications and critical Battle Management System (BMS) data can still be used while the lower priority traffic might purposely and temporarily be left without service. Bittium's system provides eight user QoS classes that allow prioritization of different services.

For example BMS systems often need to deliver the same data simultaneously to multiple users. In Bittium's system this can done effectively done using multicast.

Table 2: Bandwidth and latency requirements for video service

Usage	Required Bandwidth	Maximum latency
High quality 1080p video	4 Mbps	not critical
High quality Voice over IP	64 kbps	200 ms
Remote control	Low	100 ms

Network Management

Management of the communication network is straightforward. Bittium Tactical Network Management system provides tools for optimized network planning, real-time monitoring of the network and analyzing the network behavior.

With the planning tool it is possible to verify the network connectivity of the chosen network topology while taking into account the variations in the terrain. This enables defining the best position for the radio nodes in addition to estimating both coverage areas and link budgets for selected nodes. In operative use, the manager tool provides in-depth information on node configurations and locations, and data on the link statuses. See Figure 3 for planning views.

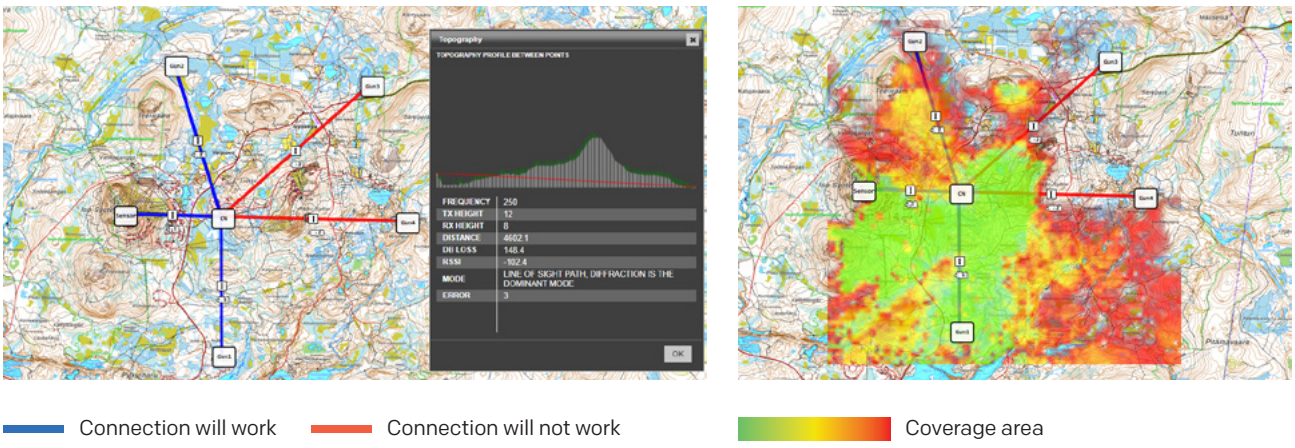

Figure 3: Planning views of Bittium Tactical Network Management system

ECCM capabilities

Protection from electronic countermeasures is provided by multiple different methods to enable reliable communications. TAC WIN Waveform is always encrypted using AES-256. It supports frequency hopping, and enabling this function will make jamming the communications significantly more difficult. The waveform has optimized interference cancellation algorithms built in and the self-healing MANET routing of the waveform will make the system more robust against jamming. The communication system is not dependent on external time source such as GPS due to its unique self-synchronization technology. Even if one node's communications could be completely jammed this does not have to affect other nodes if there is an alternative route available for the communications. In addition, the system can indicate visually in the Network Manager which nodes are affected by jamming, giving the operator a good visibility to jamming conditions and the capability to act accordingly. Figure 4 depicts the ECCM features of the system.

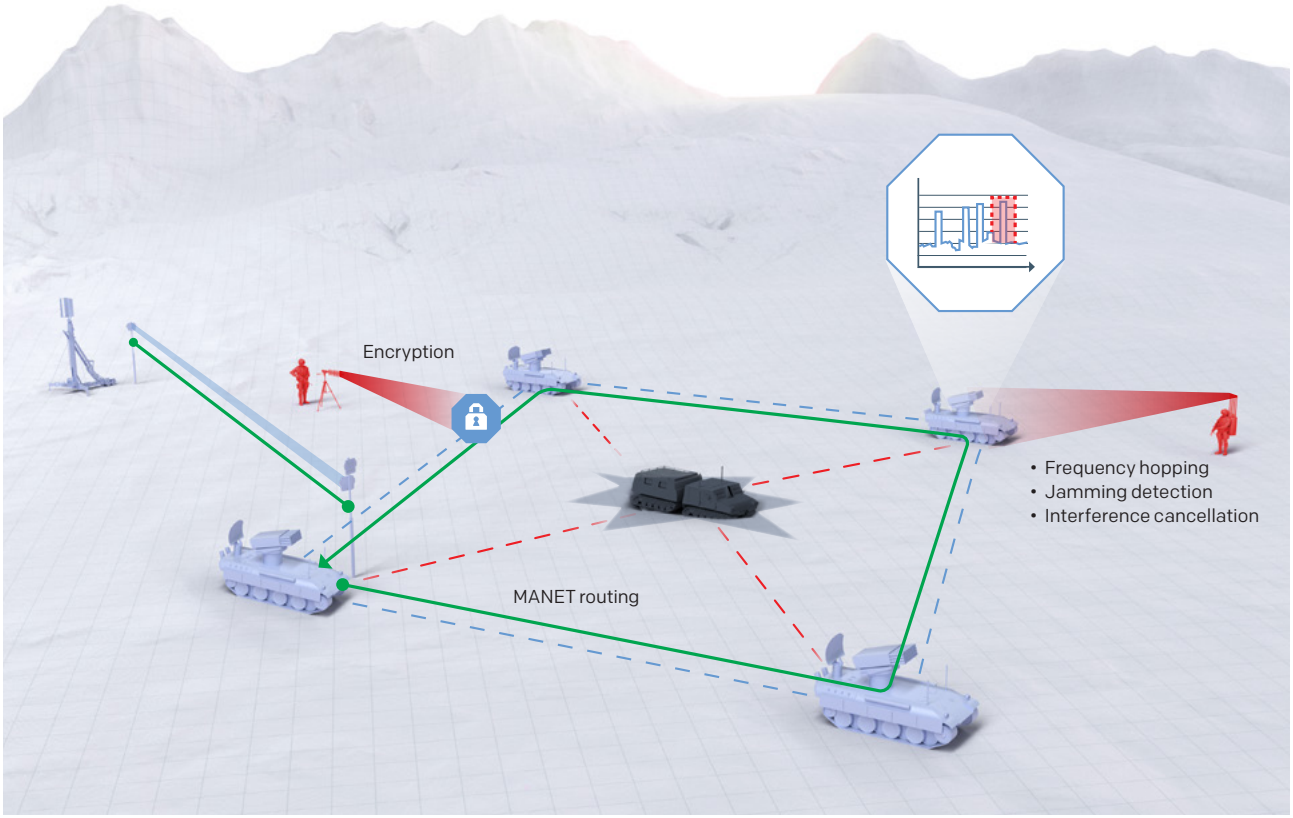

Figure 4: ECCM capabilities of the communication system

Conclusion

Effective use of ground-based air defense systems sets requirements of high performance and robustness for the communications systems integrated with them. Meeting the requirements is a difficult challenge for any conventional system, but Bittium's tactical communications system fulfills them all. Especially the high capacity, low latency, self-healing and self-configuring and ECCM features combined with the ease of use, make the IP based system the optimal solution.