Broadband MANET Naval Communications

Application Note

Bittium

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Published January 2022

Requirement for Self-Forming Broadband Communications

Reliable broadband communication is a mandatory requirement for modern, highly effective naval operations. Today's navies often operate with HF and VHF solutions that can only support voice and narrowband non-IP data. To achieve real time situational awareness and seamless command chain, the communication system must be able to transmit broadband data from any IP network node to the operations and command centre and back via self-forming and -healing networks. With higher bitrates, the option to use even unmanned vessels with remote control and real time video becomes possible. Some applications such as transport of radar data also benefit from very low latencies.

Another important requirement is the integration of naval communications with land-based communication systems. This brings along benefits by expanding the total network coverage and thus enhancing communications between the service branches. This applies for example to battle management systems (BMS) and voice over IP (VoIP).

The requirements are met with Bittium's modular, software-defined, and interoperable IP-based communications products and systems, including Bittium Tactical Wireless IP Network™ (TAC WIN) system and Bittium Tough SDR™ radios.

High-Performing Modular & Flexible IP Network

MANET for Ship-to-Shore and Ship-to-Ship Communications

Bittium TAC WIN Waveform™ provides the complete broadband IP communication network with a single system. TAC WIN system's features enable creation of a mobile ad-hoc network (MANET), point-to-point (P2P), and point-to-multipoint (P2MP) connectivity for both ship-to-ship and ship-to-shore communications. The unique approach includes P2P link radio communications for connecting the network's fixed nodes together. Ships at sea form a MANET together with the land-based fixed nodes. The network is self-healing which means that if connectivity to one ship or node is lost, the data will be automatically re-routed to the next available node.

TAC WIN system's Radio Head IV (NATO Band IV) is used to create P2P links that can connect remote sites easily over distances of 75 kilometers with Line-of-Sight spans. These sites can then act as base stations for ships, or land-based vehicles. The network is one logical MANET, allowing connections beyond the coverage of any fixed station using another ship or vehicle as a relay (Figure 1). This can be especially useful in a coastal area that is dotted with islands, making it difficult to achieve full network coverage with fixed network base stations only.

In naval use, higher frequencies are usually more optimal compared to their use in land-based operations. Lower frequencies have better ability to penetrate vegetation, but this does not bring any benefit at sea. On UHF, the radio signal requires less space around the Line-of-Sight line when the frequency range is higher. This gives a benefit when antennas are relatively close to the sea level.

TAC WIN system's Radio Head III (NATO Band III) is typically used for ship-to-ship and ship-to-shore communications. It can offer up to 26 Mbps bitrates and excellent range in naval conditions. The ship-to-ship range is typically up to

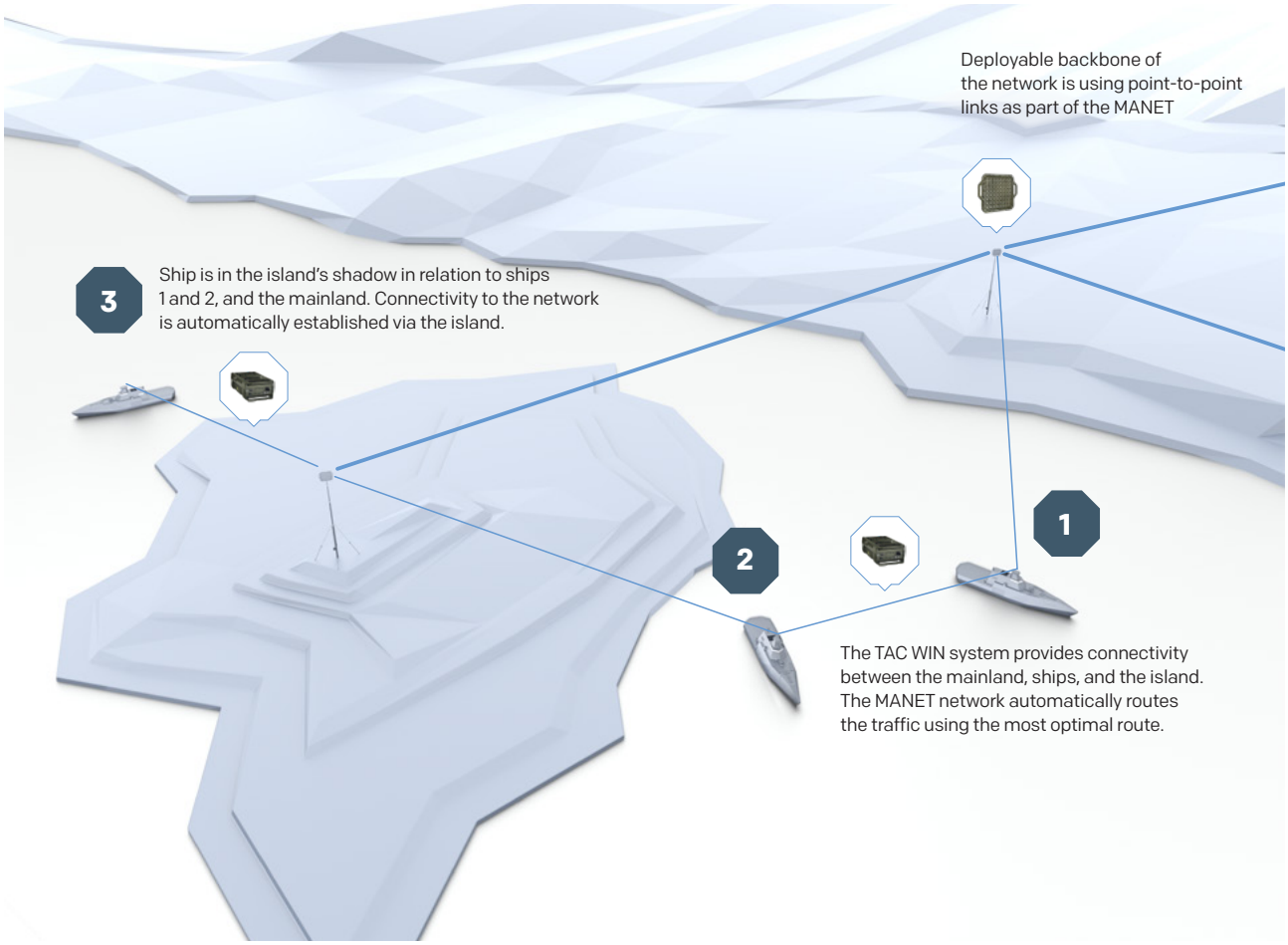

Figure 1: The deployable TAC WIN backbone of the network is using point-to-point links as part of the TAC WIN MANET.

Medium	Frequency range and bandwidth	Typical scenario	Range	User data throughput	Antenna configuration
 TAC WIN Radio Head III (RH-III)	1350–2400 MHz BW 5/10 MHz	Ship-to-ship, ship-to-shore	Ship-to-ship up to 25 km, ship-to-shore up to 75 km+	Up to 26 Mbps	Omnidirectional or sector, external antenna
 TAC WIN Radio Head IV (RH-IV and RH-IV High Gain)	4400–5000 MHz BW 5/10/20 MHz	Backbone links	Up to 75 km+	Up to 50 Mbps	Internal beam steering antenna or external parabolic antenna
 Tough SDR Vehicular	30–2500 MHz BW 25 kHz to 10 MHz	Ship-to-ship/light vessels, ship-to-shore	Ship-to-ship up to 25 km, ship-to-shore up to 75 km+	Up to 26 Mbps	Omnidirectional or sector, external antenna
 Tough SDR Handheld	30–2500 MHz BW 25 kHz to 10 MHz	Ship-to-light vessels	Ship-to-light vessels up to 5 km	Up to 26 Mbps	Omnidirectional antenna

Table 1: Typical performance characteristics of the TAC WIN Radio Heads and Tough SDR radios.

25 kilometers, and from a land-based node located on higher ground, the ship-to-shore range can be up to over 75 kilometers (see Table 1 for more performance characteristics).

Even at extreme ranges, the system can still provide megabits per second of throughput. TAC WIN Waveform has extremely low latency of typically less than 20 ms per hop. Quality of service can be used to ensure that the most critical services will be available as long as any radio connection can be maintained.

TAC WIN Tactical Router is the routing and waveform processing unit for the TAC WIN system (Table 2). It can support

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
- Supports up to 1000 nodes in one network

Table 2: Main features of the TAC WIN Tactical Router and TAC WIN Waveform

one to three TAC WIN radios heads (RH-I, RH-III, RH-IV, RH-IV HG), which can be operated simultaneously and in any combination. This system architecture enables relaying from one frequency band to another. In addition to wireless connections, the TAC WIN IP network can be extended with wired connections, both copper field wire and copper or fiber optic Ethernet are supported.

For providing a robust, distributed voice service throughout the network, the TAC WIN system can host Bittium Tough VoIP Service™. As the voice service is distributed, a loss of a single element in a central role will not cripple the service, instead, any node in the system can claim that role. As the TAC WIN system is IP-based, also applications, such as Battle Management Systems (BMS), work seamlessly with it.

Extend the Network

The same TAC WIN Waveform can also be used with Tough SDR Vehicular and Handheld radios. This enables smaller vessels/vehicles to seamlessly extend the network. For example, a crew of light assault boats or unmanned reconnaissance boats leaving from the ship to execute a mission can communicate with the ship using Tough SDR radios, while TAC WIN radio connections provide the back-bone communications. The high bitrate offered by the network makes it possible to lead the mission from the ship by utilizing real time video feed from helmet or body cameras.

Also, land forces' MANET networks can be seamlessly integrated to the network with the same TAC WIN Waveform (Figure 2).

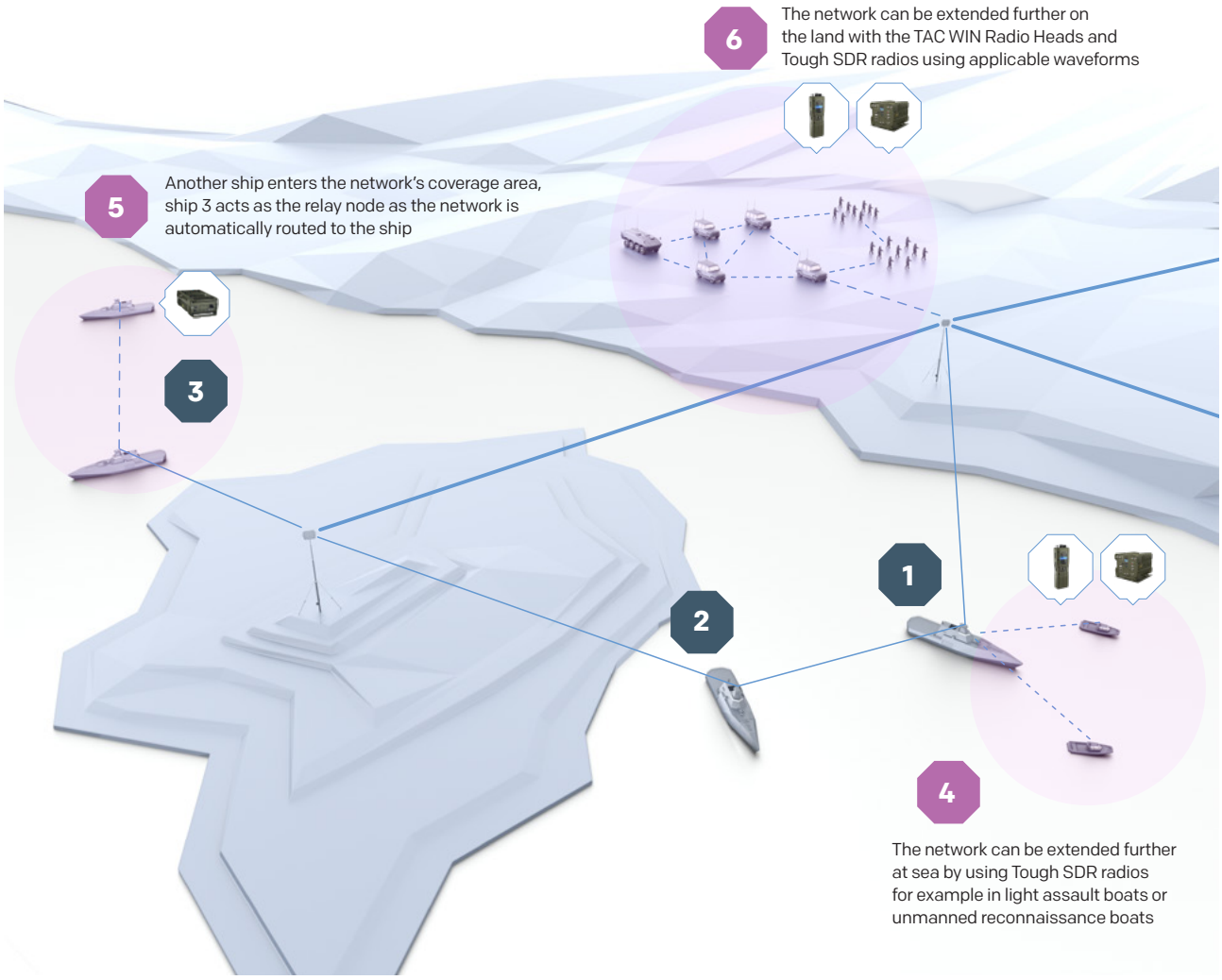

Figure 2: The network can be easily extended both at land and sea, for example with Bittium Tough SDR radios using the same TAC WIN Waveform

Tough SDR Vehicular radio supports the use of two different waveforms simultaneously. For example, Bittium Narrowband Waveform™ can be used in parallel with the TAC WIN Waveform. The Narrowband Waveform provides voice and data communication, operating in VHF/UHF band from 30 MHz to 512 MHz with 25 kHz channel bandwidth.

The Narrowband Waveform can be used with gateway functionality. This gateway can carry both PTT voice and data. It connects the Tough VoIP Service with the Narrowband Waveform's PTT services and forwards narrowband data to the TAC WIN Waveform's IP domain. (Figure 3).

Network & Device Management

Managing the TAC WIN and Tough SDR networks is straightforward. Bittium Tactical Network Management™ system offers easy-to-use and visual tools for managing both the networks and their nodes. The planning tool is used for planning the locations of the networks and their nodes so that optimal network performance can be achieved. This is done by verifying the network connectivity of the chosen network topology while considering the variations in the terrain. This enables defining the best position for the radio nodes in addition to estimating both

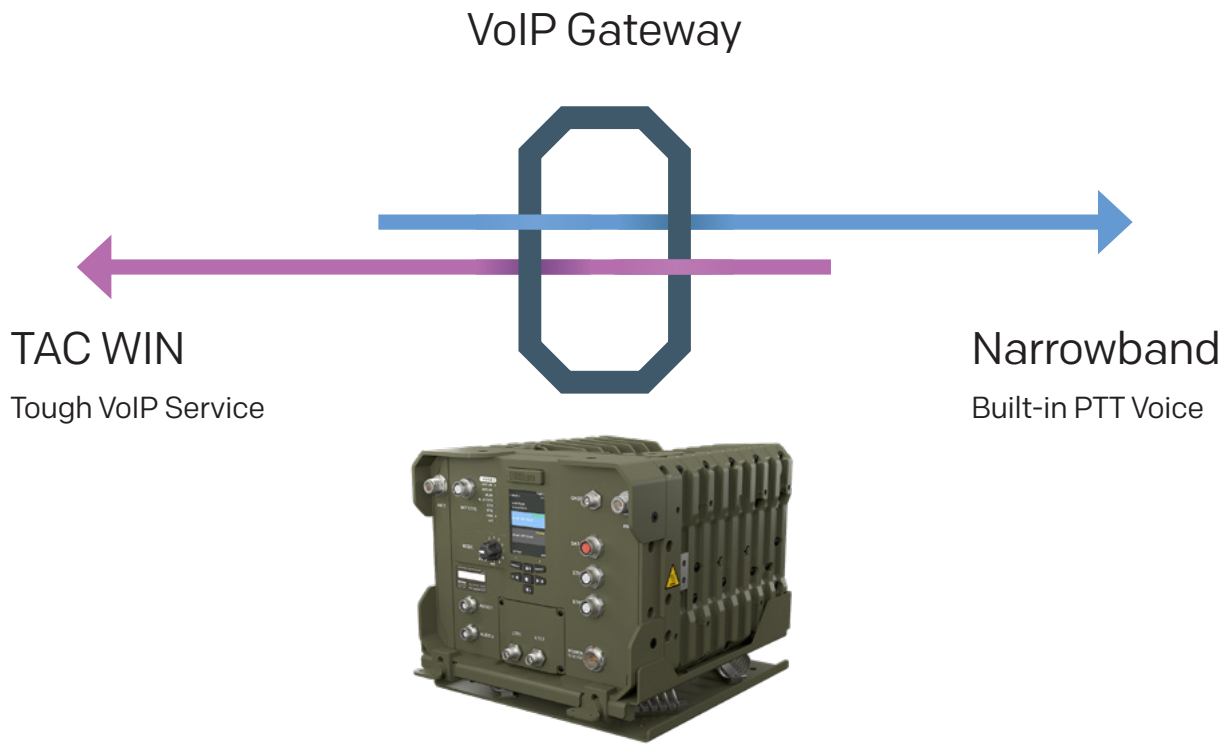

Figure 3: Tough SDR Vehicular radio supports the use of two different waveforms simultaneously, and the Narrowband Waveform can be used with data and VoIP gateway functionality.

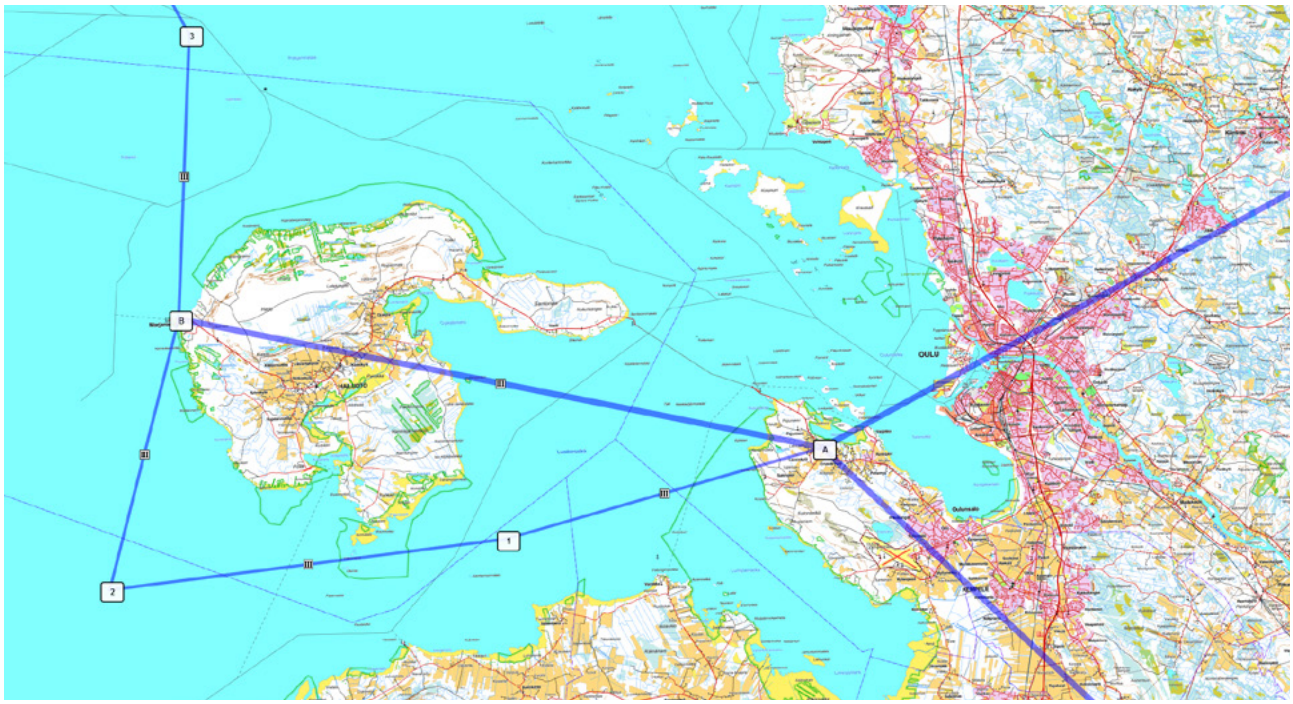

Figure 4: Management view of the Bittium Tactical Network Management™ system provides a real-time and reliable status view of network operation and node configurations.

coverage areas and link budgets for the selected nodes. When the networks are in operational use, the system provides a real-time and reliable status view of the provided connectivity service and the node configurations (Figure 4). The data collected from the networks and nodes during operation is recorded and it can be easily analyzed. This enables optimizing the network performance for upcoming operations.

To complement the network management solution, Bittium Tactical Device Management™ system enables secure deployment and operative use for the Tough SDR radios. With the system, it is possible to maintain sovereign, centralized, and efficient control when preparing the devices for operative use, including commissioning, software updates, and key management.

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. TAC WIN supports frequency hopping which makes jamming the communications significantly more difficult. The waveform has built-in optimized interference cancellation algorithms, and the self-healing MANET routing of the waveform will make the system more robust against jamming. TAC WIN 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 it does not impact the other nodes if there is an alternative route available for the communications. In addition, TAC WIN system can indicate visually in the Tactical Network Management system which nodes are affected by jamming, giving the operator a good visibility to jamming conditions and the capability to act accordingly.

Conclusion

Effective naval communications call for high performance and robustness. Meeting the requirements is challenging but Bittium's TAC WIN system together with the Tough SDR radios match the expectations where conventional systems would fail. Furthermore, as Bittium's radios and systems are software-based the future's hostile measures can be countered with software upgrades only. Especially taking the advantage of the elevated terrain on the coastal area, high throughput and range can be achieved for the fleet of naval forces out on the sea. The high capacity and low latency, self-healing and self-configuring features and ECCM capabilities combined with the ease of use make the IP-based TAC WIN system an optimal connectivity solution for any modern naval force.