

## Army Network Modernization

The FY16 National Defense Authorization Act directed the DOD to conduct a comprehensive assessment of the current and future capabilities and requirements of the Army's air-land, mobile tactical communications and data networks, including technological feasibility, suitability, and survivability. The study encompasses all Army air and land tactical communication systems; developments to date, planned enhancements (primarily programs of record), and potential future developments.

Army programs of record include: Warfighter Information Network – Tactical (WIN-T); Mid-Tier Networking Vehicular Radio (MNVR); Handheld, Manpack, Small Form Fit (HMS) Rifleman Radio; HMS Manpack Radio; and Small Airborne Networking Radio (SANR). This report includes initial findings from the assessment to include:

- Capabilities of the currently fielded mobile tactical network
- Current and future operational needs that are not met by the existing capabilities
- Challenges in the Army's network modernization plans with an emphasis on the software-defined radio programs (HMS Rifleman Radio, HMS Manpack Radio, MNVR, and SANR)
- Analysis of software and hardware design concepts to understand root causes of these challenges

The final report is expected to be complete in March 2017. It will include an assessment of which challenges can improve with the current systems, which would require significant redesign of the network or individual systems, whether or not solutions, including technology alternatives, exist.

The Army's goal for its tactical network is to provide higher data rates to the individual user, to transfer voice and data simultaneously, and in the case of WIN-T Increment 1, replace multiple stove-piped systems to allow for a network with open communication within and beyond theater. Demonstrated performance to date of the mobile line-of-sight (LOS) tactical network indicates that it will not meet the Army's operational needs. The software-defined radio programs of record with their Mobile Ad hoc Network (MANET) design have struggled to meet requirements for range, power consumption, and message completion rate (MCR). The network as a whole is limited to between 30 and 40 nodes per channel and therefore requires complex planning and management and restricts unit task reorganization. The network has demonstrated poor survivability in contested electronic warfare environments, which is the primary driver for the Army's network modernization.

Performance shortfalls and the disconnect between the Army's Network Modernization plan and its operational priorities stem from multiple gaps in requirements, software (networking waveforms, network management), and the isolated hardware acquisition strategy. The bandwidth requirements, as defined

in the radio requirements documents, are not driven by mission command network priorities, but rather by what the network can supply. Certain shortfalls such as the electromagnetic signature susceptibility are trade-offs in network design that are expected when the choice is the MANET. In that case, the capability to operate stealthily was not an operational priority when the Army originally conceived the network modernization plan. Other performance gaps, like high power consumption and network management complexity, are intrinsic to MANET waveforms. The expectation was that as technology evolved these gaps would narrow and the software-defined radios would ultimately outperform their legacy counterparts. In the meantime, the Army has tied requirements of future networking radios to existing waveforms, which are limited by the performance shortfalls intrinsic to those waveforms.

The hardware acquisition approach is such that the Army retains ownership and responsibility for the waveforms and the radio developers retain the rights to the hardware. Industry competitors who supply radio hardware cannot dictate the optimal implementation of the software; instead, they are expected to compete with the minimal possible technology solution that is the lowest cost and simplest to interoperate with other vendors in the multiple source non-developmental item (NDI) selection. They are continuing to build individual software-defined radios, rather than a functioning, integrated network. The effect on the Army's network is that the current path (future radio requirements, capabilities, and acquisition strategies) will not mitigate the performance shortfalls demonstrated to date. The Army should consider not specifying the waveform in requirements documents but rather allowing industry to compete with integrated end-to-end solutions consisting of the waveform and the radio hardware that are based on realistic threat and mission command data needs.

There is opportunity for the Army to recover performance trade-offs, re-align requirements with operational needs, and pursue technology solutions that could more effectively mitigate these shortfalls. Frequent program restructuring and acquisition delays over the past decade have translated into very few radios fielded to date. Three major tactical radio programs, MNVR, HMS Manpack Radio, and HMS Rifleman Radio, have re-entered source selection to allow for full and open competition. SANR is not scheduled for full-rate production until FY23. WIN-T Increment 2 began full-rate production in 2015, but heavy brigades cannot begin fielding until Armored Multi-purpose Vehicle production in 2021. The notable exception is WIN-T Increment 1, which completed fielding, but is still undergoing product improvements.

## PERFORMANCE SHORTFALLS

As implemented, the Army's mobile LOS tactical network design diverges from the original MANET architecture. The original design had an ad hoc number of nodes on a single subnet. The idealized MANET architecture was self-healing and self-forming. The ad hoc features allowed a node to seamlessly self-organize into geographically advantageous partitions within the context of the larger, simpler, inclusive network. MANET waveforms include Soldier Radio Waveform (SRW), Wideband Networking Waveform (WNW), and Highband Networking Waveform (HNW). This architecture has been replaced by multiple defined subnets. The effect of breaking the network into a number of small subnets places an increased burden on network planners who must manually configure each user device to constrain communication to a specific set of nodes. Units are dependent on contractors to design and configure this complex network.

### **Electromagnetic Signature Vulnerability**

In comparison to legacy systems, the Army's networking radios are more susceptible to electronic surveillance. Legacy push-to-talk radios limit their electromagnetic expression to those instances when user data need to be transmitted. Networking radios are constantly emitting in order to discover neighbors, maintain connectivity, and evaluate link conditions. Reducing the signal strength to mitigate this vulnerability requires reducing the transmit power of the signal, while to improve the LOS range requires increasing the power. Given that the Capabilities Production Documents (CPDs) for the software-defined radios currently require the radios to operate MANET waveforms, programs as currently defined cannot expect to produce systems with a reduction in electromagnetic signature.

### **Shorter Line-of-sight (LOS) Range than Legacy Radios**

Range expectations for tactical networking radios are that they meet or exceed those set by their legacy counterparts. Reductions in range would require the Army to reconsider how they conduct tactical combat operations. Progress in radio frequency technology has not translated into better range performance for networking radios. This can be attributed to the constraints under which software-defined radios running SRW or WNW are operating relative to a straightforward Single Channel Ground Air Radio System (SINCGARS) implementation. SRW and WNW operate at higher frequencies than SINCGARS. The higher operating frequencies are more susceptible to range-limiting losses in even benign terrain conditions.

The exchange of information over a MANET is dependent on the health of the direct link between two nodes, the distance between them, and the complex process by which the two communicate. A node must take the time to "join" the network, be recognized by other members, and participate in extensive routing optimization and maintenance before actual data are transmitted or received. Since the nodes are mobile, network formation is an ongoing process, rather than a problem solved at the outset of a mission.

As a result, the effective range of a node in a network is limited by a number of factors, (and very difficult to quantify in dynamic conditions). MCR is tied to the node's dynamic membership in the network, rather than the instantaneous condition of a link at the time a message is sent.

### **Network Complexity**

The network is difficult to establish and maintain. Network components, including mission command systems, network manager and the radios, are challenging to use. The value added in having an integrated network to enhance mission command is diminished due to pervasive task complexity. Additionally, the Army is challenged to achieve and maintain user proficiency. Units are dependent upon contractors to plan and support the integrated network. Thus, the Army has implemented the MANET waveforms (WNW, SRW, and HNW) as pre-configured and rigid networks. This architecture has resulted in increased time and complexity required to execute task reorganization, when a unit is attached to a new headquarters. Presently, when unit task reorganization is required, a new network plan has to be created and loaded on to the radios.

### **High Power Consumption**

The Army's software-defined radios have not benefited from technology innovations with respect to power consumption. The fields of battery technology, software-defined power management, improved circuit design, and microfabrication techniques have led to significantly less power needed to operate hardware. Soldiers are burdened with carrying and charging batteries to support dismounted radios. Mounted radios require vehicles to operate more hours per day than legacy radios, precluding the ability to perform silent watch missions and increasing the logistics support burden with increased fuel and vehicular maintenance requirements.

The root cause of the discrepancy can be traced to the design of the MANET radios themselves. Unlike legacy systems that only expend power when the warfighter is communicating, the software-defined radios are operating at near-maximum energy all the time because they must be constantly transmitting and receiving in order to maintain the network, and their presence on it, even when there is no need to transmit any voice or data messages. In the current designs, the best way to minimize the power expended during operation is to leave the network by turning off the radio. In the case of the dismounted HMS Manpack radio, soldiers observed high external temperatures during FOT&E — a common outcome of prolonged operation of high-power devices.

### **Low Message Completion Rate (MCR)**

MCR is a measure of both the functionality of the networking software (i.e., its ability to correctly transmit, route, and parse messages), and the radio frequency connectivity of the underlying

links. The current software-defined radios have not demonstrated their requirements for MCR. The demonstrated MCR for situational awareness messages is lower than for command and control messages. Situational awareness messages consist of position location information and other messages related to battlefield entities, e.g. hazard and obstacle map icons that are automatically generated by Joint Battle Command – Platform (JBC-P). Situational awareness messages are transmitted once, and if they do not reach their destination, are dropped. Command and control messages, because of their higher priority, are programmed to keep retransmitting until the sender receives an acknowledgement of receipt.

The low MCR for situational awareness messages can be attributed to the design of the network. In moving away from the original MANET construct into multiple small subnets, the network lost its resiliency of allowing messages to make multiple hops through any node in its immediate proximity. To avoid consuming the available bandwidth, the number of nodes that a message can hop through is limited to those on its subnet even when there may be other nodes in LOS range. Not able to find a route through the network, it drops the situational awareness message causing the blue picture to be stale or inaccurate.

### **Absence of Anti-Jamming Capability**

Two of the Army’s principal LOS networking waveforms, SRW and WNW, have not demonstrated their effectiveness against a jamming threat. Anti-jamming techniques involve sophisticated algorithms that consume more bandwidth and produce reduced data rates in return. This would further reduce connectivity and

MCRs for waveforms that cannot meet requirements under more benign conditions (open terrain and no jamming). The SRW and WNW standard modes of operation are not intended for a contested electronic environment. SRW’s electronic warfare mode offers some jamming resistance but only at reduced data rates. The Army does not intend to use the electronic warfare mode. WNW has an anti-jam mode of operation intended to provide a more robust signal, albeit at lower data rates. Neither the SRW electronic warfare mode nor the WNW anti-jam mode has been demonstrated in an operational test environment. Given the poor performance in benign conditions, the additional constraints added by anti-jam algorithms may make an anti-jam mode not viable without re-investment in the design of the network approach as a whole.

### **Limited Scalability**

To work effectively, the current networking waveforms limit the network to 30-40 nodes per channel. To operate the network with more than 40 nodes requires the MANET to use all the overhead bandwidth establishing and maintaining connectivity among nodes rather than sending and receiving voice or data communications. As currently configured, the radios continue to run software with ad hoc routing algorithms, but the Army has planned and configured the network to prevent ad hoc connectivity by restricting the number of nodes on a particular subnet, and in some cases, constraining exactly which nodes the data could hop through and which other nodes are retransmission vehicles.

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## **REQUIREMENTS AND ACQUISITION APPROACH**

The Army has tied the software-defined radio requirements to the existing waveforms for MNVR, HMS Manpack Radio, HMS Rifleman Radio, and SANR. Through this approach, the Army hoped to enhance competition among hardware developers and ensure waveform interoperability across different host systems. Radio capabilities will be limited by the electromagnetic signature susceptibility, high power consumption, low MCR, and network complexity, which are all performance shortfalls intrinsic to the MANET waveforms.

The network requirements are not consistent with the Army’s operational needs. The bandwidth requirements, as defined in the radio CPDs, are not driven by mission command network priorities. They are based on what the network can supply rather than how much data are needed at each echelon. The data requirements drive the requirement to operate in higher operating frequencies and are a trade-off with LOS range performance.

The Army’s requirements for its tactical networks do not take into account the evolving threat capable of advanced electronic warfare. While the requirements remain rooted in MANET waveforms as currently implemented, the networking solutions will continue to lack sufficient anti-jamming features to mitigate

against the effects of electronic attack and remain effective. Direction-finding systems will threaten the survivability of soldiers and host platforms.

The current acquisition approach for HMS Rifleman, HMS Manpack, MNVR, and SANR is a modified NDI in which the Army is retaining ownership and responsibility for the waveform and network manager, and the radio developer is retaining rights to the hardware. Hardware and software developers lack the design control necessary to implement new technology solutions. Hardware contractors have no financial incentive to integrate new technology if the Army’s requirements force them to run waveforms that cannot take advantage of those capabilities. In some cases, the contractor may already have its own commercial off-the-shelf waveform optimized for its advanced hardware platform, but may instead opt to deliver a less capable hardware system that better suffices the Army’s waveform requirement.

Though the government-run reference integration labs continue to make incremental improvements to the Army’s networking waveforms, the fundamental design of these waveforms remains rooted in the MANET protocols and hardware functionality of the early 2000s. Since the waveforms were originally developed,

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research has produced routing protocols that are inherently more scalable and power efficient. Hardware capabilities have similarly advanced, enabling improved signal processing and greater spectrum efficiency. While the commercial sector has widely adopted many of these capabilities, the Army's waveform development and hardware acquisition strategies lack the agility to do so in a timely and efficient manner.

Given these barriers to technology integration, the current acquisition strategy is detrimental to delivering an effective,

suitable, or survivable piece of operational equipment to the warfighter. The Army cannot hold the most critical technological element of the radio — the waveform — constant, and at the same time, expect hardware partners to demonstrate sweeping advancements in capabilities. The Army should consider not specifying the waveform in requirements documents but rather allowing industry to compete integrated solutions of the waveform and the radio hardware based on realistic threat and mission command data needs.

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## PATH FORWARD

Frequent program restructuring and acquisition delays have translated to very few radios fielded to date. To date, the Army has procured less than 10 percent of its full procurement goal. HMS Rifleman Radio has fielded 7 percent of its procurement goal and has re-entered source selection to allow for full and open competition. The remaining tactical radio programs (MNVR and HMS Manpack) are in the early stages of source selection for full and open competition. WIN-T Increment 2 went into full-rate production in 2015, but heavy brigades cannot begin fielding until Armored Multi-purpose Vehicle production in 2021. The notable exception is WIN-T Increment 1, which completed fielding, but is still undergoing product improvements so there is still opportunity for technology injection.

In addition to limited fielding, several aspects of network design are still being deliberated. The Army will conduct an Analysis of Alternatives to the current mid-tier networking solution, MNVR

operating WNW. A departure from WNW would represent a major shift in the Army's network plan, affecting not only MNVR, but also SANR, the Army's future aerial networking radio. With network design still being conceptualized and SANR NDI activities yet to start, a clear opportunity exists to influence the direction of the aerial tier.

There is opportunity for the Army to recover performance trade-offs, re-align requirements with operational needs, and pursue technology solutions that could more effectively mitigate these shortfalls. Regardless of the extent to which the Army's networking radios have been fielded or procured, to adapt to the changing threat landscape, a re-direction from the current path is necessary. In order to adapt to these threats the Army will need to adopt new technology (hardware and waveforms) and confront trade-offs in performance.