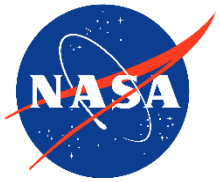

Interoperability Review of Wireless Hardware in Emergency Air-To-Ground Mesh Networks

Project: ACERO (Advanced Capabilities for Emergency Response Operations)
Project Team: Second Shift Capabilities
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INTRODUCTION

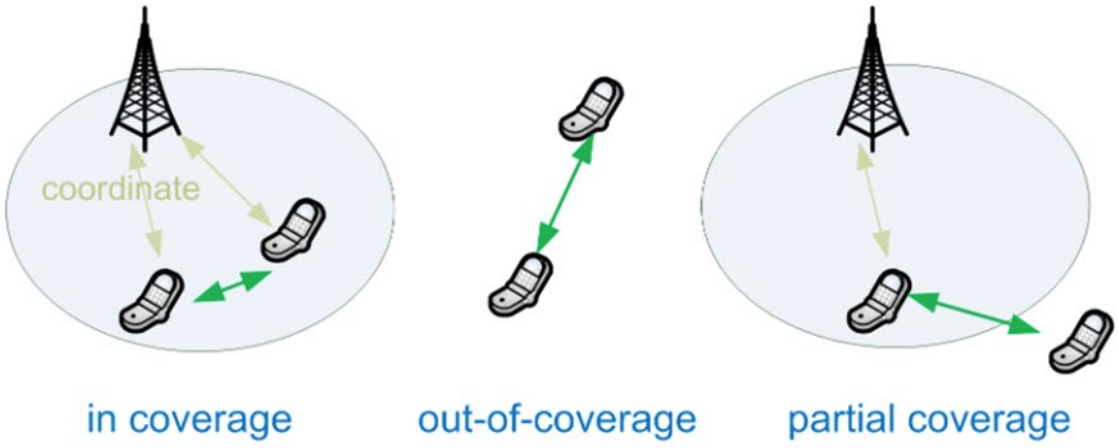
The air-to-ground network has the goal of advancing the capabilities and versatility of communications in wildfire and emergency scenarios. To ensure compatibility and keep costs low for emergency services interoperability between hardware is an important step in development of the mesh network. For the purposes of this evaluation interoperability of hardware is described as the ability for hardware from different vendors to be interchangeable within the network with minimal initial setup and no functional change from an operator's viewpoint. This report will also focus on the features and limitations in addition to the interoperability of the major wireless hardware systems core to the function of the proposed air-to-ground mesh network. The hardware systems involved are ADS-B receivers, 3GPP Sidelink devices, mesh radios, and commercial ISM band radios. For early testing the mesh radios will be in the 900 MHz frequency range using the DoodleLabs RM-1700-22W Mesh Rider Radio as the lab reference. This report will consider and categorize desirability of features, the amount of setup required before deployment, the effect on performance characteristics from nominal and maximum load, and the ability to interface with other vender devices.

ADS-B

An ADS-B receiver will be used to collect nearby aircraft activity and location information to help inform users of the mesh network without access to flight data. This device will only be used to receive flight data and will have no ability to send out messages or communicate with other devices. One-way communication will make interoperability easier to achieve as the receiver will only need to decode ADS-B signals following a national standard protocol. Therefore, specific device selection will be based on performance metrics such as reliability, max airplane capacity, power consumption, and range. For full compatibility with all ADS-B transmissions the receiver should be capable of receiving and processing all data from 978 and 1090 MHz signals to cater to both the Universal Access Transceiver and Extended Squitter channels.

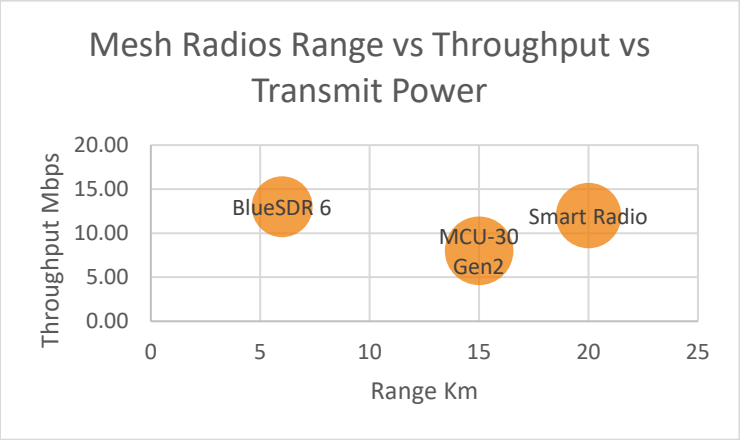
SIDELINK

The sidelink device will allow the system to connect mobile equipment without access to a mesh radio into the mesh network. Devices separated from the mesh network can also use sidelink to connect to one another as a backup communication method for geographically close devices. Additionally, devices can use sidelink as a backup or for specific purposes even when connected to the mesh network. Sidelink devices will use a recent release of the 3GPP developed protocol for 5G communications, interoperability between sidelink enabled devices will be contingent on following the release standards and guidelines. Since sidelink devices will be distributed to individual ground unit members these devices will be the most sensitive in price, weight and power consumption. There is the possibility that consumer products will become a viable option as a sidelink device soon, which may make interoperability more achievable.



MESH RADIO

The mesh radio will be the most important communication hardware device in the network which makes interoperability a necessary design consideration when choosing device requirements. However, interoperability will be a significant challenge with mesh radios because each company currently has developed proprietary mesh routing and networking protocols that are unlikely to be compatible. As with all communications hardware there is a scale of complexity when it comes to compatibility, from matching transmission and receiving frequency to data routing and handling. Compatibility between hardware will require that layer 1 - 3 protocols can either be changed to interface with the reference hardware or come interoperable by default. Matching frequencies from different vendors is generally the most flexible and simple requirement for hardware but will be the first step in ensuring interoperability. Access scheme and modulation technique matching will be the next aspects that are required to maintain compatibility. Finally mesh routing, addressing and traffic control will allow the hardware to correctly connect to the mesh network and handle data as expected by the network. Hardware requirements for the radios should include an acceptable range of transmit range, throughput capability, and transmit power. There should also be a minimum requirement for the number of devices the mesh network can handle. Mesh radios will be the most difficult to manage interoperability as



ISM BAND RADIO

Low power 900 MHz and 2.4 GHz frequency radios are quickly gaining traction as a useful tool in the emergency response communication toolkit. There are many implimentations of the technology with many focusing on device-to-device communication, remote sensors, and personal tracking. Many projects use off-the-shelf hardware with a specialized software layer to handle mesh routing, data ingress and device connectivity. Here is a quick summary of popular project examples which may have a use case in emergency communications. XBee is an outdoor LOS long range Zigbee implimentation that uses the 900 MHz band, it is a low data rate and low power device line used mostly for remote sensor connectivity. Long range bluetooth decives are similar to the XBee technology as they often integrate Zigbee technology and are useful in medium range scenario. The bluetooth protocol offers better data rate and is complelling for use cases within 2000 meters. Meshtastic is an open source off-grind mesh network project that uses the LoRa protocol, it boasts long range LOS capabilities, generic hardware compatablility and encrypted communication. Gotenna is a propriety tactical mesh networking device with a focus on asset tracking, text communication and ATAK compatability. In general the ISM band radios would be useful to an emergency communications use case if the requirements allowed for limited data rates and was able to deploy a relatively large number of radios. These types of radios can also be more suited for data sensor connectivity which could be used to supply operations with sensor data within the operational area. These radios may also be useful for last mile communications delivery, where many users are located within a relatively small area but wish to use more than voice communications.

Radio Examples	Pros				Cons	
XBee	Low Power	Small size	Simple setup		Low Data Rate	Limited use cases
Long Range Bluetooth	Low Power	Small size	Highly programmable	High Data rate at medium distance	Limited relative range	
Meshtastic	Hardware flexability	Communication focused	Interoperability focus	ATAK Integration	Security Concerns	
Gotenna	Low Power	Little additional integration required	ATAK Integration	Communication and position focused	Proprietary	Limited Hardware