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Potential Uses for High-Bandwidth, Low-Latency Wireless Networks in Radar Imaging Sensors

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ACRONYMS AND DEFINITIONS

Abbreviation	Definition
CPU	Central Processing Unit
FPGA	Field Programmable Gate Array
GPS	Global Positioning System
IMU	Inertial Measurement Unit
MTI	Moving Target Indicator
RFSoC	Radio Frequency System on Chip
SAR	Synthetic Aperture Radar
SNL	Sandia National Laboratories
SoC	System on Chip
UAS	Unmanned Aircraft System

1. HEADING 1

High-bandwidth, low-latency communications, such as that expected from 5G networks, could be very useful in future Synthetic Aperture Radar (SAR) and Moving Target Indicator (MTI) radar systems. The ability to use such a network as a data link surrogate in local testing of radars to be deployed on unmanned aircraft would be an immediate benefit to our organization. Future radar receivers could be made much smaller if they were able to only receive and digitize the reflected signals and then forward the result to a processor elsewhere through such a wireless network. Such decrease in size and required power with a precision sensor opens the application space for radar imaging sensors.

One potential application of a 5G network link is in support of development and maintenance testing of radar systems to be deployed on unmanned aircraft systems (UAS). The UAS typically has its own dedicated data link but maintaining such a data link for local manned sensor testing operations can be costly. Sandia National Laboratories (SNL) radar groups have performed such testing for many years with the same or a surrogate data link similar to what will be on the UAS, but the existing link recently reached the end of its life and failed completely. Replacing such custom data links with a 5G link from the aircraft would decrease the need for specialized equipment, both on the aircraft and on the ground. The ground station could be anywhere (and could more easily be virtualized) once the requirement to be located near the ground end of the data link was removed. If the UAS is to be used in an area where 5G service is available and reliable, the same communications link could be used in operation, allowing the UAS data link to free up for other sensors on board (or entirely replacing the UAS data link, if sufficient on-board autonomy exists to make that a safe operating mode).

A second potential set of applications is in remote processing of sensor data. Typical high-precision airborne radar systems like those developed at Sandia National Laboratories (SNL) require significant post-processing of the raw phase history data to form the images and the various informational products derived from those images. The hardware required to perform this post-processing can be a significant portion of the required hardware for a near-real-time system. However, our typical airborne radars create no more than 10s of megabytes of raw phase history data per second on average. This exceeds the usable bandwidth of most current datalinks, requiring processing and data reduction to happen on board (or after the flight). But it would easily fit in the projected 20Gbps of 5G networks. A radar sensor which simply digitizes and forwards the raw phase history data to a processor either in a dedicated facility on the ground or in the cloud could potentially be made much smaller and require much less power than our current systems. Further savings in size, weight, and power could be achieved by using bistatic or multistatic systems where the transmitted signal comes from some other system and each sensor is only required to receive the reflections, digitize them, and forward to a processing system. Recent advancements in processors and digitizers like the combined FPGA and CPU in a System-On-Chip (SoC) (like the RFSoC) can also be used to create smaller radar receivers.

High precision systems forming fine resolution images require accurate knowledge of the location and orientation of the radar throughout the data collection process. This is typically done through combining data from a Global Positioning System (GPS) receiver and an Inertial Measurement Unit

(IMU). These components may be among the largest required for such a small collect-and-forward radar receiver. However, it may be possible to use the position measurements within the 5G system itself to augment motion measurement systems internal to the radar receiver so that the internal systems can have less stringent requirements and thus be smaller.

There are numerous potential applications of small, lightweight, but high-precision and fine-resolution radar receivers. Such systems could go on smaller, cheaper UAS systems than current systems can fit, or they could go on larger vehicles along with other sensors. They could be used in groups to enable novel collection modalities or in well-known ways to improve location measurement accuracies or to measure topography. Potential applications for inexpensive height measurements include monitoring of facility coal reserves, land subsidence or ground movements. Such systems could be used for mapping of emergency zones (if the 5G network stays up in the emergency) and for certain types of search and rescue activities. There are numerous potential applications in the security and defense arenas as well, as long as the 5G system is available in the areas of interest and during the event of interest. As one example, a fine-resolution height map was generated by an SNL radar system in preparation for a particular Winter Olympics several years ago and was instrumental in helping event security personnel create a safe and secure event.

There are numerous ways that a ubiquitous high-bandwidth, low-latency wireless network could be used in radar sensors. It could provide an immediate benefit to testing programs at SNL. With appropriate system development, it could enable much smaller sensors than currently required to produce near-real-time imagery and information products in many application spaces.