Wireless Technologies for Enhancing Small Arms Effectiveness

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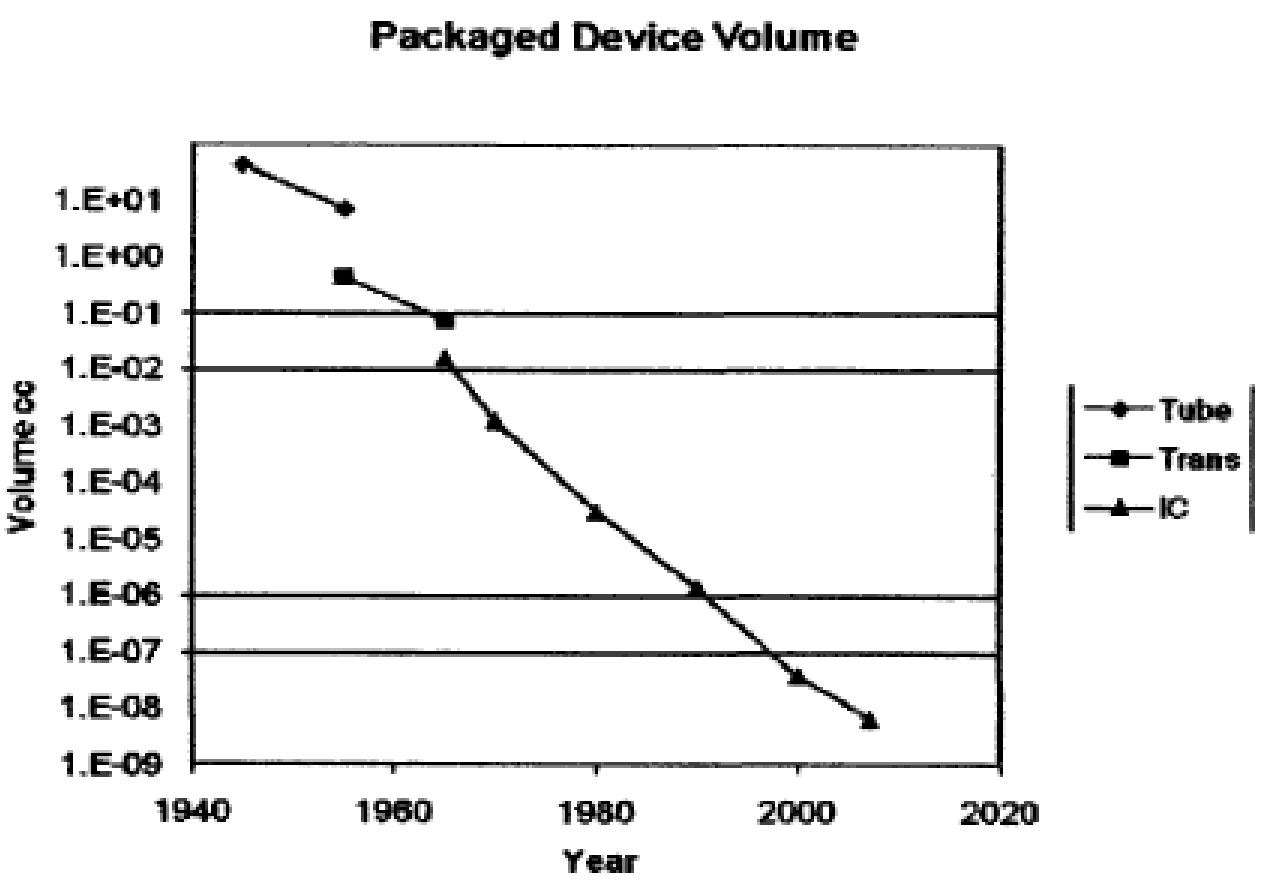
Objective

~~Explore~~ Exploit the use of wireless technologies to enhance small arms lethality and warfighter effectiveness

Drivers

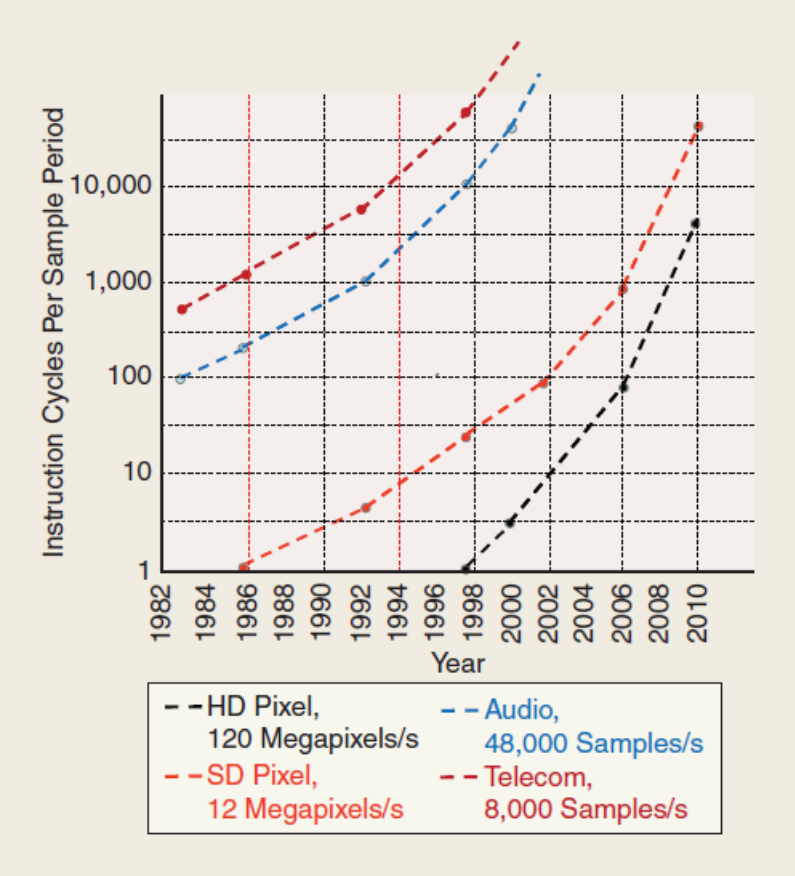
- Miniaturization of wireless systems
- Advancements in digital signal generation and processing
- Advancements in real-time computational power
- Conformal antennas

Miniaturization Trends



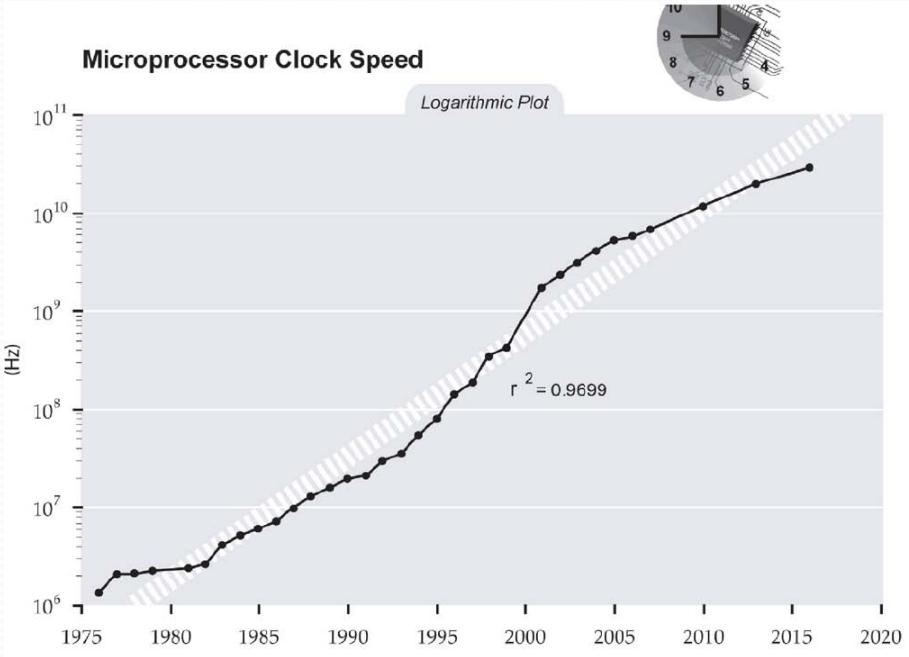
Source: L.W. Schaper, "3D-SiP: the Latest Miniaturization Technology," ©IEEE, 2008.

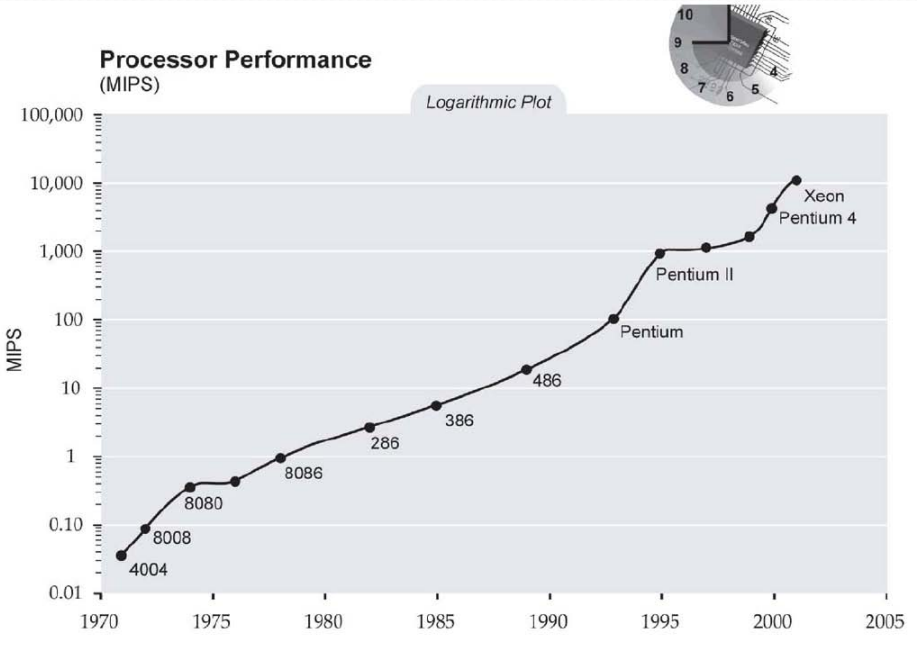
Signal Processing Trends



Source: L.J. Karam *et al.,* "Trends in Multi-Core DSP Platforms," ©IEEE, 2009.

Computational Power Trends





Source: http://www.singularity.com

Conformal Antennas

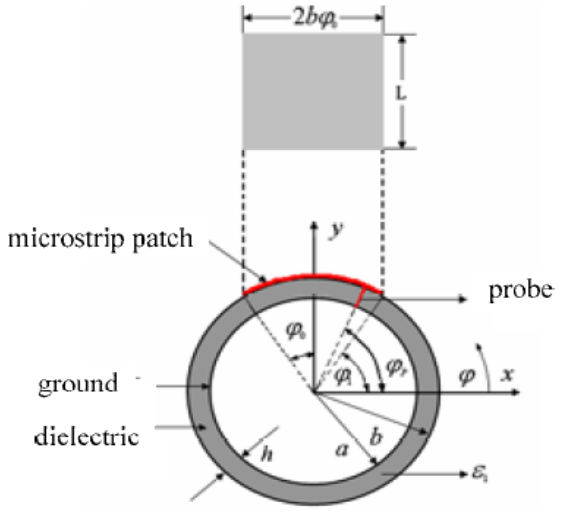


Figure 1. Cross-section diagram of the conformal microstrip antenna

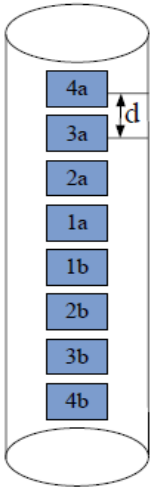


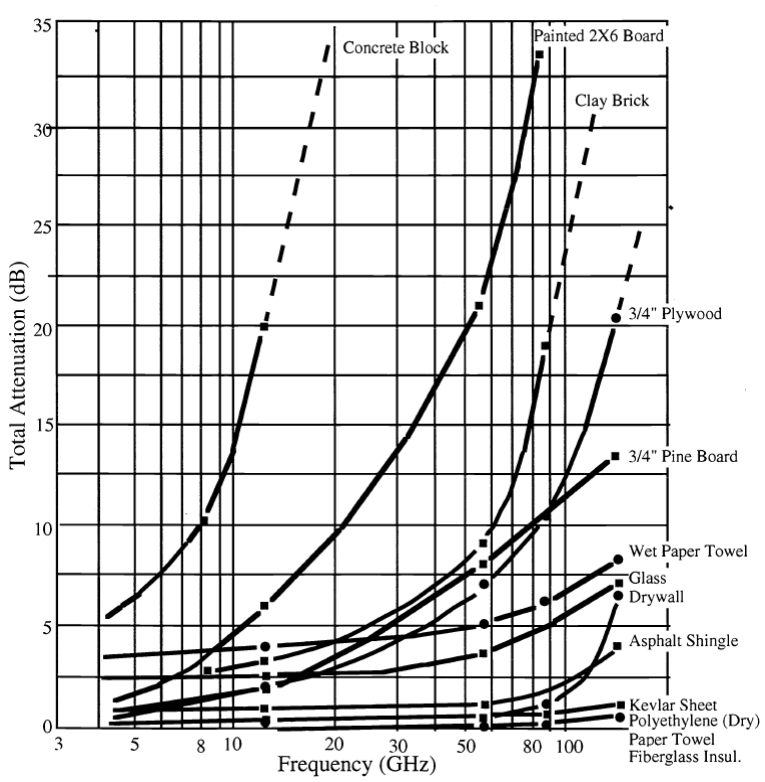
Figure 3. Conformal array of 8 array elements placed on finite length cylinder

Source: R. Han, "Simulation of radiation characteristics for cylindrical conformal phased array," ©CCSEnet, 2010.

Technologies of Relevance

- Radar detection and tracking of targets in defilade
- Micro-Doppler characterization of human activities
- Active and passive radio frequency (RF) tagging of weapons
- Ad-hoc weapon-mounted sensor networking for improved situational awareness
- Covert passive microwave radiometric detection of humans within the sensor field-of-view
- Software-defined radio techniques

Through-Barrier Radar

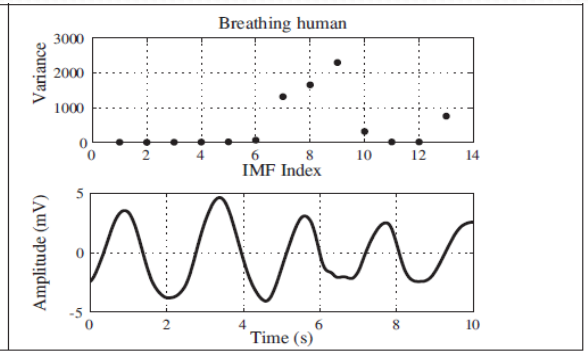


Microwave attenuation as a function of frequency for different materials.

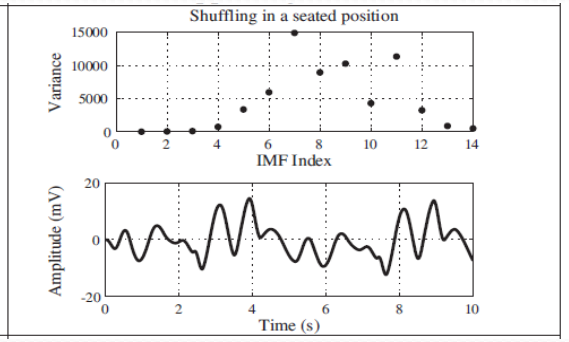
Source: Ferris and Currie, "Microwave and millimeter-wave systems for wall penetration," © SPIE, 1998.

Micro-Doppler

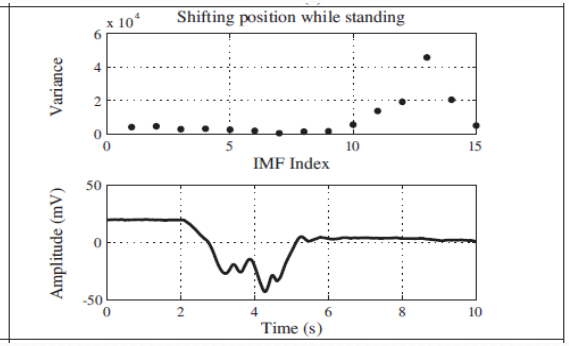
Human standing still and breathing.



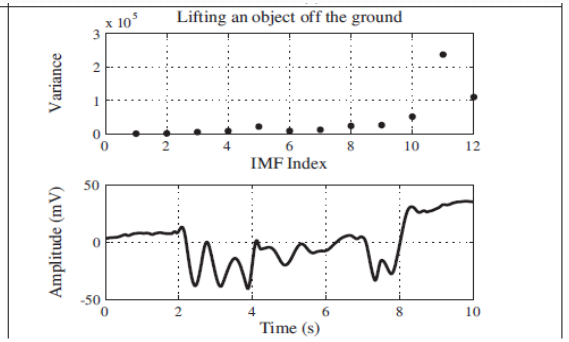
Human repeatedly shuffing in a seated position.



Human shifting position by moving for about 2 s while standing.



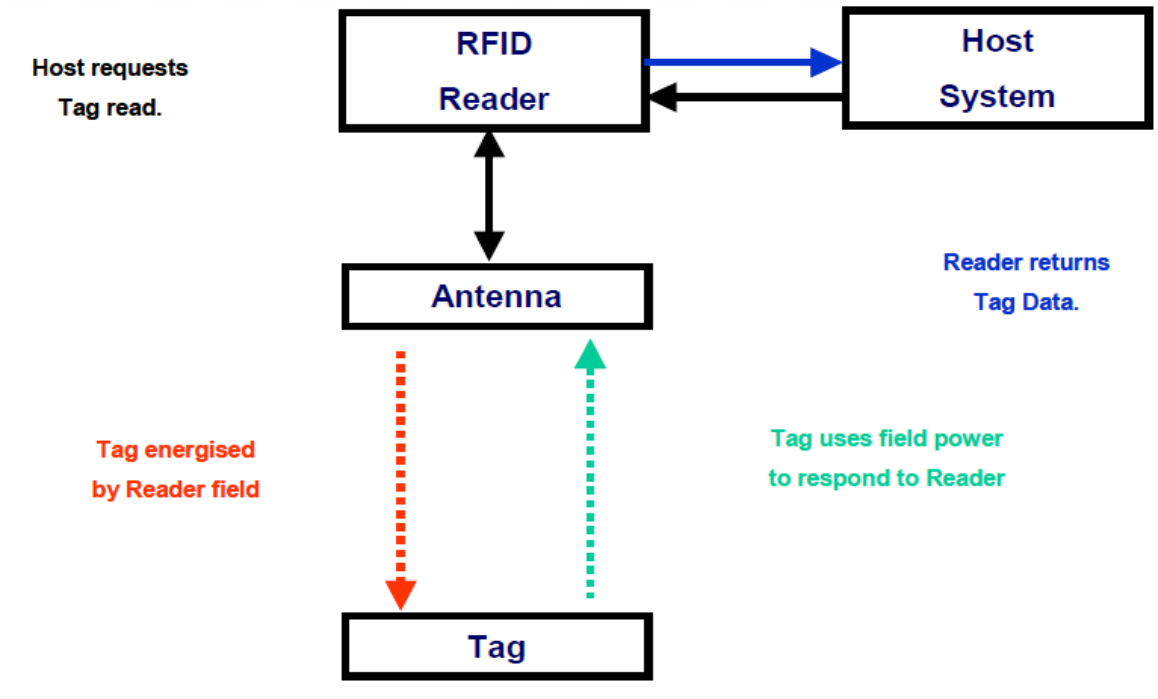
Human lifting a large object off the ground over a duration of about 7 seconds.



Measured data through a 6-inch concrete wall using a 750 MHz Doppler radar

Source: R.M. Narayanan et al., “Through-the-wall detection of stationary human targets using Doppler radar,” © TEA 2010.

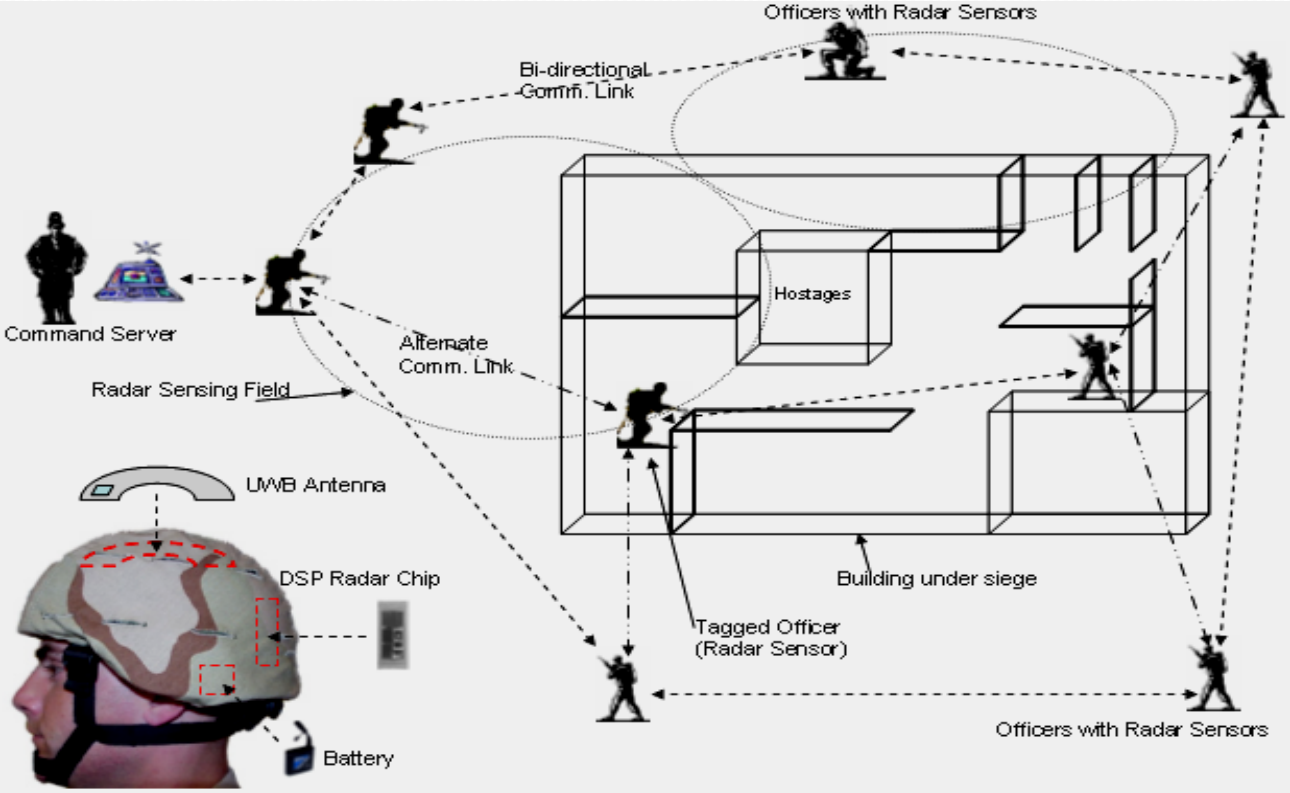
RF Tags



Host system in centralized location; Tag on weapon.

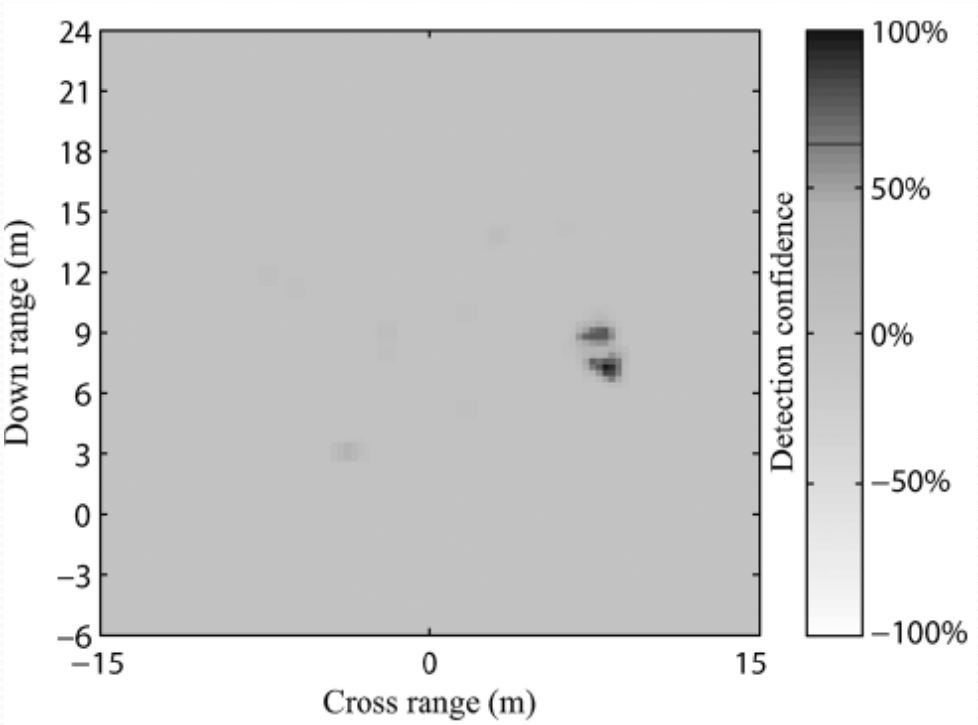
Source: Microlise Company, “RFID tagging technology,” © Microlise, 2003.

Ad-Hoc Sensor Networking



Radar detection and node-to-node communications capability.

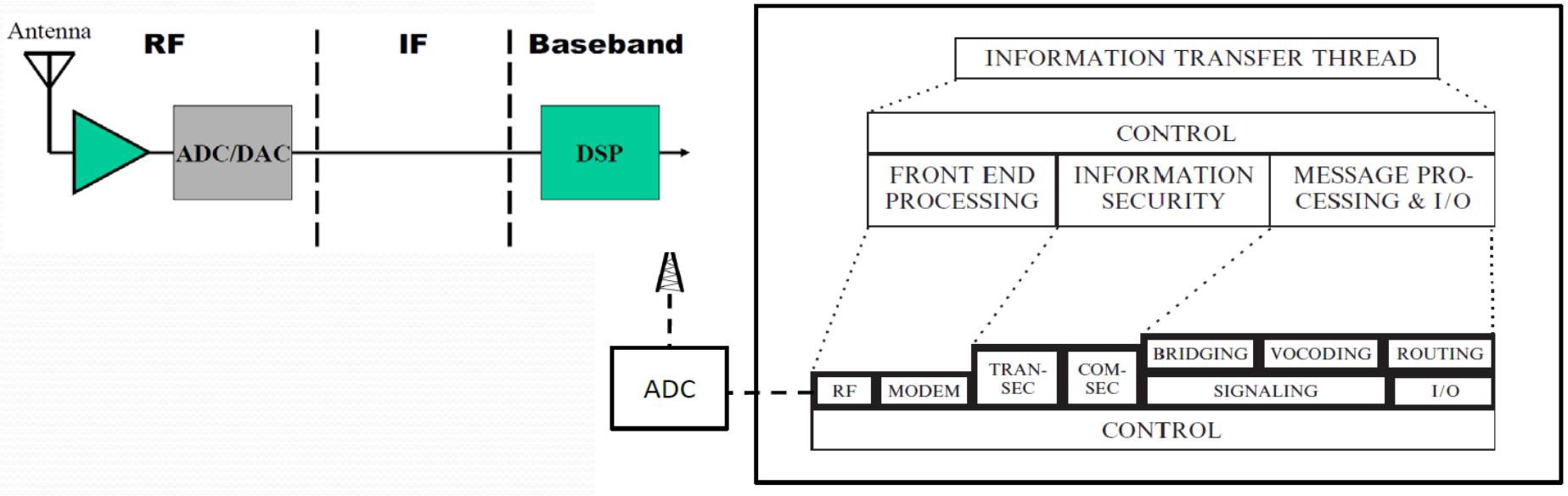
Microwave Radiometer



Detection of human using covert passive radiometer at 27.4 GHz.

Source: J.A. Nanze and R.L. Rogers, “Human presence detection using millimeter-wave radiometry,” © IEEE, 2007.

Software Defined Radio



Radio is substantially defined in *software*, i.e., Physical Layer behavior (modulation, multiplexing, filtering etc.) is implemented and modified through *software*.

Source: J. Mitola III, "Cognitive Radio Architecture," © Wiley, 2006.

Important Considerations

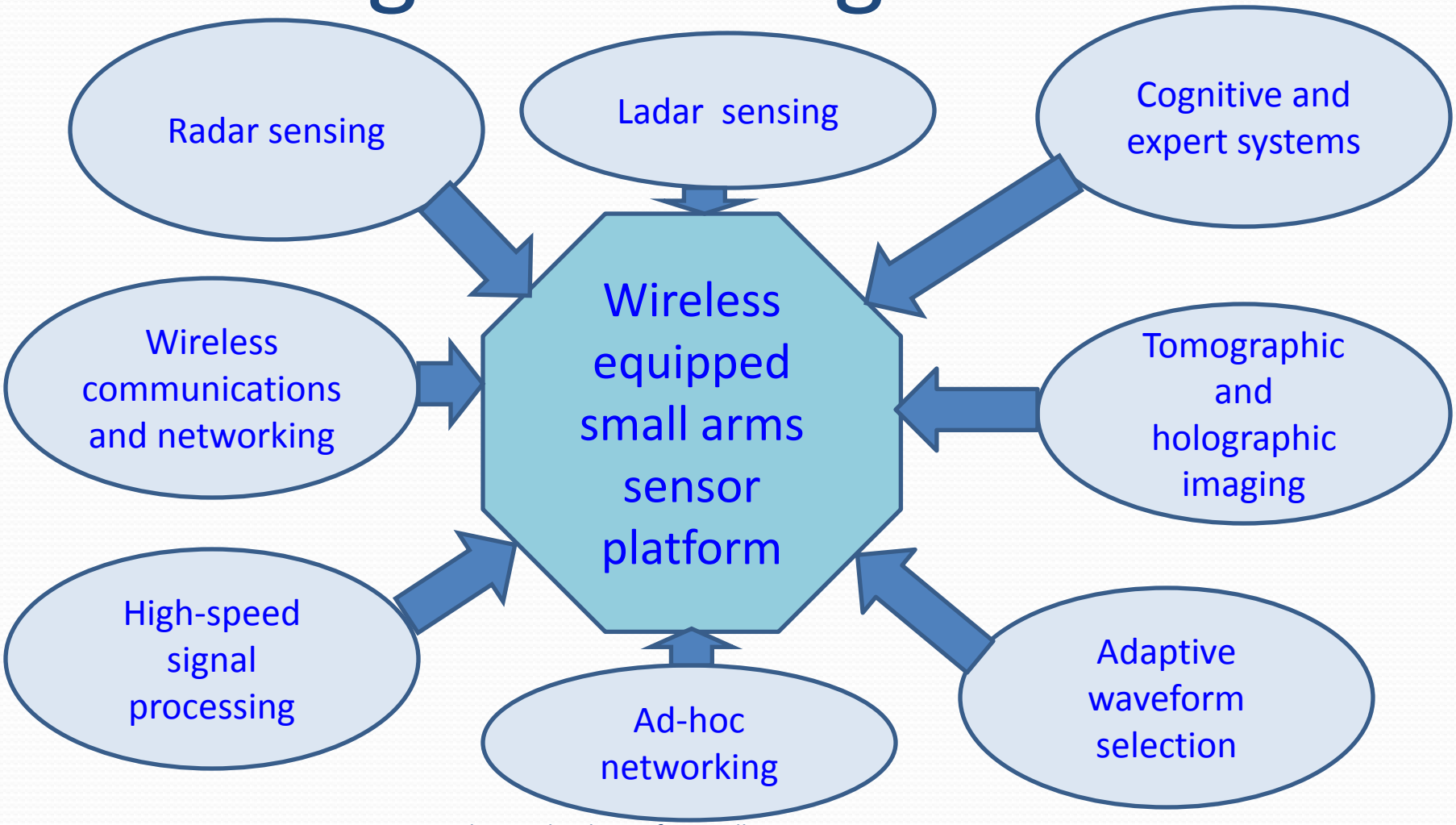
- Size
- Shape and conformability
- Weight
- Battery power
- Energy harvesting
- Shock and vibration resistance
- Warfighter-friendly
- Non-interference with warfighter operations
- Message delivery

Crystal Ball

Multifunctional Wireless Radar/Ladar Camera for Total Situational Awareness (~ 8–10 years ahead)

- Ladar for precision wide-area targeting via UAVs (5-10 sq. km)
- MM-wave radar for intelligent projectile guidance and long-range targeting (100-500 m)
- Microwave radar for through wall detection of humans and building geometries (10-20 m)
- UHF ground penetration radar for detection of caves and tunnels (30-50 m)

Enabling Technologies



Future CONOPS

- Combination of desirable features (multiple functions, multiple operating frequencies, arbitrary waveform generation, and cognition) in a simple and single user-friendly, lightweight handheld
- Single device obviates the need to carry multiple sensors
- In use, the operating mode of the multifunctional wireless sensor is switch-selected by the warfighter depending upon the application at hand
- Data gathered by warfighters wirelessly transferred to the commander for processing, fusion, and decision making

System Benefits

- Lightweight, handheld operation (like an “aim and shoot” camera)
- Simple controls
- Mode selection
- Adaptable to environment and terrain characteristics

Big Question

Is such a sensor possible at all ????

Historical Answer

Was this imaginable in the past ???

Conclusions

- Wireless technology capabilities of relevance exist **today**
- Integration of wireless technologies at the warfighter level is a **game changer**
- Recommend substantial **targeted funding** to develop and architect foundational building blocks
- Recommend **intensive collaboration** between academia, industry, and government to develop relevant technologies
- Recommend **close interaction** with the user, namely, the warfighter, in assessing needs and requirements

Questions/Comments ?