

60GHz Communications, RFID moving to PWST

Donald Kimball

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Overview

- ☞ Motivation of building V-band based technology- Physical Characteristics of V-band
- ☞ ViFi- V-band wireless technology toolset
 - ☞ Fixed Network Architecture
 - ☞ Mesh Network Architecture
- ☞ VERSA - V-band Enhanced RFID/Sensing

Physical Characteristics of V-band

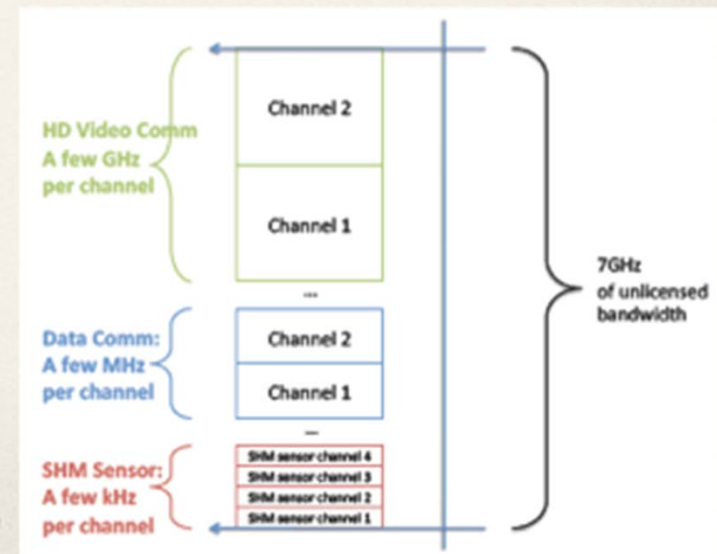
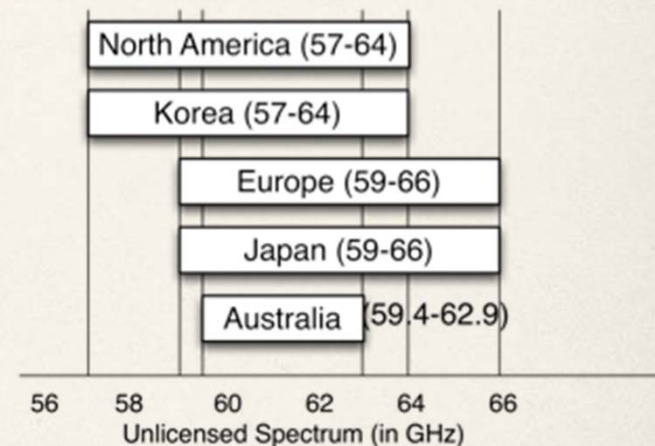
Multi-operation Support

Bandwidth: 59-64 GHz band (also known as V-band) has been established as unlicensed band throughout most countries.

High speed support

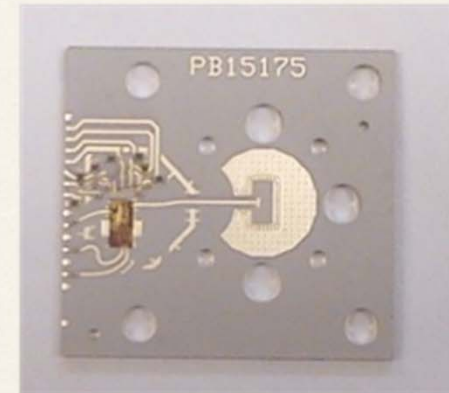
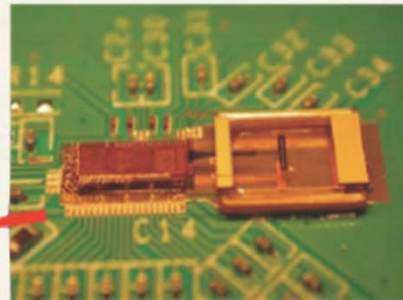
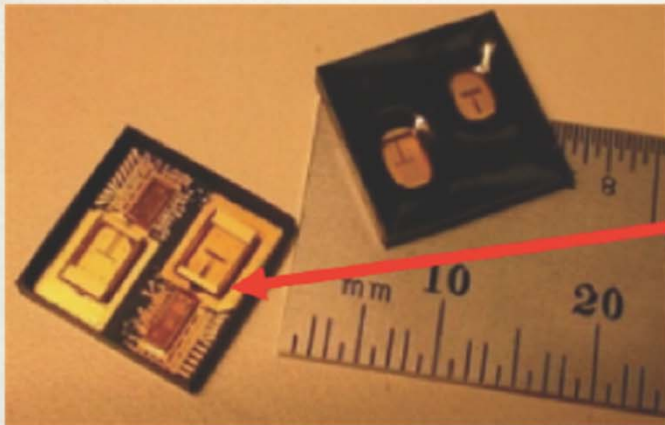
Large link capacity support

5-7GHz available BW

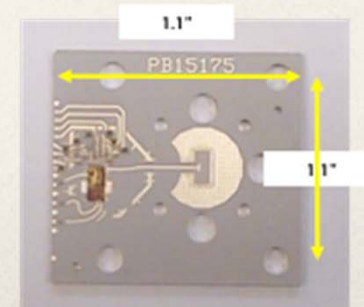


System Weight and Size

Highly integrated MMIC chipset selection

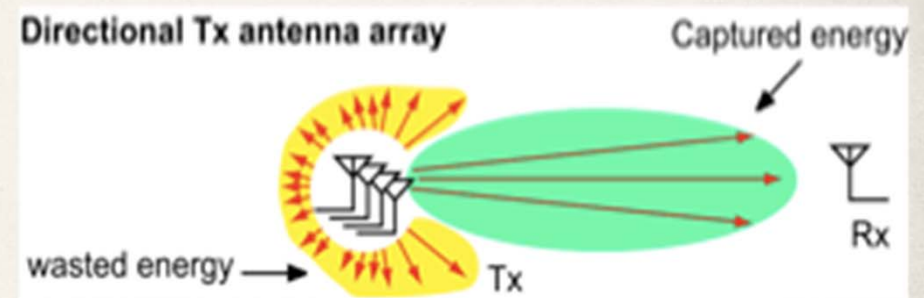
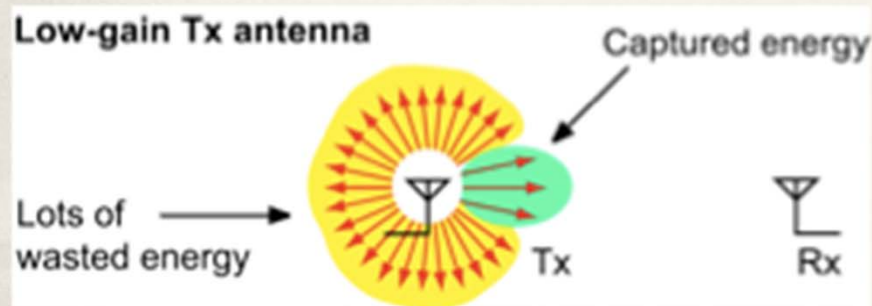


V-band Tx or Rx test board with dipole Ant.



Beamforming @ V-band

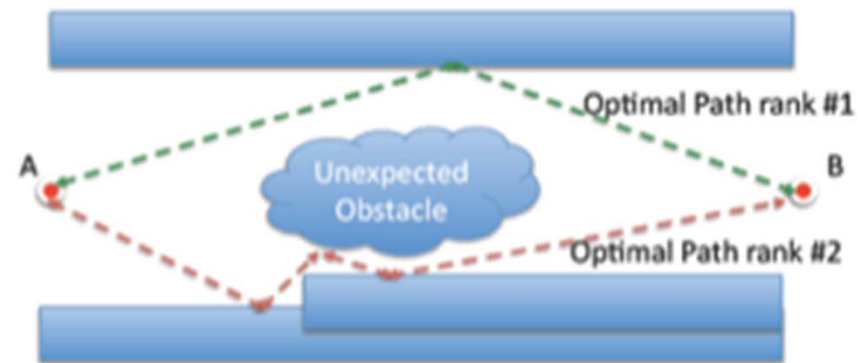
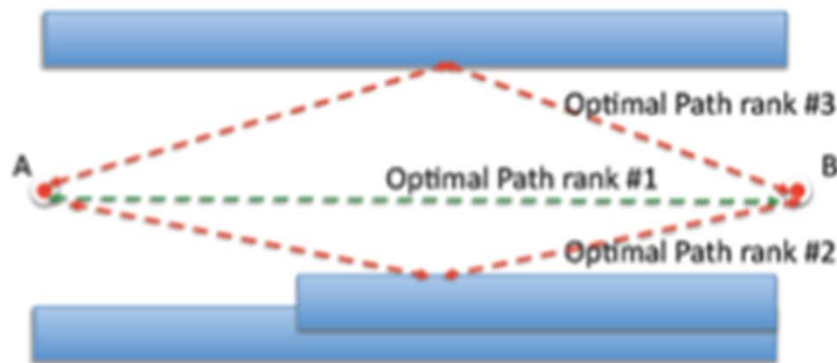
- Component size lead to efficient implementation of beamforming
- e.g. $\pm 75^\circ$ steering range, 9.5° resolution, SiGe 8HP 130um process, 8 elements



The 60GHz “reflective” environment

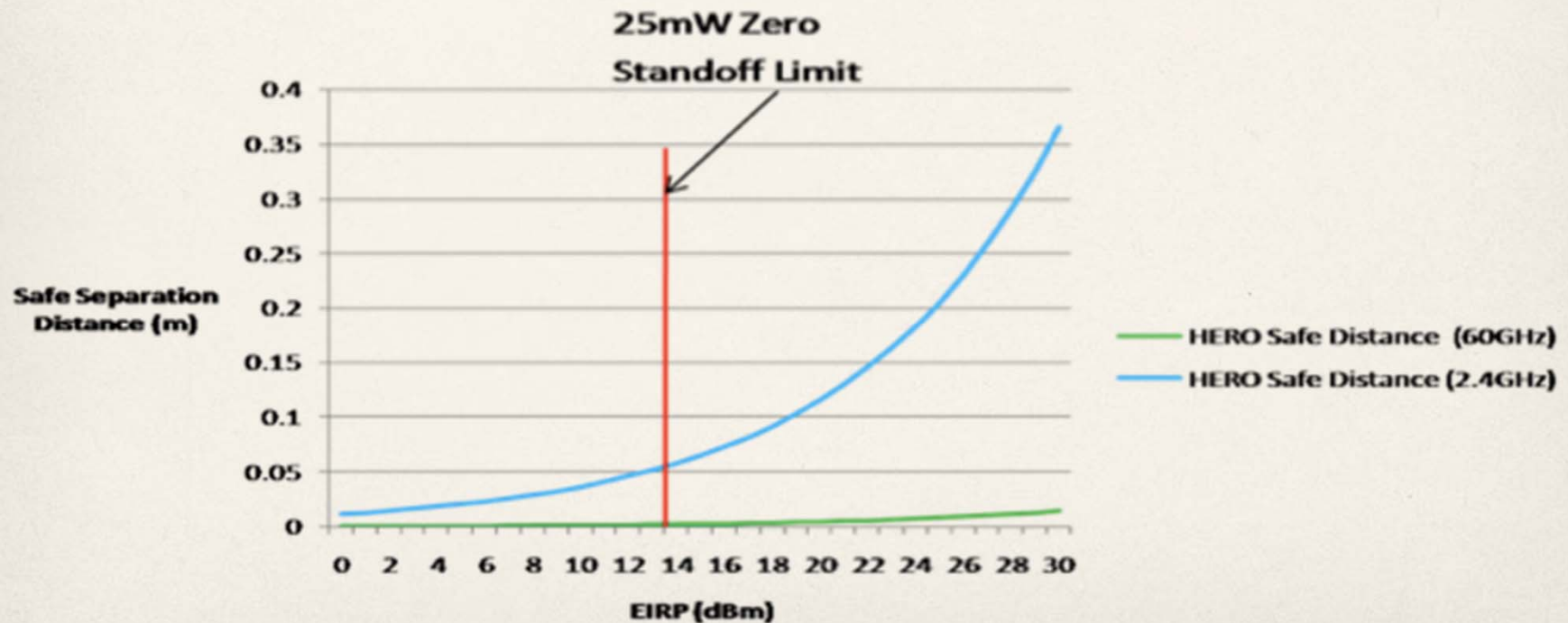
Material	Transmissivity %	Reflectivity %
Aluminum	<0.06	>99
Brass	<0.06	>99
Wood	6.3	2
Plate board	42-63	2-3
Chipboard	4.5	20
Concrete	0.0001	16
Glass	25	16

} Highly reflective in spacecraft environment

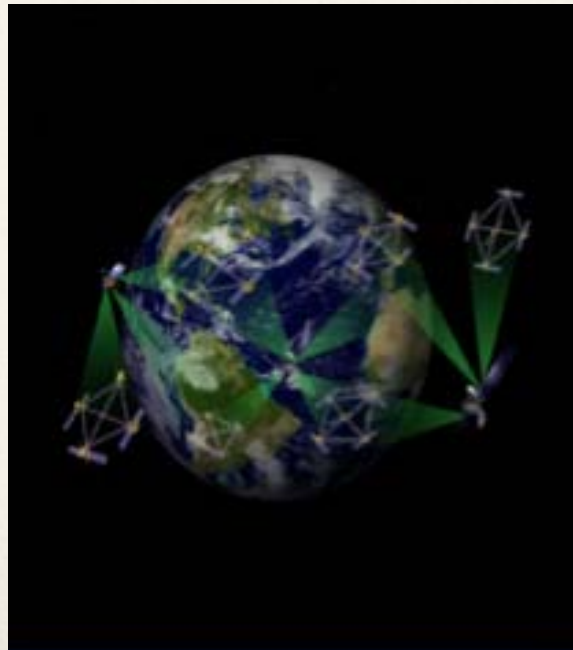


Electromagnetic Radiation Safety

HERO (Hazards of Electromagnetic Radiation to Ordnance)



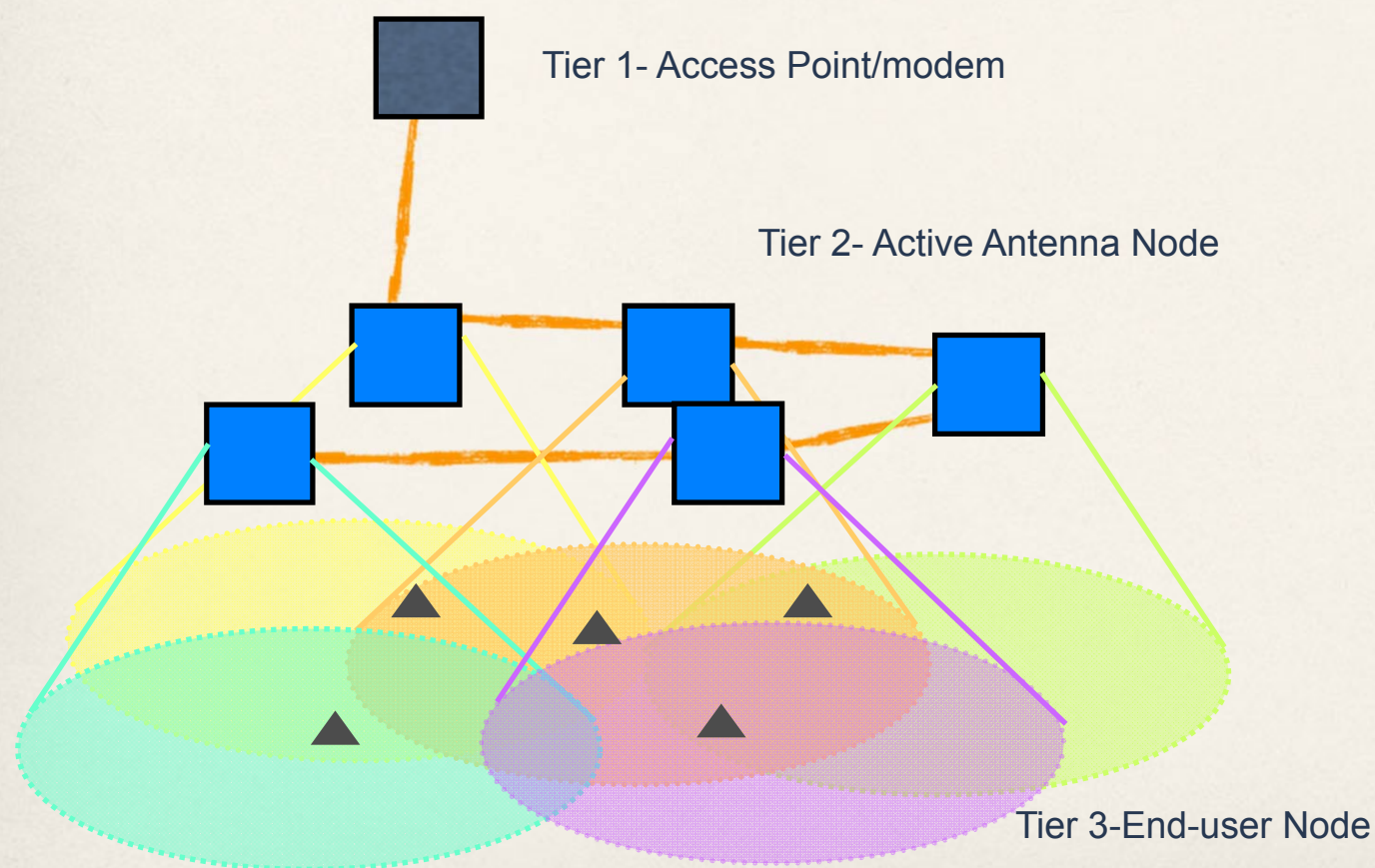
ViFi- V-band Wireless Toolset



ViFi Toolset

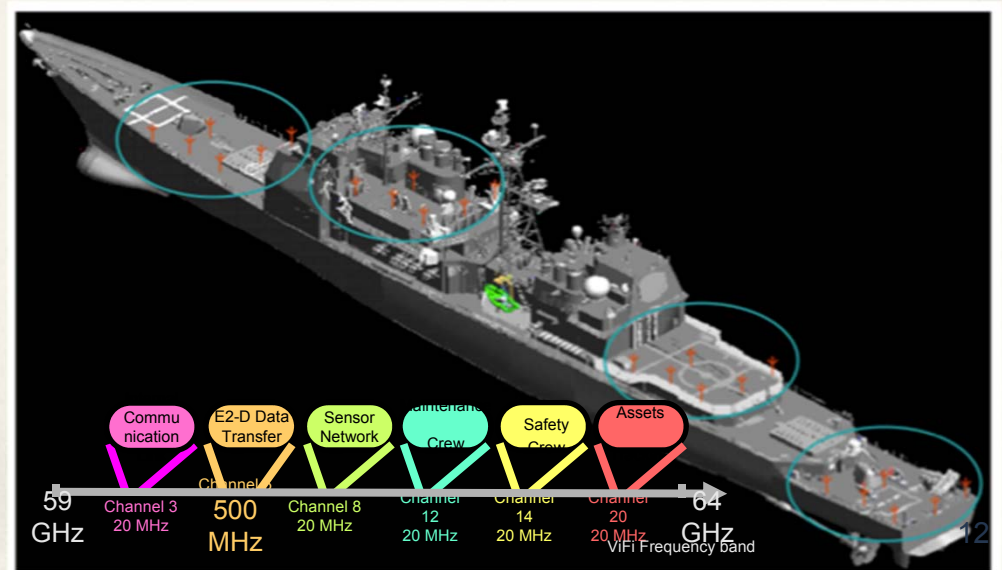


Fixed Network Architecture



Sample Application

- Topside ship application
 - Supports several non- overlapping networks (i.e. Maintenance, Assets, security,...)
 - Supports multiple waveforms depending on the service needs (802.11, bluetooth, UWB)



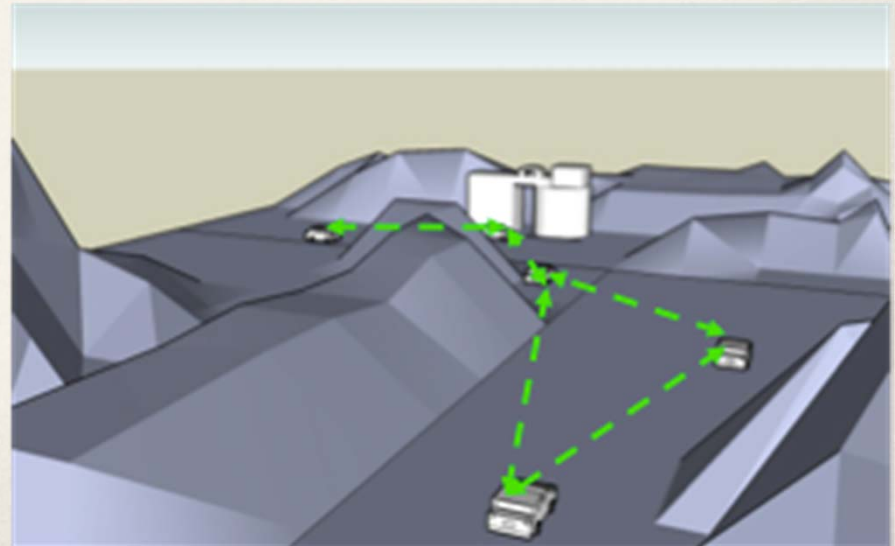
Hardware Specification

- ☞ Capability to allow for multi-channel operation
- ☞ Support of signal bandwidth up to 1.5 GHz (can be extended to 7 GHz)
- ☞ Power Consumption = 4.8 Watt
- ☞ Maximum Output Power = 10~13dBm EIRP
- ☞ Noise Figure =11dB
- ☞ Phase Noise @ 60GHz
- ☞ -72dBc/Hz @ 10kHz offset



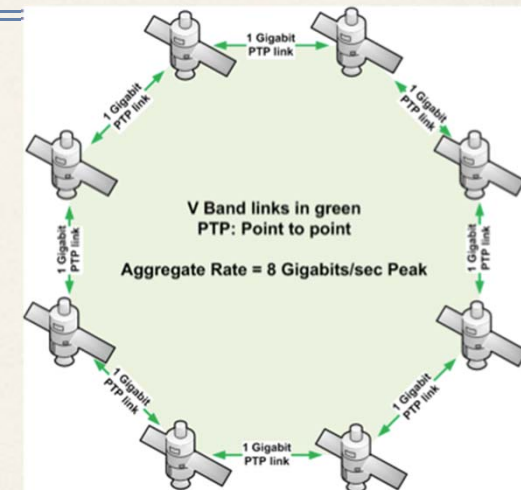
ViMesh- Mesh Networking

- Memory based agile mesh network
 - Support for Ad-hoc Mesh Networking
 - High Data Rate Support (>Gbps)
 - Delay Tolerant (Memory-based)
 - Ethernet Compliant



Sample Application

- **Provides gigabit data transfers between modules**
- **Point-to-Point**
 - Allows for multiple connections at the same time
 - As cluster size increases so does cluster aggregate data rate
- **Risley Prism Antennas**
 - Narrow band
 - 3° beam width at broadside
 - Steerable
 - 120° conical Field of Regard
 - Highly resistant to interference
- **Operates at 55 to 65 GHz**
 - Does not interfere with terrestrial communication
- **Interface to TP**
 - Data - SGMII over Serdes (TLK2711)
 - Control - SpaceWire



Wireless Ethernet for Space

DARPA F-6 Project

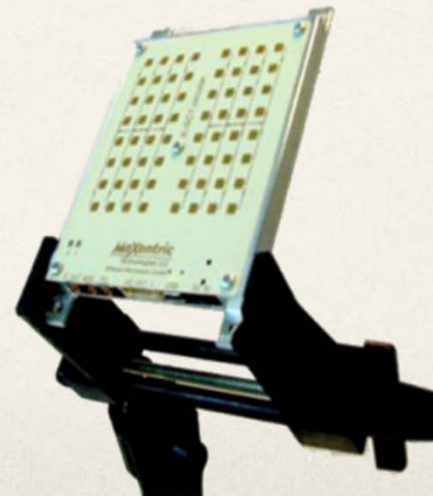
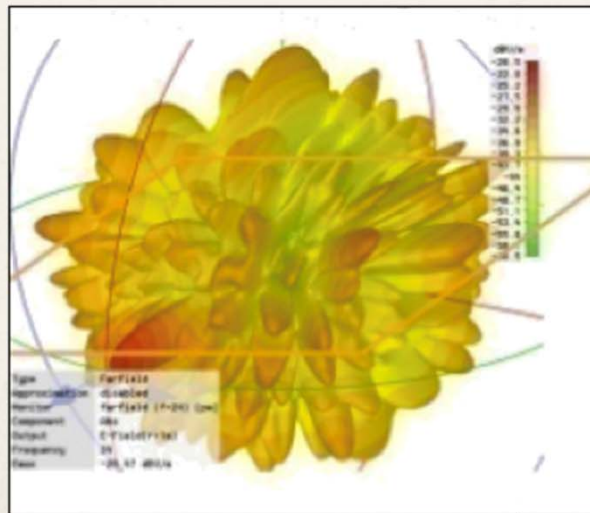
Team: Aeronix, BBN, FirstRF, and MaXentric

ViMesh Hardware Specification

- 🌀 V-band wireless replacement for a wired GigE Ethernet connection
- 🌀 Support for MIMO operations
- 🌀 Ad-hoc routing support
- 🌀 Specifications
 - 🌀 Modulation scheme: MSK, DQPSK, D-OQPSK, BPSK
 - 🌀 Full Duplex Operation
 - 🌀 Data rate: 1.3 Gbps and adjustable to 10 Mbps
 - 🌀 FPGA: Altera Cyclone 4

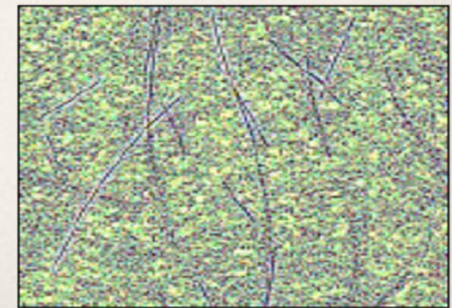


VERSA: V-band Enhanced RFID/Sensing Architecture



VERSA Tags

- ✧ V-band Enhanced RFID Sensing Architecture
- ✧ VERSA tags are completely passive
- ✧ VERSA tags are embedded with thin metal dipoles called taggants
 - ✧ Length of the taggant and type of material determine resonant frequency
 - ✧ Current taggant implementations are several millimeters long, several micrometers wide, and hundreds of nanometers thick
- ✧ Can be manufactured on a variety of materials: paper, wood, plastic
- ✧ Unique RF signature depends on many parameters
 - ✧ Taggant orientation
 - ✧ Relative positions of taggants

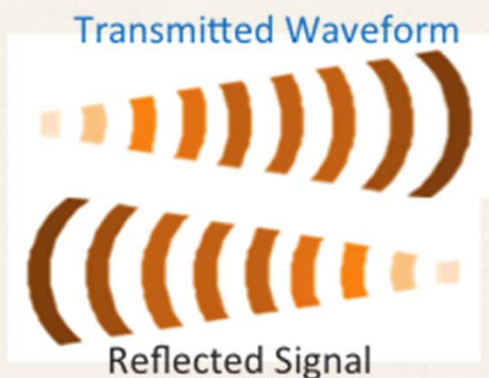
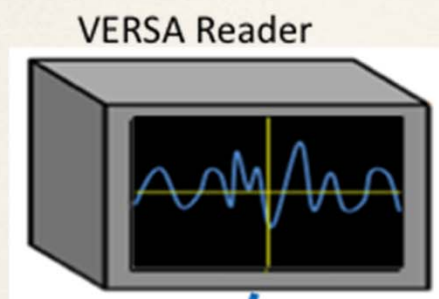


Randomly Distributed Taggants₁₈

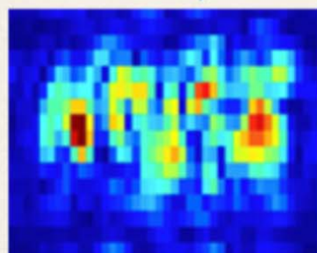
VERSA Interrogation Process

1 – Illumination – Reader transmits RF energy at a resonant frequency is directed at the VERSA tag

2 – Tag Reflection – VERSA tag scatters RF energy back at Reader based on the arrangement of taggants



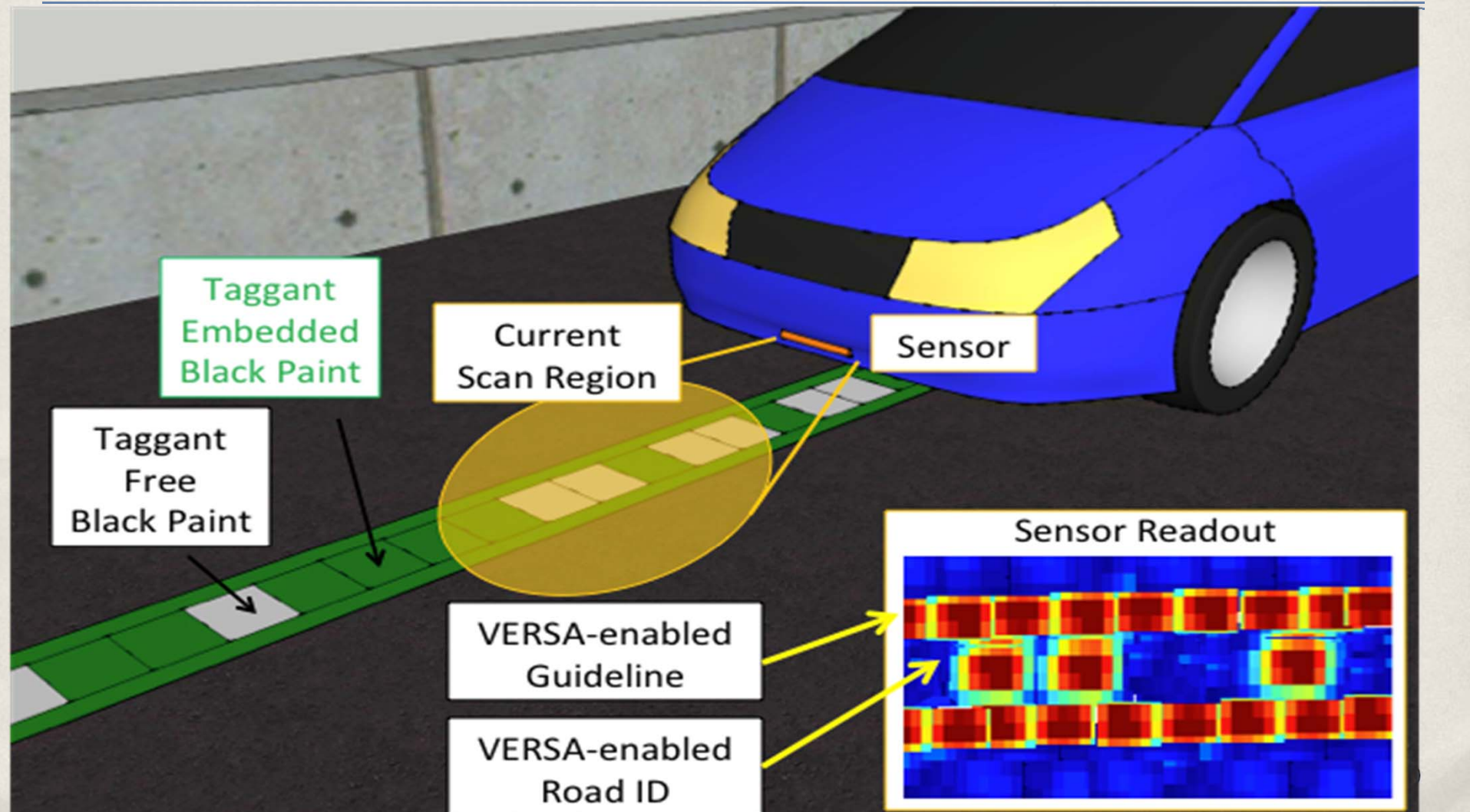
3 – Collection – Reader receives and records the reflected signal



4 – Processing – Signal processing is performed by Reader to generate a “fingerprint”

5 – Identification – “Fingerprint” is compared to a database of enrolled signatures

Sample Application: Intelligent Highway



Monitoring through Tag Deformation

- Deformation of VERSA substrate alters return signature
- Substrate can be designed to deform based on:
 - Temperature
 - Pressure
 - Voltage
- Measuring and analyzing the return signature can provide information on operating conditions
- Passive, chip-less sensors can be deployed in harsh, hard-to-access environments

Tag Deformation Example

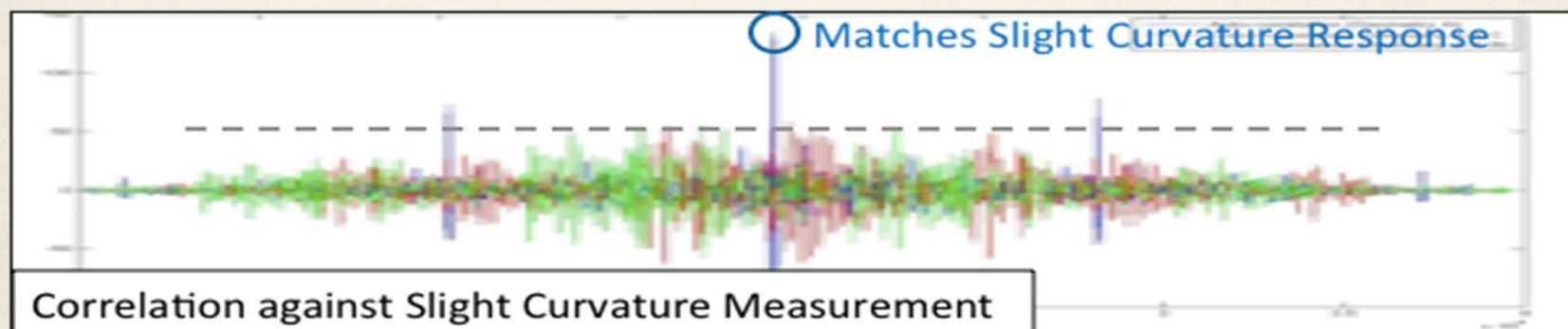
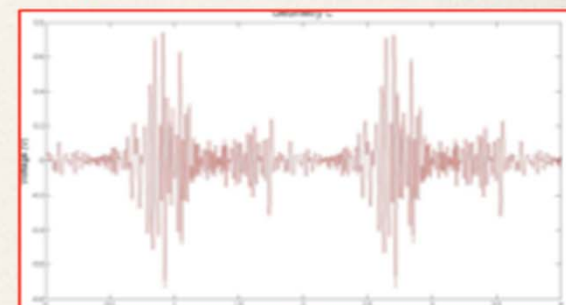
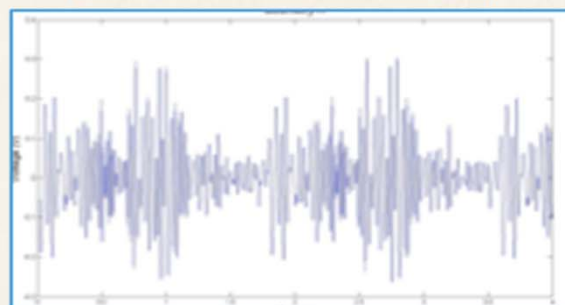
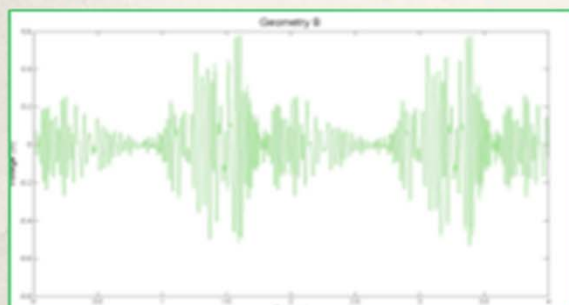
Flat



Slight Curvature



Medium Curvature

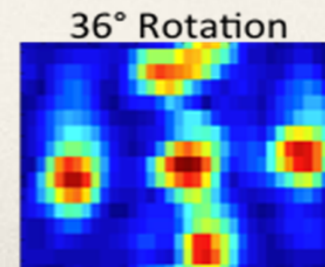
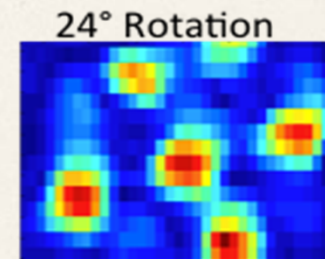
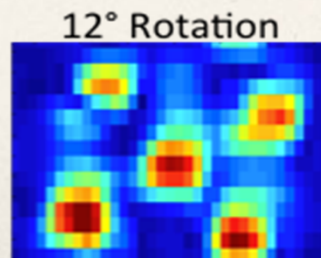
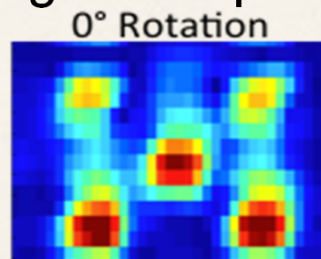


Monitoring through Orientation Change

- VERSA sensor can be mounted on platform that rotates as conditions change
- Change of tag orientation alters return signature
- Monitoring change in signature provides information on condition change



Engineered
Structured Tag



Summary

- 60GHz V-band suitable for passive wireless ID tags in based on tiny wires embedded in paper or paint
- Lower price of 60GHz transceivers vs original 24GHz prototype system
- Leverages WiGig, WirelessHD, and IEEE 802.15.3c WPAN equipment
- Passive sensors implemented by physical deformation