Use of 3D Printed Antennas for RF Energy Harvesting Purposes

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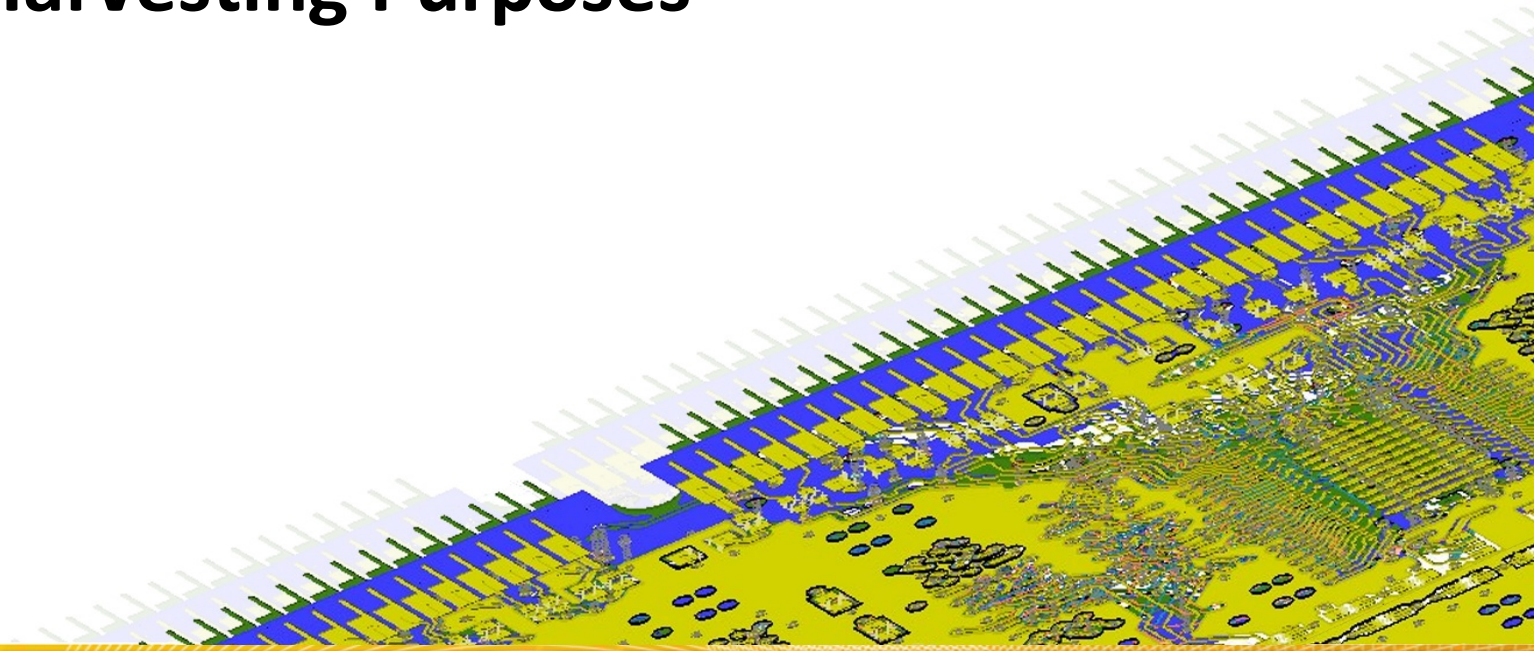


Abstract

RF Energy harvesting using 3D printed materials is a growing application both in commercial and military applications. RF energy harvesting is the use of indirect or scattered energy to enable wireless charging of low power devices such as batteries for radios, GPS devices or any other sensors. The military is interested in keeping these devices light weight and energy efficient as the devices that they need to carry can add on additional weight of up to 15 pounds. This paper will focus on the effects of using different 3D printed materials and fabrication techniques to create a planar antenna at 1 GHz. Both patch and slot type of antennas will be investigated. The dimensional length and width and proximity of the lines created with the different 3D processes will be investigated as they directly impact the functionality of each antenna and its related circuitry. The planarity of the 3D printed surface will also be addressed as part of this investigation.

Agenda

Introduction and Context

Simulation of the Connected Soldier and Battlefield Environment

Application :3D Printed Antenna Design for Energy Harvesting

Wrap Up and Q&A

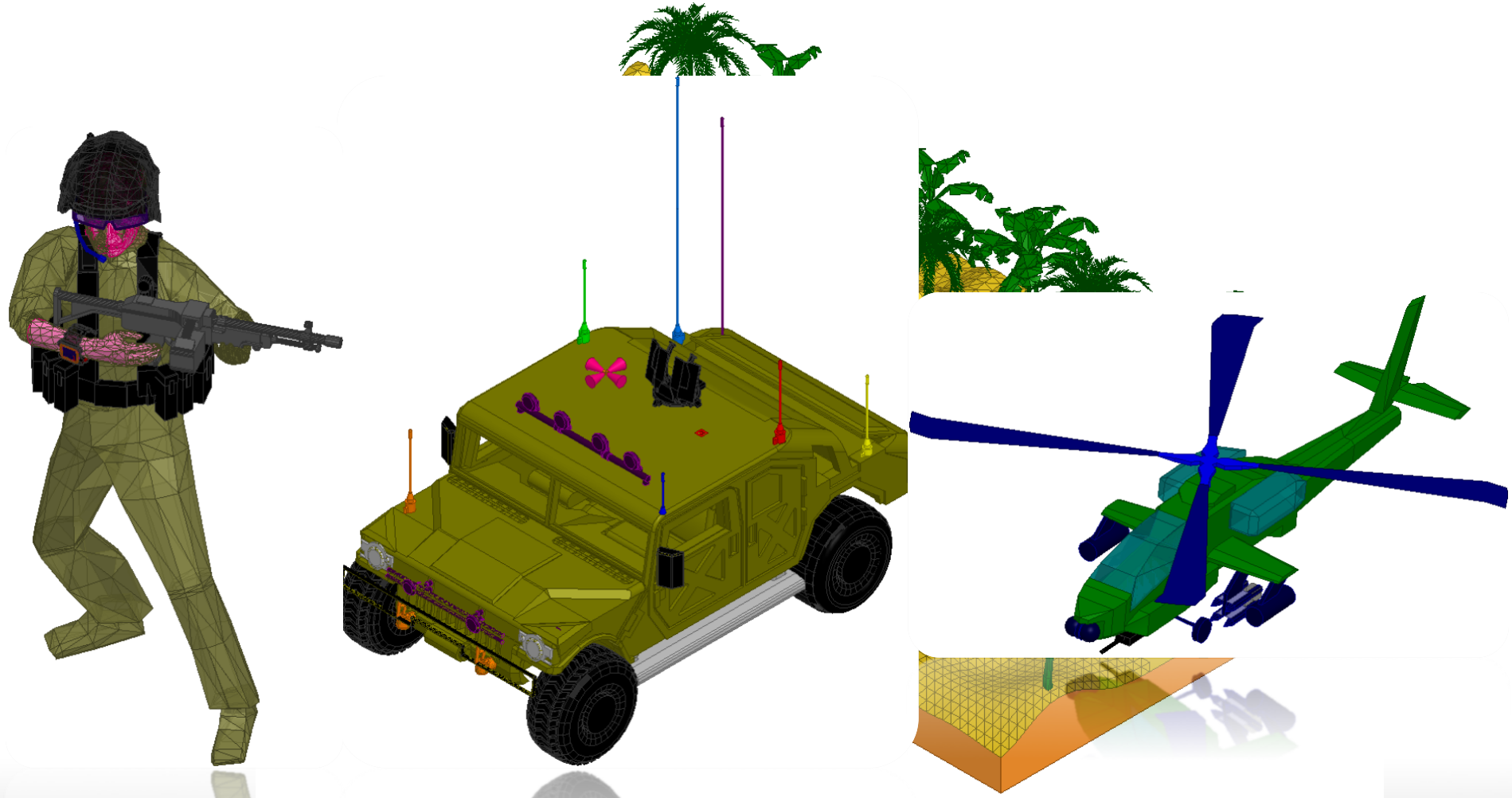
Why Energy Harvesting/Scavenging

- Not a new concept (solar, wind, thermal,RF, piezoelectric, etc)
- Proliferation of portable IOT
- Re-use of already available energy

http://nikolateslasolar.blogspot.com/2015/07/radiant-energy-harvesting-night-time.html#!/2015/07/radiant-energy-harvesting-night-time.html

Battlefield – Harsh RF Environment

The adaptation of the Internet of Things (IoT) to military applications proved to have a substantial impact on soldiers on an off the battlefield. The concept of the "Connected Soldier" relies on multiple radios for communications, navigation, data and video links.



Introduction and Context

But to be successful, technology underpinning the connected soldier must overcome 5 common engineering challenges that the “Internet of Things” just made a whole lot more difficult

- Size, weight, power and cooling
- Sensing and Connectivity
- Safety and Reliability
- Integration into the broader environment
- Durability

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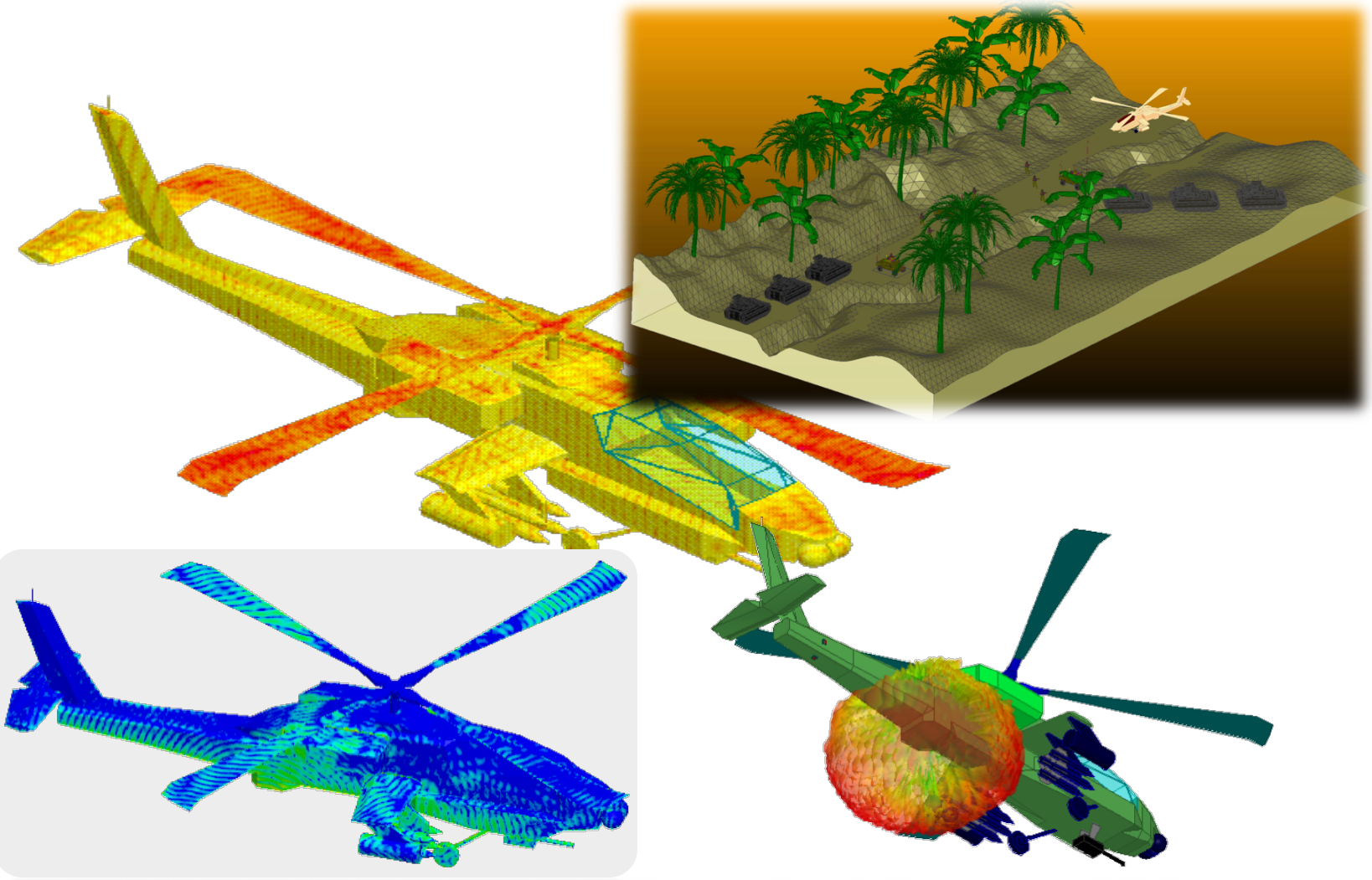
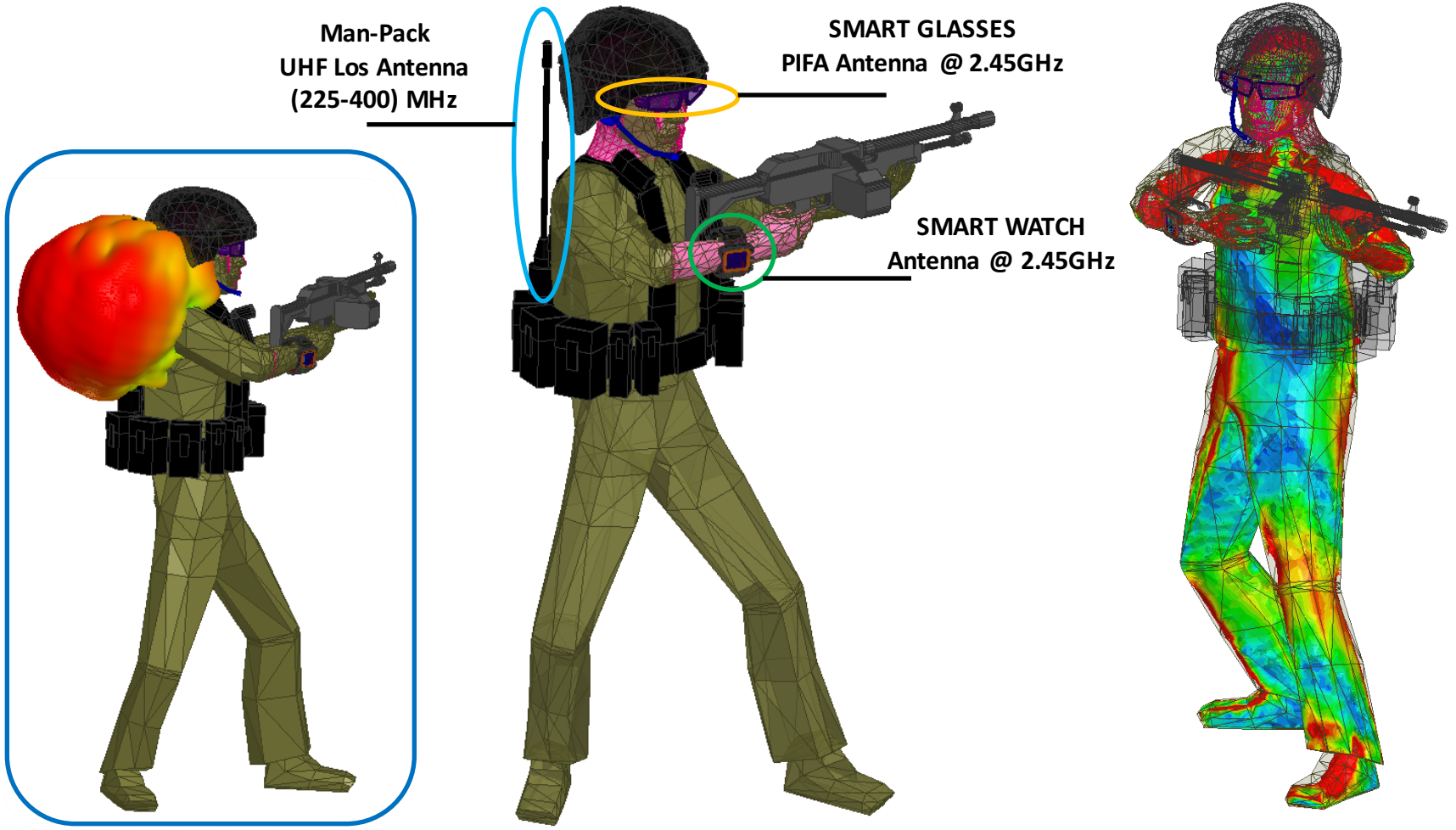
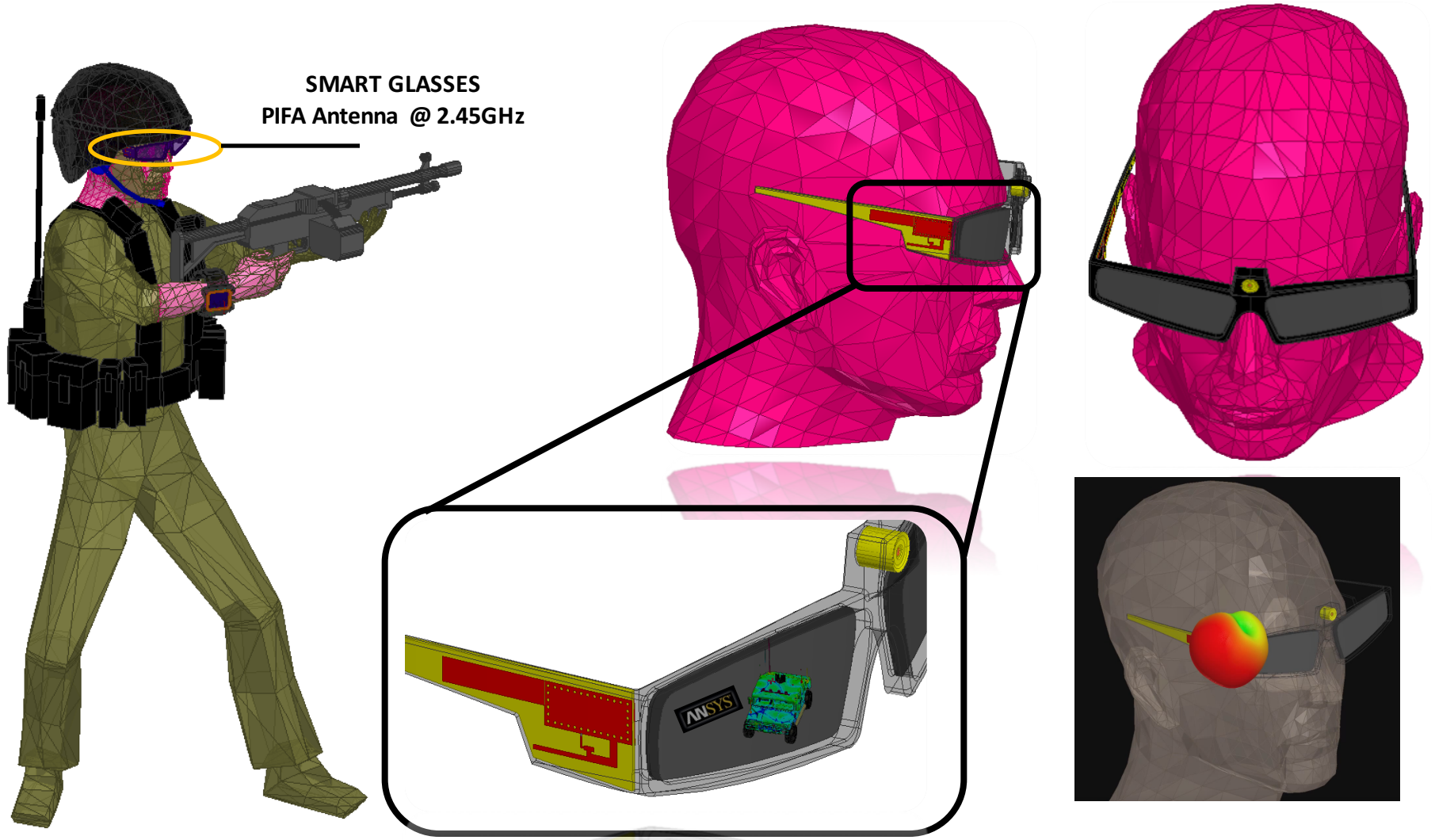
Wireless Communication for Battlefield Security …



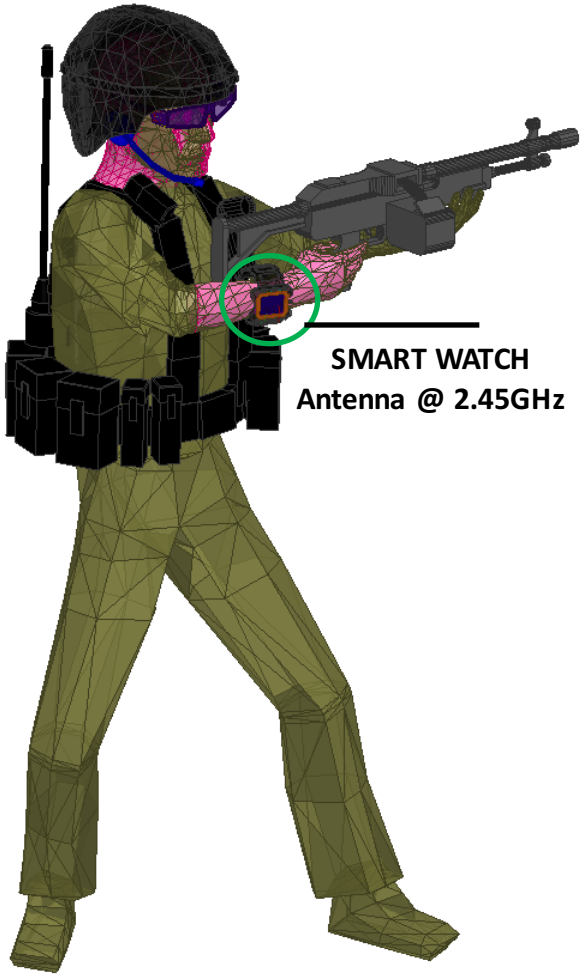
Smart Wearable Technologies for The Connected Soldier …



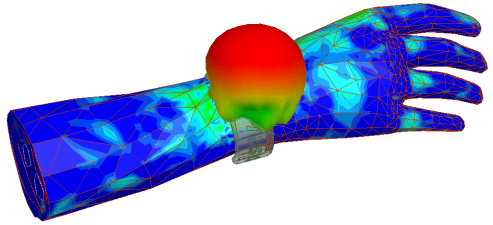
Smart Glasses Technology Integration

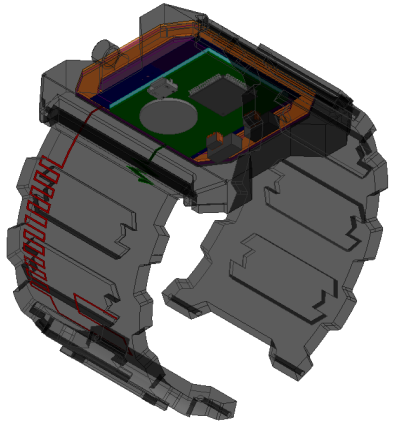


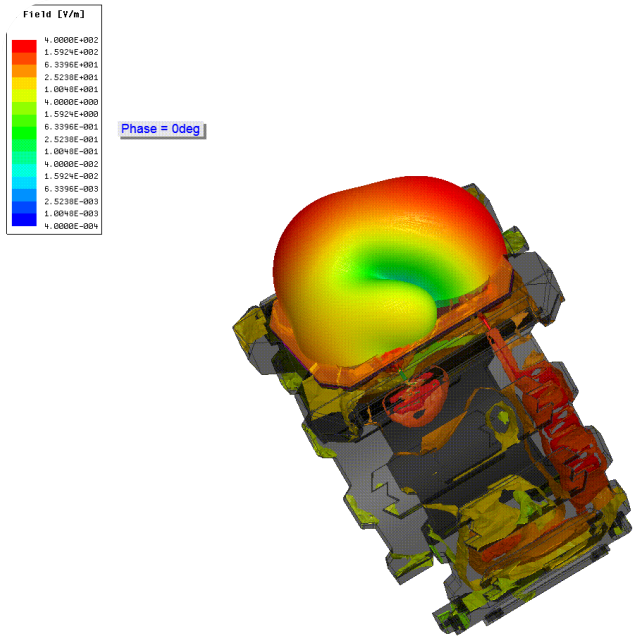
Smart Watch Technology Integration



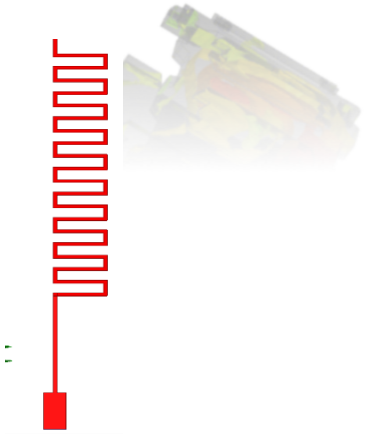
SMART WATCH
Antenna @ 2.45GHz





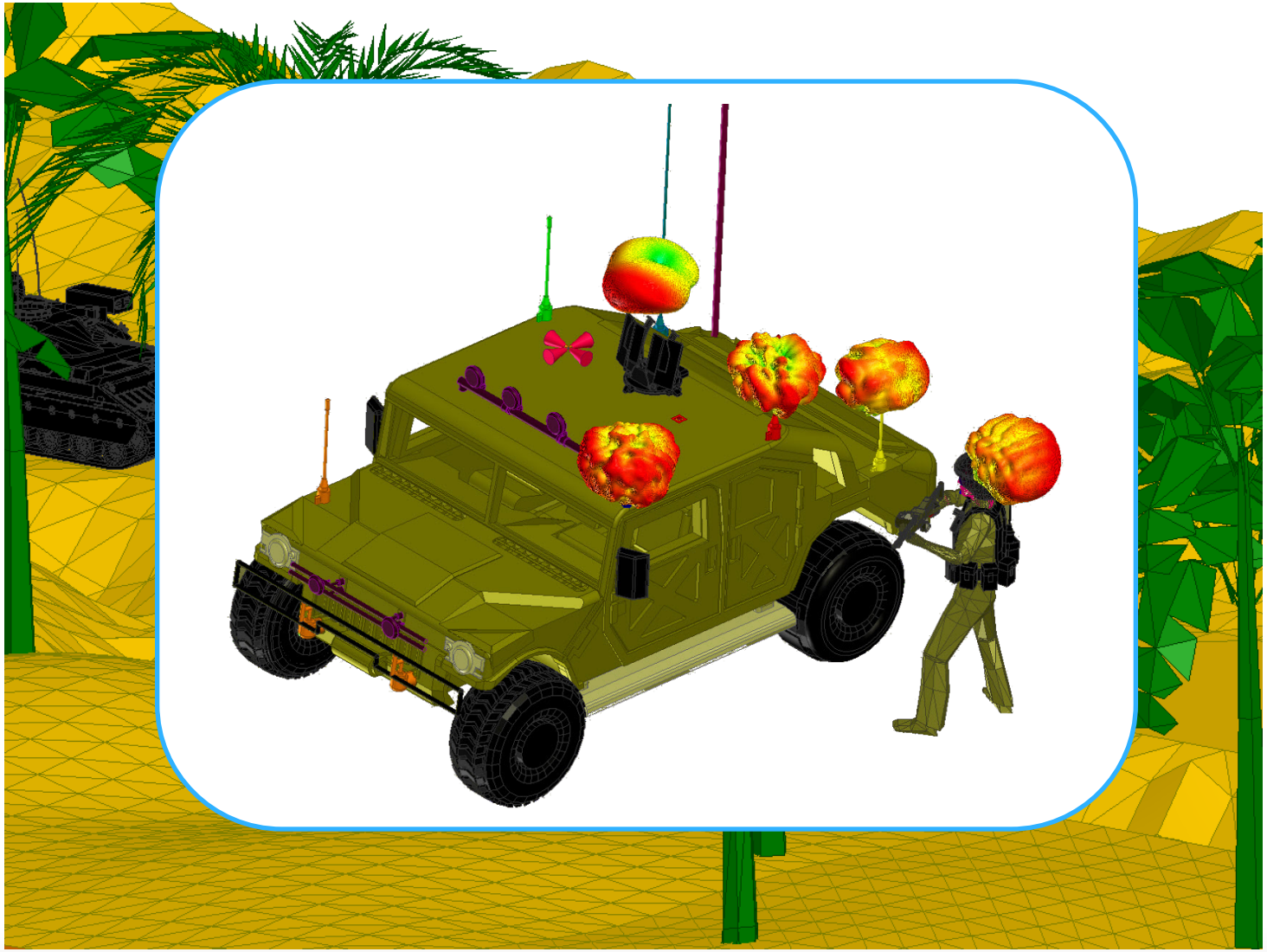


Bluetooth Antenna
(2.4-2.485) GHz



Bio-Sensor Antenna
(400-450) MHz

Battlefield Wireless Communication



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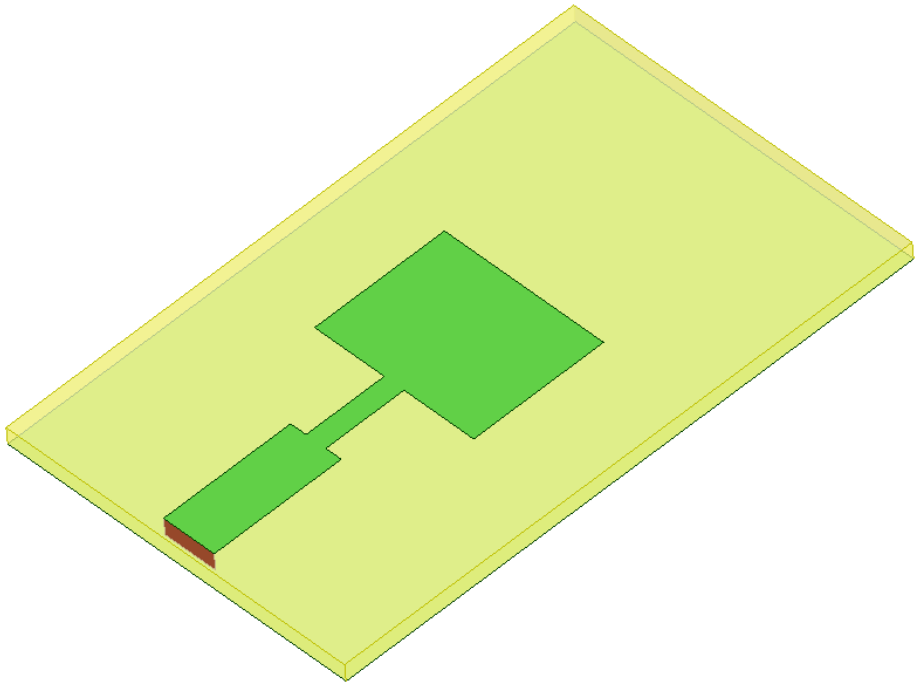
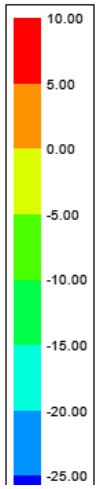
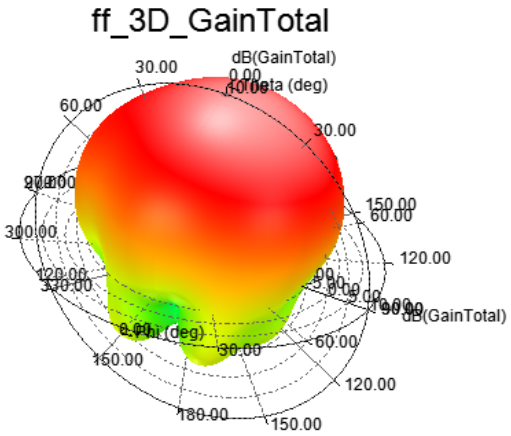
3D Printed Substrate

- MakerBot – 1.7 filament
- Expansion of metal trace (100 um spread after print)
- Material: ABS er=2.2
- 3D print nozzle size
- Planarity - Smooth by sanding surface off stepped surface; Hole/gap fill with epoxy

HFSS Simulated Quarter Wave Patch Antenna

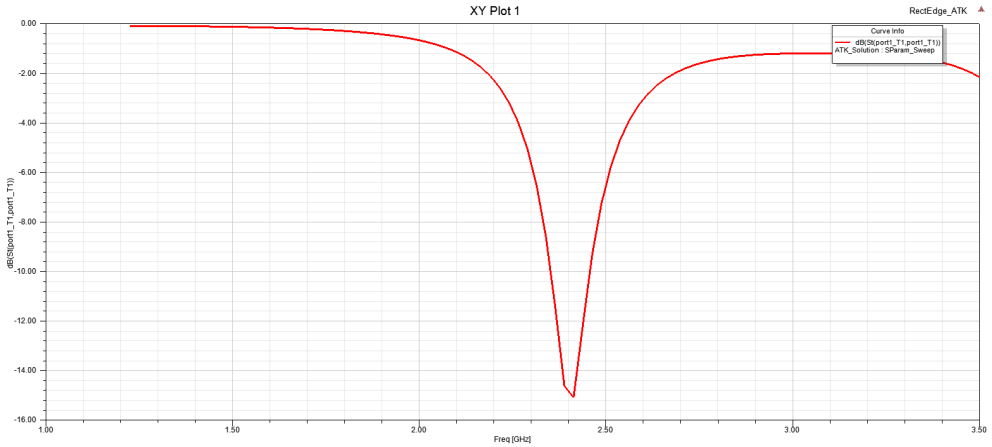




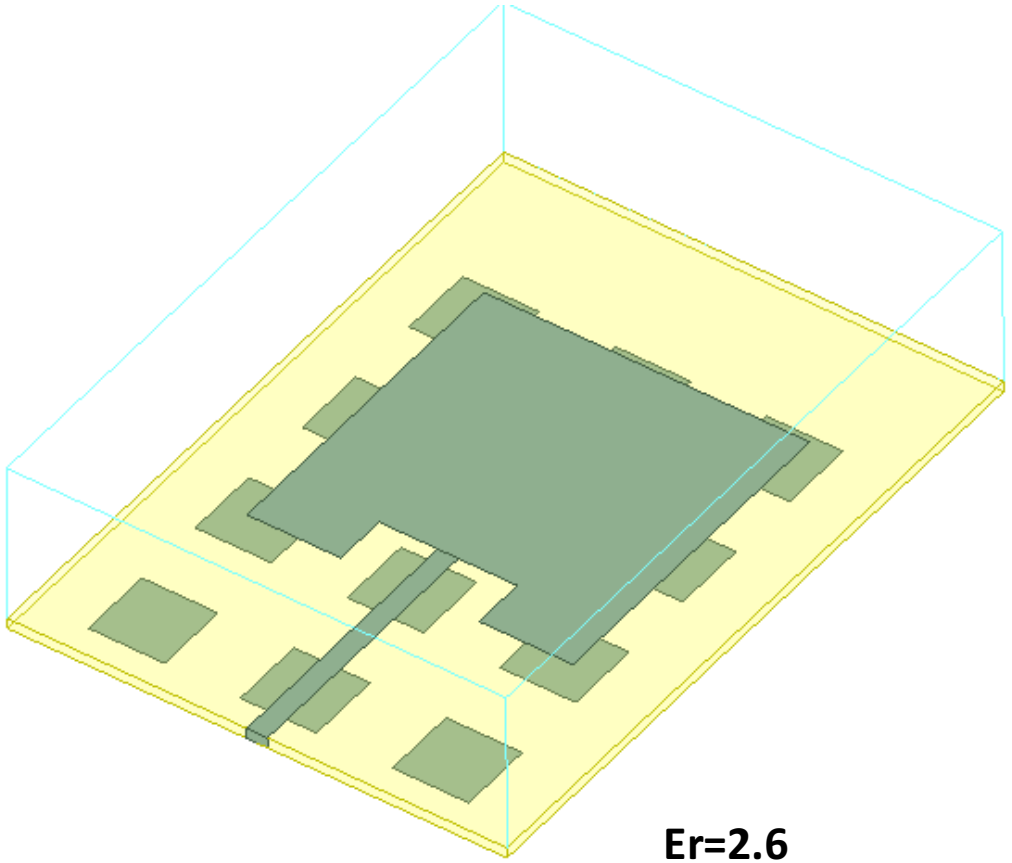


Er=2.6

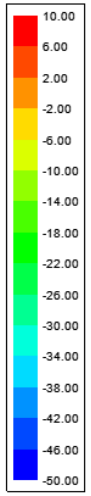
ABS Thickness: 50 um

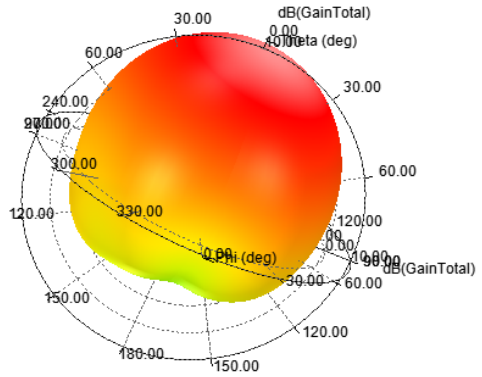


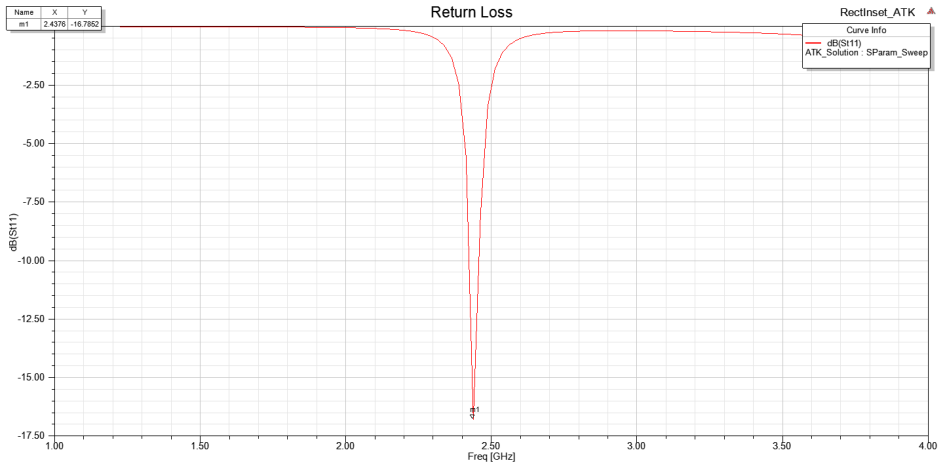
HFSS Simulated Inset Fed Patch Antenna



Er=2.6
ABS Thickness: 50 um

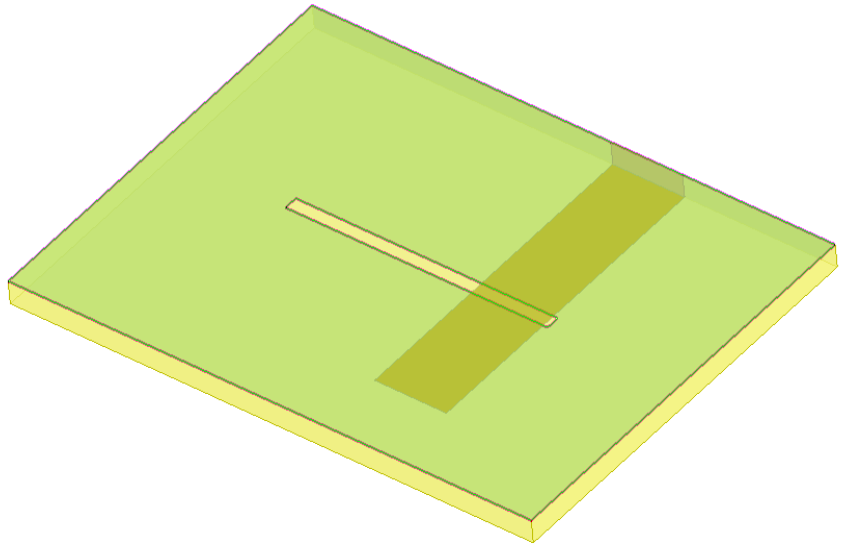


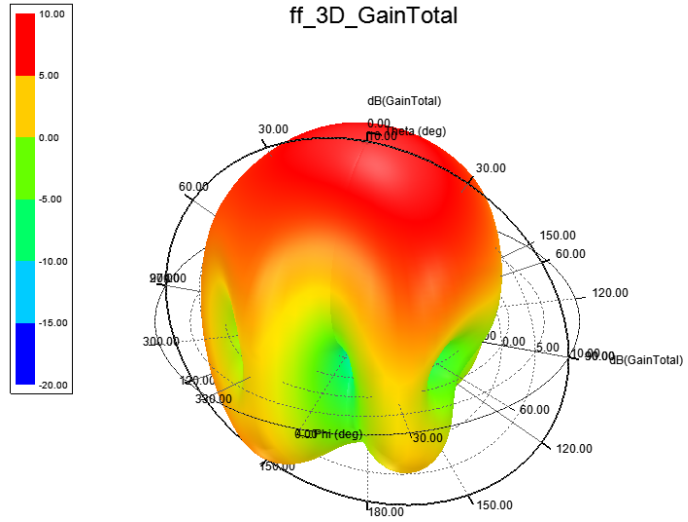


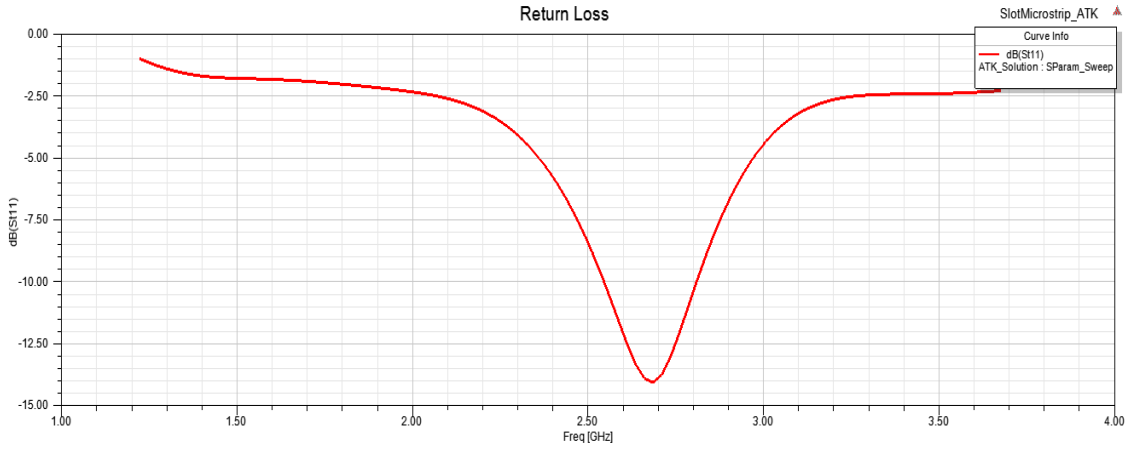


HFSS Simulated Microstrip Slot Antenna

Er=2.6
ABS Thickness: 50 um

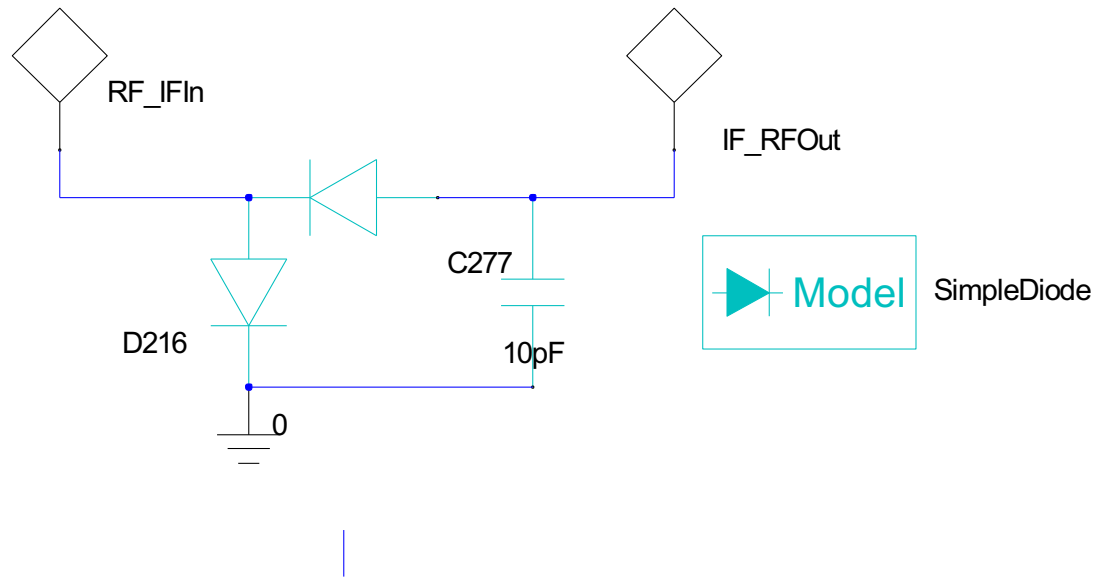






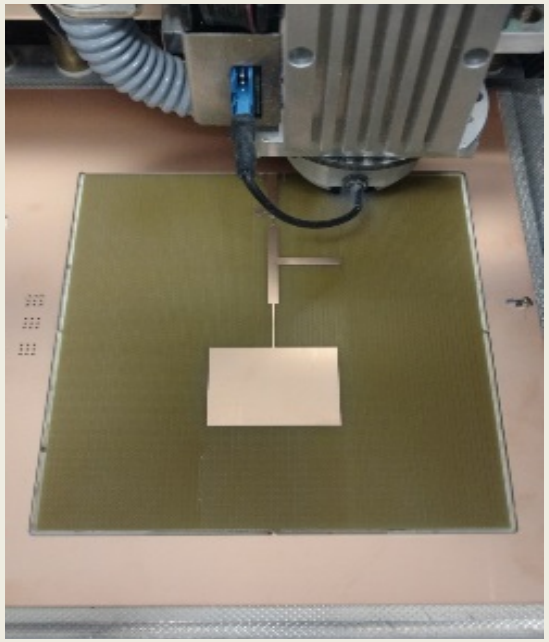
Simulated Rectifying Circuit

- **Schottky barrier diode**
  - **half wave**
  - **Voltage drop of .14 - .45 V**

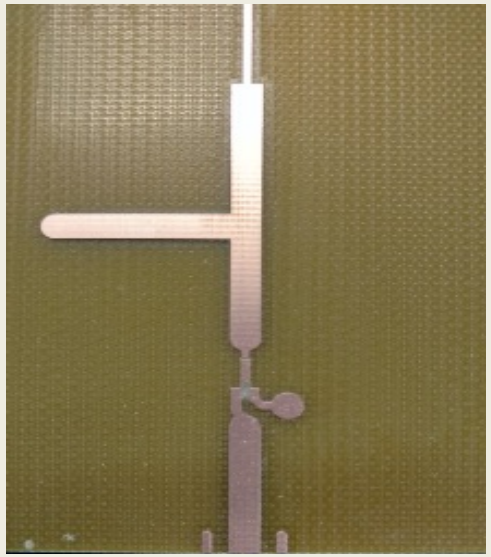


Fabrication and Measurement – APG

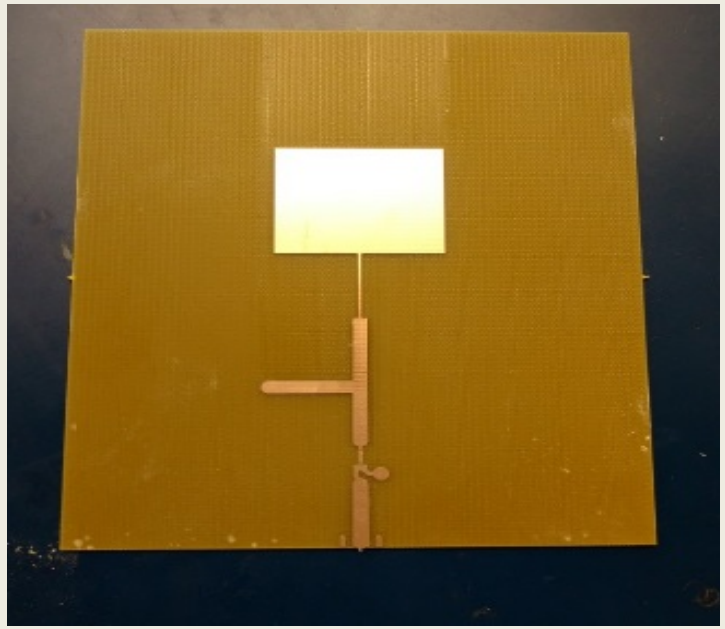
- Antenna, rectenna tested separately then together
- Matching Network (Z11) created from measured S parameters



Fabrication of
2.4 GHz Patch Antenna



Tuning and Rectifying Structure

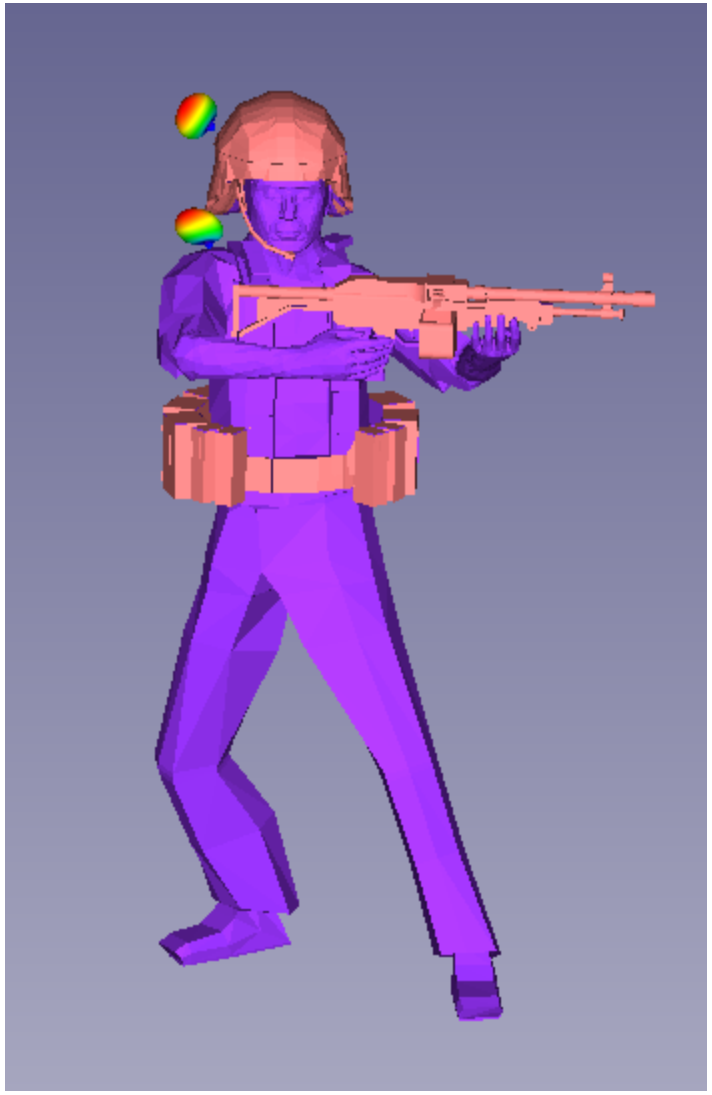


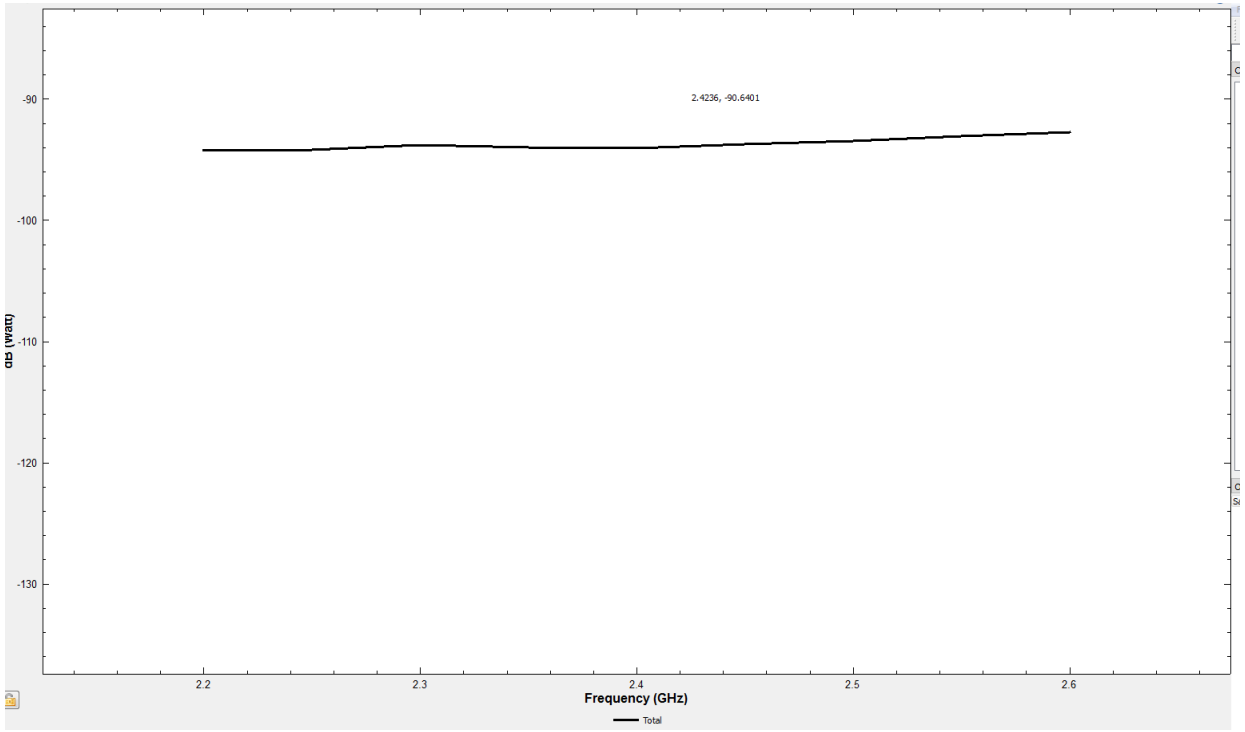
Fabricated 2.4 GHz Rectenna

Coupling Antennas

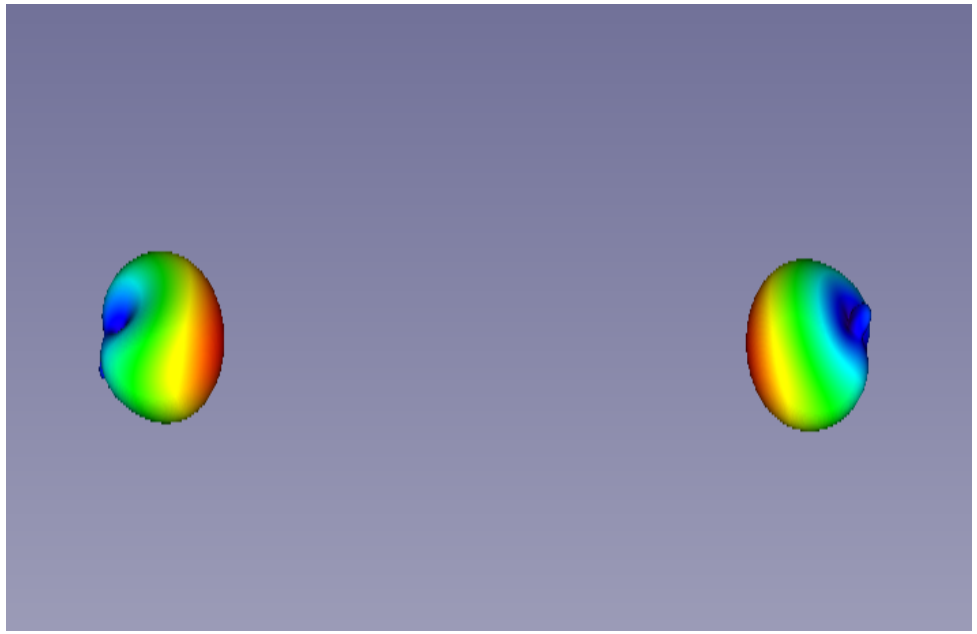
- Explicit HFSS simulation with 2 patch antenna
- Effects of cloth on patch
- Effect of soldier uniform using SBR+ simulation

Soldier Man Patch Antenna Coupling

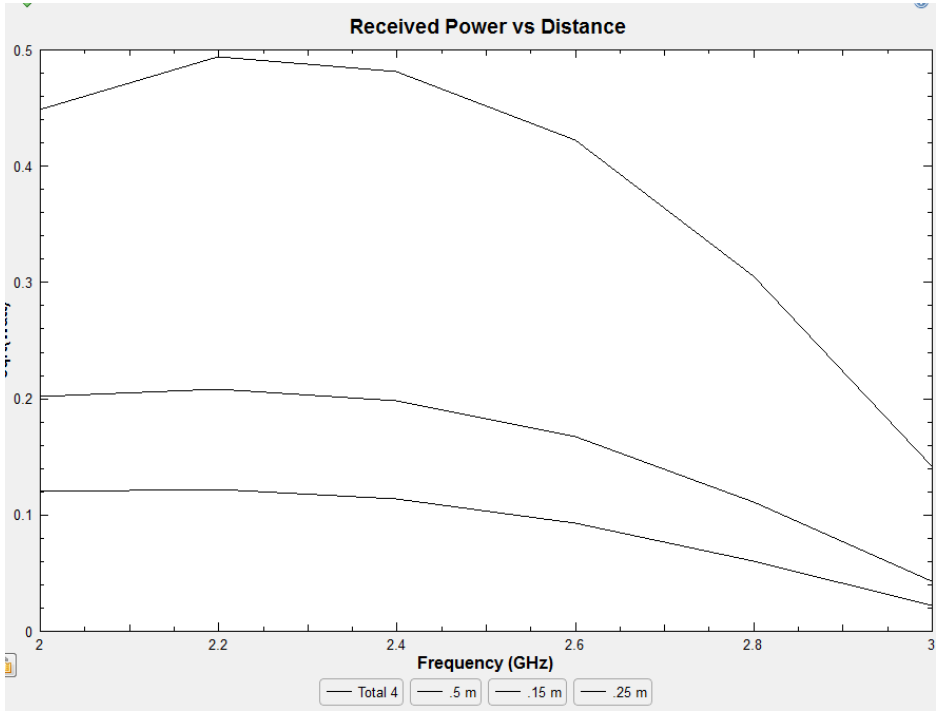




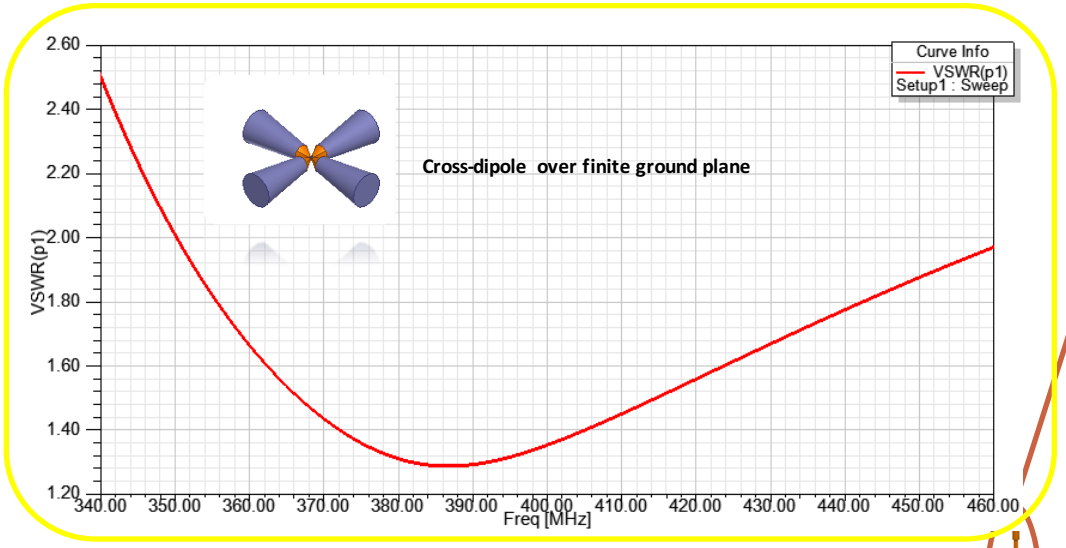
Inset Patch to QuarterWave Patch Coupling – Main Beam

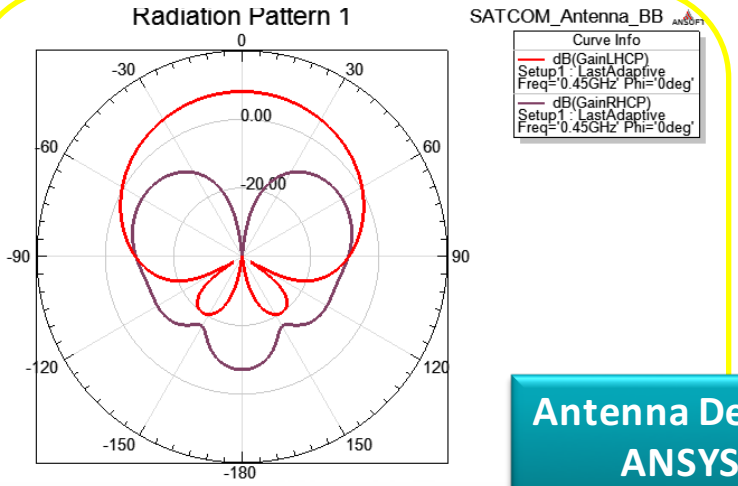


Distance	Receive Voltage
3in	.48V
1 m	.12V

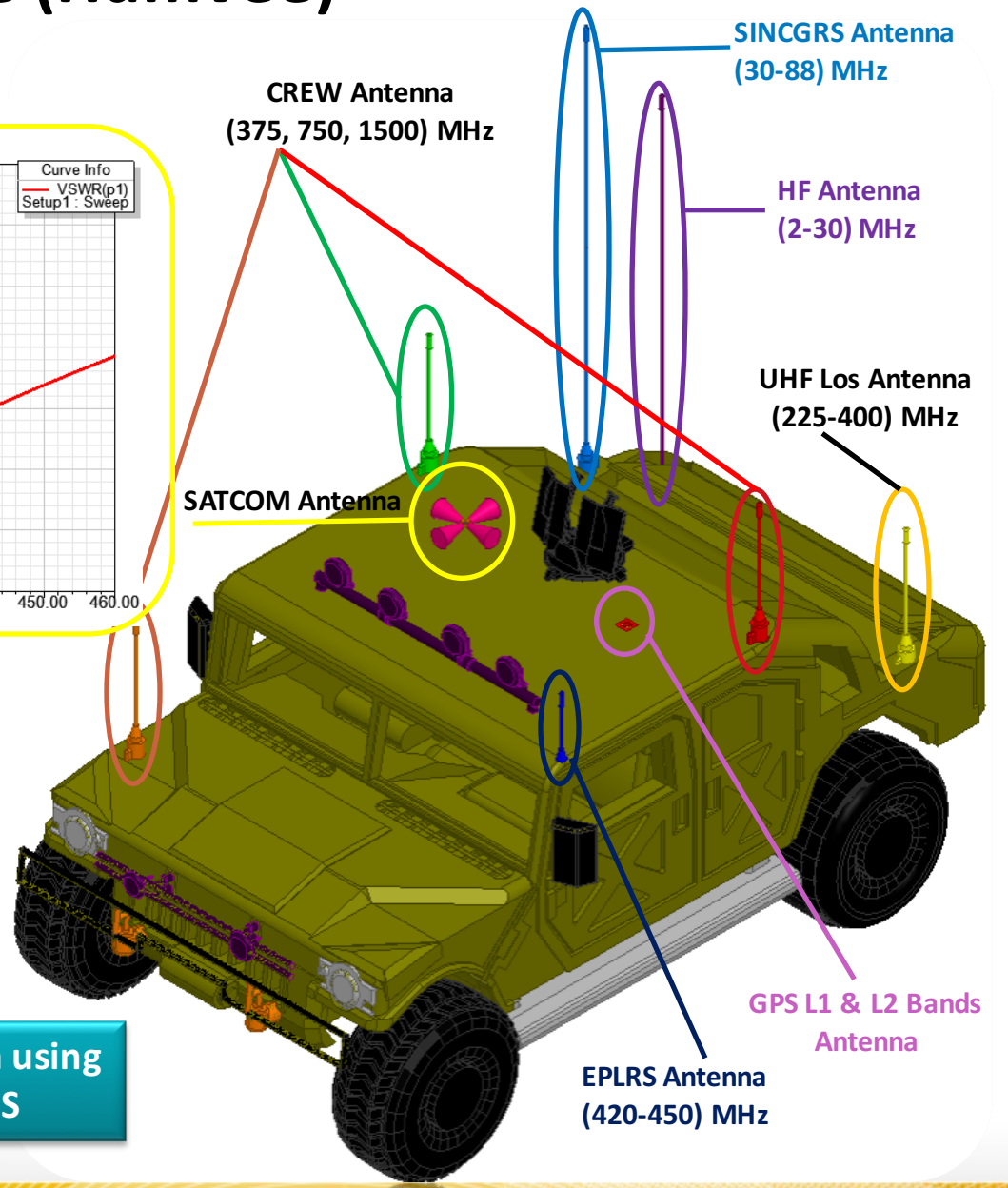


Antenna Design on Military Vehicle (Humvee)





Antenna Design using ANSYS HFSS



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ACKNOWLEDGEMENT

“THE INTERNET OF THINGS FOR CONNECTED SOLDIERS & BATTLEFIELD SECURITY”

ANSYS Inc. - Laila Salman, Fred German, Bence Gerber, Chris Quan

http://www.ansys.com//media/Ansys/corporate/images/other/nafems/Connected-Soldier-Extended-Abstract-LS-2.pdf

ANSYS Video – Connected Soldier