Verus Research Introduction
to the
Crocker Nuclear Laboratory

XL Scientific dba

Verus Research

April 2019

Wheaton Byers (Tony)
Chief Executive Officer
505-244-8501

verus™
RESEARCH

VERUS RESEARCH AT 4 ½ YEARS OLD

an XL Scientific Brand

- A new research and development (R&D) company focused on providing top-tier engineering services in the federal R&D space (established - April 2014)
- Our focused strengths and academic connections, combined with our size, make us an <u>agile and responsive</u> R&D company
- Locations in Albuquerque, Colorado Springs, San Francisco, Greenville SC
- At our 4 ½ year anniversary:
  - 2 offices, 2 lab spaces, >70 employees in 5 states
  - 8k sq. ft. office space, 9k sq. ft. lab space
  - Over 30 active programs, 15 current subcontracts
  - ~$16M current annual run rate
  - DCAA approved accounting system & provisional billing rates
  - DCMA approved property system
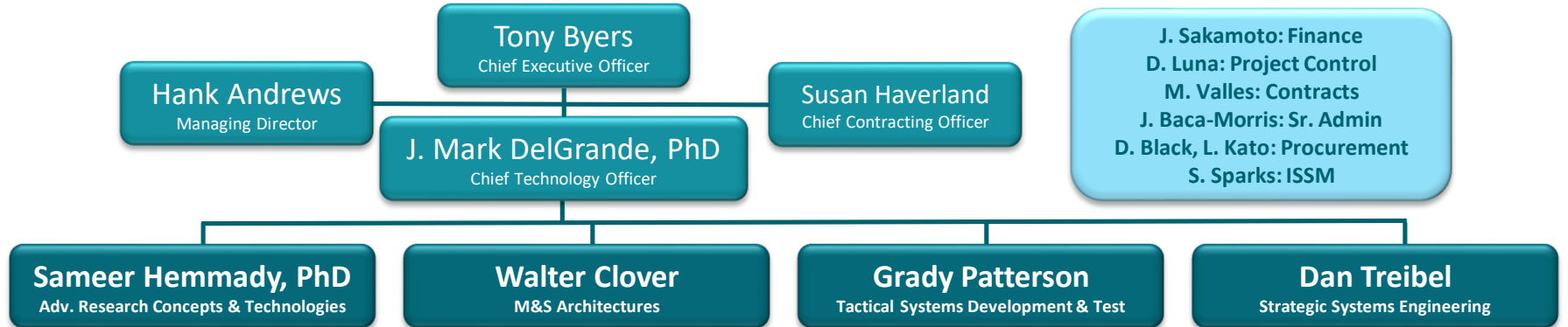 - DoD TS facility clearances. Setup to process & store up to Secret.

Our Vision is to *forge* a scientific research and development environment built around creatively solving our customer's most difficult technical problems.

We promote a culture that *creates opportunities* for the individual, benefits for the community, and strength and stability for the enterprise.

We seek to maximize the mutual *joy* in developing technical solutions that meet tomorrow's needs.

VERUS RESEARCH ORGANIZATION CHART

Tony Byers
Chief Executive Officer

Hank Andrews
Managing Director

Susan Haverland
Chief Contracting Officer

J. Mark DelGrande, PhD
Chief Technology Officer

J. Sakamoto: Finance
D. Luna: Project Control
M. Valles: Contracts
J. Baca-Morris: Sr. Admin
D. Black, L. Kato: Procurement
S. Sparks: ISSM

Sameer Hemmady, PhD
Adv. Research Concepts & Technologies

Walter Clover
M&S Architectures

Grady Patterson
Tactical Systems Development & Test

Dan Treibel
Strategic Systems Engineering

Core Capabilities

Nuclear	Systems Integration	Hardware Design & Development		Software Design & Development		Test & Evaluation	
Dr. B. Ballard		Dr. M. Butcher	J. Lowe	Dr. M. Alan	Dr. K. Lang	A. Baca	J. Ruscetti
Dr. D. Beutler	B. Gorgas	J. Coffrin	R. Roy	Dr. S. Coy	S. Oetzel	B. Bahkta	J. Sloane-Warren
Dr. J. Henley	M. Grange	Dr. J. Degnan	M. Sanchez	Dr. D. Dietz	Dr. Y. Shao	L. Decker	S. Strickland
Dr. N. Myers	J. Osowski	Dr. M. Domonkos	D. Smith	G. Gershanok	Dr. B. Xu	G. Hadi	B. Snow
Dr. Rich Shaw		D. Frew	H. Trujillo	C. Kirby		F. Rahmer III	S. Strickland
		C. Kief					

| **Customer:** AFRL/RV | **POC:** Sean Phillips | **PoP:** 3/23/18-12/23/18 | **Funding:** $150k |

Program Objectives

- Develop verification methods for spacecraft with autonomy
- Implement a spacecraft benchmark with autonomous behavior that requires verification to catch instabilities
- Test existing verification tools and develop new tools to verify performance of benchmark

Key Results

- Successfully developed a benchmark with non-obvious instabilities
- Caught said instabilities using a variety of developed methods
- Created a verification process using a combination of statistical, optimization-based, and formal methods
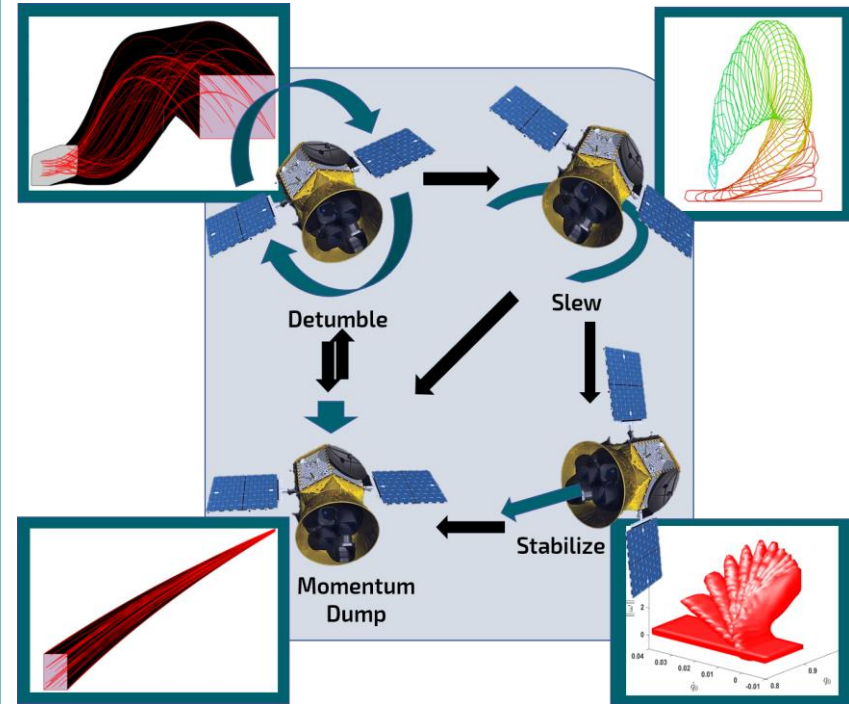
ADVANCED RESEARCH AND DEVELOPMENT
FUTURE AVIATION SYSTEMS SAFETY SBIR, PHASE-I

Customer: NASA Langley	**POC:** Kenneth Goodrich	**PoP:** 7/27/18-1/27/19	**Funding:** $125k

Program Objectives

- Verify safety of proposed trajectories and enable real-time path corrections/re-planning to ensure safe unmanned vehicle operations

- Offline trajectory safety assessment incorporating trajectory predictions under various conditions

- Real-time monitoring for safety violations with auto-corrections to ensure safety is always enforced

- Goal is increasingly permissive flight with guarantees of safety

Key Results

- Generated a crash projection tool with visualization that is fast and encompasses all possible landing sites without relying on simulation
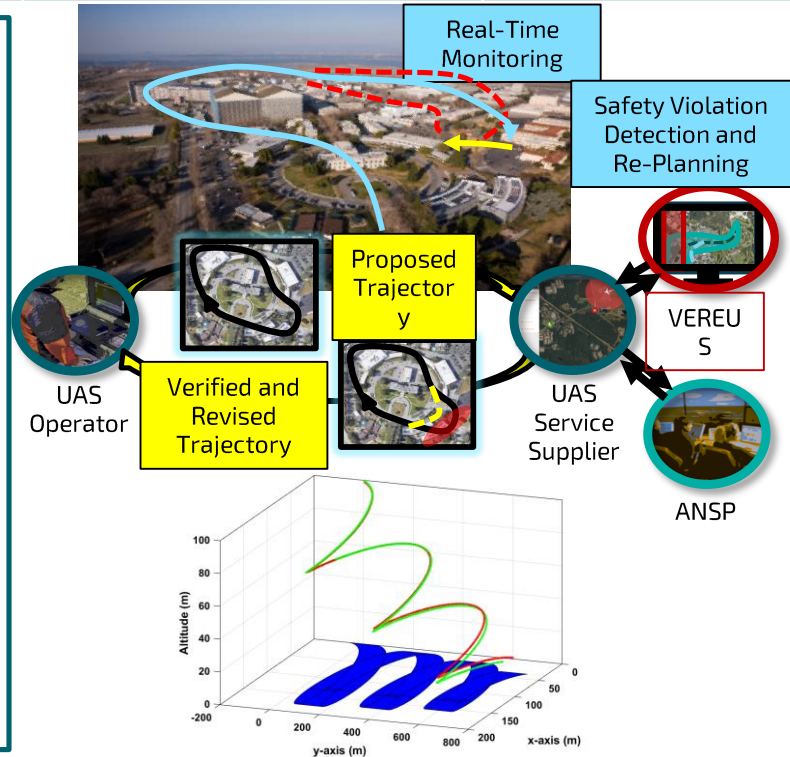
| **Customer:** ARMY/SMDC	**POC:** Mark Rader	**PoP:** 6/14/2017-Present	**Funding:** $1.1M

Program Objectives

- Develop novel miniaturized antennas for UWB HPM radiation
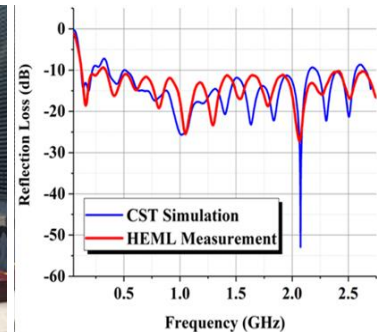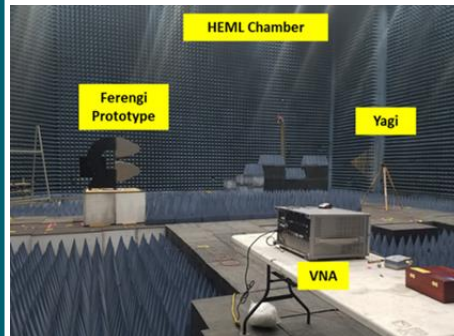- Support radiation of UWB NLTL source from BAE Systems

Key Results

- Conceived and developed a novel "Ferengi family-of-antennas" topologies to allow antenna miniaturization to approach Chu-Harrington limit for HPM applications
- Developed evolutionary Particle-Swarm-Optimization (PSO) techniques for antenna design methodology to meet user requirements
- Fabricated and demonstrated a low dispersion (<1.2ns), UWB (>188% BW), up to 10MW, antenna prototype for HPEW and HPRF applications.
- Patent Pending
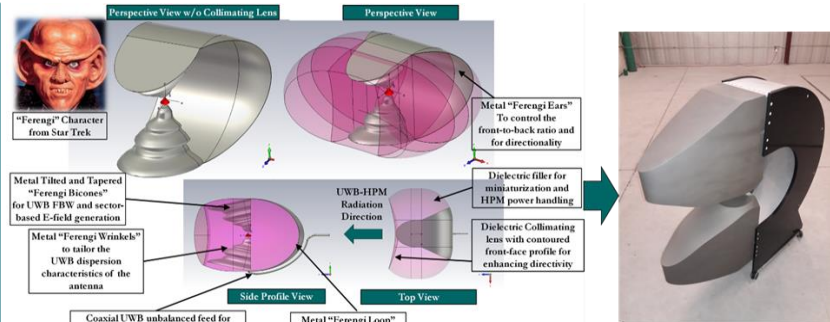
Base Ferengi Concept with customizable features

Ferengi Prototype developed under Army A16-123 Phase-I SBIR to meet the Army's requirements

**Customer:** SteelCity Optronics | **POC:** Jonathan Partee | **PoP:** 5/15/2018 - Present | **Funding:** $100K

Program Objectives

- Design mm-wave (~100GHz) near field arrays and spatial light modulators for mm-wave compressive sampling imaging systems

Key Results

- Designed and developed components that comprise a compressive imaging spatial light modulator for remote detection of person-borne Improvised Explosive Devices and/or Baggage Screening

- In Progress

S-Parameters [Magnitude in dB]
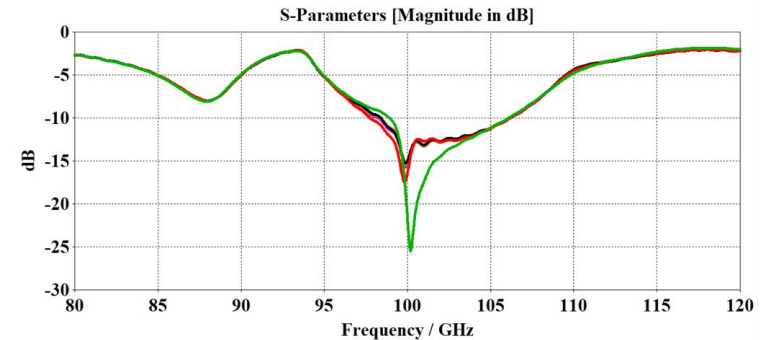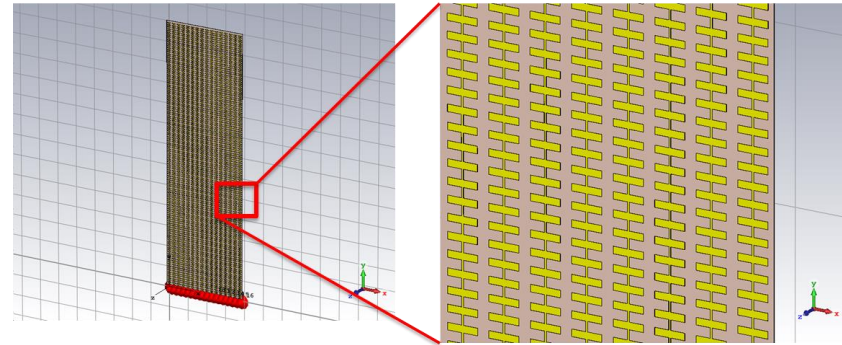
ADVANCED RESEARCH AND DEVELOPMENT
W-BAND PROPULSION DEVELOPMENT

Customer: AFRL/RDHP	**POC:** Tony Baros	**PoP:** 2/10/2015 - 3/30/2016	**Funding:** $120K

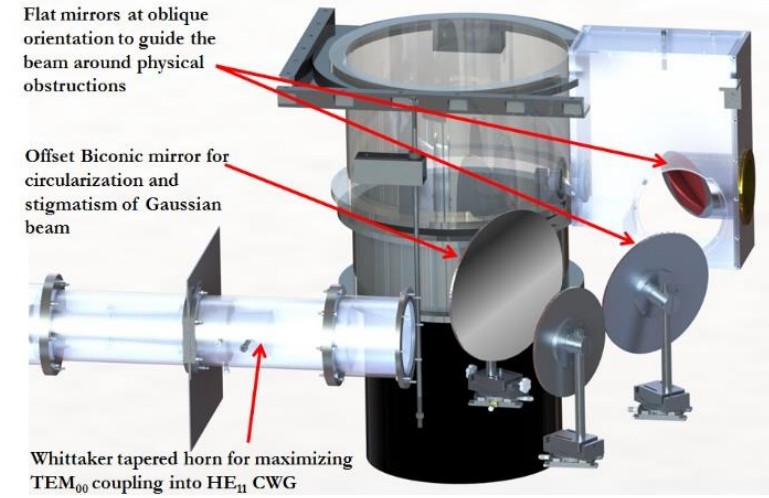### Program Objectives

- Investigate and demonstrate the use of HPM mm-wave energy for power beaming applications
- Re-engineer, modify and optimize the existing Active Denial System (ADS System 0) to support power beaming research

Key Results

- Engineered and Adapted the existing Active Denial System (ADS-0) to support power beaming research through the W-band Optics for Matching Beams with Astigmatism and Tilt (WOMBAT)
- Utilized high fidelity modeling and simulation analysis to design and fabricate mm-wave optics to match astigmatic and tilted beams from the ADS-0 Gyrotron source and into a heat exchanger with >99% efficiency
- Supported AFRL in experimental design and setup to demonstrate the feasibility of mm-wave power beaming

IEEE SPECTRUM

Flat mirrors at oblique orientation to guide the beam around physical obstructions

Offset Biconic mirror for circularization and stigmatism of Gaussian beam

Whittaker tapered horn for maximizing TEM_{00} coupling into HE_{11} CWG

ADVANCED RESEARCH AND DEVELOPMENT
## UNDERWATER ACOUSTIC COMMUNICATIONS

Customer: ONR CODE 30 | **POC:** ROBERT HEADRICK | **PoP:** 7/11/2016-5/10/2017 | **Funding:** $80K

Program Objectives

- Develop UnderWater Acoustic (UWA) Low-Probability of Intercept/Detection (LPI/LPD) modem for covert communications

Key Results

- Demonstrated the use of coherent chaotic waveforms for LPI/LPD UWA communications

- Demonstrated the technical feasibility of transmitting and receiving digital information across a UWA channel using LPI/LPD chaotic waveforms

- Developed and demonstrated a UWA cognitive modem and a UWA signal interceptor modem

- Developed a modeling and simulation engagement tool for predicting the covertness of LPI/LPD UWA comm links (to include platform trajectories, Tx/Rx modem characteristics, LPI/LPD modulation schemes, beamforming sonar capabilities, SNR/SNJ and SINAD estimation and tracking)
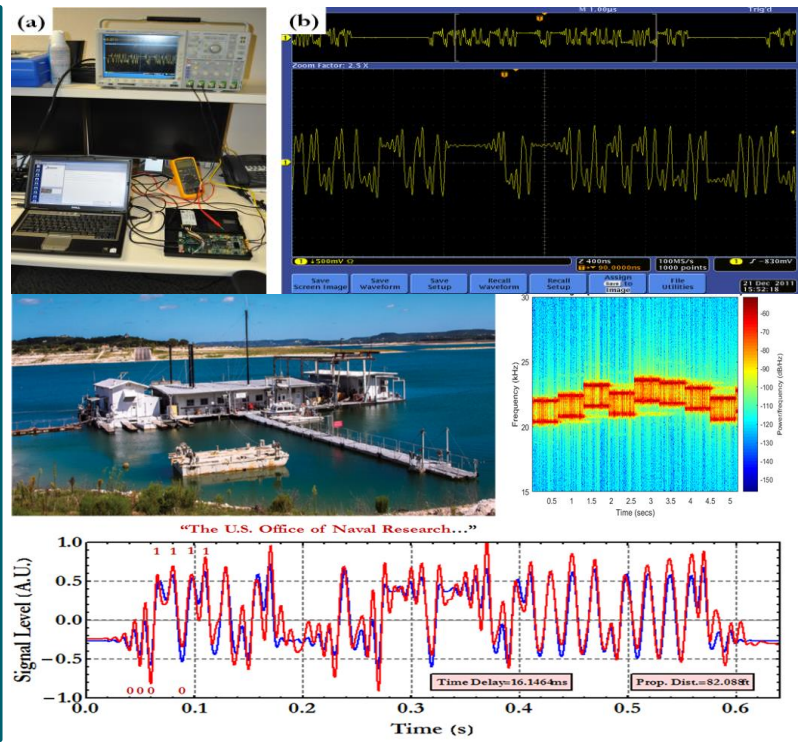
Design, development and test of operational systems and sub-systems for tactical employment

Active Contracts: 11	Active Ceiling: $20.9M

Key Capabilities

- This portfolio examines state-of–the-art solutions to transition technology to the warfighter
- Active contracts span HPM system development and test – from enabling subsystems and system integration to empirical effects testing and data archival
- Efforts include both innovative design and effective prototype development

Active Efforts

- HPM Source Design and Development
- Efficient hardware development for frequency agility
- HPM effects standardization and web-base database
- Full system design and development for rapid prototyping
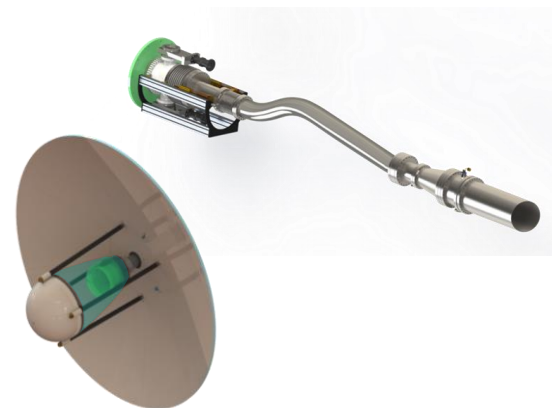
Customer: AFRL/RDH	**POC:** Erin Pettyjohn	**PoP:** 9/26/18 – 12/30/23	**Funding:** $1M

Program Objectives

- Develop prototype triggered sealed switch for integration with HPM pulsed power system
- Demonstrate required performance characteristics
- Qualify for 5-10 year storage life:
  - Via analysis
  - Via Highly Accelerated Life Testing
- Integrate with HPM System for Air Force specified platform

Key Results

- Self-break sealed switch prototype demonstrated
- Preliminary designs for triggered design

Self-Break Sealed Switch

Switch Design

Electrostatic Simulation
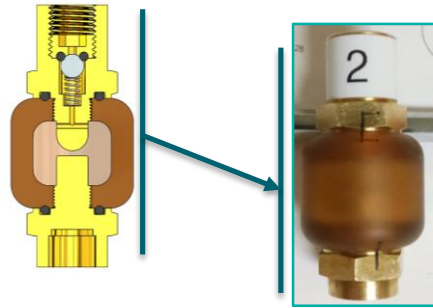
Simulated Deformation
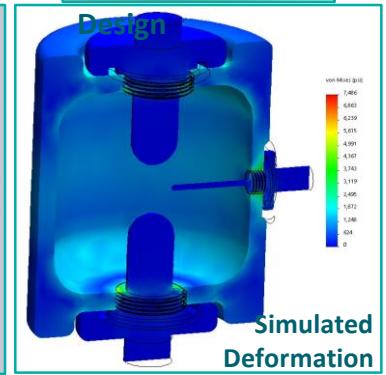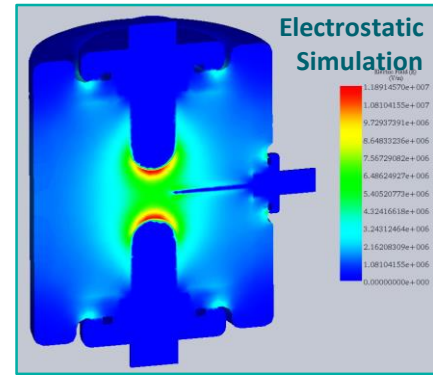
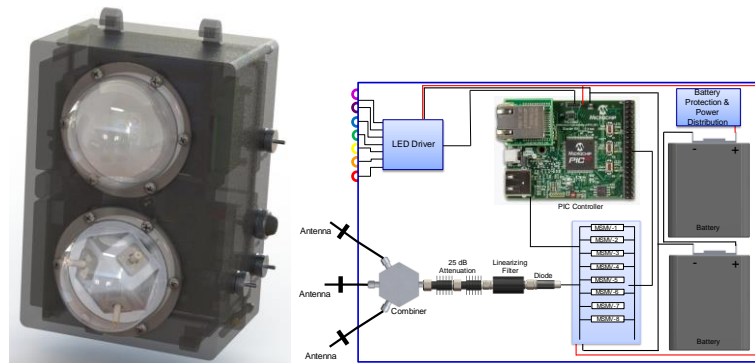# VERTICAL SENSOR NETWORK ARRAY

Program Objectives

- Develop a real-time electric field detection capability to assess HPM weapon system surface-to-air performance at range (far field)
- System should be portable and report HPM beam width over a large area (100' x 100')
- Detection capability from 500MHz to 4GHz

Key Results

- Designed hardened detection box that lights a bright LED with a color based on the incident HPM field strength (8 distinct levels)
- Three axis detection capable of measuring V/H polarization
- Diode detection capability demonstrated above 5GHz
- Brass-board design demonstrated with surrogate HPM source
- Operational for over a week with existing battery power design
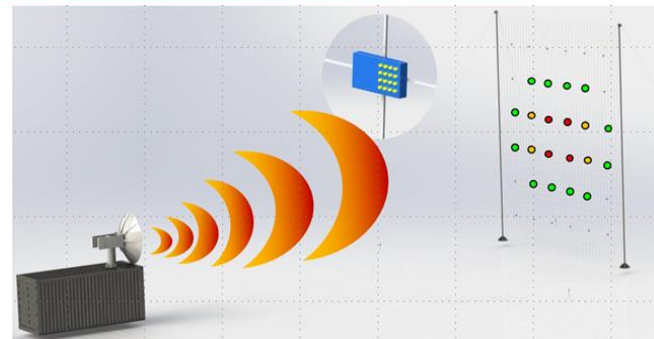
VSNA Operational Concept

# ENHANCED SENSOR NETWORK ARRAY

Program Objectives

- Develop a network of HPM sensor nodes to record field strength and communicate data wirelessly.
- Flexible mobile detection capability for outdoor testing. Diagnostics for open air developmental, static, and operational testing.
- Enhanced data acquisition and distribution over wide area.

Key Results

- Baseline design development underway with selection of an 8-channel (4Gs/sec each) FPGA
- RF detection of wideband and narrowband signal
- Battery operated throughout the test day
- Wireless communication of test data back to base station
- Thermal analysis shows viability for desert environments
- Baseline GUI developed to streamline outdoor test operations
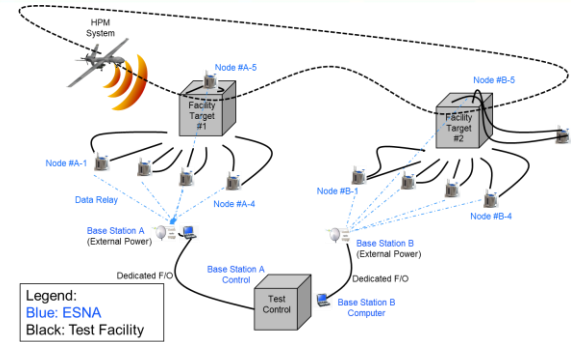
ESNA Operational Concept
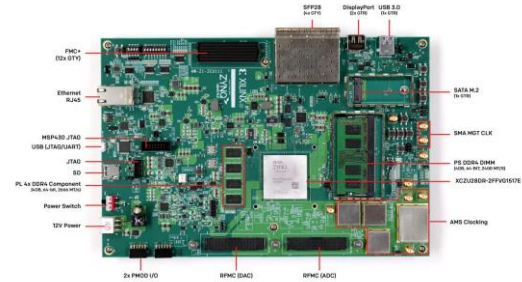
Nuclear Effects and Systems-Level Multidisciplinary Engineering to Deliver Confidence and Capabilities

Active Contracts: 4	Active Ceiling: $12.7M

## Key Capabilities

- Nuclear Effects Modeling, Simulation, Assessment, and Testing
- Nuclear Survivability Test Capability Development
- System-level Analysis, Design, Integration, Test

Active Efforts

- Dense Plasma Focus - Fission Pulsed Neutron Test Capability Development
- Nuclear Survivability Test Facility Modernization
- Multidisciplinary Science and Technology Assessment
- Space Radiation Assessment Tool Development

STRATEGIC SYSTEMS ENGINEERING

NASA SBIR PHASE I: COMPUTER AIDED DESIGN (CAD) RADIATION INTEGRATION TOOL (CRIT)
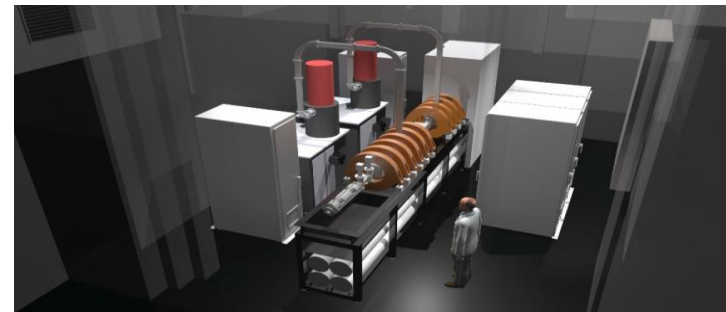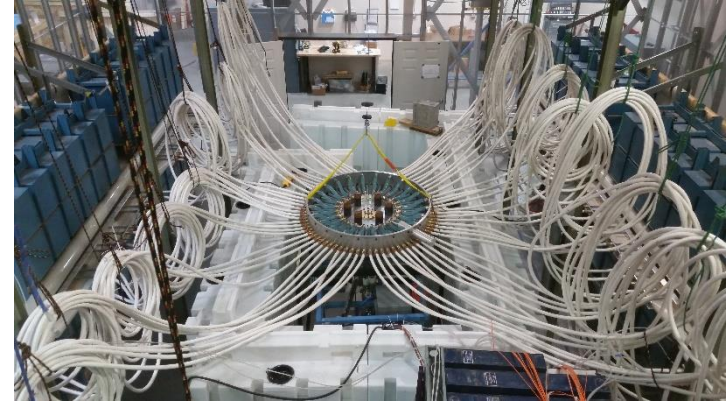
| **Customer:** NASA	**POC:** Dr. Robert Singleterry	**PoP:** 06/10/16 - 12/09/16	**Funding:** $125K

Program Objectives

- Develop processes and tools that reduce the time needed to perform radiation transport modeling on complex National Aeronautics and Space Administration (NASA) Computer Aided Design (CAD) models

Key Results

- Developed CRIT, a parsing tool that inputs CAD models and creates extensible markup language (XML) input for processing through the On-Line Tool for the Assessment of Radiation in Space (OLTARIS) to perform transport modeling
- Successful demonstration of CRIT led to a Phase II SBIR award to continue development efforts
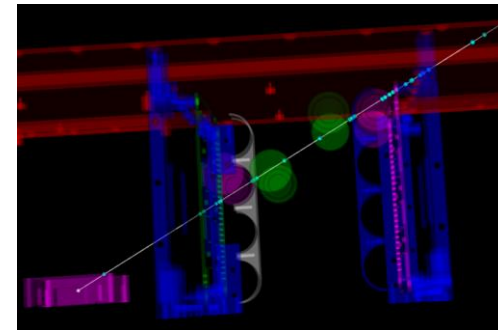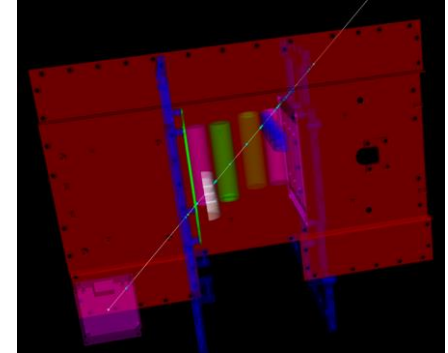
CubeSat used in tests (above) and sample ray cast by CRIT (right)

CONTACTS AT VERUS RESEARCH

Chief Executive Officer:
  Wheaton Byers
    wheaton.byers@verusresearch.net
    phone: 505-244-8501
    cell: 505-362-1250

Chief Technology Officer:
  Dr. J. Mark DelGrande
    j.mark.delgrande@verusresearch.com
    phone: 505-222-4914
    cell: 505-239-2886

Chief Contracting Officer:
  Susan Haverland
    susan.haverland@verusresearch.com
    phone: 505-244-8502
    cell: 505-362-1623

Contracts & Subcontracts Manager:
  Catherine Lambert
    catherine.lambert@verusresearch.net
    phone: 505-338-2214
    cell: 571-338-5672

Verus Research
Headquarters:
  6100 Uptown Blvd NE, Suite 260
  Albuquerque, NM 87110
Main Phone Line:
  505-244-8500
CAGE Code: 73S36
DUNS Number: 079360382