Capabilities Statement

Agency: IARPA
Program: Effective Quantitative Antenna Limits for Performance (EQuAL-P) Research Program

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1. Infrastructure

1.1 Design Studio and Prototyping Laboratory

The Design Studio and Prototyping Laboratory is a state-of-the-art facility focusing on the engineering, design, measurement, and implementation of complex radiocommunication systems and wireless sensing networks. It is a collection of laboratory spaces with over 2,200 sq. ft. dedicated to the conception, design, and testing of advanced electromagnetic devices, mobile systems, materials characterization, wireless networks, and a range of other capabilities. This includes a wide range of fabrication, assembly, and automated measurement capabilities for adaptive and multifunctional RF, microwave, and millimeter antennas, circuits, and systems. The equipment housed in this facility includes:

- Vector Network and Signal Analyzers (4 ports up to 70 GHz with time domain analysis)
- Vector Network Analyzer (2 ports up to 120 GHz)
- Signal Analyzer (0-50 GHz and 110 GHz-170 GHz)
- RF power sensor (up to 120 GHz) and RF signal generators (up to 67 GHz)
- Probe Station for On-Wafer Measurement
- Thermal Imaging Systems
- Automated Circuit Etching and Fabrication
- Advanced Additive Manufacturing and Post Processing
- Full-Wave Electromagnetic and Multi-Physics Field Solvers and Simulation Tools
- Integrated Circuit Design and Simulation Tools
- Materials Characterization of Solids and Fluids

1.2 Anechoic Chamber and Automated Antenna Measurement Systems

This state-of-the-art automated three-axis dual-polarized antenna measurement system resides in a newly renovated anechoic chamber with testing capabilities up to 70 GHz. It features a 1m quiet zone using an automated measurement system for RF, microwave, and millimeter-wave frequencies and full volume dual-polarized scanning. This measurement system provides post-processing calculations that include derivation of antenna half-power beamwidth, directivity, gain, radiation efficiency, total radiated power, and a myriad of additional performance metrics and advanced analysis tools. Other capabilities include a free-space time-gated compact range system

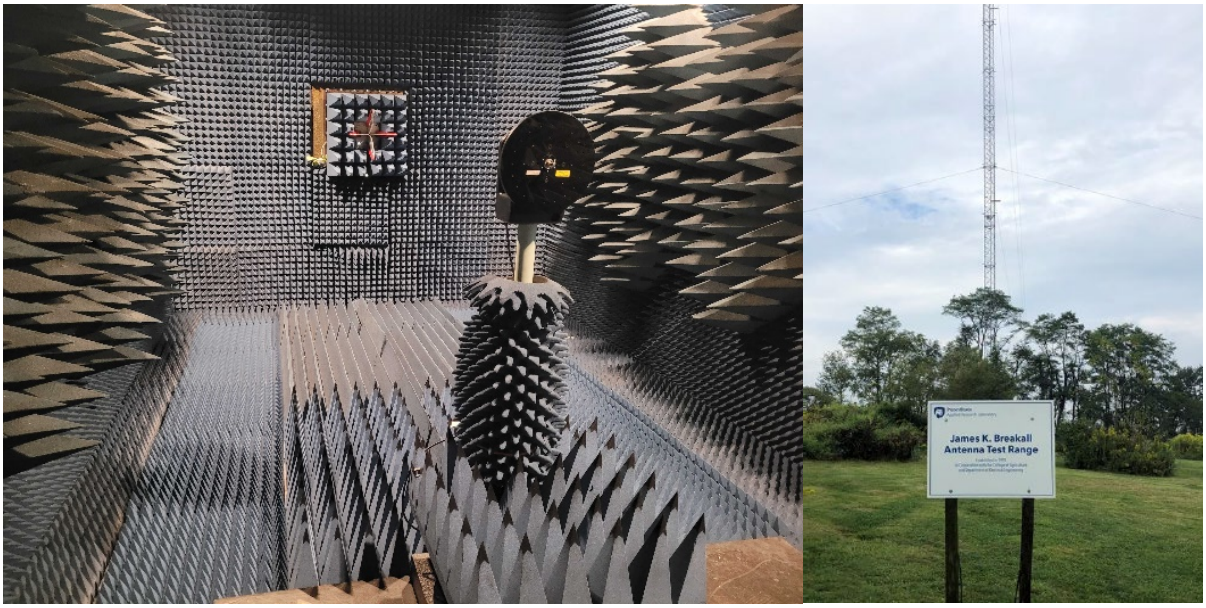
for radome and frequency selective characterization. The laboratory also has access to an outdoor antenna test range with towers heights up to 100m.

1.3 Hybrid Beamforming Testbed

The laboratory will soon be home to a fully configurable 32 channel phase-coherent software defined radio testbed operating from 100 MHz to 6 GHz. The extensible system utilizes open-source (GNU Radio) tools and includes a range of analog beamforming components for hybrid and antenna reconfiguration techniques that can be accessed through the control plane of the software-designed architecture. The testbed also includes MEDUSA 2.0, an apparatus with 32 reticulated arms for mimicking UAV swarms and other unstructured and disparate beamforming systems.

1.4 Raj and Jeannette Mittra Microwave Lab

The laboratory space is dedicated to the advancement of undergraduate education in applied and computational electromagnetics. It supports instructional activities for courses on UHF and Microwave Engineering, Engineering Electromagnetics, Antenna Engineering, Satellite Communication, Software Defined Radios, and other special topics RF/mm-wave Engineering and Design courses. It also provides students with access to a range of experimental capabilities for hand-on coursework, capstone senior design, and other student research projects.



Anechoic chamber (left) and 40 m tower at the outdoor antenna test range control room (right)

2. Institute for Computational and Data Sciences-Advanced Cyber Infrastructure

Penn State's Institute for Computational and Data Sciences (ICDS) operates the Advanced CyberInfrastructure (ICDS-ACI), the university's state-of-the-art high-performance research cloud.

2.1 Data Center Facilities

ICDS-ACI equipment is located a newly constructed Data Center facility at Penn State's University Park Campus. This facility operates in compliance with all Penn State IT policies.

2.2 Data Center Resources: The ICDS-ACI high-performance research cloud is composed of hardware that is interconnected over high-speed network fabrics and includes various software offerings and services.

2.3 Hardware: ICDS-ACI maintains 26,000 computational cores. ICDS-ACI offers four different core configurations: high-memory cores (1TB RAM per server), standard-memory cores (256 GBRAM per server), and basic-memory cores (128 GB RAM per server), and GPU cores (using NVidia Tesla K80 GPU accelerators).

2.4 Storage: ICDS-ACI maintains 20 PB of data storage capacity. The storage is comprised of 8 PB of active storage pools that provide immediate data access and retrieval, and 12 PB of near-line storage for long-term and archival purposes.

2.5 Software: ICDS-ACI maintains and regularly updates an expansive software stack. The stack currently contains 240 applications, with more added at regularly scheduled intervals. The applications include security monitoring software (e.g., OSSEC), batch schedulers (e.g., MOAB, Torque), compilers, file transfer programs, and communication libraries (e.g., MPI, OpenMP). The stack also contains software applications commonly used by researchers, such as MATLAB, COMSOL, R, and Python, as well as programs for performing specialized tasks, such as Abaqus, Quantumwise, TopHat, and Ansys HFSS.

2.6 ICDS-ACI Support: ICDS-ACI is maintained by the ICDS staff, who provide network monitoring, backup services, software updates, code optimization, and service-desk support. ICDS uses Solarwinds network monitoring software to monitor the health and status of the network, hardware, and storage.

2.7 ICDS Domain-Specific Consultation: ICDS offers domain-specific consulting to assist researchers with optimizing code, leveraging various software applications and in general increasing the efficiency of their research operations. Consultants cover disciplines including Engineering, Chemistry and Materials Science, Data Visualization, Parallelization, and Science Gateways for Big Data Research.