



Division Overview

Dawn Emerson

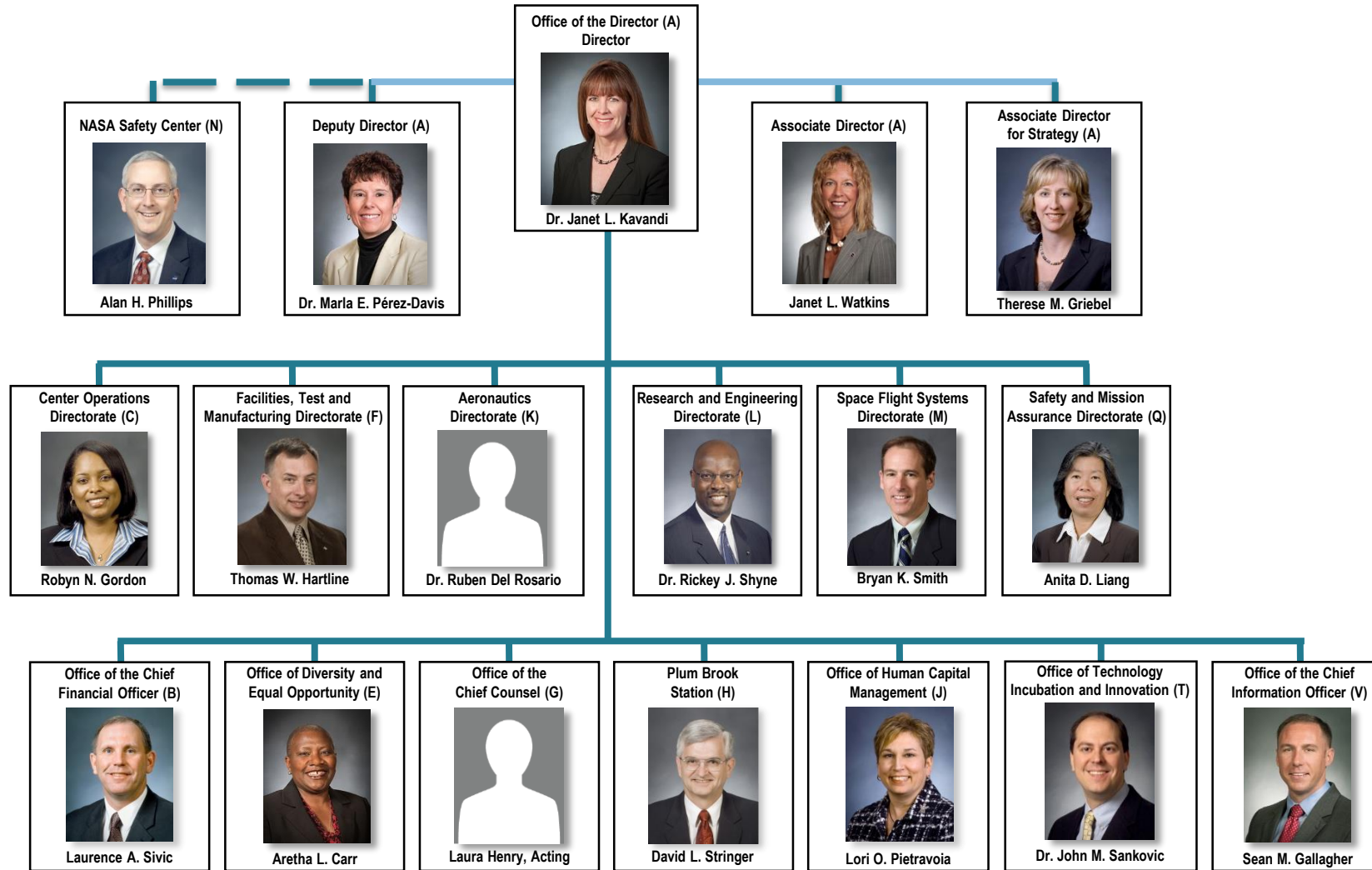
January 26, 2017

**COMMUNICATIONS &
INTELLIGENT SYSTEMS DIVISION**

NASA GLENN RESEARCH CENTER



Glenn Senior Management



*Recruitment in progress



Research and Engineering Directorate Leadership Team




**Deputy Director of
Research and Engineering (L)**



Dr. Ajay K. Misra

**Director of
Research and Engineering (L)**



Dr. Rickey J. Shyne

**Associate Director of
Research and Engineering (L)**



Maria Babula

**Chief Engineer
Office (LA)**



Richard T. Manella

**Management Support
and Integration Office (LB)**




Susan Kolibas

**Communications and Intelligent
Systems Division (LC)**




Dawn C. Emerson

**Power
Division (LE)**




Randall B. Furnas

**Materials and Structures
Division (LM)**




James J. Zakrajsek, Acting

**Systems Engineering and
Architecture Division (LS)**



Derrick J. Cheston

**Propulsion
Division (LT)**



Dr. George R. Schmidt

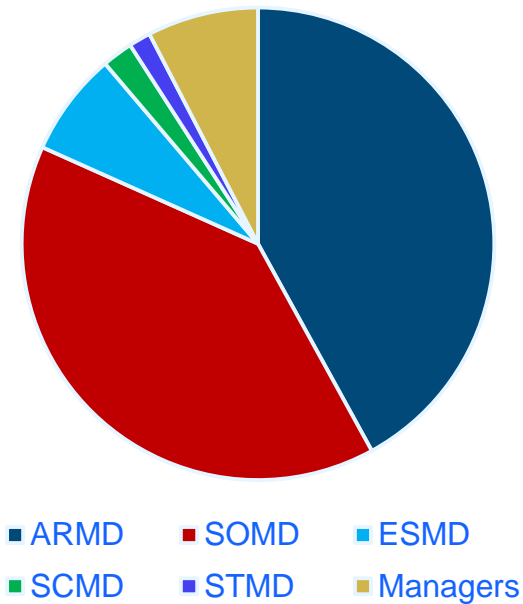


Communications and Intelligent Systems Division (LC)



Provides expertise, plans, conducts and directs research and engineering in the competency fields of advanced communications and intelligent systems with emphasis on advanced technologies, architecture definition and system development for application in current and future aeronautics and space systems.

LC Support to Mission Directorates



LC Competency Elements:

Space Communications (SpaceComm) & Aeronautical Communications (AeroComm)

Expertise:

- Networks & Architectures
- Information & Signal Processing
- Advanced High Frequency
- Optical Communications

Intelligent Systems – Cross-Cutting Competencies

Expertise:

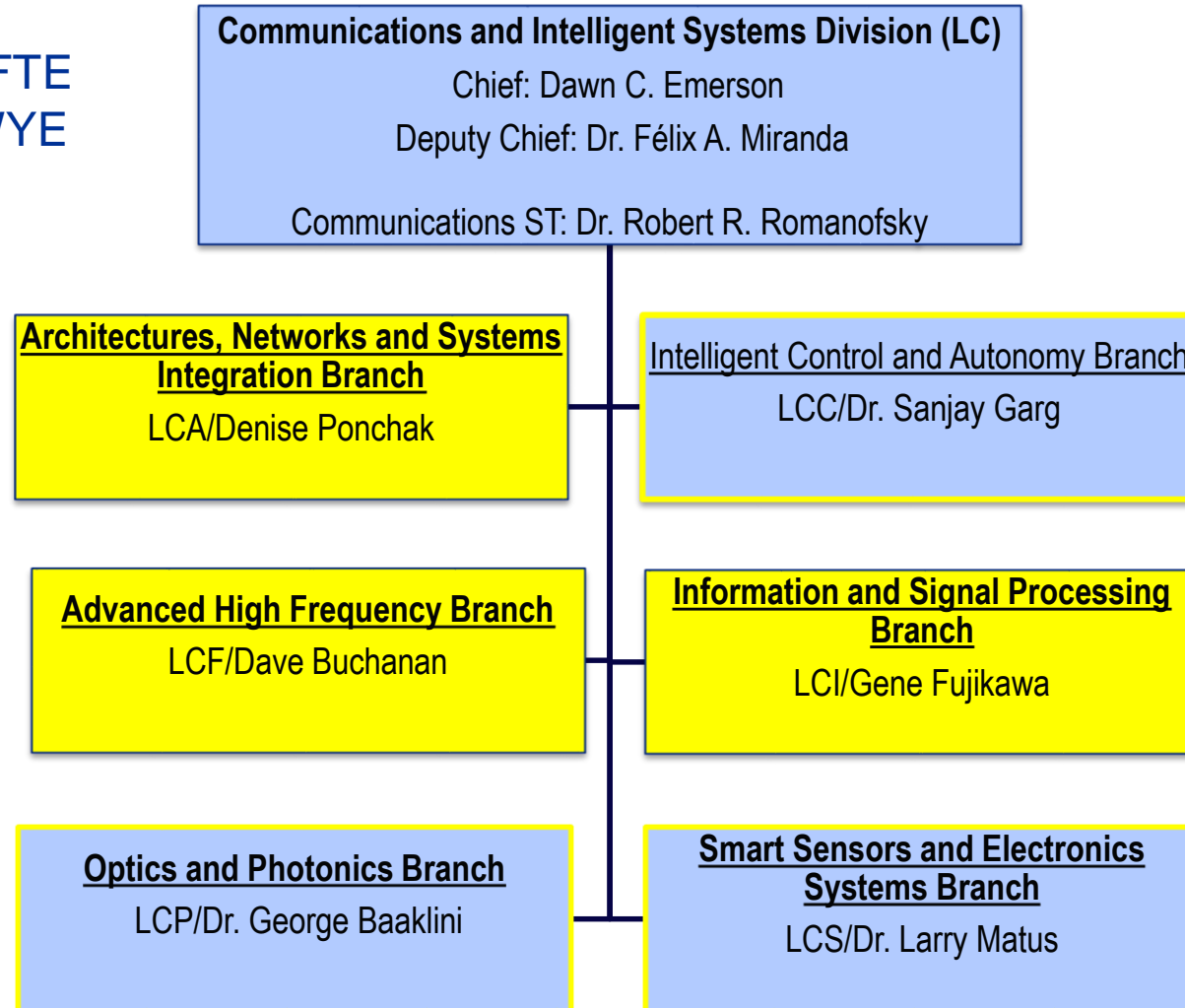
- Optics and Photonics
- Smart Sensor Systems
- Instrumentation- Electronic
- Controls- Dynamic System Modeling and Controls



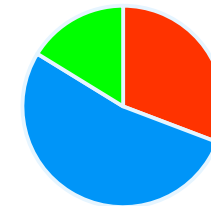
Communications and Intelligent Systems Division (LC)



115 FTE
58 WYE

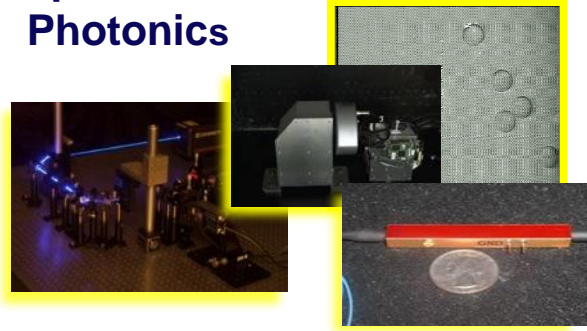


Education



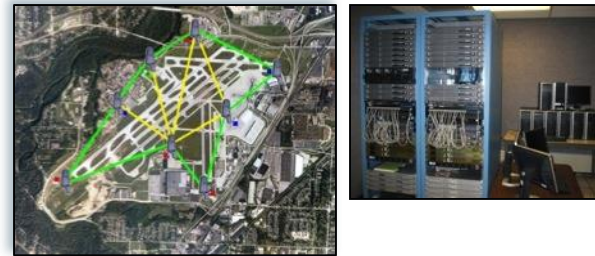
■ PhD ■ MS ■ BS

Optics and Photonics



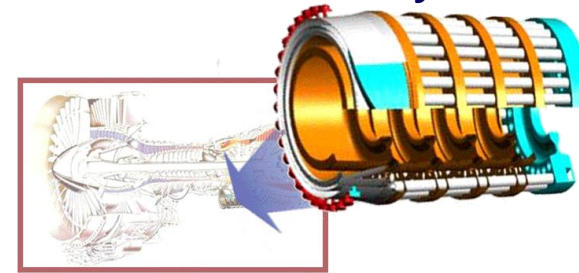
Optical Instrumentation
Optical Communications
Health Monitoring

Architectures, Networks and Systems Integration



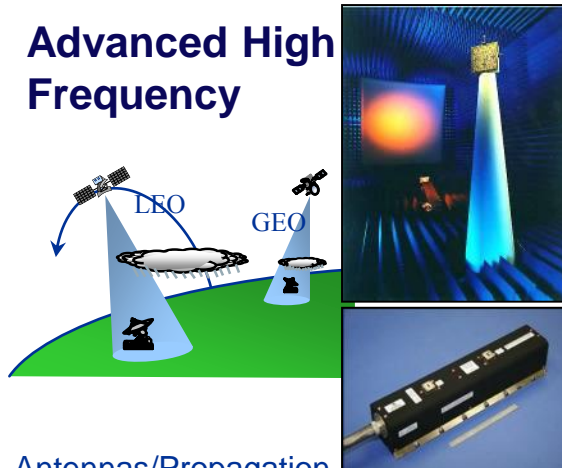
Communications Architectures
Modeling and Simulation/Tech Demos
Spectrum and Link Analysis

Intelligent Control and Autonomy



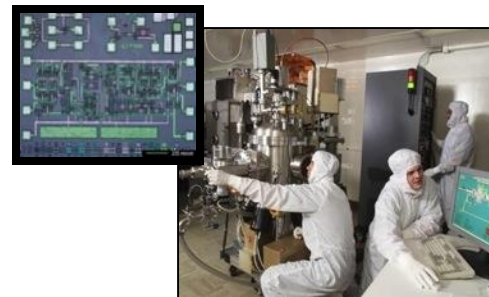
Intelligent Controls
Dynamic Modeling
Health Management

Advanced High Frequency



Antennas/Propagation
RF Systems and Components
3-D Electromagnetic Modeling

Smart Sensors and Electronics Systems

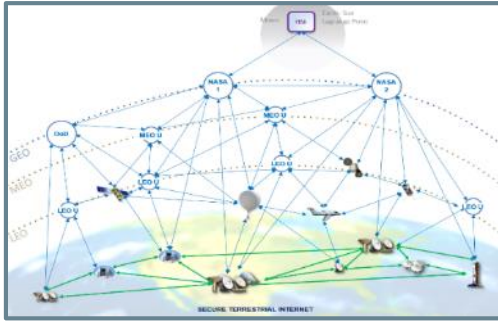


Thin Film Physical Sensors
High Temp/Harsh Environment Focus
Wireless Technologies

Information and Signal Processing

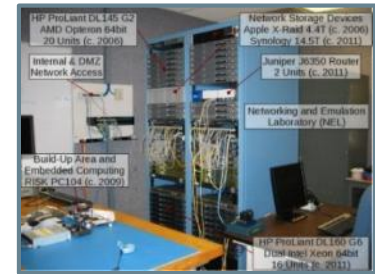
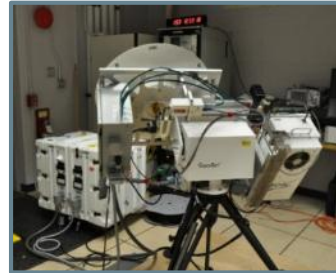
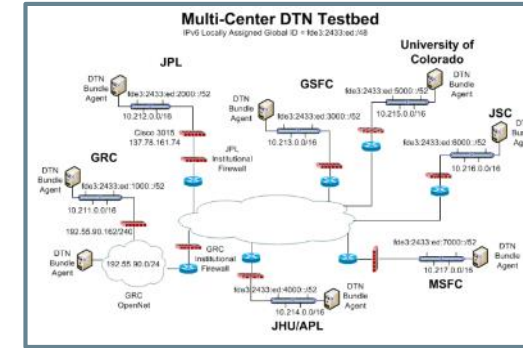


Radio Systems – SDRs, Cognitive
Bandwidth and Power-Efficiency
Waveform Development



Communications Systems

- Systems engineering of future SCAⁿ Integrated Network Architecture.
- Requirements decomposition, systems definition, development, hardware and software build up, test and delivery of Space Network compatibility test unit including TDRS signal simulator.



Aeronautical Communications

- Includes air-to-air, air-to-ground, and ground-based mobile wireless communications, information networking, navigation and surveillance research, technology development, testing and demonstration, advanced concepts and architectures development, and national and international technology standards development.

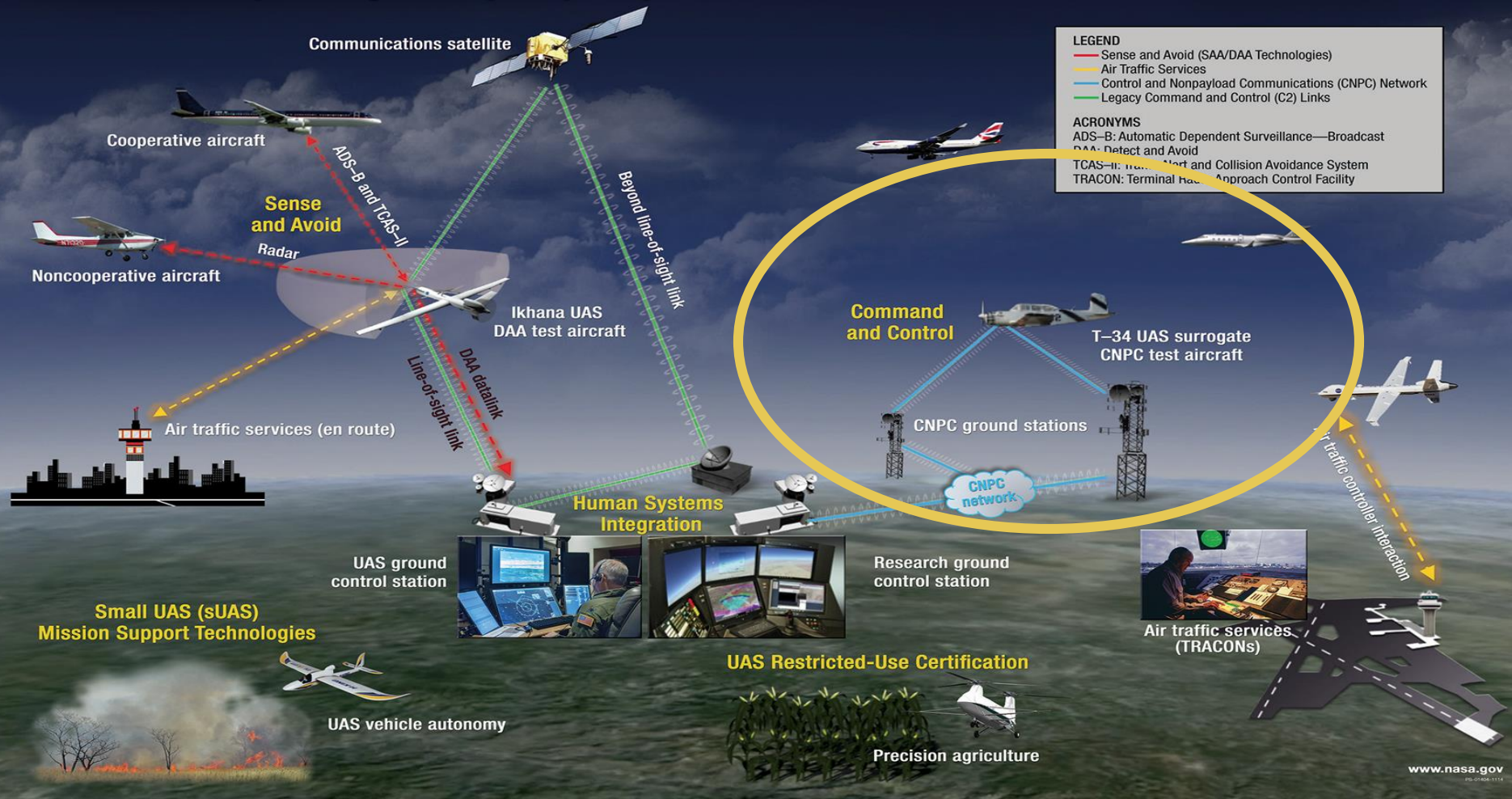


Network Research

- Development of network components, design of network layers and networked systems architectures. Emphasis is on secure wireless mobility, protocol characterization and development, requirements definition, and flight software/hardware component assessment. Also includes "virtual" mission operations.

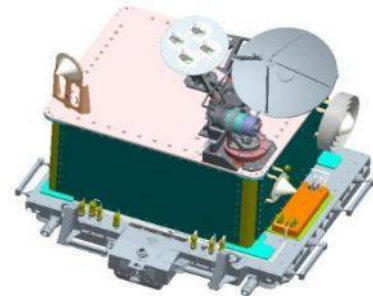
Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project

National Aeronautics and Space Administration



LCI Overview

Conducts research and technology development of information and signal processing methods and approaches of digital communications systems for aerospace applications. Emphasis on software-defined and cognitive radios; open SDR architectures and waveform development; position, navigation and timing methods; spectrum and power efficient techniques; reconfigurable microelectronic devices



SCaN Testbed

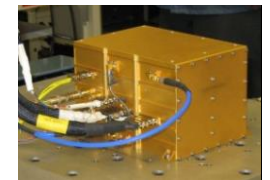


Facilities/Labs

- Software-Defined and Cognitive Radio Technology Development Laboratory
- Digital Systems and Signal Processing Lab
- EVA Radio and Integrated Audio Lab
- SCaN Testbed on ISS Available for Experimenters



Software Defined Radios

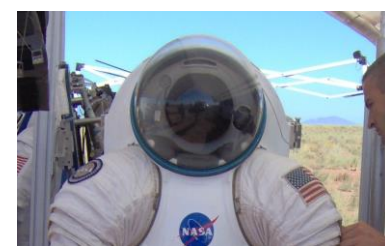


Focus Areas

- Software-Defined and Cognitive Radios
 - Space Telecommunications Radio System (STRS)
 - STRS-compliant Hardware and Software
 - SDR Waveform Development
 - Digital Core for RF/Optical Terminal
- High Speed Signal Processing
 - Computer Modeling and Simulation Tools
 - Wireless and Microelectronic Devices for Communications
- Advanced Exploration Systems
 - Integrated Audio/Microphone Arraying
 - EVA Radio Development
 - Surface Navigation
- SCaN Testbed Flight Radio Experiments and Demonstrations
 - GPS Navigation and Timing
 - Ka-Band, Bandwidth-Efficient, High Rate Waveform
 - S- and Ka-Band IP Networking and Routing
 - Adaptive Modulation and Coding for Cognitive Radio



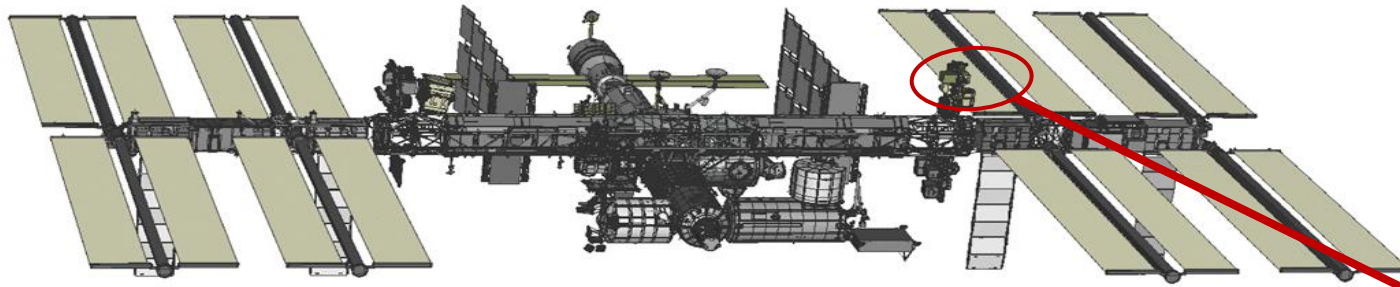
Extra-Vehicular Activity (EVA) Radio



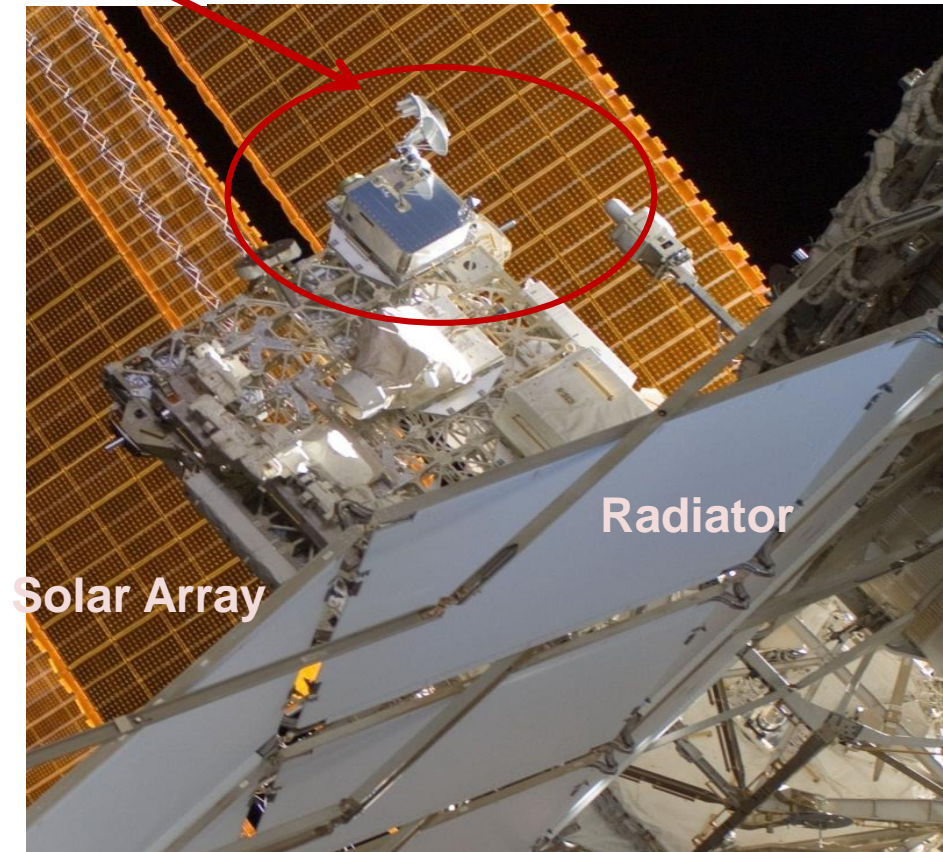
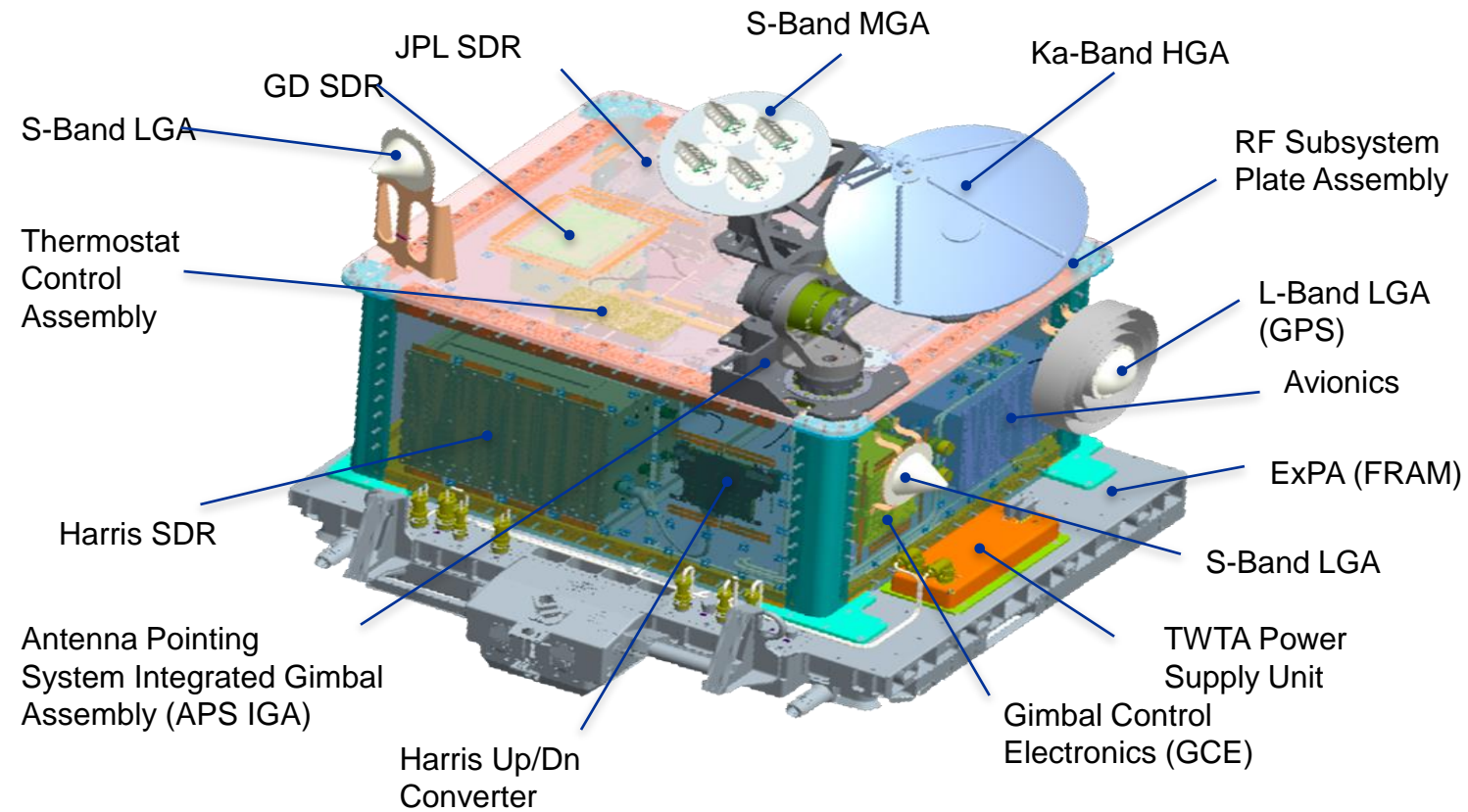
AES/EVA Integrated Audio



iROC Flexible Digital Core



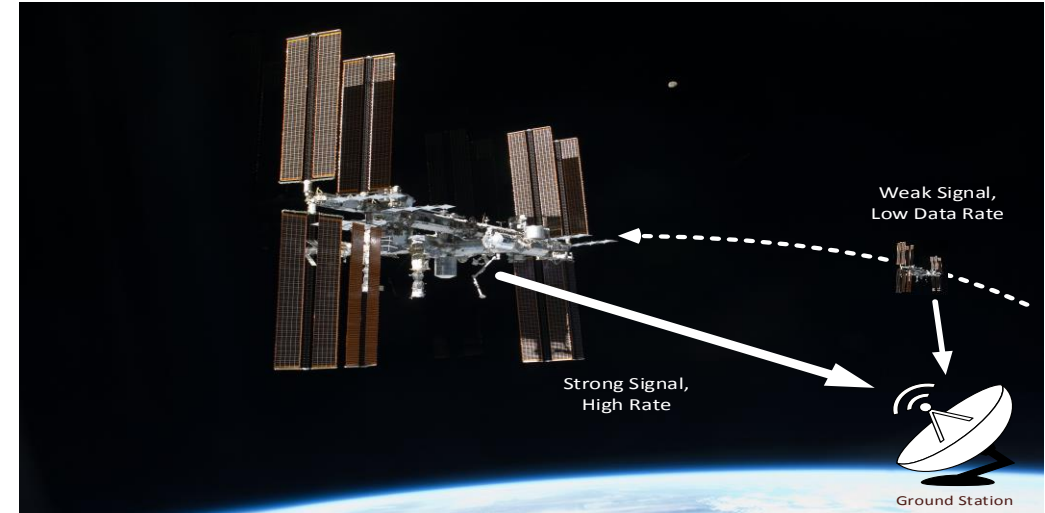
SCaN Testbed aboard International Space Station



Goal: Develop next generation cognitive technologies for communications to increase mission science return and improve resource efficiencies.

SCaN Test Bed is an early proving ground for experiments in cognitive communications

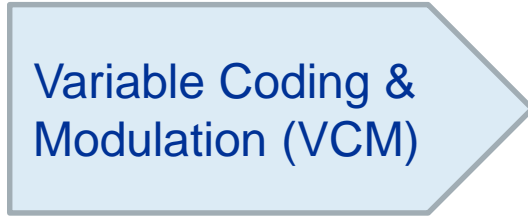
- Performed experiments in VCM and ACM
- Moving toward cognitive communications
 - Enhanced adaptive capability- More efficient use of spectrum, power and network resource management. Adapt mission operations based on internal and external environments.



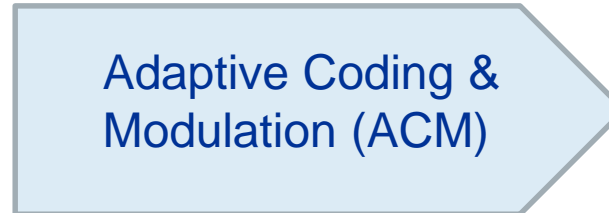
Automatically compensate for dynamic link environment



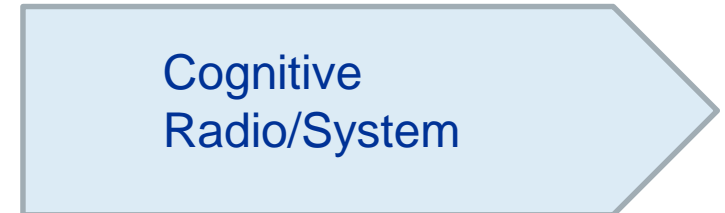
Configurable Properties



Reconfigure system based on predictions



Dynamic reconfiguration based on feedback



Adapting and learning to form intelligent systems: cognitive radios, intelligent networking, user initiated services

Branch Overview

- Conducts research and technology development, integration, validation, and verification at frequencies extending up to the terahertz region in the areas of semiconductor devices and integrated circuits, antennas, power combiners, frequency and phase agile devices for phased arrays, and radio wave propagation through Earth's atmosphere, in support of NASA space missions and aeronautics applications.
- R&D is conducted in-house and also in collaboration with academia and industry to develop low mass, small size, high power and efficiency traveling-wave tube amplifiers, solid state power amplifiers; novel antenna technologies (e.g., wideband antennas, hybrid antennas (i.e., RF/Optical), ground stations, among others.
- The Branch supports development of advanced technologies such as superconducting quantum interference filter (SQIF) for ultra-sensitive receivers and Ka-band multi-access arrays for NASA's next generation space communications.
- Facilities include planar and cylindrical near-field, far-field and compact antenna ranges, cryogenic microwave and millimeter-wave device and circuit characterization laboratory, high power amplifier characterization laboratory, radio wave propagation laboratory, and clean room facilities.
- Semiconductor device modeling and high frequency circuit simulation, fabrication, and integration facilities are also available.

AlphaSat Propagation Terminal in Milan, Italy

Hybrid RF/Optical Antenna

Inflatable Antennas

Semiconductor/Nanofabrication Clean Room Facility

Nanoionic Switch

High Efficiency Power Combining TWTAs

NanoFETs

SQIF Chip

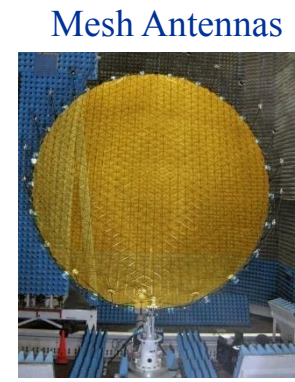
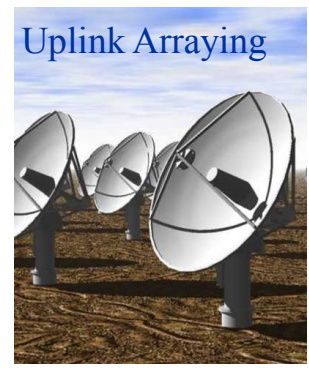
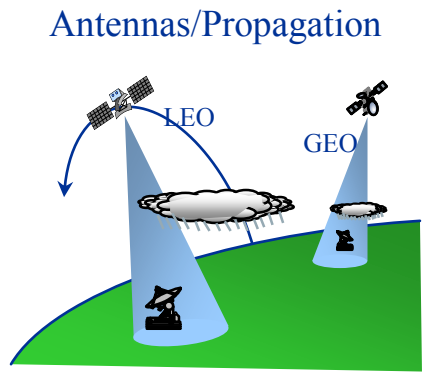
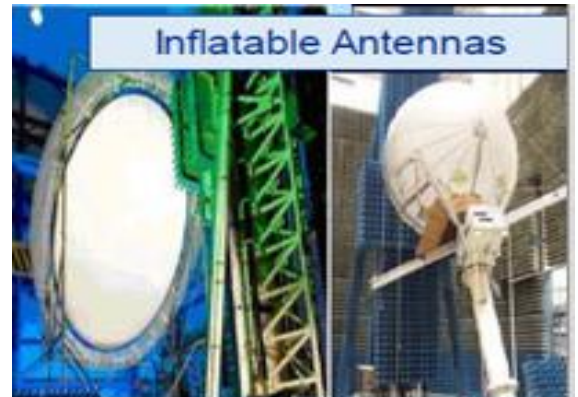
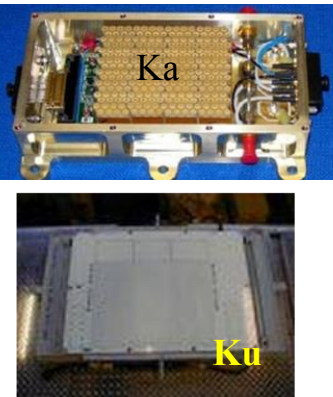
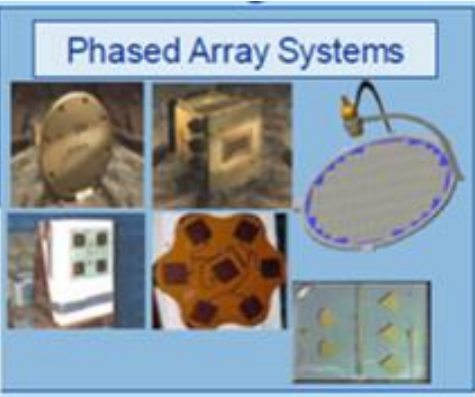
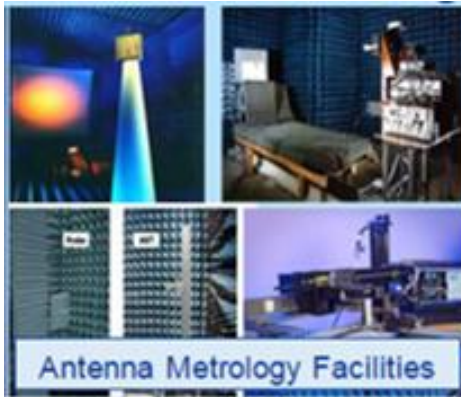
R&D Award Winning Technologies

Ka-Band TWTAs

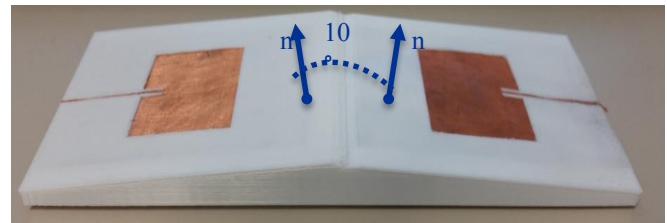
Antenna Metrology Facilities

Phased Array Systems

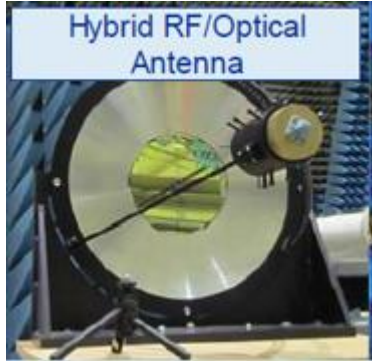
Advanced RF Antenna and Optical Technologies



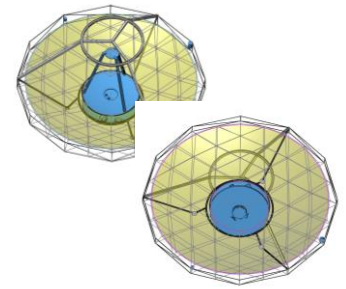
3-D Printed Antennas for Cubesats



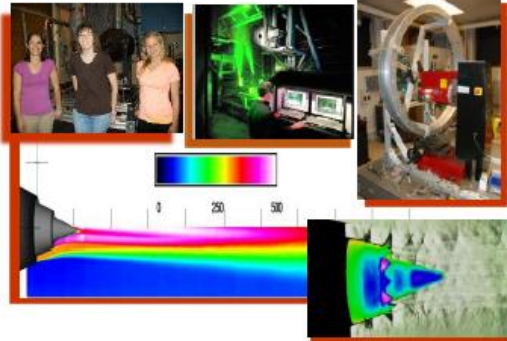
SCaN Testbed Ground Station



Teletenna Concept



Optical Instrumentation



<http://www.grc.nasa.gov/WWW/Optinstr/>

- Our data and instrumentation help designers understand the fundamental physics of new systems, validate aeronautics computational and life models, and improve space optical communications for human and robotic explorations.

- Our data leads to improved designs, validation and verification of systems performances, increased communications, safety and security and reduced design cycle times for many of the core technologies developed at Glenn and across NASA.

Photonics and Health Monitoring



Flow/Noise Diagnostics

- Particle imaging Velocimetry (PIV)
- Background Oriented Schlieren
- Rayleigh Scattering
- PIV Tomography
- Combustion diagnostics
- Raman Diagnostics (Species, T)
- Plasma generation

Surface Diagnostics

- Temperature Sensitive Paint
- Pressure Sensitive Paint
- Stress Sensitive Film

Engine Icing

- Light Extinction Tomography
- Light Extinction Probes
- Raman Spectroscopy
- Impedance Sensor

Optical Communications



Free Space Communications

- Optical Teletennas
- Beaconless Pointing Systems
- High Data Rate for Deep Space & Near Earth

Secure Quantum Communications

- Quantum Entanglement
- Pulsed photon Pairs
- Quantum Illumination
- Quantum Key Distributions

Mobile and Remote Sensing

- On-Orbit Solar Cell Characterization MISSE 5-8; TACSAT- 4;
- Hyperspectral Imaging
- Mobile Sensing Platforms

Communications

- Communications over power lines
- Communications Interface Boards
- High Data Rate

Health Monitoring

- Microwave Blade Tip Clearance
- Self diagnostic Accelerometer
- Fiber optics sensors
- Morphology dependent resonance
- Phosphor Thermography
- Capacitance & piezo patches sensors
- Wireless and wired techniques



Remote Sensing of Harmful Algal Blooms (HAB) in Lake Erie



Current status

- Airborne hyperspectral sensing capability for monitoring potentially harmful algal blooms
- 14 flights in 2014, 26 flights in 2015 and 6 flights this year
- Provide HAB data on water intakes in Lake Erie, small lakes and the Ohio river



NASA aircraft

Research partners also conduct water sampling and ground optical measurements

- NOAA GLERL
- University of Toledo
- Kent State University
- Michigan Tech Research Institute
- Bowling Green State University
- OhioView
- Naval Research Lab



Shore radiance measurements

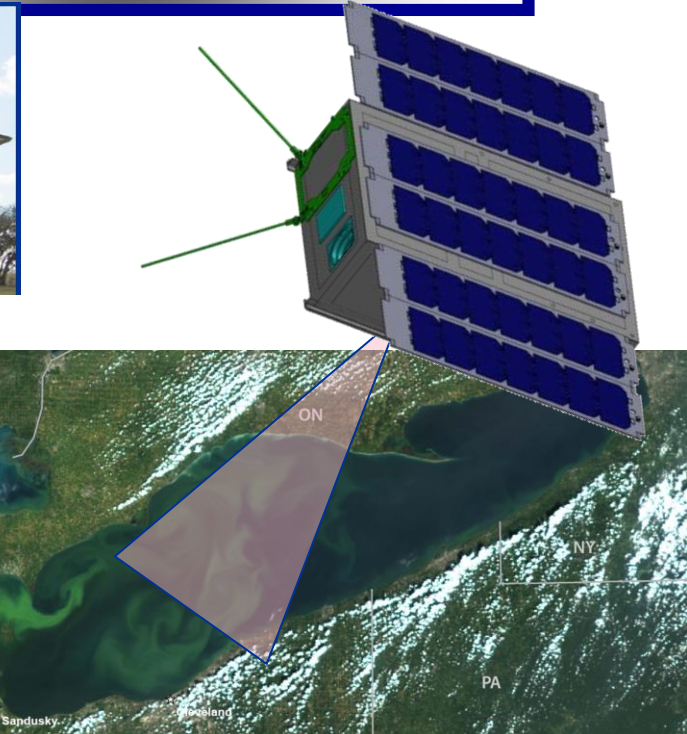
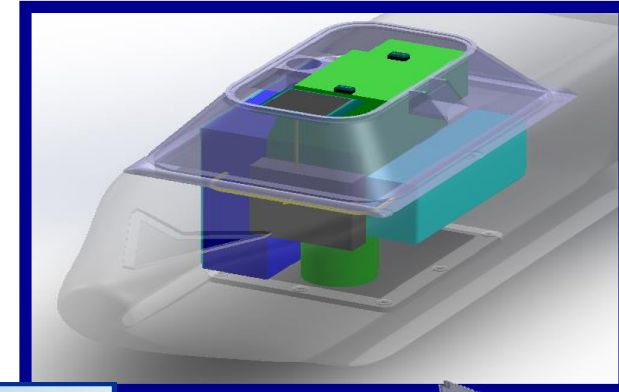


Shore water sampling



HAB information provided by remote sensing and water sampling can provide for early warning to ensure proper water treatment and shutoff avoidance

- New Platforms:
 - Integrate a hyperspectral imager into an unmanned aerial vehicle (UAV) starting in August 2016
 - Two hyperspectral imagers in development that are appropriate for a cubesat
- New Algorithms
 - Mirror based atmospheric correction
 - Verimax rotated principal component analysis
 - Tuned Cyanobacteria index

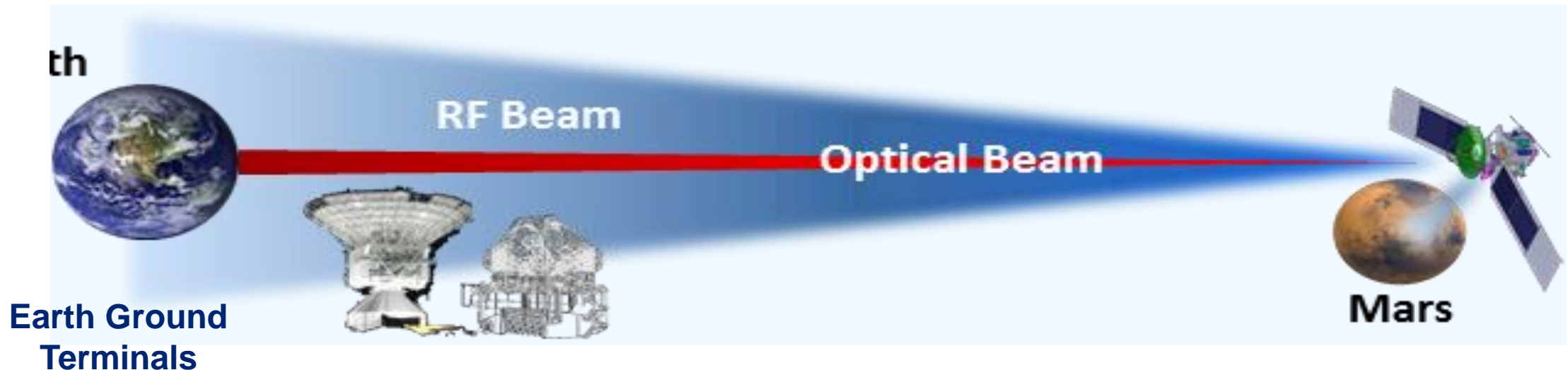


iROC Objectives:

- Combine the best features of deep space RF and optical communications elements into an integrated system:
- Increase data throughput while reducing spacecraft mass, power and volume.
- Extensible to, and mitigates risk for missions from near Earth to deep space.
- Prototype and demonstrate performance of key components to increase TRL, leading to an integrated hybrid communications system demonstration.

Key enabling technologies :

- Combined RF/optical Teletenna
- Precision beaconless pointing /navigation through sensor fusion
- RF/optical Software Defined Radio (SDR)
- Networked RF/optical link management (DTN)



Description

Conducts research and development of adaptable instrumentation to enable intelligent measurement systems for ongoing and future aerospace propulsion and space exploration programs. Emphasis is on smart sensors and electronics systems for diagnostic engine health monitoring, controls, safety, security, surveillance, and biomedical applications; often for high temperature/harsh environments.



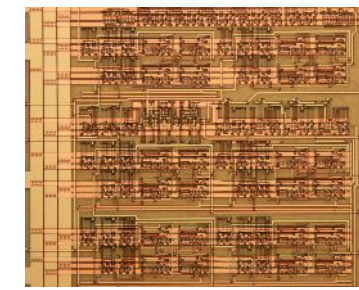
Microsystems Fabrication Facility

Facilities/Labs

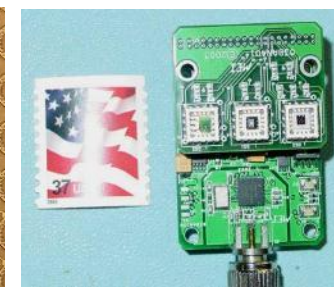
- Microsystems Fabrication Facilities
 - Class 100 Clean Room
 - Class 1000 Clean Room
- Chemical vapor deposition laboratories
- Chemical sensor testing laboratories
- Harsh environment laboratories
 - Nanostructure fabrication and analysis
 - Sensor and electronic device test and evaluation

Focus Areas

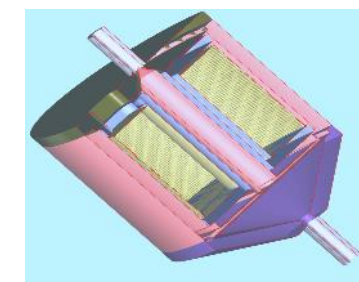
- Silicon Carbide (SiC) - based electronic devices
 - Sensors and electronics for high temp (600°C) use
 - Wireless sensor technologies, integrated circuits, and packaging
- Micro-Electro-Mechanical Systems (MEMS)
 - Pressure, acceleration, fuel actuation, and deep etching
- Chemical gas species sensors
 - Leak detection, emission, fire and environmental, and human health monitoring
- Microfabricated thin-film physical sensors
 - Temperature, strain, heat flux, flow, and radiation measurements
- Harsh environment nanotechnology
 - Nano-based processing using microfabrication techniques
 - Smart memory alloys and ultra low power devices



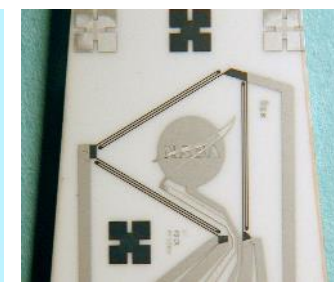
SiC Signal Processing



Chemical Gas Sensors

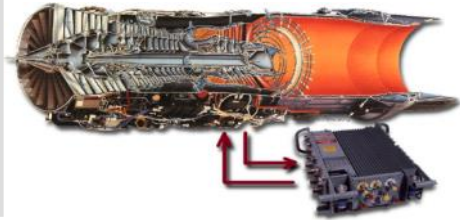


MEMS Fuel Actuation



Thin Film Physical Sensors

Propulsion Controls



Active Combustion Control

Control of Thermo-acoustic Instability
High Bandwidth Fuel Actuation

Advanced Control Architecture

Distributed Engine Control
Hardware-in-the-loop Test-bed

Intelligent Engine Control

Enhanced Engine Response for
Emergency Operations

Robust Engine Control

Model-Based Engine Control

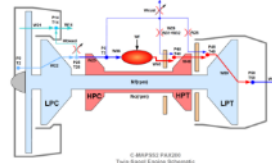
V&V of Advanced Controls

High Speed Propulsion

Aero-Propulso-Servo Elasticity for
Supersonic Propulsion System

Mode Transition Management for Air-
Breathing Hypersonic Propulsion

Health Management



Propulsion & Power Systems

Gas Path Health Management
Sensor Selection

Sensor Data Qualification

Fault Modeling and Diagnostics

Model-Based Engine Simulation for
Engine Test, Calibration and
Performance Analyses

Current NASA Programs

Aeronautics Research Mission

Advanced Air Vehicle

Airspace Operations and Safety

Transformative Aeronautics Concepts

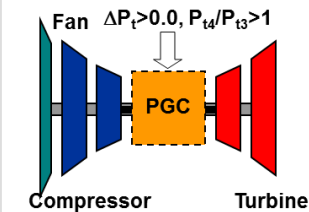
Human Exploration and Operations Mission

Space Launch System

SCAN

Orion

Advanced Propulsion Concepts



Unsteady Propulsion

Pulse Detonation Engine

Pressure Gain Combustion

Communications

Integrated Radio and Optical Comm

Spacecraft Attitude Estimation

Spacecraft Structural Dynamics

Software Tools

Engine Modeling & Control

C-MAPSS (Commercial Modula Aero
Propulsion System Simulation)

C-MAPSS40k (40,000 lb Thrust Engine)

T-MATS (Tool for Modeling and Analysis
of Thermodynamic Systems)

Combustion Instability Simulation