NRA Number: NNC07ZRP001N

NASA Research Announcement

Research and Technology Glenn Research Contracts

NRA Number: NNC07ZRP001N

- Introduction
- Proposal and Submission
- Proposal Review, Evaluation and Selection
- Contract Awards

NRA Number: NNC07ZRP001N

- This NASA Research Announcement (NRA) entitled *RESEARCH AND TECHNOLOGY GLENN RESEARCH CONTRACTS* solicits proposals for research and development to advance the state-of-the-art technologies in support of the following National Aeronautics and Space Administration (NASA) missions: Aeronautics Research, Exploration Systems, Science, and Space Operations.
- A major focus of this solicitation is to foster a working, contractual relationship with organizations that can request the utilization of the facilities at the Glenn Research Center (GRC) in Cleveland, Ohio.

NRA Number: NNC07ZRP001N

- Based upon the current program plans and budget allocations, it is anticipated that the total award for all tasks will be approximately $25M for the performance period, Fiscal (FY) 07-12.
- This estimate is subject to change per the annual NASA budget appropriation and program planning cycle.

NRA Number: NNC07ZRP001N

- All proposals are due by April 30, 2007
  - Must be submitted in electronic format filed to a CD and postmarked and/or delivered by midnight April 30, 2007
  - Late proposals will not be accepted
  - Please refer to section III of the solicitation for additional information and requirements

NRA Number: NNC07ZRP001N

Proposal Evaluation

- Technical Quality
  - Technical Merit
  - Past Experience
  - Key Personnel
- Utilization Plan
- Cost

Relative Importance

- Technical Quality and Utilization Plan are approximately equal in importance, and combined together, both are significantly more important than cost
- Within Technical Quality Factor: Technical Merit, Past Performance, and Key Personnel are all equally weighted
- Relative Importance of Price: all evaluation factors other than cost, when combined are greater than cost

NRA Number: NNC07ZRP001N

- The peer review(s) panel develops a recommendation for selection based on the results of each proposal's evaluation. Recommendations are presented to the SO. The SO select proposals to be funded.
- The final selection results from a process in which the merit of the proposal is balanced with programmatic requirements and available budgetary resources

NRA Number: NNC07ZRP001N

- Contract Awards
  - Notification
  - Negotiation Phase

NASA GRC plans to award the selected contracts in mid to late June, 2007

NRA Number: NNC07ZRP001N

- All Questions and Answers from this briefing will be posted in the website

1.0 High Temperature Materials and Structures

Dr. Ajay Misra
Deputy Chief, Structures and Materials Division

GRC NRA Briefing
NRA Number: **NNC07ZRP001N**
RESEARCH AND TECHNOLOGY GLENN RESEARCH CONTRACTS
March 30, 2007

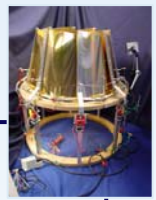
Structures and Materials Division Capabilities For Aerospace Systems

Fan containment for gas turbine engine

Advanced Drive Systems

- Combustor liners
- Turbine blade/vane
- Rotor systems
- Fan containment
- Space lubricants
- Oil-Free engines
- Injectors
- High-power motors
- Cryogenic tanks
- Nacelles, Nozzles
- Mechanical drive sys.
- High temp. seals
- Cryogenic seals
- Magnetic bearings
- Fuel cell system
- Space nuclear power
- Composite structures
- Surface mobility

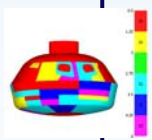
Oil-Free Foil Turbomachinery



Actively-Controlled Variable Area Nozzle

Advanced Thermal Barrier Seals

Composite CEV Crew Module



Core R&T Capabilities

Stirling engine for space nuclear power

- Structural mechanics
- Life prediction
- Probabilistic analysis
- Structural optimization
- Mechanics of materials
- Multifunctional structures
- Adaptive structures
- High temperature alloys
- Structural ceramics and composites
- Polymer matrix composites
- Functional polymers and ceramics
- Protective coatings/Durability
- Computational materials science
- Extreme environment lubricants
- Nanotechnology
- Surface science
- Structural dynamics
- Aeroelasticity
- Mechanisms
- Seals
- Terramechanics

Turbine engine Components

Enable lightweight, durable, reliable, and safe material and structural systems

Structures and Materials Division

Division Office (RX)
Chief: Dr. Gary Seng

Deputy: Dr. Ajay K. Misra

Senior Technologist: *Dr. James A. DiCarlo, Dr. James L. Smialek, Dr. Bruce M. Steinetz, and Mr. Erwin V. Zaretsky*

Senior Engineer: *Dr. John P. Gyekenyesi*

Senior Scientist: *Dr. Rebecca A. MacKay*

Advanced Metallics Branch (RXA)
Chief: Dr. Michael V. Nathal

- *Alloy Development and Processing*
- *Microstructure - Property Relationships*
- *Materials Application Engineering*

Ceramics Branch (RXC)
Chief: Dr. Andrew J. Eckel

- *Structural Ceramics and Composites*
- *Solid Oxide Fuel Cells and Electrolysis Membranes*
- *Functional Ceramics*

Durability and Protective Coatings Branch (RXD)
Chief: Ms. Leslie A. Greenbauer-Seng

- *Protective Coatings*
- *Environmental Durability/Life of Materials*
- *High Temperature Chemical Behavior of Materials*

Mechanics and Life Prediction Branch (RXL)
Chief: Dr. Steven M. Arnold

- *Analytical and Computational Mechanics of Materials*
- *Experimental Mechanics*
- *Life Prediction*

Mechanical Components Branch (RXM)
Chief: Mr. James J. Zakrajsek

- *Drive System and Mechanisms*
- *Seals*
- *Terramechanics*

Polymers Branch (RXP)
Chief: Dr. Michael A. Meador

- *Polymer Matrix Composite*
- *Nanostructured Materials*
- *Functional Polymers*

Structures and Dynamics Branch (RXS)
Chief: Mr. George L. Stefko

- *Dynamic Systems*
- *Aeroelasticity and Active Structures*
- *Components and Large Structures*

Tribology and Surface Science Branch (RXT)
Chief: Dr. Phillip B. Abel

- *Oil – Free Turbomachinery*
- *Extreme Environment Tribology*
- *Surface Science*

Material Processing Capability

Vacuum induction melting

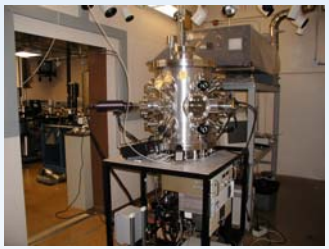
Welding and joining

Rheometer

Tape casting with freeze casting capability

Mechanical alloying

Sputter PVD



Pulsed laser deposition

Polymer composite laboratory

Vacuum hot press

Plasma spray coating

Laser float-zone crystal growth

Aerogel synthesis laboratory

Materials Characterization Capability

Hitachi S4700-FESEM

JEOL 8200 Electron Probe

Thermal analysis capability

Philips CM200 TEM

Piezoelectric property measurement

40 MHz NMR

Impedance spectroscopy

High temp mass spectrometer

Structural, Environmental, and Dynamic Test Capabilities

Ballistic impact

Multiaxial benchmark test rig

Spin pit test

Burner rig

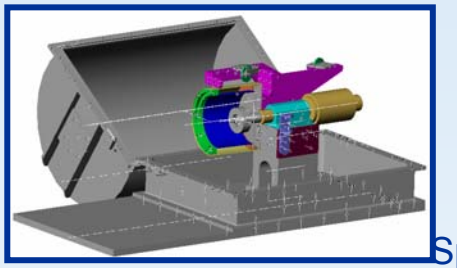
Cryogenic motor test rig

Thermal gradient testing in laser rig

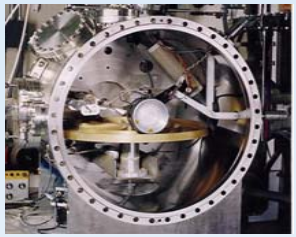
Mechanical Test Capabilities:

- ~100 creep test rigs with a wide range of temperature and environmental capabilities, including vacuum
- 18 high temperature low cycle fatigue test rigs for testing in air, inert, vacuum. and moisture environments
- 2 high cycle fatigue rigs with high temperature capability
- 5 torsion-compression-torsion fatigue (multiaxial TMF) test rigs
- 7 fatigue crack growth rigs
- Fiber tensile and bend test
- Acoustic emission

Mechanical Components Facilities



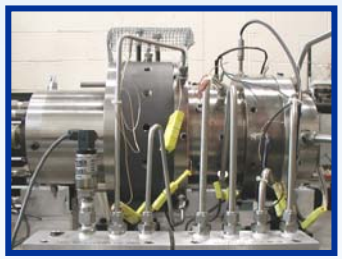
Foil bearing ambient pressure test rig



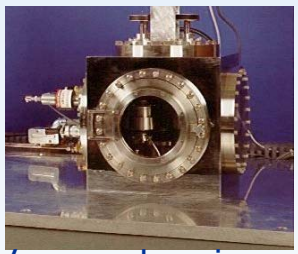
Space mechanisms accelerated test chamber

Structural seal flow fixture

Hot compression/scrub seal test rig



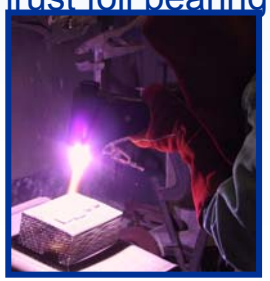
Hot, high-speed thrust foil bearing rig



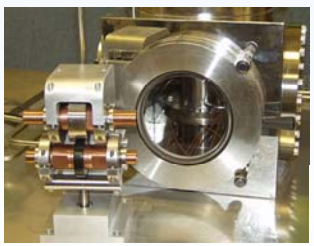
Vacuum bearing facility

Transmission system test facility

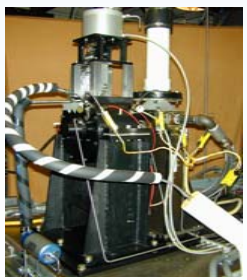
High temperature, high speed turbine seal rig



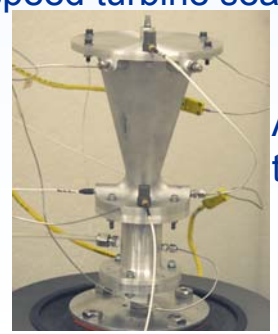
Solid lubricant coating deposition facility



Space drives test facility



Wave bearing rig



Acoustic seal test facility

Computational Tools

NASA Developed Software:

Predict Composite Mechanical/Thermal Properties & Durability

- ICAN – FOR POLYMER MATRIX COMPOSITES (PMC'S) WITHOUT PLASTICITY
- MAC/GMC – FOR COMPOSITES WITH MATERIAL NONLINEARITIES
- CEMCAN – FOR CERAMIC MATRIX COMPOSITES (CMC'S)
- ImMaC – INTEGRATED MULTISCALE MICROMECHANICS ANALYSIS

Predict Durability And Life Of Ceramic Components

- CARES/*Life* – FOR STRUCTURAL CERAMIC APPLICATIONS IN FATIGUE
- CARES/*Creep* – FOR STRUCTURAL CERAMICS CREEP BEHAVIOR

- **Structural Optimization**
  - Comet Boards – OPTIMIZATION OF LARGE STRUCTURES
- **Aeroelasticity**
  - Turbo-AE – AEROELASTIC ANALYSIS OF PROPULSION COMPONENTS

COMMERCIAL STRUCTURES / LIFING SOFTWARE:

- ANSYS, ABAQUS, MSC/NASTRAN, MARC, PATRAN
- DARWIN, NESSUS, FASTRAN, AFGROW, NASGRO, FRANC

COMMERCIAL COMPUTATIONAL THERMODYNAMICS SOFTWARE:

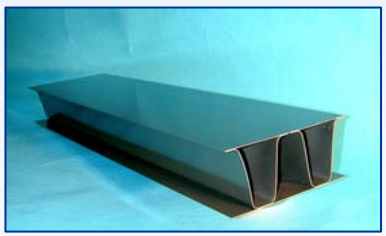
- CHEMSAGE, THERMOCALC, PENDATA

High Temperature Metallic Materials

Alloy Development and Processing

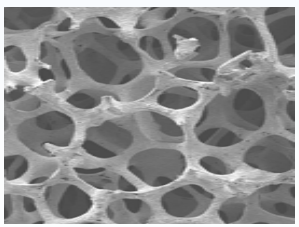
Turbomachinery disk alloy and process develop to improve life and temperature capability

Low density single crystal turbine blade alloy



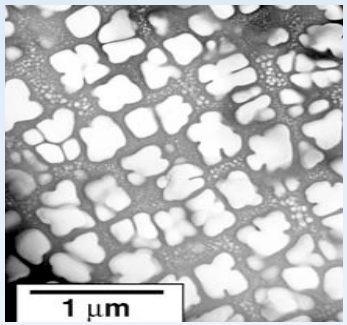
Titanium aluminide For hypersonic engines

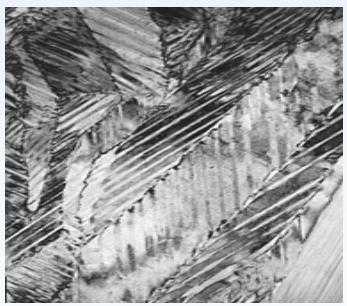
High temperature shape memory alloy (HTSMA) for adaptive structures

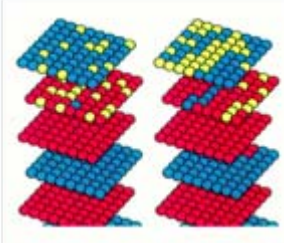


High temperature porous alloy for multifunctional structure

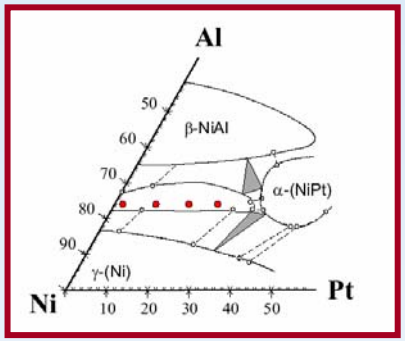
Structure – Property Relationship



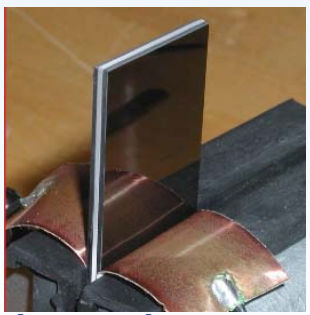




Computational alloy design for HTSMA



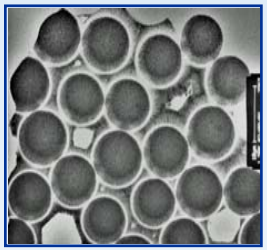
Computational Thermodynamics and High Temperature Reaction

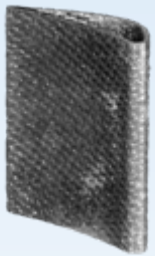


Advanced thermoelectric material (new materials + sublimation barrier coating)

High Temperature Ceramic Material

Structural Ceramics

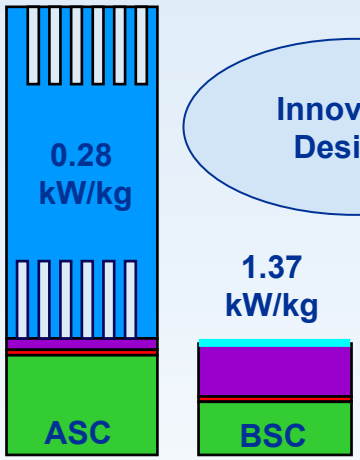




Improved composite properties through constituent modification, constituent modeling, process modeling, Temperature range of interest – 2000 – 3200 F

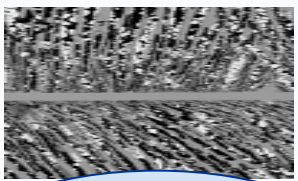
Joining of ceramics to ceramics and to metals

Solid Oxide Fuel Cells and Electrolysis Membranes



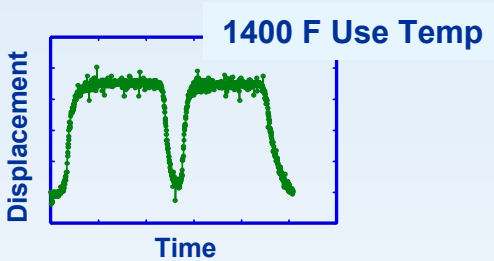
Innovative Designs

Increased Operating Temperature

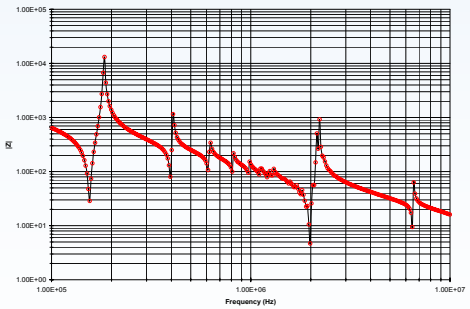


Engineered Microstructures

Functional Ceramics



High Temperature Piezoelectrics for adaptive structures



Measurement of piezoelectric properties at high temperature

High Temperature Polymeric Materials

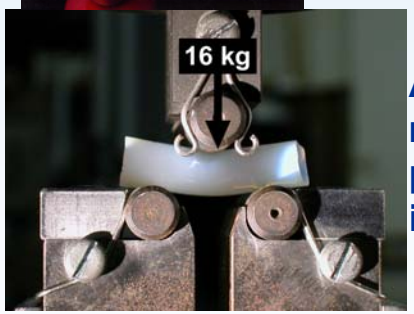
High Temperature PMC

RTM Processed PR-520 LH2 Duct

R&D 100 Award
High Temperature Polymer Matrix Composite (DMBz-15)

Nanostructured Material

Aerogels offer superior thermal insulation



Aerogel mechanical properties improved

Polymer-Clay Nanocomposites for Propellant Tanks

Functional Polymers

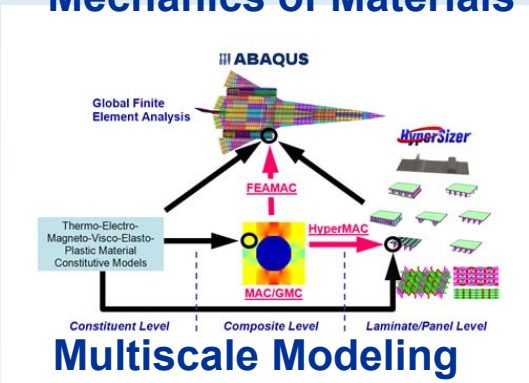
Solid Electrolytes for Lithium-Polymer Batteries

PEM fuel cell membrane with higher temperature capability

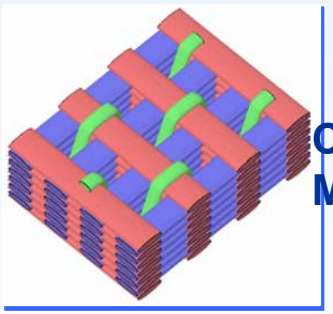
Adaptive Polymers

Mechanics and Life Prediction Methodologies

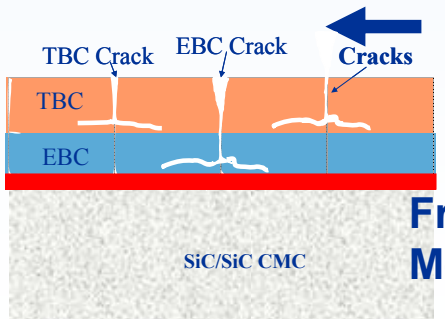
Computational Mechanics of Materials



Multiscale Modeling



Composite Micromechanics



Fracture Mechanics

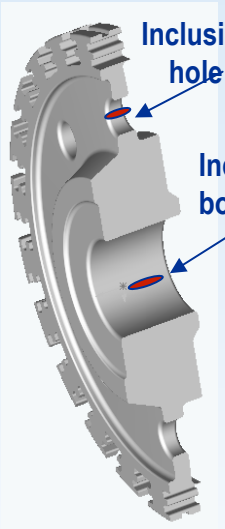
Experimental Mechanics

Multi-Axial Testing of Stirling Engine Heater Head

Composite Pressure Vessel Rupture Analysis

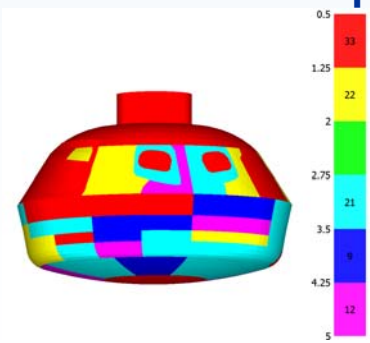
Characterization of Space Shuttle TPS System

Life Prediction



Life prediction modeling of disk with controlled defects

Advanced Concepts



All composite CEV design

Structures and Dynamics Technologies

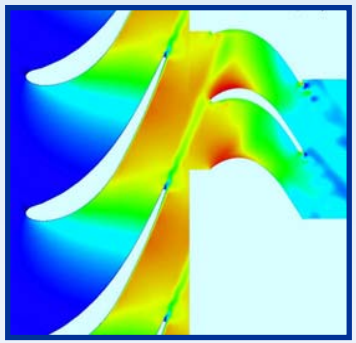
Structural Dynamics

Switched reluctance motor

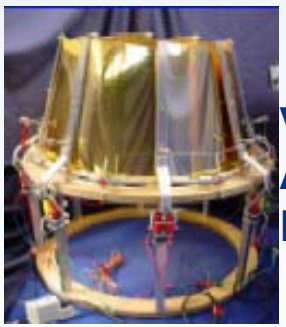
Ballistic Impact Mechanics

Space Shuttle Impact Modeling and Testing

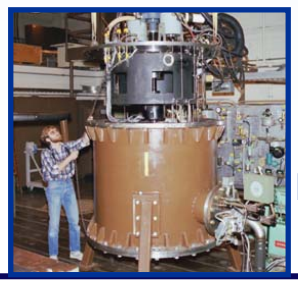
Aeroelasticity and Active Structures



Fluid-Structure Interaction



Variable Area Nozzle

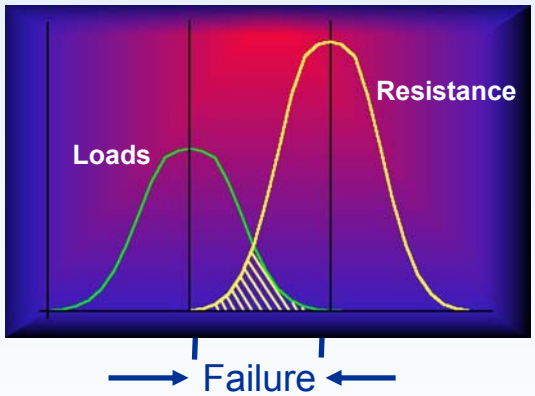


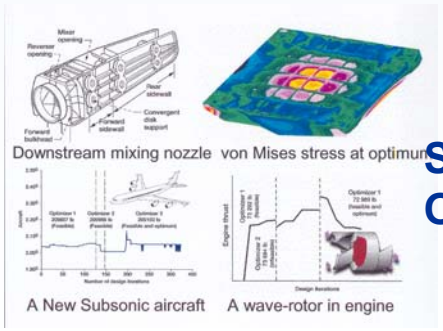
Blade Damping and Mistuning

Components and Large Structure

Multifunctional Fan Containment Structure

NESTEM Probabilistic Analysis

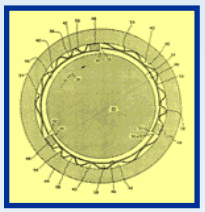




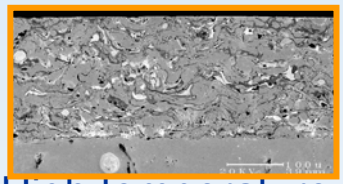
Structural Optimization

Mechanical Components

Oil-Free Turbomachinery

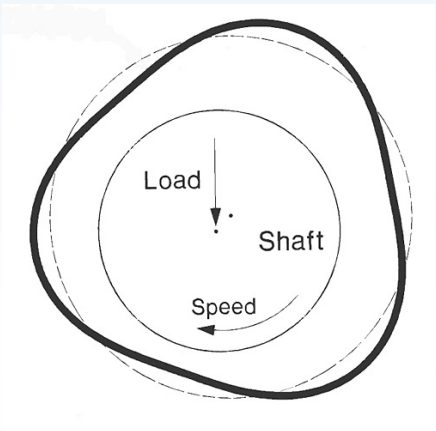


Foil air bearings



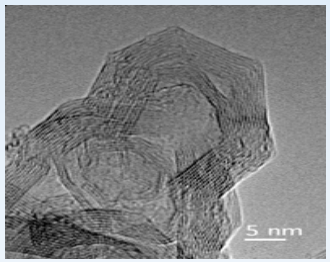
High temperature solid lubricants

Advanced Bearings



Wave Bearing

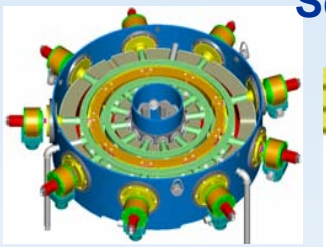
Extreme Environment Tribology

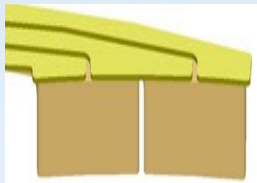


Nanostructured lubricant

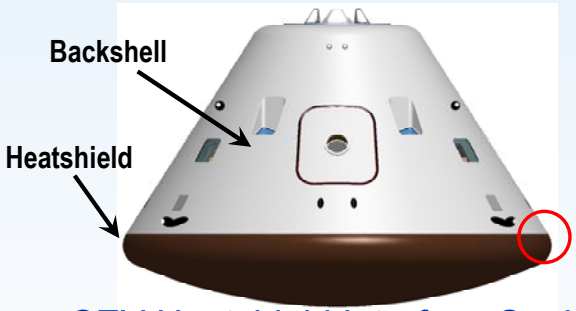
Improved space grease

Seals

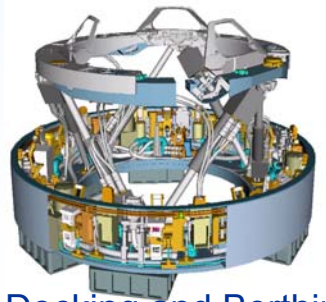




Non-contacting finger seals for ultra efficient turbine engines



CEV Heatshield Interface Seal



LIDS Docking and Berthing System Seal

2.0 Propulsion

Dr. D. R. Reddy

Chief, Aeropropulsion Division

GRC NRA Briefing

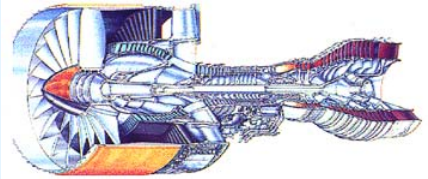
NRA Number: **NNC07ZRP001N**

RESEARCH AND TECHNOLOGY GLENN RESEARCH CONTRACTS

March 30, 2007

Aeropropulsion Division

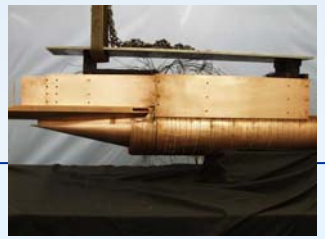
Aeronautics



Space Access

Propulsion Systems

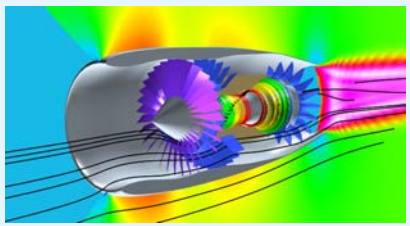
Compressors	Turbines
Inlets	Nozzles
Combustors	Engine Systems
Icing	Acoustics



Components

Fundamental/ Applied Research

System Simulations



Core R&D Capabilities

Fluid Mechanics	Heat Transfer	Simulation Models	Combustion
Acoustics	Turbulence	Transition	Diagnostics
Plasma Physics	Ice Accretion	Turbulence/Chem Kinetics	

AEROPROPULSION DIVISION

Dr. D. R. Reddy
Chief

Turbomachinery & Heat Transfer Branch

J. P. Veres
Chief

- Performance Improvement
- Multi-Stage Flow Physics
- Stall Line Management
- Transition & Loss Mechanisms
- Unsteady Aerodynamics
- Coolant flow management
- Film Cooling – Heat Transfer
- Design/Analysis Code

Combustion Branch

Dr. C. M. Lee
Chief

- Sprays
- Combustion Diagnostics
- Ignition
- Combustion Stability
- Emissions
- Fuel Characterization
- Chemical Kinetics
- Design/Analysis Codes

Inlet & Nozzle Branch

M. J. Long-Davis
Chief

- Overall Performance Evaluation
- Active and Passive BLC
- Specific Flow Phenomena
- CFD Applications
- Unsteady Aerodynamics
- Stability and Control
- Enhanced Mixing & Shear Layer Stability
- Noise Suppression

Acoustics Branch

E. B. Fite
Acting Chief

- Engine Noise Reduction Concepts
- Acoustic Source Identification Methods
- Advanced Noise & Flow Measurement Methods
- Computational Methods & Noise prediction

Icing Branch

T. H. Bond
Chief

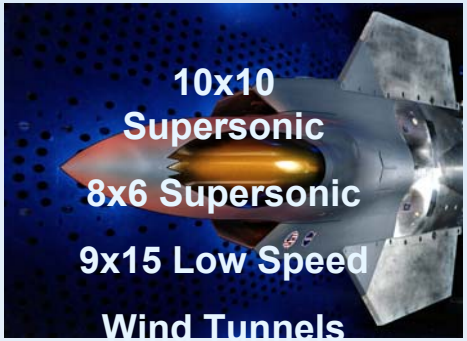
- Experimental Methods
- Protection/Detection
- Accretion Physics Modeling
- Flight Testing
- CFD Applications
- Aircraft Icing Effects

Engine Systems Branch

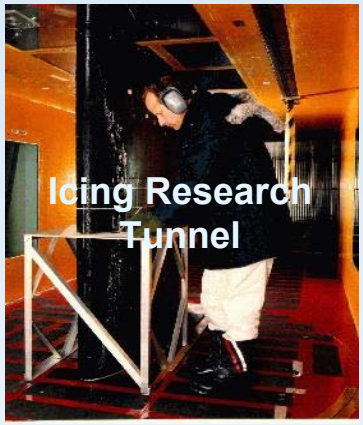
R. A. Claus
Acting Chief

- Engine Systems
- Combined Cycles
- Multi-Discipline Analysis
- Multi-Component Analysis
- Engine Systems and Modeling
- Parallel Processing

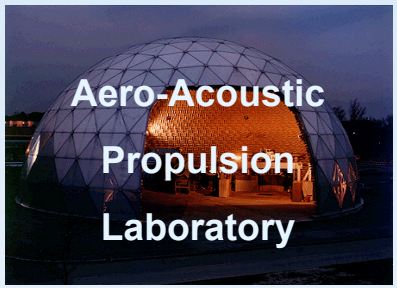
Aero Test Facilities



Eminent NASA Propulsion Subsonic, Transonic, Supersonic complex



World's Largest Refrigerated Icing Tunnel



Nozzle Acoustic Test Rig

Powered Lift Rig

NASA's Only Full Scale Engine Altitude Facility

Clean Air Simulated

Thirty-six Versatile Engine Component Test Rigs

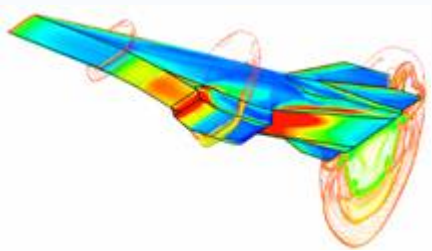
CD-99-78753

Aero Propulsion – Thrust Areas

- **Subsonic**
  - **Performance – Fuel burn & Weight reduction**
  - **Noise and Emissions (NOx and CO_2) Reduction**

- **Supersonic**
  - **Variable Cycle (Cruise efficiency & Take-off reqmnts.)**
  - **Integration (sonic boom & performance)**
  - **High Altitude Emissions**

- **Hypersonic**
  - **Mode transition**
  - **Scramjet performance**
  - **Thermal Management**



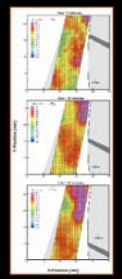
World-Class Turbomachinery Compressors

✧ Measurements ✧ Analysis ✧ Simulations ✧

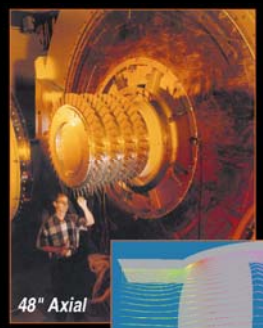
Small High-Speed Compressor Test Facility

High-speed impeller for turboshaft engine

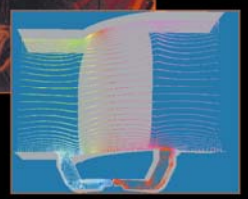
Particle Image Velocimetry measurements of unsteady impeller diffuser interaction



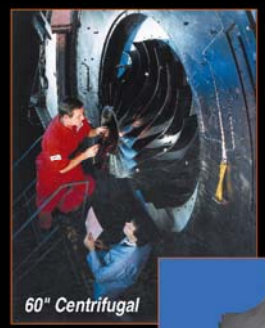
Low Speed Research Facility



48" Axial



CFD Simulation of stator flowfield including under-platform seal cavity

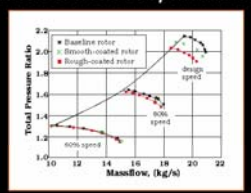


60" Centrifugal

CFD Simulation Calculated Particle Traces

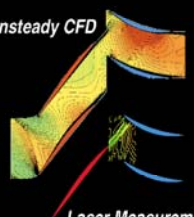
Transonic Compressor Facility Laser Measurement System

Use of rough coatings to simulate effects of erosion on performance



Wake-Blade Interaction

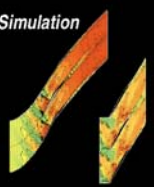
3D Unsteady CFD



Laser Measurements

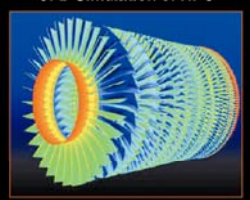
Transonic Rotor Flowfields Axial Velocity Near the Tip

CFD Simulation



Laser Measurements

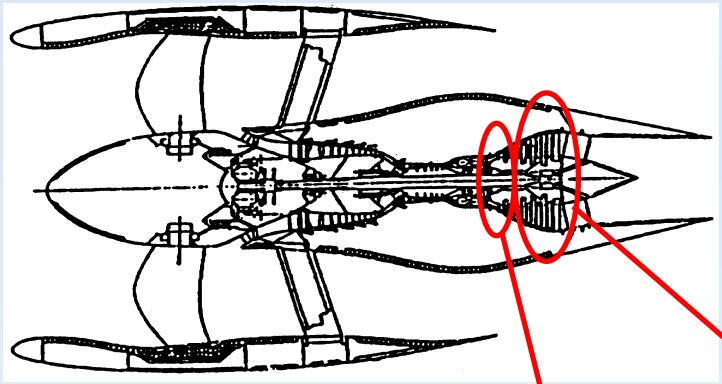
CFD Simulation of HPC



Turbine Research (Aerodynamics & Heat Transfer)

Experimental and Numerical Research for:

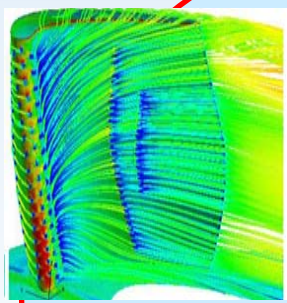
- **High-Pressure Turbine (HPT) -**
  Improved computational models for losses, heat transfer, and coolant flow.
- **Low-Pressure Turbine (LPT) -**
  Understand, model, and control the physical mechanisms responsible for high loss variations



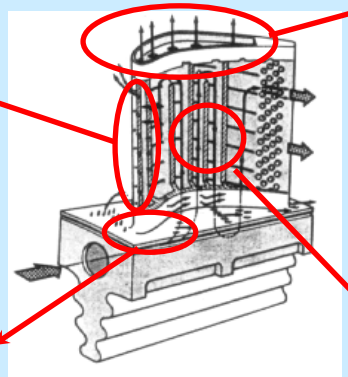
OUTCOME:

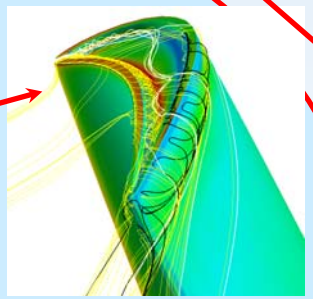
- **Reduced design cycle time & cost**
- **Improved component robustness & efficiency**

SOME CRITICAL HPT MODELING ISSUES

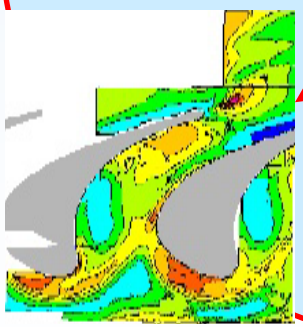


Film Cooling

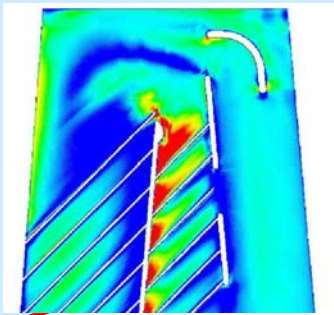




Tip Clearance Flows

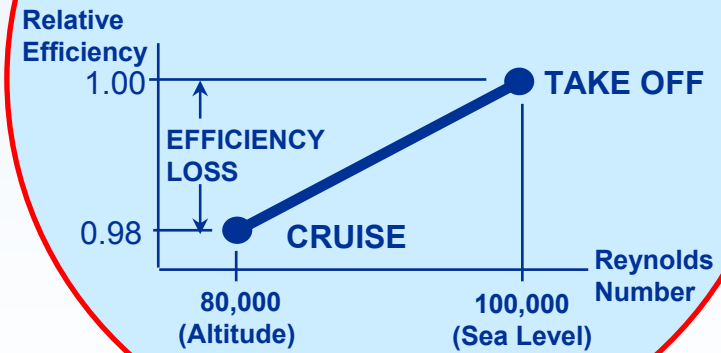


Endwall Secondary Flows



Internal Coolant Flow

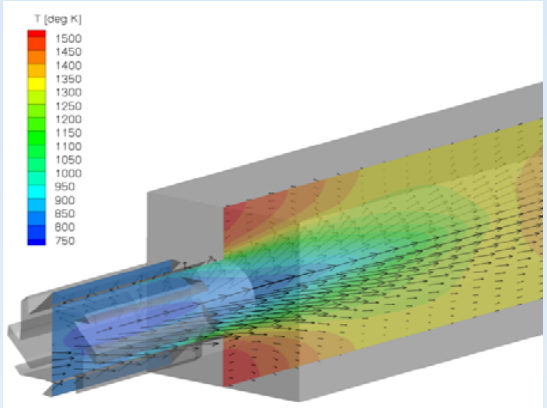
CRITICAL LPT MODELING ISSUES



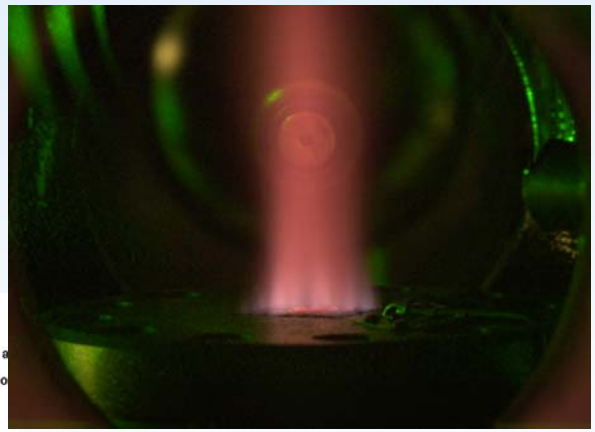
Combustion Branch

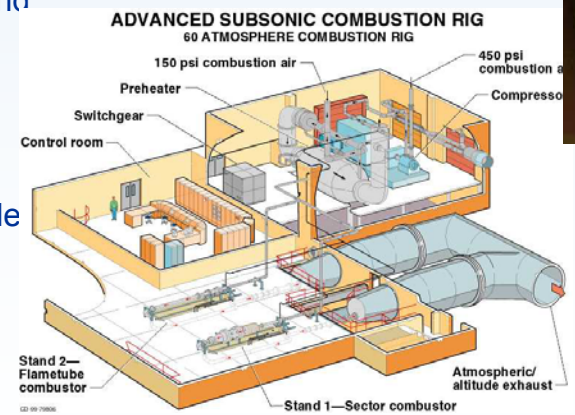
Current Research Areas

- Low Emissions Combustor Development and Testing
- Laser Diagnostics Measurements in Combustion Environments
- Fuel Reforming for Fuel Cells
- In-Situ Fuel Utilization for Planetary Missions
- Ceramic Materials Characterization in Rocket Exhaust
- Constant Volume Combustion Cycle Engine
- Active Combustion Control
- Minimum Ignition Energy Measurement for Fire-Safe Fuels
- National Combustion Code Development and Application
- Combustion Generated Particulate Measurement
- Low NOx Hydrogen Combustion
- Chemical Equilibrium with Applications Code and Thermodynamic Database



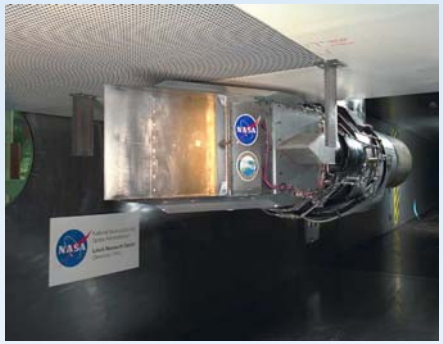
Reacting Flow CFD Predictions


Spontaneous Raman Scattering Laser Diagnostic Development

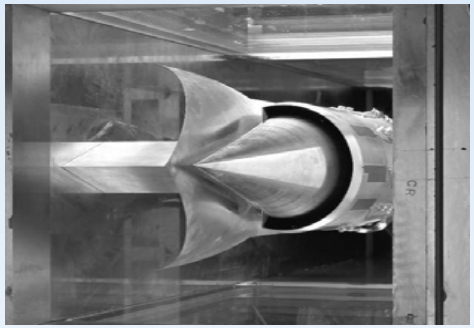


60 atm combustor test facility with laser diagnostics

INLET & NOZZLE RESEARCH



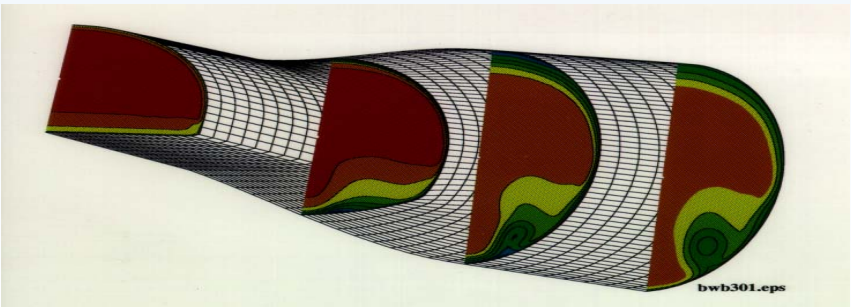
10x10 SWT



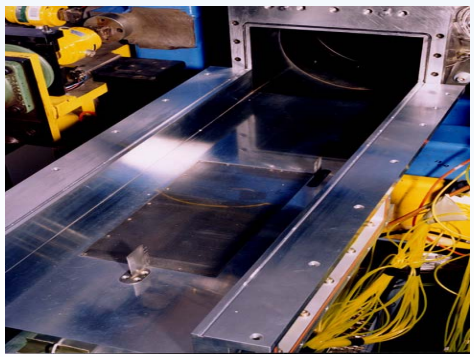
1x1 SWT

FLIGHT

LARGE-SCALE APPLICATIONS



COMPUTATIONAL ANALYSES



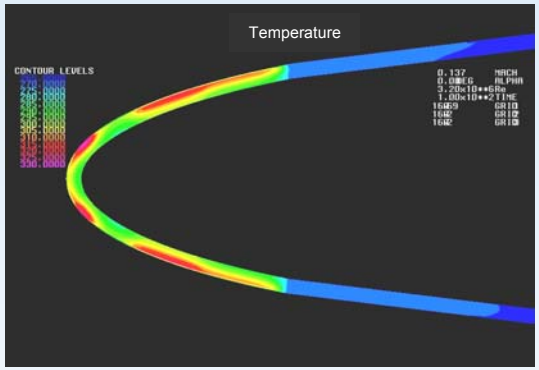
FUNDAMENTAL RESEARCH

Icing Branch
Aircraft Icing Research

Icing Tunnel Research

Experimental Methods & Databases

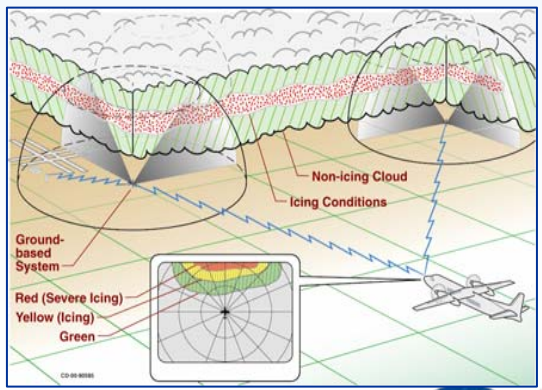
Computational Tools



Flight Research

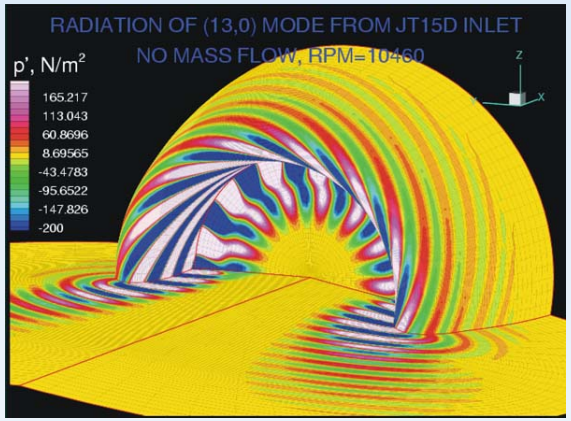
Education & Training Tools

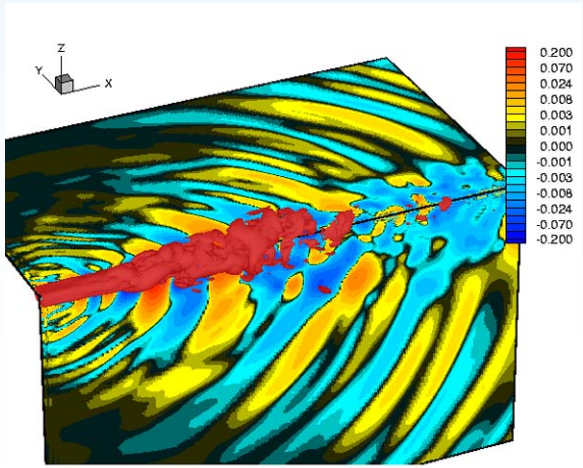
Aircraft Ice Protection



RTA/ Acoustics Branch

Propulsion Systems Noise Research





Noise Reduction

- Concept development

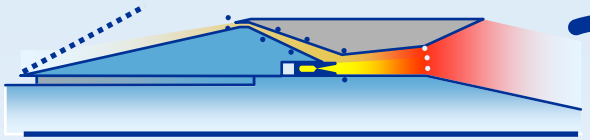
Experiments

- Engine noise source identification
- Concept evaluation

Numerical Methods

- Model development
- Noise Prediction

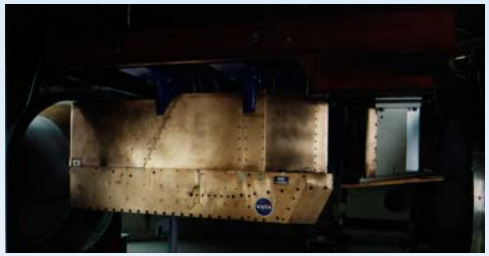
Engine Systems Branch



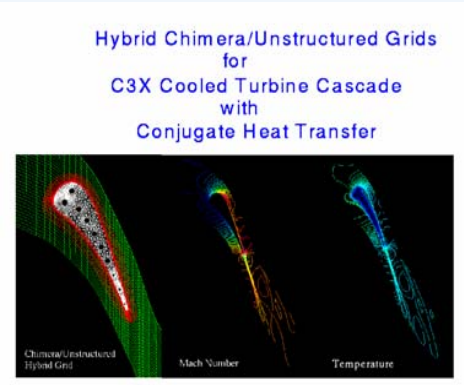
•Engine System Concepts
•RBCC, TBCC
•Component Interactions

Advanced Propulsion Systems and Technology

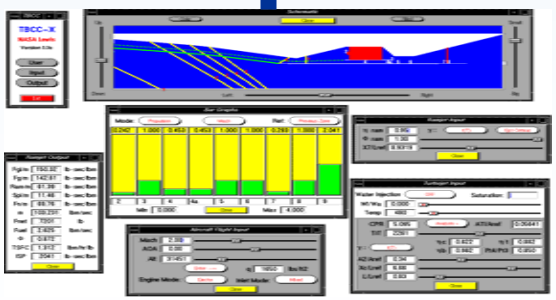
•New concepts
•Improved Propulsion System:
– Efficiency
– Affordability
– Performance
– Environment



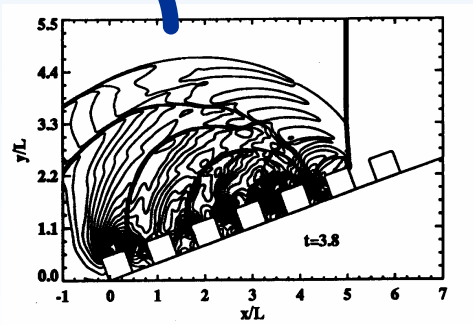
•Engine System Testing
•Testing Techniques



•Multidisciplinary Methods



•Propulsion System Simulation



•Advanced Numerical Methods
•Parallel Processing

Funding Opportunities

Turbomachinery

- Numerical Simulation – Steady & Unsteady RANS – Single and multi-stage flows – Flow control strategies – Stability and Performance impacts – Physics-based loss predictions for highly loaded turbomachinery

Engine Systems

- Tool development for conceptual and Preliminary through three Dimensional analyses/simulations - Integrated performance of Turbine Based Combined Cycle and Rocket Based Combined Cycle concepts (Computational & Experimental) – Variable Cycle engine technology across wide Mach No. range – Mode Transition
- Advanced Numerical Methods – Robust & accurate higher order methods – Nonlinear limiting schemes (shocks & smooth regions) – Methods for structured & unstructured meshes
- Multidisciplinary/ Multi-Fidelity Methods - System analysis tools with component / discipline integration - frameworks for Multi-Discipline/Multi-Fidelity Optimization - Data coupling, expansion, contraction techniques to capture multi-scale, multi-discipline affects – Coupling of high-fidelity component simulations with lower fidelity models

Funding Opportunities (Contd.)

Combustion

- Numerical Simulation – Large Eddy Simulation of reacting, multiphase flow - Turbulence-chemistry interaction - Two-phase flow simulation models including liquid breakup and vaporization - Combustion instability modeling and validation
- Laser-based diagnostics and novel experimental techniques for measurements in reacting flows - validation data & novel designs - Validation data sets for physics-based model development
- Novel low emissions combustion concepts for subsonic and supersonic engines - Active combustion control methodologies
- Combustion physics and mechanisms, enhanced mixing concepts, ignition and flame holding for scram jets – vitiated test media effects - operability, reliability

Acoustics

- Computational Aeroacoustics(CAA) – Development of efficient CAA algorithms, non-reflecting boundary conditions to predict turbomachinery broadband noise - Validate using model- or full-scale experimental data –
- Non-Axisymmetric Nozzle Acoustic Propagation - Development of source and directivity models needed to predict the jet noise from non-axisymmetric nozzles
- Spacecraft Aeroacoustic Environment Definition - review state-of-the-art and develop alternative approaches to improve accuracy of environment definition - wind tunnel test guidance and support for model development

Funding Opportunities (Contd.)

Inlets & Nozzles

- Numerical Simulation – Advanced methods for steady and time-dependant simulations – Flow Control phenomena – Inlet/Fan Interactions effects – Performance & stability
- Novel concepts for inlets, mixers, augmentors, ejectors, and nozzles are sought for all flight regimes

Icing

- Innovative approaches to ice accretion physics model development based on analytical and experimental research - Incorporation of new models into existing ice accretion computational simulation methods
- Simulation of icing cloud conditions within ground-based icing test facilities
- Development and application of scaling methods for both ice growth and thermal system modeling
- Aerodynamics of ice contaminated aircraft surfaces - Identification of critical physical processes affecting performance

3.0 In-Space Propulsion

Bryan K. Smith
Deputy Chief, Power and In-Space Propulsion Division

GRC NRA Briefing
NRA Number: **NNC07ZRP001N**
RESEARCH AND TECHNOLOGY GLENN RESEARCH CONTRACTS
March 30, 2007

3.0 In-Space Propulsion

- The In-Space Propulsion area is focused on research and technology development of low cost, highly reliable, highly efficient space propulsion components and systems for Science and Exploration missions. These areas include: Solar electric propulsion, advanced chemical propulsion and propellant system components.

- Specific areas of interest include:
  - 3.1 Solar electric propulsion thrusters, power processing units and associated modeling techniques for increased performance, lifetime prediction and test validation.
  - 3.2 Advanced chemical engine systems modeling, test characterization and model validation for ignition, performance, combustion stability and thermal management.
  - 3.3 Technologies, techniques and models for cryogenic fluid measurement, acquisition, distribution and thermal management.

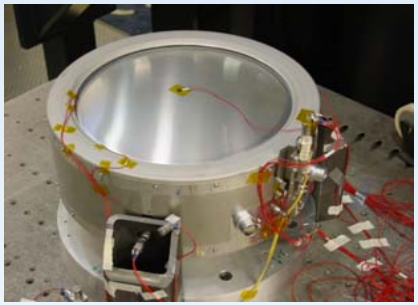
3.1 Electric Propulsion

Description

- High fuel efficiency.
- High fuel efficiency allows a much smaller spacecraft to be developed.
- Smaller spacecraft can be launched on a smaller less expensive launch vehicles

Focus Areas

- Ion & Hall thruster design, fabrication, evaluation, test
- Power electronics design, bread-boarding, evaluation, test
- Thermal, stress, vibration analysis and test
- Modeling, lifetime prediction
- Increased performance



Ion Thruster

Hall Thruster

Facilities

- 16 Vacuum Chambers
  - Volume (.02 to 1133 cubic meters)
  - Pumping speeds up to 3,600,000liters per second air at 1x10-5 torr
- ~ 12 assorted sized bell jars
- Control rooms/machine shop/clean room
- Precision thrust stands
- Electro Magnetic Interference measurement apparatus
- Plasma diagnostics apparatus

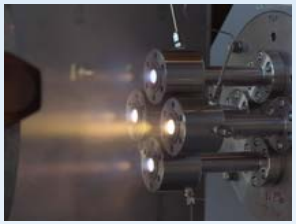
Vacuum Facility 5

3.2 Advanced Chemical Systems

Description

- Research and technology development for advanced chemical propulsion capability required for Exploration and Science missions.

Conceptual Aerojet 100-lbf Thrust Reaction Control Thruster



Detonation Wave Ignition Testing

Optically Accessible Combustion Chamber

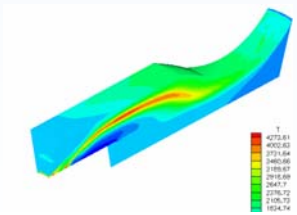
LO2/LCH4 Ignition Testing

Lunar Surface Access Module (LSAM) Propulsion

Focus Areas

- Reliable ignition systems
- Combustion performance/ stability (injectors)
- Thrust chamber cooling
- Advanced chamber/nozzle materials
- Non-toxic propulsion
- Monopropellant and advanced bi-propellant systems
- Reaction control and main propulsion applications
- Altitude and sea level testing
- Computational modeling

High Temperature Chamber Materials Test



Computed Temperature Contours for Rocket Combustor

Facilities

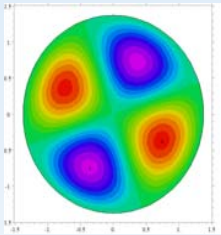
- Sea level and altitude ignition stands
- Sea level component combustion stands
- Low Thrust Altitude Stand
- Altitude Combustion Stand (ACS)
- Heated Tube Facility
- *Various propellants available at all stands*

3.3 Cryogenic Fluids

Description

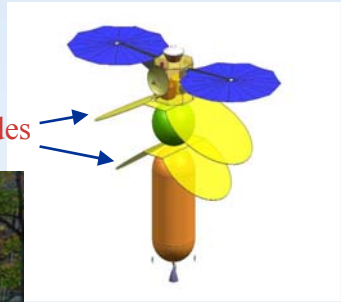
Efficient storage and distribution of cryogens enabling the use of high performance propellants in support of Exploration and Science Mission objectives.

Breadboard Screen Channel Liquid Acquisition Device



Radio Frequency Propellant Gauging Simulation

Creek Road Cryogenics Complex



Cryogenic Propellant Spacecraft Concept for Science Mission

Focus Areas

- Long duration cryogen storage for in-space and planetary environments (thermal and pressure control)
- Low gravity propellant management (vapor free liquid acquisition, quantity gauging, fluid transfer)
- Efficient propellant distribution to thrusters
- Propellant densification
- Analytical and computational thermal and fluid dynamic modeling

Thermal Vacuum Test Article for Zero Boil-Off Long Duration Storage

Facilities

- Creek Road Cryogenics Complex
  - Thermal vacuum chamber
  - Cryogenic component facility
  - LO2, LH2, LCH4, LN2, gases
- Control rooms/machine shop/clean room/MLI lay-up facility
- Propellant Gauging Laboratory
- Plum Brook Station: Large propellant and thermal vacuum capabilities

4.0 Power

Bryan K. Smith
Deputy Chief, Power and In-Space Propulsion Division

GRC NRA Briefing
NRA Number: **NNC07ZRP001N**
RESEARCH AND TECHNOLOGY GLENN RESEARCH CONTRACTS
March 30, 2007

4.0 Power

- The Aerospace power discipline is focused on research and technology development of aerospace power systems. Power technologies include photovoltaic, batteries and fuel cells, energy storage, thermal energy conversion, power management and distribution and electronic components. This area also includes space and extraterrestrial environments as related to power system performance.

- Specific areas of interest include:
  - 4.1 Photovoltaic device and array technologies
  - 4.2 Battery and fuel cells
  - 4.3 Energy storage, recovery and control technologies
  - 4.4 Thermal energy conversion, heat rejection, and control techniques
  - 4.5 Electronic device research and technology
  - 4.6 Electrical components and modular power technologies
  - 4.7 Space environments and mitigation techniques

4.1 Photovoltaic Technologies

Description

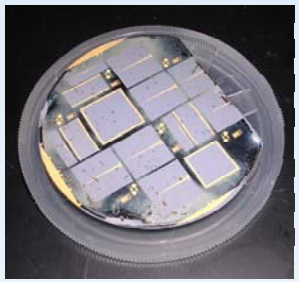
Expertise in:

- Materials growth
- Device fabrication
- Measurement, characterization & testing of PV cells & blanket technologies
- Modeling/measurement of space environmental interactions with PV arrays
- Advanced PV cell, blanket & array designs and technology development

Focus Areas

- Polycrystalline Thin Film III-V PV
- Independent Analysis - performance testing and data verification for Exploration
- Off-pointing performance analysis
- Solar cell measurement & calibration
- Lunar and planetary performance-optimized solar cell designs
- Dust mitigation technologies
- Extended temperature solar cells
- Nanomaterials and nanostructures
- Thermophotovoltaic technology
- Advanced PV blanket technologies

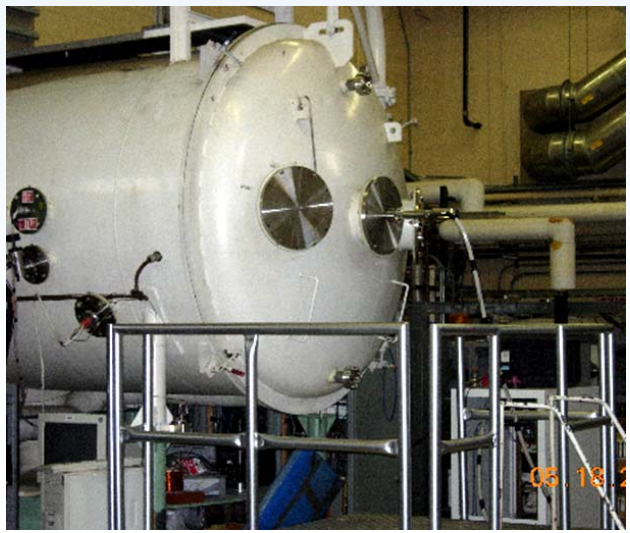
Polycrystalline III-V Thin Film PV



Facilities

- Several chemical vapor deposition reactors
- Plasma Interaction Facility (PIF)
- Continuous and flash AM0 solar simulator measurement facilities
- Thermal cycling and extended temperature measurement capability
- Lear jet AM0 calibration platform
- Electron microscopy facilities
  - Atomic force microscopy
  - Scanning tunneling optical resonance

Plasma Interaction Facility (PIF) for high voltage testing of solar arrays within a space environment



4.2 Batteries and Fuel Cells

Overview

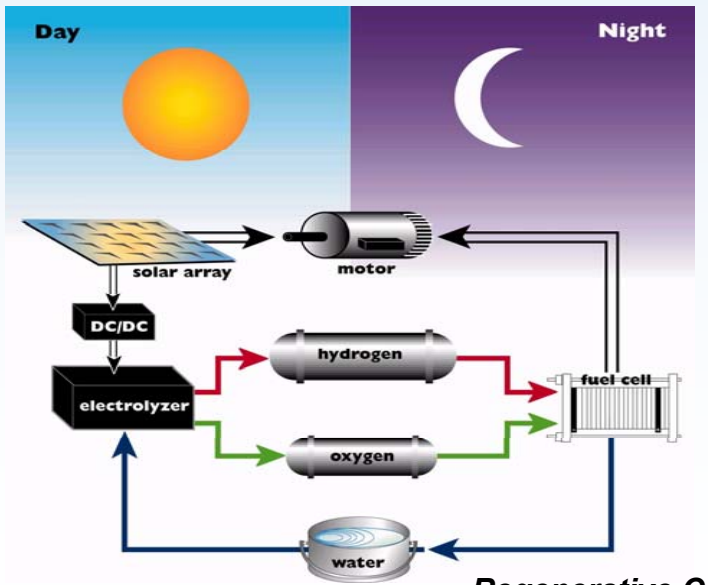
- **Fuel cells** provide a primary source of power by converting hydrogen and oxygen to water and electricity
- Regenerative **fuel cells** combine a fuel cell with an electrolyzer capable of converting water back into hydrogen and oxygen (functions like a battery)
- **Batteries** - versatile, reliable, safe, modular, lightweight, portable energy sources
  - lithium based batteries offer lower weight, smaller volume, and low temperature operations capability.

Facilities/Labs

- Battery and fuel cell component development and characterization facilities
- Fuel cell test facilities for performance, life testing of cell stacks/ systems (up to 25 kilowatts)
- Regenerative fuel cell test facility
- Dry room (1% relative humidity) for handling moisture sensitive materials used in lithium batteries
- State-of-the-art battery cycling facilities with >100 independent test channels
- Environmental chambers to evaluate performance as a function of temperature (-75 °C to +200 °C)

Focus Areas

- Battery and fuel cell materials development
- Component design, development & characterization
- Electrochemical characterization of single cells and stacks
- Battery charge control methodologies
- System modeling and analysis
- Fuel cell system balance of plant optimization
- Technology validation, Mission operations
- Lifetime and specific energy



Regenerative Cell

4.3 Energy Storage and Recovery

Description

- High- speed (60,000+ rpm) carbon fiber wire suspended on magnetic bearings capable of storing & delivering multi-kilowatts of power through a coupled motor/generator.
- Can be integrated with the attitude control system to provide space craft energy storage & multi-axis attitude control.

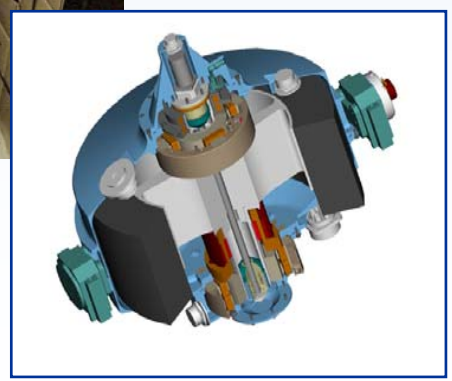
Focus Areas

- High strength composites for increased speed & energy storage.
- Low loss magnetic & Cryo bearings.
- Flight demonstration opportunity.

Facilities

- High-Energy Momentum Control Facility
- Flywheel Spin Rig Facility
  - Rotor certification facility.

Advanced Flywheel System



4.4 Thermal Energy Conversion/Heat Rejection

Description

- Fission surface power
- Radiator development
- Stirling Radioisotope power
- Modeling and conceptual design
- System performance modeling
- Integrated system testing

High temperature water heat pipe lab

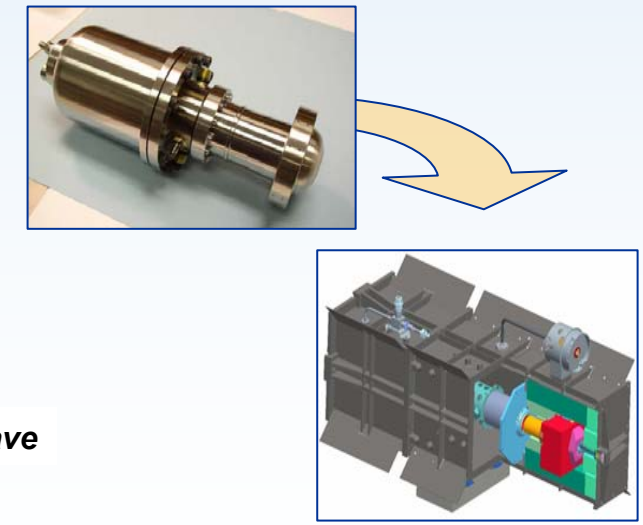
Facilities/Labs

- Thermal-Vacuum facility (24 meters x 8 meters diameter.)
- Simulated lunar test facility
- Heat pipe lab
- Stirling ambient test stands (6) and thermal vacuum facility
- Polymer composites laboratory

Focus Areas

- Reactor (with DOE)
- Brayton and Stirling power conversion
- Heat rejection
- Power management and distribution
- Control Techniques
- Isotope (DOE lead)
- Stirling components development
- Power matrix composite radiators

Radiator Coupon Autoclave



Stirling converter and generator

4.5 Electronic Device Research and Technology

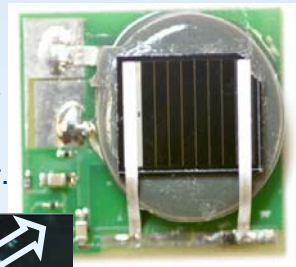
Description

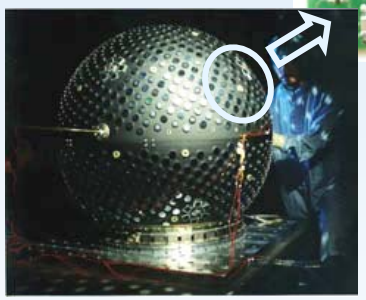
Electronic device/component development and reliability assessment for aerospace applications

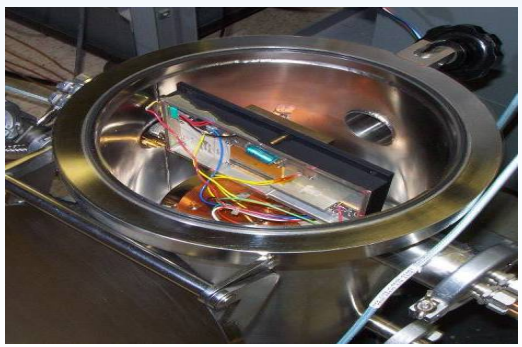
Focus Areas

- Electronic components for power generation/rectification that cross and combine various satellite subsystems
  - power
  - communications
  - propulsion
- Reliability and risk mitigation for electronic parts required for extreme temperature applications
  - Space exploration missions
  - Jet engine instrumentation

1 in2 Integrated Micropower System (IMPS) on a chip.
Successfully flown aboard Starshine 3 providing continuous power for on-board temperature sensors.







Space Shuttle GPS Preamp in cryogenic/vacuum chamber

Facilities/Labs

- Environmental (atmospheric pressure) chambers for testing electronic parts in various temperature regimes
  - thermal cycling and steady state soak
  - 3 chambers for temperature range between -195 °C and +200 °C
  - Chamber for ultra-low temperature down to 30 K
  - Chamber for high Temperature up to +300 °C
- III-V compound semiconductor development capabilities
  - 2 state of the art Organo Metallic Vapor Phase Epitaxy (OMVPE) III-V semiconductor compound deposition systems
  - In situ and ex situ materials characterization capabilities

4.6 Electrical Components and Modular Power Technologies

Description

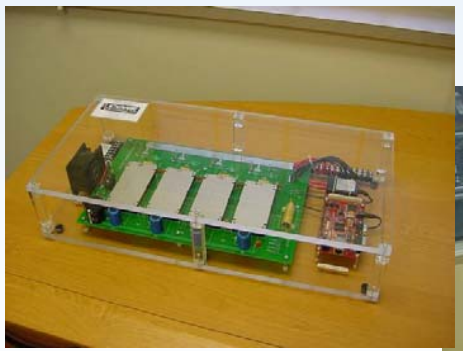
- End-to-end, power systems using key components:
  - AC or DC distribution including switchgear
  - Sources: photovoltaic, dynamic.
  - Loads: motors, thrusters, power converters
  - Intelligent power system monitoring and control

Facilities

- End-to-end power system test-bed.
- Flight qualification testing:
  - Thermal vacuum.
  - EMI chambers.
  - Vibration.
- Flywheel spin rig facility
  - Rotor certification

Focus Areas

- Intelligent / modular power systems.
  - Power distribution units.
- Advanced power components.
  - Switches / converters.
  - Capacitors / magnetics.
- Advanced actuators.



Modular Converter

Advanced Electric Power Test-bed

4.7 Space Environments

Description

- High performance coatings, surfaces and materials for space power systems and aerospace applications
- Space and lunar environment effects, durability evaluation, prediction and mitigation

Lunar Dust Adhesion Bell Jar

Focus Areas

- Simulation, Testing, Prediction and Mitigation of Space Effects
  - Atomic Oxygen (AO)
  - Ultraviolet (UV) Radiation
  - Thermal Cycling
  - Contamination
  - Combined Effects
- Lunar Dust Interactions, Mitigation and Simulant Development
- Protective Coatings and Surfaces
- Tailored Optical, Electrical and Magnetic Coatings for Aerospace Applications
- Intercalated Graphite Materials

Facilities

- Atomic Oxygen
  - 2 Large-Area Atomic Oxygen Facilities
  - Combined AO, UV, heating, in situ reflectance
  - Atmospheric Atomic Oxygen System
  - Atomic Oxygen Plasma Chambers
- Vacuum UV/Near UV Exposure Facility
- Lunar Dust Adhesion Bell Jar
- Ozone Exposure System
- Vacuum Thermal Cycling Facility
- Simulated Solar Flare X-ray System
- 3 Extreme Temperature Electronics Test Chambers
- Coating Deposition Systems
- Optical Properties Characterization
- Polymer Film Tensile Testing
- Intercalated Graphite Fabrication and Characterization

Materials International Space Station Experiments (MISSE)

Atomic Oxygen Exposure of Elastomer Seals

5.0 Instrumentation, Sensors, Electronics & Controls

Dr. Mary V. Zeller
Chief, Instrumentation and Controls Division

GRC NRA Briefing
NRA Number: **NNC07ZRP001N**
RESEARCH AND TECHNOLOGY GLENN RESEARCH CONTRACTS
March 30, 2007

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- **Active Controls**
- **Health Management**
- **Intelligent Engine Controls**
- **Propulsion Control Theory**
- **Propulsion Control System Simulation, Implementation and Demonstration**
- **Propulsion System Dynamics Theory and Modeling**
- **Cooperative Control of mobile robots**

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- **Optical Measurement Research**
  - **Instrumentation Development**
  - **Flow Path Characterization**
  - **Surface Pressure and Temperature**
- **Nondestructive Evaluation Research**
  - **Material Characterization**
  - **Defect Detection &Certification**
- **Photonics and Nanophotonics**
  - **Sensors and Systems Development**
  - **Control of Nanodevices**
- **Flight Electronics**
- **Propulsion System Diagnostics & Prognostics**

Sensors and Electronics Branch (RIS)

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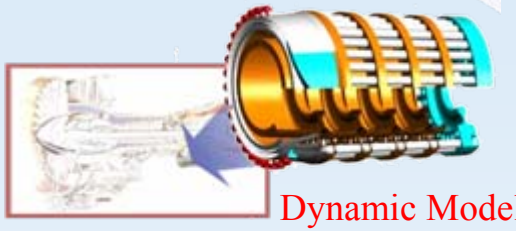
- **Propulsion Systems Research Sensor Development**
- **Thin Film Sensors**
- **High Temperature Electronics & Crystal Growth**
- **MEMS and NEMS Technology**
- **Chemical Sensor Development**
- **Smart Sensor**
- **Health Monitoring**

Instrumentation and Controls Division

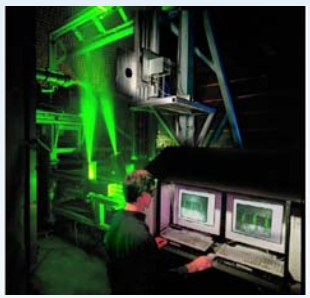
www.grc.nasa.gov/WWW/ictd/

Branches

- Controls and Dynamics
- Optical Instrumentation and NDE
- Sensors and Electronics



Dynamic Modeling



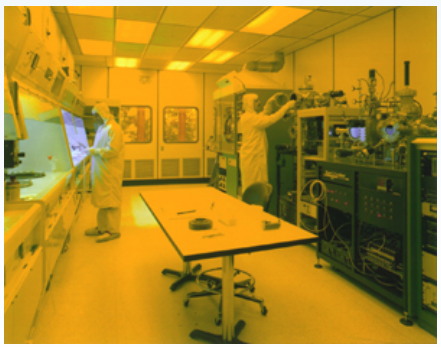
Particle Imaging Velocimetry for Jet Noise Characterization

Selected Facilities

- Dynamic Modeling
- Propulsion Health Monitoring
- Particle Imaging Velocimetry
- Flight Electronics Lab
- Micro Computed Tomography
- Microsystems Fabrication Clean Rooms
- SiC Chemical Vapor Deposition
- Harsh Environment Micro/Nano-device Laboratories

Selected Focus Areas

- Active Control for Flow & Combustion
- Intelligent Adaptive & Life Extending Control
- Propulsion Health Monitoring
- Optical Flow Path Measurements
- NDE Methods Development
- Robotics Technology Development
- SiC based electronic devices
- MicroElectroMechanical Systems-MEMS



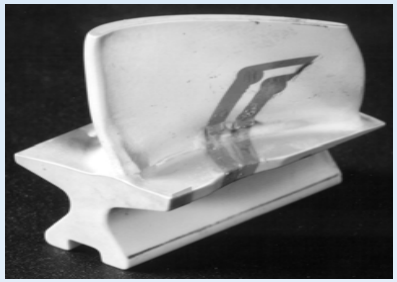
Microsystems Facilities

Recent Accomplishments

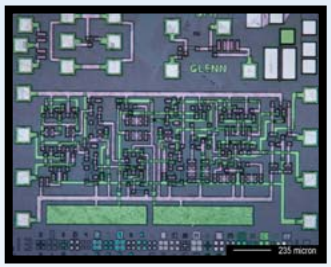
- 1400 ºC temperature sensitive paint sensor
- Zero false alarm fire detection system demonstrated (R&D 100 Award) - *2005*
- High temperature (600°C) SiC pressure transducer demonstrated - *2006*

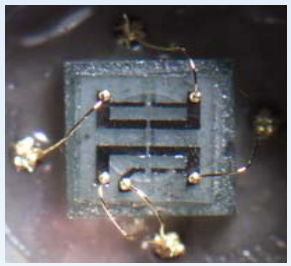
Instrumentation & Controls Division

Sensors & Electronics

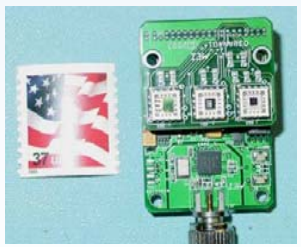


High Temperature
(>1000 °C)
Thin Film Sensors

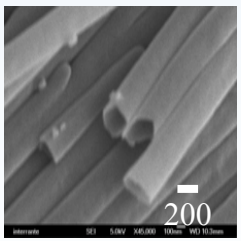




High Temperature (600 °C)
SiC Electronics & Sensors

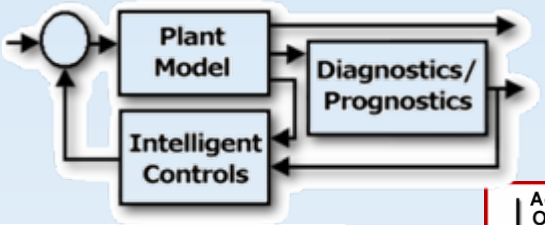


Chemical
Sensors

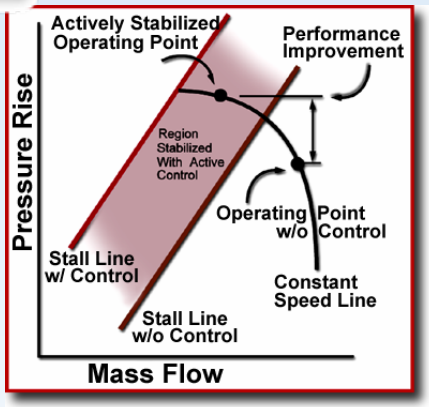


SiC Nanotubes

Controls & Health Management

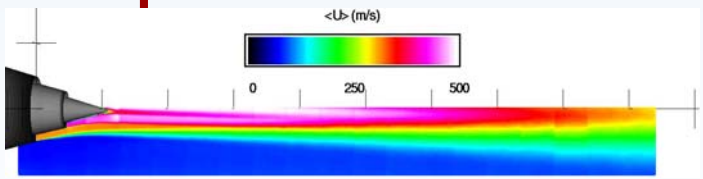


Intelligent Control &
Health Management



Active Control Technologies

Optical Instrumentation & NDE

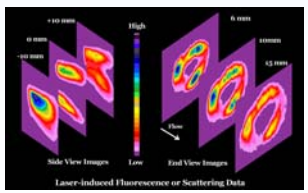


Facility Instrumentation

NDE

Electro-Optics
& Mobile Sensors

Combustion
Diagnostics



Specific Areas of Interest for **Instrumentation and Controls**

Sensors and Electronics Area:

5.1.1 Thin film sensors for temperature, strain, heat flux and flow measurements

5.1.2 Chemical species sensors for leak detection, and emission and safety monitoring

5.1.3 Silicon carbide (SiC) crystal growth and SiC-based electronic devices and sensors

5.1.4 Micro-ElectroMechanical Systems (MEMS), e.g., pressure, acceleration, flow measurements

5.1.5 Nanotechnology for harsh environment sensors and electronic devices

5.1.6 Packaging technology for sensors and electronic devices

Optical Instrumentation and NDE Area:

5.2.1 Planar optical diagnostics for flow field measurements and optical systems build up

5.2.2 Integration of NDE and Finite element modeling and image visualization

5.2.3 Development of acoustics, tomography and radiography sciences and facilities operations

5.2.4 Propulsion health monitoring system development and instrumentation

5.2.5 Firmware and software for electronic platforms in harsh environments

5.2.6 Structural health monitoring theory and physics based modeling

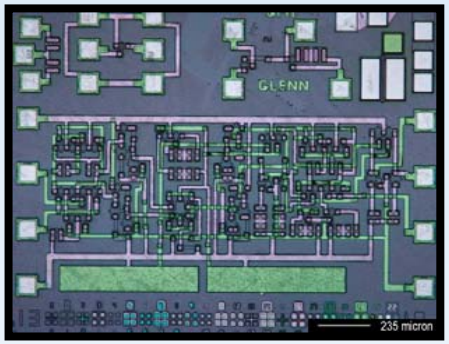
5.1 Sensors and Electronics

Most Critical Areas:

5.1.3 Silicon Carbide (SiC) crystal growth and SiC-based electronic devices and sensors

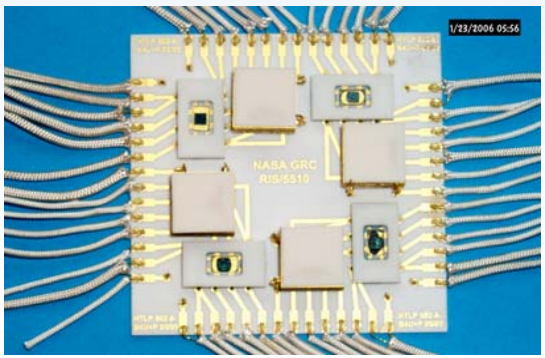
SiC Crystal Growth Facilities

Cleanroom Fabrication Facilities



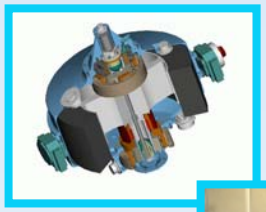
SiC Electronic Device Fabrication

5.1.6 Packaging Technology for Sensors and Electronic Devices

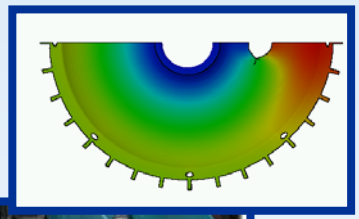


Packaging Technology Suitable to 600°C

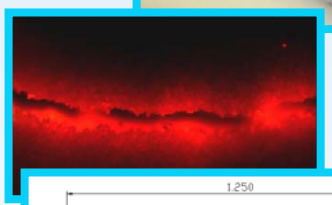
5.2 Optical Instrumentation and NDE Branch

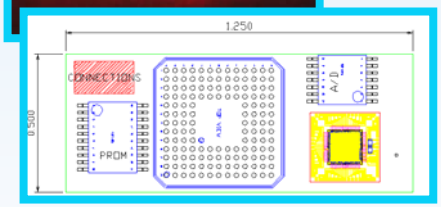


5.2.2 & 5.2.3 NDE Methods Development; Finite Element Modeling; Certification …

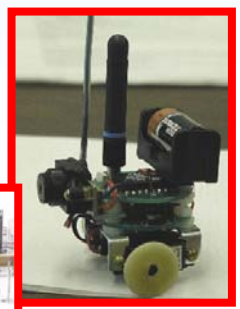


5.2.4 & 5.26 Propulsion Health Monitoring System Development and Instrumentation

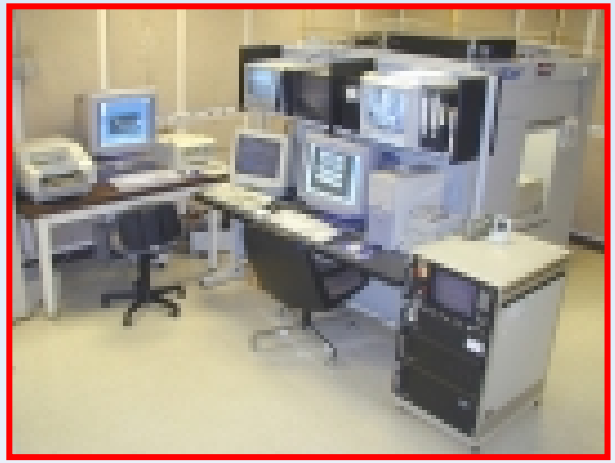




5.2.5 Firmware and Software for Electronic Platforms in Harsh Environments



NASA GRC Research Laboratories



Non-Destructive Evaluation

Low Speed Flow Control Facility

Electronics Crystal Growth Facility

Class 100 Clean Room

6.0 Communication and Navigation

Dr. Rainee N. Simons
Chief, Electron & Optical Devices Branch

GRC NRA Briefing
NRA Number: **NNC07ZRP001N**
RESEARCH AND TECHNOLOGY GLENN RESEARCH CONTRACTS
March 30, 2007

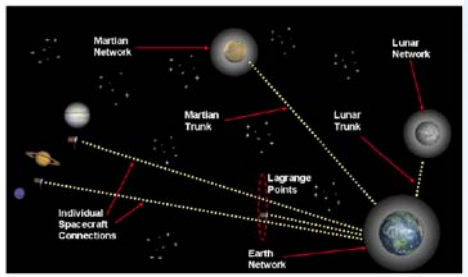
RC/Communications Division

Description

- Increased capacity communication systems maximizing information throughput, performance and portability for space, surface, mobile and aeronautical applications
- Development of communications systems and networks based on technologies that include radio frequency components and devices, digital and wireless communications systems, ground systems and communications networking techniques.

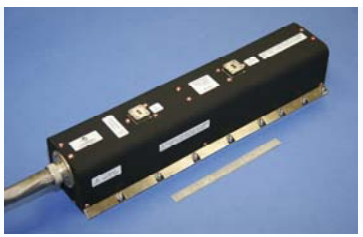
Near Field Antenna Facility

Architecture



Focus Areas

- Large-aperture and miniaturized antennas.
- Ka-band Atmospheric calibration studies
- Software defined radios
- Low power, reconfigurable transceivers
- Signal processing and Networking devices
- Radio frequency amplifiers and devices
- Communications networks based on Internet Protocols
- Providing the highest integrity, end-to-end system solutions.



High efficiency 200 Watt Traveling Wave Tube

Facilities/Labs (a sample)

- Antenna ranges including near- and Far-field antenna ranges, compact range, cylindrical near filed range
- Radio Frequency propagation laboratories
- Electronic Component Fabrication and Characterization Laboratories
- Network Emulation Laboratory
- Digital Systems Laboratory
- Space Telecommunications radio system Laboratory

Accomplishments

•Demonstrated 4m x 6m class large aperture deployable antennas (2005)
•Studies: Communications and Navigation Architecture, Lunar Surface Communications, Crew Exploration Vehicle Antenna Coupling, Avionics RF / Optical Networking Assessment, Space-based router and networking for lunar communications, Requirements definition of the Common Communications Adapter (CCA) for extension of the Internet to spacecraft. Array.
•Antenna element trade-off for Tracking and Data Relay Satellite System multiple access antenna (2006)
•Software defined radio architecture framework for space-based radios (2006) and Space network router (2005)
•High Efficiency 200 W Traveling Wave Tube Amplifier
•High speed, Spacewire® networking interface controller (2006)
•Inter-spacecraft communications and ranging system (2005)
•Demonstrated the effective use of Ka Band for Space Communications (1995)

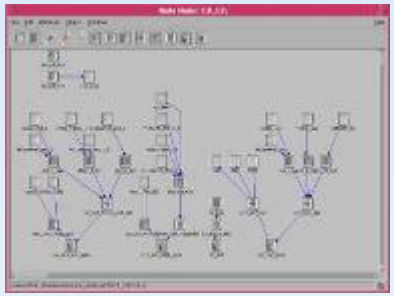
RCI/Communications Systems Integration Branch

Description

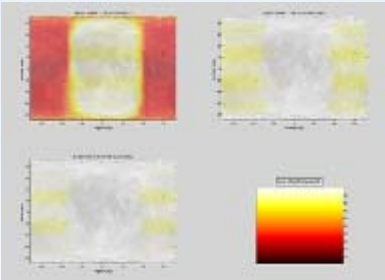
- Communications and Navigation system-level performance analysis, simulation, sub-system integration and testing of leading-edge technology.
- Providing the highest integrity, end-to-end system solutions.
- Providing timely and relevant system-level products for agency aeronautics and space missions.

Focus Areas

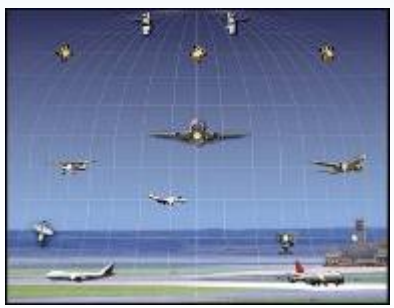
- Link analysis, navigation performance estimation.
- Orbital geometry analysis.
- Technology sizing, technology assessment and performance prediction.
- Communication and Navigation Architecture development.
- Communications Systems Performance Testing and Integration



Constellation Data Flow Model



Lunar System Availability



Next Generation Air Traffic System

Facilities/Labs

- EVA Audio Lab AND DSP Voice Interface
- NGATS Surface System Testbed
- Analysis Software
- Communications Simulation and Modeling software
- Navigation Simulation Lab

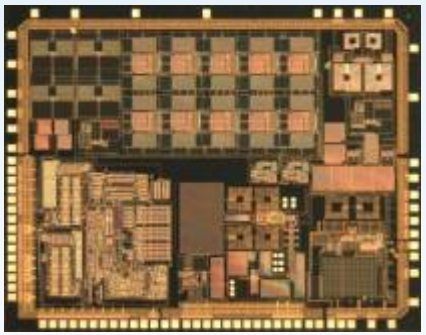
Accomplishments (2005-06)

- Developed Communication and Navigation Architecture Description Document for a CEV to ISS mission.
- FAA Future Communications Study
- Completed a data flow model of the “Crew Transport to/from ISS” Design Reference Mission
- Assessed the position fixing capability of a Lunar Network of Spacecraft.

RCD/Digital Communication Systems Branch

Description

- Development of digital and wireless communications systems
- Emphasis on open architectures, while maximizing information throughput, performance and portability



Photomicrograph of ultra-high frequency receiver chip

Software reconfigurable signal processing platform

Facilities

- Space Telecommunications radio system lab
- Digital systems lab
- Computer modeling and simulation tools
- Field programmable gate array design
- Proof-of-concept fabrication
- Experimental test and characterization

Focus Areas

- Software defined radios
- Low power, reconfigurable transceivers
- Signal processing
- Networking devices
- Modulation and coding
- Integrated wireless and microelectronic devices

Accomplishments

- Software defined radio architecture framework for space-based radios (2006)
- Space network router (2005)
- High speed, Spacewire® networking interface controller (2006)
- Low power, silicon-on-insulator complementary metal oxide semiconductor transceiver chip (2006)
- Inter-spacecraft communications and ranging system (2005)

RCN/Satellite Networks and Architectures Branch

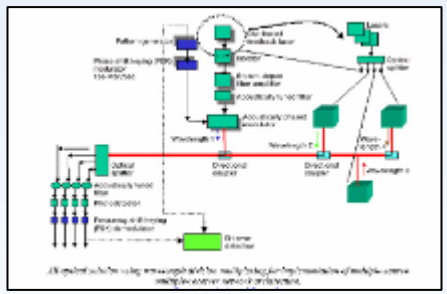
Description

- Research and development of next-generation, NASA Aeronautic and Space-based information systems .
- Network Operations Research, Simulation and Modeling.
- Requirements Definition, Internet Protocol Standards Development
- Datalink, Transport, Network and Application Layer Research
- Ad Hoc Networks
- Network Security

Focus Areas

- IVHM Sensor Network Architectures
- Networking for Space Base Range and Launch support
- NASA DSN/GN/WS Network Interoperability for outages, SC anomaly, preventive maintenance, scheduling and end-end operations.

Network Emulator Lab



Optical Network Architecture

Cisco 3251 Router Assembly

Facilities/Labs

- VMOC/CLEO Networking Lab
- Network Emulation Lab (NEL)
- DHS/FAMS Secure Lab
- Analysis Software
- Communications Simulation and Modeling software
- Navigation Simulation Lab

Accomplishments (2005-06)

- Completed Avionics RF / Optical Networking Assessment Studies.
- Completed Feasibility Investigation of a space-based router and networking for lunar communications.
- Requirements definition of the Common Communications Adapter (CCA) that permits a network of spacecraft to function as an extension of the Internet.
- LiveCD Version of the Channel Emulator that operates as a link-layer bridge providing delay, jitter, packet duplication, packet reordering, QoS, etc.

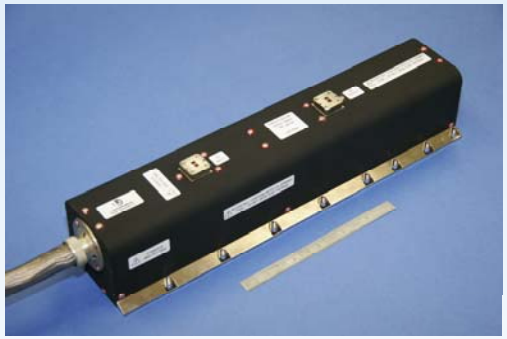
RCE/Electronic and Optical Devices Branch

Description

- Research and develop power efficient electronic devices
- Research in MEMS and nanodevices for switching.
- Develop concepts for power combining.

Facilities/Labs

- Fabrication and development laboratories
- Device Simulation and Modeling capability



200 Watt Ka-Band Traveling Wave Tube

Focus Areas

- Traveling Wave Tube Amplifiers
- Solid State Power Amplifiers
- Radio Frequency switchers
- Electro-Optical devices for on-board switching and routing

Accomplishments (2005-06)

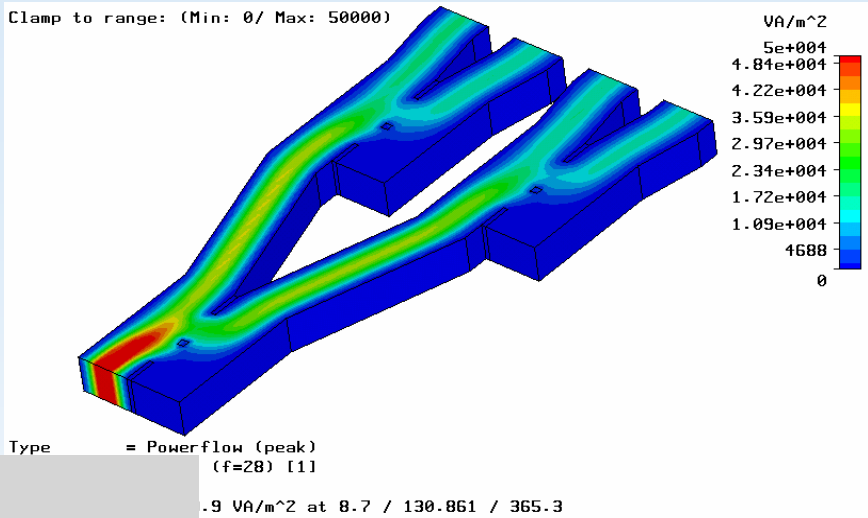
- High efficiency 100 Watt Traveling Wave Tube Amplifier (2004)
- 60% efficient 200 W Traveling Wave Tube Amplifier (2005) – recognized with R&D 100 Award
- Demonstrated wave guide power combining technique for greater radiated power up to 1kiloWatt.

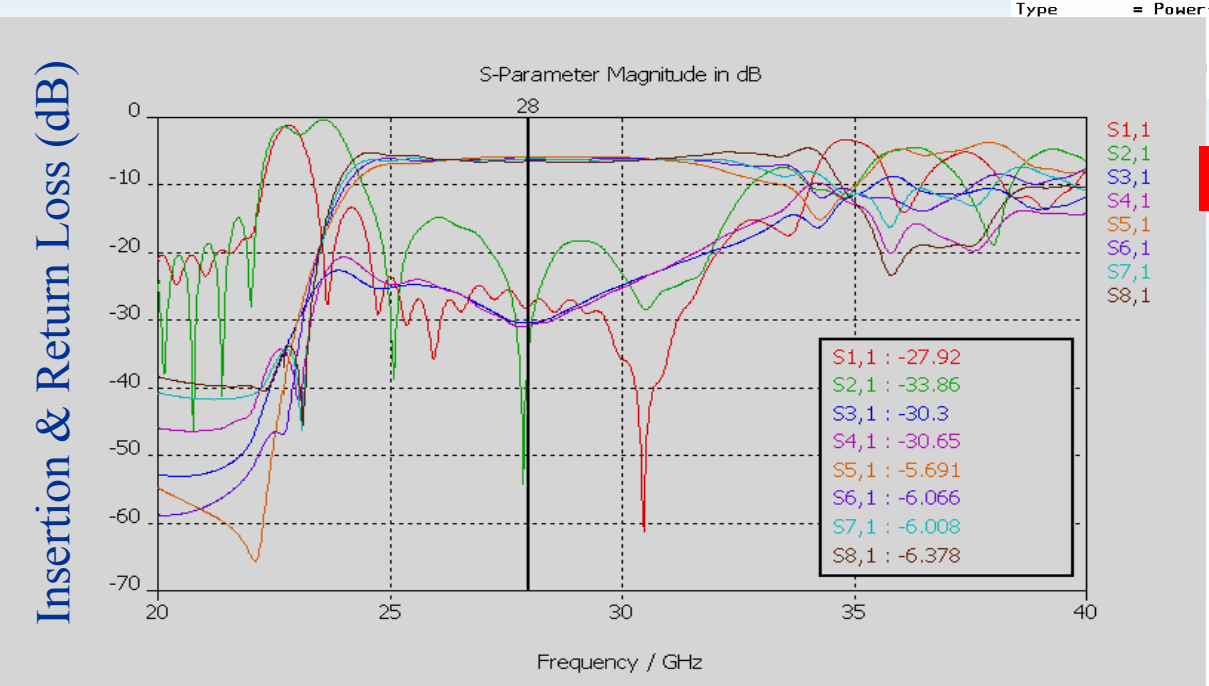
Solid State Power Amplifier

Objective:

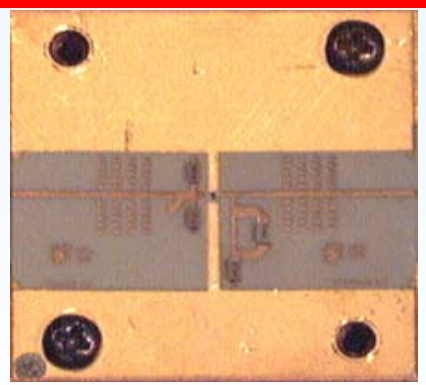
- Power Combiner Architecture
- Radiation Hardness

1:4 Short Slot Coupler Based Divider with 0.4 Inch Center-to-Center Separation for Inserting Packaged MMIC Power Amplifiers





AFRL X-Band GaN Hybrid Amplifier



V_{ds}= 20V, V_{gs}= -2.5V, 3W/mm, PAE= 40%, Power gain = 7 dB @ X-Band

Space Traveling Wave Tube (TWT) Power Combiner Test Bed

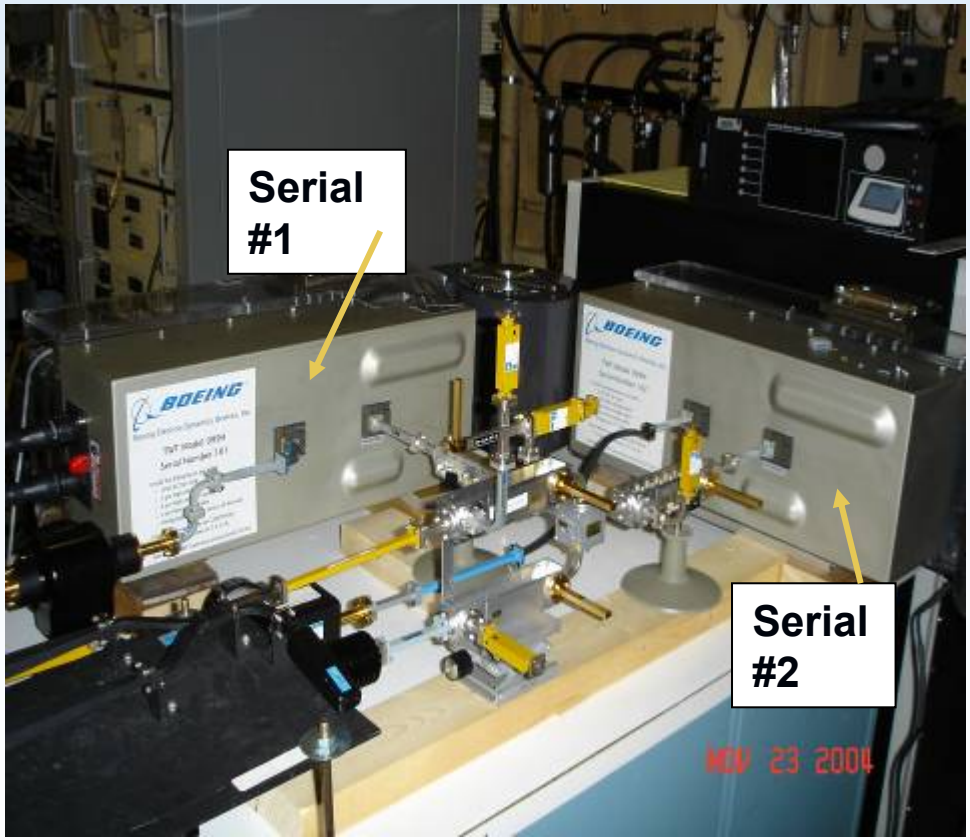
Program Goals

Demonstrate a high power high-efficiency space TWT Power Combiner for NASA Space Science missions (31.8 – 32.3 GHz) such as Project Prometheus (JIMO)

- **Achieve >90% overall efficiency with about 200 Watt combined RF Power**
- **Demonstrate 622 Mbps QPSK data through put through the combiner**

Combiner Test Bed

Boeing TWT Model 999H

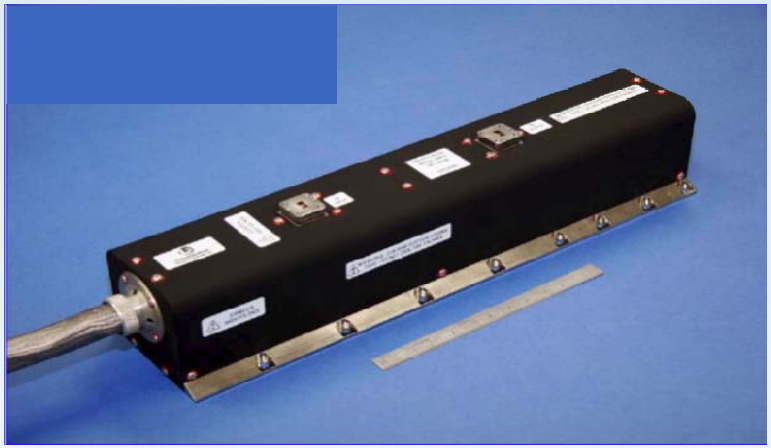


Ka-Band TWTA Flight Program

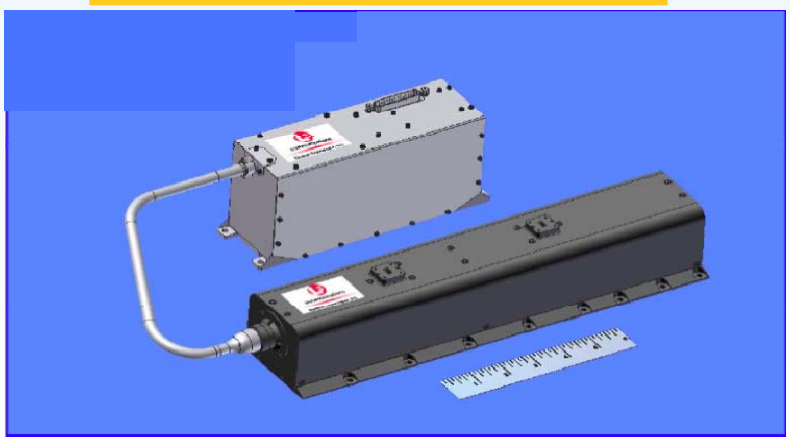
Lunar Reconnaissance Orbiter

- Program awarded May 2006
- Frequency = Ka-Band (25.5 to 25.8 GHz)
- Power = 40 Watts min.
- Weight
  - EPC = 3 lbs
  - TWT = 3.5 lbs
- Dimensions
  - EPC = 3.2” wide x 7” long x 3.9” high
  - TWT = 3.2” wide x 13.6” long x 3.3” high
- One Flight Model deliverable TWTA
  - Scheduled for Dec 2007
- One Proto-Flight deliverable TWTA
  - Scheduled for Feb 2008

Model 9835H TWT



Model 2300HE TWTA



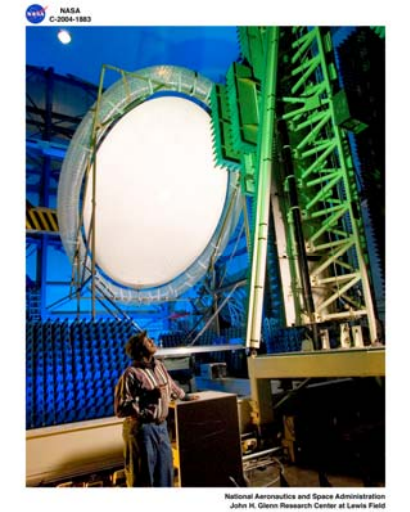
RCA/Antenna, Microwave and Optical Systems Branch

Description

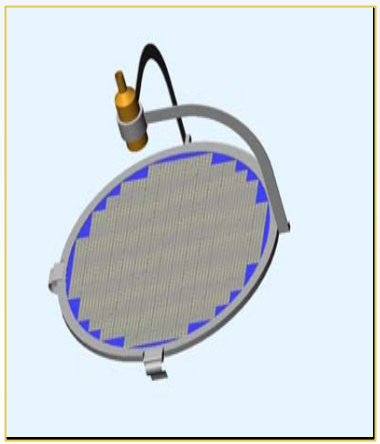
- Development of antenna, microwave and optical systems, subsystems, components and techniques
- Research efforts include radiofrequency and optical propagation phenomena through atmospheric, plasma and turbulent media, development and validation of communication systems and related electromagnetic phenomena.
- The Branch develops, maintains, and operates, state-of-the-art antenna metrology facilities for measurement and characterization of diverse antenna systems.

Focus Areas

- Large-aperture inflatable antennas
- Monolithic Microwave Integrated Circuits-based phased arrays and array feeds.
- Miniaturized antennas.
- Low cost space-fed active array and reflectarray concepts.
- Non-Monolithic Microwave Integrated Circuit-based arrays using ferroelectric, micro-electro-mechanical systems and optical technology.
- Ka-band Atmospheric calibration



Inflatable Antenna (4 meters x 6 meters)



K-band reflectarray antenna

Facilities/Labs

- Vertical near-field antenna range
- Far-field antenna range
- Compact antenna range
- Cylindrical near filed range
- Planar near field probe scanner
- RF propagation laboratories
- Microwave/cryogenic devices characterization laboratories

Accomplishments (2005-2006):

- RF characterization of 4m x 6m class large aperture deployable antennas
- Thin film ferroelectric-based reflectarray antenna technology which combines the best attributes of gimbaled (gain and efficiency) and conventional phased array (electronic steerability) technology.
- Ka-band Atmospheric Calibration Phenomena for next generation Deep Space Networks.
- Trade-off study for Crew Exploration Vehicle Antenna Coupling study
- Antenna element trade-off for Tracking and Data Relay Satellite System multiple access antenna
- Flexible Nano-Field Effect Transistors for Large Array Deployable Antennas

Microwave Systems Laboratory

(Bldg. 7; POC: Dr. Félix A. Miranda 216-433-6589)

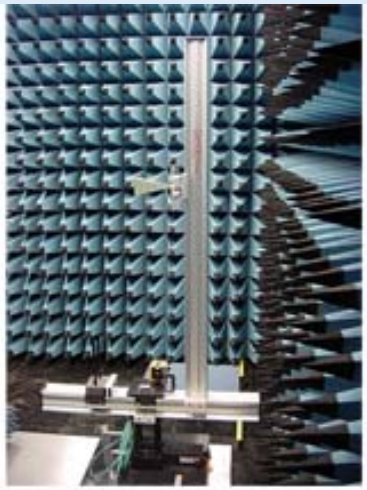
The Microwave System Laboratory houses five antenna measurement ranges which are available for use by Glenn staff and their industrial and academic associates. The ranges support the work being done at the center in the research and development of communication systems. Although used primarily to observe and characterize the performance of microwave antennas, the ranges can be used for communication system studies and to study other types of electromagnetic phenomena such as scattering.

Examples of measurements which have been performed at the facility include:

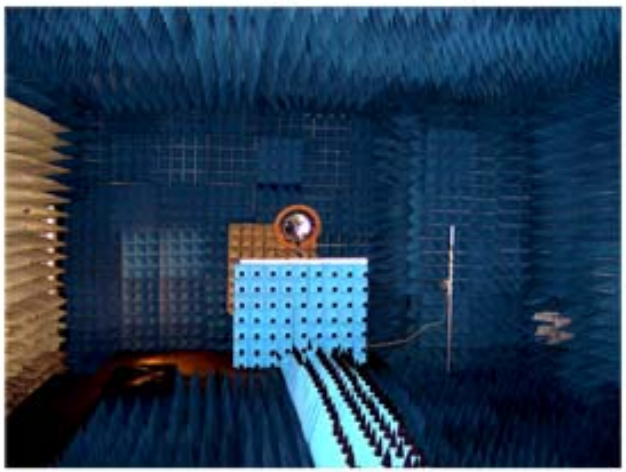
- Satellite communication antennas for space and ground segment terminals
- Aeronautical terminal antennas
- Phased array antennas, reflectarray antennas
- Large aperture inflatable antennas
- Electromagnetic scattering
- Multibeam antennas
- Mobile antennas
- Bit Error Rate performance of scanning antennas
- Miniaturized antennas
- Electromagnetic scattering of antenna structures and materials.

Planar Near-Field Range

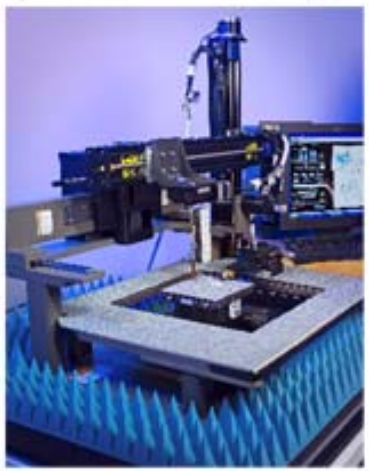
Compact Range



Cylindrical Near-Field Range



Far-Field Range



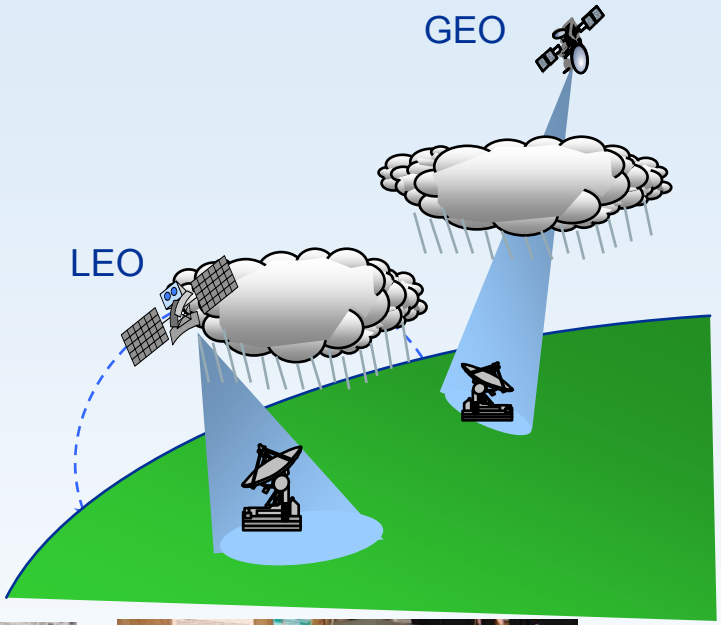
Probe Station Scanner

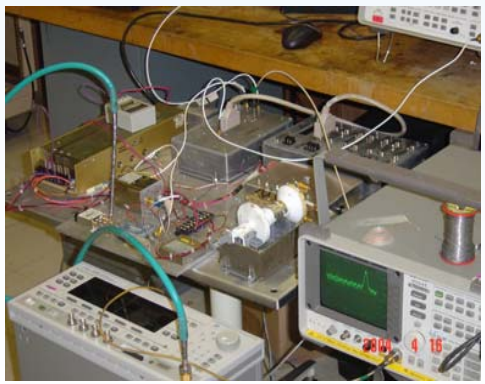
RF Propagation Research Laboratory

(Bldg. 55, R. 209 POC: Dr. Roberto Acosta, 216-433-8370)

Laboratory Objectives

- Evaluate GEO and LEO propagation links and validate models that will enable NASA, DoD and commercial communication system designers to optimize spacecraft power requirements and reduce cost.
- Establish the first LEO Ka-band propagation measurements techniques and modeling approaches.
- Developed one-of-kind digital receiver techniques and radiometry sensing techniques for characterizing radio frequency waves at Ka-band





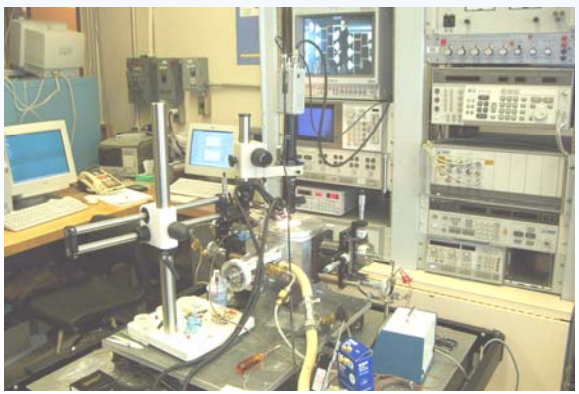
RCA Cryogenic Microwave Electronics Laboratory

(Bldg. 77, R. 252-253; POC: Dr. Robert Romanofsky, 216-433-3507)

Description: The Cryogenic Microwave Electronics Laboratory is used to evaluate innovative microwave materials, devices, and circuit technologies in support of the Communications Division's effort to develop next generation communications systems for Space Exploration. The facility has been used to evaluate space qualified cryogenic receiver components, superconducting phased array antennas, tunable thin-film ferroelectric based oscillators, filters and phase shifters, ferroelectric/semiconductor heterostructures, SiGe low noise amplifiers, InP HEMT low noise amplifiers, and more.

Capabilities::

- S-parameters from 100 MHz to 40 GHz at temperatures from 30 K to 300 K (room temperature to 67 GHz)
- Noise parameters up to 40 GHz at temperatures from 30 K to 300 K
- Magnetoresistance
- Hall and Van der Pauw measurements (plus mobility spectra)
- Shubnikov deHass
- Resistance to 1011 Ohm
- Antenna Far Field Patterns up to 10 cm apertures cooled to 30 K
- 3D measurements at nanometer scale using phase-shift interferometry
- AFM/STM



40 GHz Cryogenic On-Wafer Probe Station

2.5 K, 9 T Hall System

77 K, 1.2 T Hall System

Terrestrial Hybrid Environment for Verification of Aeronautical Networks (THEVAN)

(Bldg. 7 ; POC:Mr. Doug J. Hoder 216-433-3438)

Description:

- Ford Econoline E450 cutaway chassis with a custom van body
- Designed to simulate an airborne platform, yet be cheaper to operate and not require the extensive safety inspections necessary for an actual aircraft

Features

- Ring-laser gyroscope and Global Positioning System (GPS) for ARINC-429 navigational data
- Ku-band satcom terminal (512 kb/s Tx and 2 Mb/s Rx)
- Line-of-Sight VHF (19.2 kb/s duplex)
- 802.11 wireless LAN (5 Mb/s duplex)
- Cisco router for connections with RF systems
- AC generator 120 V/60 Hz and 3-Phase 400 Hz
- Easily reconfigurable to support multiple communications test scenarios

Research Project

- Mobile testbed for communication, navigation, surveillance, and networking technologies

Opportunities

- 6.0 Communication and Navigation

- The specific area of interest is:

  6.1 Investigation of ferroelectric materials for frequency and phase agile microwave components and systems. These efforts are relevant to the development of tunable microwave components such as resonators, filters and phase shifters required to develop advanced communications systems such as electronically steerable phased array antennas in support of NASA missions.

7.0 Bioscience and Technology and 8.0 Microgravity Research

Dr. Bhim S. Singh

Chief, Space Processes & Experiments Division

GRC NRA Briefing

NRA Number: **NNC07ZRP001N**

RESEARCH AND TECHNOLOGY GLENN RESEARCH CONTRACTS

March 30, 2007

Space Processes and Experiments Division Overview

Investigate the effects of the microgravity and reduced-gravity environments of space on physical, chemical, and biological systems. Apply this knowledge to develop a spectrum of innovative processes and technologies needed to support NASA's mission.

Program Areas

- Exploration Systems Mission
  - Advanced Capabilities:
    - Exploration Technology Development (Fire Prevention, Detection and Suppression; Exploration Life Support; Thermal Control System; In Situ Resource Utilization; International Space Station (ISS) Research; Dust Mitigation, etc.)
    - Human Research Program (Exploration Medical Capabilities and Human Health and Countermeasures)
  - Constellation Program
    - Service Module thermal control and micrometeoroid orbital debris
- Aeronautics Research Mission
    - Biofuels and aviation safety (human aspects)
- Space Operations Mission
    - Shuttle engineering support

Bioscience and Technology Branch

- Biological systems research including human systems
- Novel noninvasive optical probes for interrogating biological and physical systems
- Computational and analytical modeling of complex interactive systems
- Advanced imaging and microscopy including cellular and sub-cellular levels

Combustion and Reacting Systems Branch

- Fire prevention, detection and suppression in exploration environments
- Material flammability in reduced-gravity under a range of O_2/N_2 concentrations
- Sensors for fire detection and environment monitoring
- Analysis and design of chemical processes for ISRU applications

Fluid Physics and Transport Branch

- Analytical and computational modeling of multiphase systems in variable gravity
- Advanced thermal control for spacecraft using multiphase technologies
- Liquid inventory management and phase separation technologies for low-gravity environments
- Advanced diagnostics for fluid property and flow field measurements

Unique In-House Capabilities

- 2.2 Second Drop Tower
- 5.2 Second Zero Gravity Facility
- Access to NASA's Low-Gravity Aircraft
- Telescience Support Center to provide link to ISS for operation and monitoring of space flight experiments
- Bio-photonics Lab includes two-photon microscope, three-dimensional near-field microscope, and optical coherence tomography
- Vision and Bio-device Lab with state-of-the-art light scattering and imaging
- Cell Culture Lab for mammalian cell culture with immunofluorescence staining, cryostorage, ribonucleic acid (RNA) isolation and gel electrophoresis capabilities

Unique In-House Capabilities (continued)

- Exercise countermeasures lab
- Aerosol lab with capabilities to measure and characterize nano and micron size particles
- Combustion labs with state-of-the-art diagnostics capabilities to study materials flammability
- Access to surface mobility and soils lab
- Thermal systems development labs
- Fluid physics and diagnostics labs
- Complex fluids labs with capabilities for granular mechanics and small-scale excavation measurements
- Access to environmental and vacuum chambers
- Computational modeling and simulation, tools and capabilities

Opportunities

Bioscience and Technology:

The bioscience and technology area is focused on research and development in biological systems and applying this knowledge to improve the performance of humans, human systems, and physical systems in space as well as on Earth. Research and technology development links physics and interdisciplinary engineering with life sciences to address mission needs in astronaut and pilot health, biofuels, and Earth science

Specific areas include:

- Analysis, modeling, and testing of biological systems and components using advanced imaging and modeling tools.
- Development of novel noninvasive optical probes for interrogating biological and physical systems.
- Computational and analytical modeling of complex interactive systems

Opportunities (continued)

Microgravity Research:

Microgravity research focuses on elucidating the effects of microgravity and reduced gravity environments; physical, chemical, and biological processes and phenomena and applying this knowledge to develop advanced technologies for space exploration.

Specific areas include:

- Developing novel sensors, analytical tools, and strategies for fire prevention detection and suppression in exploration environments for microgravity and reduced-gravity conditions.
- Analytical and computational modeling and testing of multiphase systems including liquid acquisition and management in microgravity
- Analysis and design of physical and chemical processes for In situ Resource Utilization on Moon and Mars
- Development of sensors for detection of fire and for environment monitoring including detection of particulate matter
- Development of advanced spacecraft thermal control technologies