

NASA research priorities are defined by the Mission Directorates (Aeronautics Research, Human Exploration & Operations, Science, and Space Technology), and NASA's ten Centers. Each Mission Directorate and Center covers a major area of the Agency's research and technology development efforts.

Research Priorities for the NASA Centers

Examples of research interest areas from the following Centers and the respective Point of Contact (POC) are listed below.

Goddard Space Flight Center (GSFC), POC: David J. Rosage, david.j.rosage@nasa.gov

- Advanced Manufacturing - facilitates the development, evaluation, and deployment of efficient and flexible additive manufacturing technologies. (ref: NAMII.org)
- Advanced Multi-functional Systems and Structures - novel approaches to increase spacecraft systems resource utilization
- Micro - and Nanotechnology - Based Detector Systems - research and application of these technologies to increase the efficiency of detector and optical systems
- Ultra-miniature Spaceflight Systems - miniaturization approaches from multiple disciplines - materials, mechanical, electrical, software, and optical - to achieve substantial resource reductions
- Systems Robust to Extreme Environments - materials and design approaches that will preserve designed system properties and operational parameters (e.g. mechanical, electrical, thermal), and enable reliable systems operations in hostile space environments.
- Spacecraft Navigation Technologies
 - Spacecraft GNSS receivers, ranging crosslink transceivers, and relative navigation sensors
 - Optical navigation and satellite laser ranging
 - Deep-space autonomous navigation techniques
 - Software tools for spacecraft navigation ground operations and navigation analysis
- Mission and Trajectory Design Technologies
 - Mission design tools that will enable new mission classes (e.g., low thrust planetary missions, precision formation flying missions)
 - Mission design tools that reduce the costs and risks of current mission design methodologies
 - Trajectory design techniques that enable integrated optimal designs across multiple orbital dynamic regimes (i.e. earth orbiting, earth-moon libration point, sun-earth libration point, interplanetary)
- Spacecraft Attitude Determination and Control Technologies
 - Modeling, simulation, and advanced estimation algorithms
 - Advanced spacecraft attitude sensor technologies (e.g., MEMS IMU's, precision optical trackers)
 - Advanced spacecraft actuator technologies (e.g. modular and scalable momentum control devices, 'green' propulsion, micropropulsion, low power electric propulsion)

- CubeSats - Participating institutions will develop CubeSat components, technologies and systems to support NASA technology demonstration and risk reduction efforts. Student teams will develop miniature CubeSat power, pointing, communication, command/telemetry, structure, deployable (etc.) sub-systems and/or integrate such components into complete off-the-shelf “CubeSat bus” systems, with a goal of minimizing “bus” weight/power/volume/cost and maximizing available “payload” weight/power/volume. NASA technologists will then use these components/systems to develop payloads that demonstrate key technologies to prove concepts and/or reduce risks for future Earth Science, Space Science and Exploration/Robotic Servicing missions. POC: Thomas P. Flatley
- On-Orbit Multicore Computing - High performance multicore processing for advanced automation and science data processing on spacecraft. There are multiple multicore processing platforms in development that are being targeted for the next generation of science and exploration missions, but there is little work in the area of software frameworks and architectures to utilize these platforms. It is proposed that research in the areas of efficient inter-core communications, software partitioning, fault detection, isolation & recovery, memory management, core power management, scheduling algorithms, and software frameworks be done to enable a transition to these newer platforms. Participating institutions can select areas to research and work with NASA technologists to develop and prototype the resulting concepts. POC: Charles P Wildermann.

Ames Research Center (ARC), POC: Elizabeth Cartier, Elizabeth.A.Cartier@nasa.gov

Ames research Center enables exploration through selected development, innovative technologies, and interdisciplinary scientific discovery. Ames provides leadership in the following areas: Astrobiology; small satellites; supercomputing; robotic lunar exploration; and technologies for exploration. Additional Center core competencies include:

- Space Sciences
- Applied Aerospace and Information Technology
- Biotechnology
- Intelligent Systems
- Biological Sciences
- Earth Sciences
- High Performance Computing
- Advanced Aerospace Materials and Devices
- Space Transportation Technology/Thermal Protection Systems
- Human Systems Integration
- Small Spacecraft
- Airspace Systems

Glenn Research Center (GRC), POC: Mark David Kankam, mark.d.kankam@nasa.gov

Research and technology, and engineering engagements comprise including:

- Acoustics
- Advanced Energy (Renewable Wind and Solar, Coal Energy and Alternative Energy)
- Advanced Microwave Communications
- Aeronautical and Space Systems Analysis
- Computer Systems and Networks

- Electric (Ion) Propulsion
- Icing and Cryogenic Systems
- Instrumentation, Controls and Electronics
- Fluids, Computational Fluid Dynamics (CFD) and Turbomachinery
- Materials and Structures, including Mechanical Components and Lubrication
- Microgravity Fluid Physics, Combustion Phenomena and Bioengineering
- Nanotechnology
- Photovoltaics, Electrochemistry-Physics, and Thermal Energy Conversion
- Propulsion System Aerodynamics
- Space Power Generation, Storage, Distribution and Management
- Systems Engineering

The above engagement areas relate to the following key GRC competencies:

- Air-Breathing Propulsion
- Communications Technology and Development
- In-Space Propulsion & Cryogenic Fluids Management
- Power, Energy Storage and Conversion
- Materials and Structures for Extreme Environment
- Physical Sciences and Biomedical Technologies in Space

Armstrong Flight Research Center, (AFRC) POC: Oscar Murillo, Oscar.J.Murillo@nasa.gov

- Autonomy (Collision Avoidance, Separation assurance, formation flight, peak seeking control) (POC: Jack Ryan, AFRC-RC)
- Adaptive Control(POC: Curt Hanson, AFRC-RC)
- Hybrid Electric Propulsion (POC: Starr Ginn, AFRC-R)
- Control of Flexible Structures using distributed sensor feedback (POC: Marty Brenner, AFRC-RS; Peter Suh, AFRC-RC)
- Supersonic Research (Boom mitigation and measurement)(POC: Ed Haering, AFRC-RA)
- Supersonic Research (Laminar Flow) (POC: Dan Banks, AFRC-RA)
- Environmental Responsive Aviation (POC: Mark Mangelsdorf, AFRC-RS)
- Hypersonic Structures & Sensors (POC: Larry Hudson, AFRC-RS)
- Large Scale Technology Flight Demonstrations (Towed Glider) (POC: Steve Jacobson, AFRC-RC)
- Aerodynamics and Lift Distribution Optimization to Reduce Induced Drag (POC: Al Bowers, AFRC-R)

Marshall Space Flight Center (MSFC), POC: Frank Six, frank.six@nasa.gov

Propulsion Systems

- Launch Propulsion Systems
- In-Space Propulsion (Cryogenics, Green Propellants, High Pulse Power, Electric, Nuclear - Thermal, Solar Thermal, Solar Sails, Tethers)
- Propulsion Test beds and Demonstrators
- Cryogenic Fluid Management
- Rapid Affordable Manufacturing of Propulsion Components
- Composite Structures
- Materials Research

Space Systems

- Fission Surface Power
- In-Space Habitation with Emphasis on Life Support Systems and Nodes/Elements
- In Situ Resource Utilization
- Mechanical Design & Fabrication
- Small Affordable ISS Payloads
- Robotics Platforms
- In-Space Asset Management (Automated Rendezvous & Capture, De-Orbit, Orbital Debris Mitigation)

Space Transportation

- Advanced Manufacturing with Emphasis on In-Space Fabrication & Repair
- Space Environmental Effects and Space Weather
- Lander Systems and Technologies
- Small Spacecraft and Enabling Technologies (Nanolaunch Systems)
- 3D Printing / Additive Manufacturing
- Meteoroid Environment

Science

- Replicated Optics
- High Energy Astrophysics (X-ray, gamma ray, cosmic ray)
- Heliophysics
- Interstellar & Planetary Dust
- Radiation Mitigation
- Next Generation Observatories
- Earth / Atmospheric Science
- Severe Storms Research
- Climate Dynamics
- Lightning Research
- Remote Sensing
- Planetary Geophysics/Atmospheres

Kennedy Space Center, POC Michael Lester, gregory.m.lester@nasa.gov

- Robotics, Tele-Robotics, and Autonomous Systems
- Human Health, Life Support and Habitation Systems
- Human Exploration Destination Systems
- Ground and Launch Systems
- Communication and Navigation Systems
- Modeling, Simulation, Information Technology & Processing
- Thermal Management Systems
- KSC Tech Transfer initiative to hand-off commercially viable KSC IP to universities for further development that will meet both NASA and commercial applications (i.e. Dual Use Technology):
 - Focus on low TRL-high commercial potential KSC IP that has lost NASA funding

- Provide to university faculty and/or doctorate students for development toward commercialization and NASA use
 - Use educational/external funding sources (e.g. EPSCoR, Space Grant, etc.)
 - KSC oversight of university work provided by Tech Transfer and, possibly, KSC inventors.
- Ammonia Recovery System for Wastewater:
- http://technology.ksc.nasa.gov/documents/Tops/TOPS_13681_Ammonia_Recovery_System_Wastewater.pdf
- High Performance Polyimide Powder Coatings:
- http://technology.ksc.nasa.gov/documents/Tops/TOPS_12777_Polyimide_Powder_Coatings.pdf
- Wire Damage Detection and Rerouting System:
- http://technology.ksc.nasa.gov/documents/Tops/TOPS_12866_13285_InSituWireDamage.pdf

Jet Propulsion Laboratory (JPL), POC: Linda Rodgers, linda.l.rodgers@jpl.nasa.gov

- [Solar System Science](#)
Planetary Atmospheres and Geology; Solar System characteristics and origin of life; Primitive solar systems bodies; Lunar science; Preparing for returned sample investigations
- [Earth Science](#)
Atmospheric composition and dynamics; Land and solid earth processes; Water and carbon cycles; Ocean and ice; Earth analogs to planets; Climate Science
- [Astronomy and Fundamental Physics](#)
Origin, evolution, and structure of the universe; Gravitational astrophysics and fundamental physics; Extra-solar planets and star and planetary formation; Solar and Space Physics; Formation and evolution of galaxies
- [In-Space Propulsion Technologies](#)
Chemical propulsion; Non-chemical propulsion; Advanced propulsion technologies; Supporting technologies
- [Space Power and Energy Storage](#)
Power generation; Energy storage; Power management & distribution; Cross-cutting technologies
- [Robotics, Tele-Robotics and Autonomous Systems](#)
Sensing; Mobility; Manipulation technology; Human-systems interfaces; Autonomy; Autonomous rendezvous & docking; Systems engineering
- [Communication and Navigation](#)
Optical communications & navigation technology; Radio frequency communications; Internetworking; Position, navigation and timing; Integrated technologies; Revolutionary concepts
- [Human Exploration Destination Systems](#)
In-situ resource utilization and Cross-cutting systems

- [Science Instruments, Observatories and Sensor Systems](#)
Science Mission Directorate Technology Needs; Remote Sensing instruments/sensors; Observatory technology; In-situ instruments/sensor technologies
- [Entry, Descent and Landing Systems](#)
Aerobraking, aerocapture and entry systems; Descent; Landing; Vehicle system technology
- [Nanotechnology](#)
Engineered materials; Energy generation and storage; Propulsion; Electronics, devices and sensors
- [Modeling, Simulation, Information Technology and Processing](#)
Flight and ground computing; Modeling; Simulation; Information processing
- [Materials, Structures, Mechanical Systems and Manufacturing](#)
Materials; Structures; Mechanical systems; Cross cutting
- [Thermal Management Systems](#)
Cryogenic systems; Thermal control systems (near room temperature); Thermal protection systems

Johnson Space Center (JSC), POC: Kamlesh Lulla, kamlesh.p.lulla@nasa.gov

- Propulsion systems and Technologies
- In-space propulsion technologies
- Energy Storage technologies-Batteries, Regenerative Fuel cells
- Robotics and TeleRobotics
- Crew decision support systems
- Immersive Visualization
- Human Robotic interface
- Flight and Ground communication systems
- Advanced habitat systems
- GN&C for descent systems
- Large body GN&C
- Human system performance modeling
- Imaging and information processing
- Semantic Technologies
- Simulation and modeling
- Materials and structures
- Lightweight structure
- Smallsat and antennas

Langley Research Center (LaRC), POC: Gamaliel (Dan) Cherry,
Gamaliel.R.Cherry@nasa.gov

- Intelligent Flight Systems – Revolutionary Air Vehicles (POC: Guy Kemmerly 757-864-5070)
- Atmospheric Characterization – Active Remote Sensing (POC: Malcolm Ko 757-864-8892)
- Systems Analysis and Concepts - Air Transportation System Architectures & Vehicle Concepts (POC: Michael Marcolini 757-864-3629)

- Advanced Materials & Structural System – Advanced Manufacturing (POC: David Dress 757-864-5126)
- Aerosciences - Trusted Autonomy (POC: Sharon Graves 757-864-5018)
- Entry, Decent & Landing - Robotic Mission Entry Vehicles (POC: Keith Woodman 757-864-7692)
- Measurement Systems - Advanced Sensors and Optical Measurement (POC: Tom Jones 757-864-4903)

Stennis Space Center, POC: Nathan Sovik, nathan.a.sovik@nasa.gov

- Active and Passive Nonintrusive Remote Sensing of Propulsion Test Parameters
- Intelligent Integrated System Health Management (ISHM) in Rocket Test-Stands
- Advanced Non-Destructive Evaluation Technologies
- Advanced Propulsion Systems Testing
- Cryogenic Instrumentation and Cryogenic, High Pressure, and Ultrahigh Pressure Fluid Systems
- Ground Test Facilities Technology
- Propulsion System Exhaust Plume Flow Field Definition and Associated Plume Induced Acoustic & Thermal Environments
- Vehicle Health Management/Rocket Exhaust Plume Diagnostics

PROPULSION TESTING

Active and Passive Nonintrusive Remote Sensing of Propulsion Test Parameters

The vast amount of propulsion system test data is collected via single channel, contact, intrusive sensors and instrumentation. Future propulsion system test techniques could employ passive nonintrusive remote sensors and active nonintrusive remote sensing test measurements over wide areas instead of at a few discrete points. Opportunities exist in temperature, pressure, stress, strain, position, vibration, shock, impact, and many other measured test parameters. The use of thermal infrared, ultraviolet, and multispectral sensors, imagers, and instruments is possible through the SSC sensor laboratory.

Intelligent Integrated System Health Management (ISHM) in Rocket Test-Stands

SHM is a capability to determine the condition of every element of a system continuously. ISHM includes detection of anomalies, diagnosis of causes, and prognosis of future anomalies; as well as making available (to elements of the system and the operator) data, information, and knowledge (DIaK) to achieve optimum operation. In this context, we are interested in methodologies to embed intelligence into the various elements of rocket engine test-stands, e.g., sensors, valves, pumps, tanks, etc. Of particular interest is the extraction of qualitative interpretations from sensor data in order to develop a qualitative assessment of the operation of the various components and processes in the system. The desired outcomes of the research are: (1) to develop intelligent sensor models that are self-calibrating, self-configuring, self-diagnosing, and self-evolving (2) to develop intelligent components such as valves, tanks, etc., (3) to implement intelligent sensor fusion schemes that allow assessment, at the qualitative level, of the condition of the components and processes, (4) to develop a monitoring and diagnostic system that uses the intelligent sensor models and fusion schemes to predict future events, to document the operation of the system, and to

diagnose any malfunction quickly, (5) to develop architectures/taxonomies/ontologies for integrated system health management using distributed intelligent elements, and (6) to develop visualization and operator interfaces to effectively use the ISHM capability.

Advanced Non-Destructive Technologies

Advances in non-destructive evaluation (NDE) technologies are needed for fitness-for-service evaluation of pressure vessels used in rocket propulsion systems and test facilities. NDE of ultra-high pressure vessels with wall thicknesses exceeding 10 inches require advanced techniques for the detection of flaws that may affect the safe use of the vessels.

Advanced Propulsion Systems Testing

Innovative techniques will be required to test propulsion systems such as advanced chemical engines, single- stage-to-orbit rocket plane components, nuclear thermal, nuclear electric, and hybrids rockets. New and more cost- effective approaches must be developed to test future propulsion systems. The solution may be some combination of computational- analytical technique, advanced sensors and instrumentation, predictive methodologies, and possibly subscale tests of aspects of the proposed technology.

Cryogenic Instrumentation and Cryogenic, High Pressure, and Ultrahigh Pressure Fluid Systems

Over 40 tons of liquefied gases are used annually in the conduct of propulsion system testing at the Center. Instrumentation is needed to precisely measure mass flow of cryogenics starting with very low flow rates and ranging to very high flow rates under pressures up to 15,000 psi. Research, technology, and development opportunities exist in developing instruments to measure fluid properties at cryogenic conditions during ground testing of space propulsion systems. Both intrusive and nonintrusive sensors, but especially nonintrusive sensors, are desired.

Ground Test Facilities Technology

SSC is interested in new, innovative ground-test techniques to conduct a variety of required developmental and certification tests for space systems, stages/vehicles, subsystems, and components. Examples include better coupling and integration of computational fluid dynamics and heat transfer modeling tools focused on cryogenic fluids for extreme conditions of pressure and flow; advanced control strategies for non- linear multi-variable systems; structural modeling tools for ground-test programs; low-cost, variable altitude simulation techniques; and uncertainty analysis modeling of test systems.

Propulsion System Exhaust Plume Flow Field Definition and Associated Plume Induced Acoustic & Thermal Environments

Background: An accurate definition of a propulsion system exhaust plume flow field and its associated plume induced environments (PIE) are required to support the design efforts necessary to safely and optimally accomplish many phases of any space flight mission from sea level or simulated altitude testing of a propulsion system to landing on and returning from the Moon or Mars. Accurately defined PIE result in increased safety, optimized design and minimized costs associated with: 1. propulsion system and/or component testing of both the test article and test facility; 2. any launch vehicle and associated launch facility during liftoff from the Earth, Moon or Mars; 3. any launch vehicle during the ascent portion of flight including staging, effects of

separation motors and associated pitch maneuvers; 4. effects of orbital maneuvering systems (including contamination) on associated vehicles and/or payloads and their contribution to space environments; 5. any vehicle intended to land on and return from the surface of the Moon or Mars; and finally 6. the effects of a vehicle propulsion system on the surfaces of the Moon and Mars including the contaminations of those surfaces by plume constituents and associated propulsion system constituents. Current technology status and requirements to optimally accomplish NASA's mission: In general, the current plume technology used to define a propulsion system exhaust plume flow field and its associated plume induced environments is far superior to that used in support of the original Space Shuttle design. However, further improvements of this technology are required: 1. in an effort to reduce conservatism in the current technology allowing greater optimization of any vehicle and/or payload design keeping in mind crew safety through all mission phases; and 2. to support the efforts to fill current critical technology gaps discussed below. PIE areas of particular interest include: single engine and multi-engine plume flow field definition for all phases of any space flight mission, plume induced acoustic environments, plume induced radiative and convective ascent vehicle base heating, plume contamination, and direct and/or indirect plume impingement effects. Current critical technology gaps in needed PIE capabilities include: 1. An accurate analytical prediction tool to define convective ascent vehicle base heating for both single engine and multi-engine vehicle configurations. 2. An accurate analytical prediction tool to define plume induced environments associated with advanced chemical, electrical and nuclear propulsion systems. 3. A validated, user friendly free molecular flow model for defining plumes and plume induced environments for low density external environments that exist on orbit, as well as interplanetary and other planets.

Vehicle Health Management/Rocket Exhaust Plume Diagnostics

A large body of UV-Visible emission spectrometry experimentation is being performed during the 30 or more tests conducted each year on the Space Shuttle Main Engine at SSC. Research opportunities are available to quantify failure and wear mechanisms, and related plume code validation. Related topics include combustion stability, mixture ratio, and thrust/power level. Exploratory studies have been done with emission/absorption spectroscopy, absorption resonance spectroscopy, and laser induced fluorescence. Only a relatively small portion of the electromagnetic spectrum has been investigated for use in propulsion system testing and exhaust plume diagnostics/vehicle health management.