NASA Johnson Space Center Announcement
Seeking Potential Interest in Use of Unique Capabilities

Synopsis -

There are many challenges facing our world today: Finding a cure for cancer; discovering safer and cleaner alternative energy sources; making transportation safer and more effective; producing durable, environmentally friendly materials; protecting our national assets; exploring Space, and rehabilitating our soldiers, just to name a few.

NASA's Lyndon B. Johnson Space Center (JSC) shares common, complex problems with many industries. We are seeking partners interested in using our unique technical capabilities to help solve earthbound problems. See JSC's Announcement NNJ13ZBH014L: "Seeking Potential Interest in Use of Our Unique Capabilities".

For the past 50+ years, this nation has made a great investment in space exploration and NASA JSC, resulting in JSC capabilities (disruptive technologies, expertise, knowledge, specialized skills, experience, facilities, labs and tools) that are used to better life here on Earth. Utilizing these national assets to further technological advances also saves money, not only for the taxpayer, but across industry, academia, and government agencies. In today's global economy, the key to our nation's future is dependent on our ability to advance technologies in all industries and operate in the most innovative, efficient and effective ways.

With the release of this Announcement, JSC looks forward to sharing its unique capabilities to meet the needs of others. Partnering will foster innovation through collaboration, assist in solving complex problems relevant to life on earth and create a more efficient and effective Government.

Interested parties should respond in accordance with the language provided in the Announcement.

I. Description and Purpose of this Announcement

NASA Johnson Space Center (JSC) seeks to identify potential partners for utilization of JSC's unique interdisciplinary resources to support government, university, and commercial activities. These resources include technical expertise, knowledge, specialized skills, experience, facilities, labs, and tools not reasonably available in the commercial sector. These resources are frequently referred to as "capabilities" throughout this document. These capabilities can be of great benefit to the nation by enhancing technological research and development, increasing the nation's economic vitality, expanding human knowledge, and preserving United States critical skills.

These capabilities, as outlined in Section II, have broad application within diverse industries including, but not limited to, energy, petrochemical, medical, transportation, advanced manufacturing, robotics, aerospace, commercial space, and first responders. The capabilities

also have broad application in academia and other government agencies (e.g., Department of Defense, Department of Homeland Security).

This NASA JSC Announcement of Unique Capabilities, hereafter referred to as "Announcement," is solely for information and planning purposes and does not constitute a Request for Proposal (RFP). It is not to be construed as a commitment by the government, nor will the government pay for any information provided. Since this is an Announcement, no evaluation letters or results will be issued to the respondents.

The expectation is that NASA JSC will be fully reimbursed for all costs incurred in the performance of work as described in the agreement. The purpose of this Announcement is to engage prospective partners in dialogue leading to research and development (R&D) efforts utilizing these unique capabilities. In selecting potential partners, JSC will assess the best fit use of its resources consistent with the NASA mission.

II. Index of Unique NASA JSC Capabilities

Click on the topic listed below for detailed descriptions; which can also be found in Section V.

1. Human Health and Performance
    a. Human Factors Engineering and Human Systems Integration
    b. Space Food Systems
    c. Extreme Environment Medical Capabilities
    d. Biomedical Laboratories
    e. Environmental Monitoring, Analysis, and Data Assessment
    f. Radiation Monitoring, Assessments, and Protection
2. Robotics – Development, Test, Management and Engineering Support
3. Counterfeit Parts Detection
4. Fastener and Material Testing
5. Workmanship Training
6. Estimating Risk & Performance during System or Project Design
7. Simulation
8. Software
9. Crew Exercise Systems
10. Structural & Manufacturing Testing, Analysis and Engineering Capability
11. Imaging Science
12. Battery Design, Development and Testing and Cell Analysis and Testing
13. Large Scale Underwater Testing in Controlled Environment (Neutral Buoyancy Laboratory)
14. Environmental & life support systems, air and water monitoring & recycling, active thermal control and extreme environment protective suites
15. Crew Interface Rapid Prototyping Lab
16. Propulsion System Design, Development, and Test
17. Space Vehicle Mockup Facility
18. Space Mission and Hardware Integration

III. The Process

The government and partner will jointly define the partnership, develop mutually agreed to statements of work, cost, and schedule. The government anticipates some respondents may be

interested in only one area or sub-area while others may be interested in broad efforts requiring more than one capability. Some entities may want to partner because of their direct needs, or there may be respondents who wish to utilize JSC capabilities to meet the needs of third parties. NASA will identify the appropriate legal instrument for partnering on a case-by-case basis.

IV. Information Requested from Respondents

If interested, parties will submit statements of interest electronically, via email, to the Technical Point of Contact listed below. The statement of interest shall consist of a one-page summary and one additional pages of supporting detail if needed. The one page summary response form can be found here. Responses shall contain a minimum font size of 12. To facilitate a prompt review, the one-page summary shall clearly identify planned utilization of capabilities consistent with those described in this document. Responses are required no later than close of business (COB) on the response date specified above. Information received after this date will only be considered if deemed in the Government's best interest. Please reference this Announcement, "TBD", in any inquiries. Respondents are cautioned to mark any information confidential if it is to be treated as proprietary.

Points of Contact

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V. DETAILED CAPABILITY DESCRIPTIONS

1. Human Health & Performance (HH&P) **<back to index>**

The Johnson Space Center, a world leader in human spaceflight, possesses world-class facilities and over 50 years of distinctive human spaceflight research, expertise, technologies, and laboratories that can be applied to solving human health and performance challenges here on earth—particularly those related to operating in extreme and harsh environments. Specifically, these include: Space Human Factors Engineering & Human Systems Integration; Space Food Systems; Extreme Environment Medical Capabilities; Biomedical Laboratories; Environmental

Monitoring, Analysis, and Data Assessment; and Radiation Monitoring, Assessments, and Protection.

a. <u>Human Factors Engineering & Human Systems Integration</u> <back to index>

JSC's world-class Spaceflight Human Factors Engineering & Human Systems Integration expertise, knowledge, rigorous processes, and research labs can be applied to the development of new systems and improvement on evaluation of existing systems including:

- Spacecraft for commercial crew, commercial orbital facilities, and space tourism;
- Automobiles and other transportation devices;
- Human-machine interactions including displays and controls and wearable systems;
- Terrestrial challenges including design for operations in extreme environments or remote environments such as ocean or arctic exploration;
- Optimizing human performance for working in harsh environments; and
- Human-centered design and evaluation of lighting, viewing, and display systems.

These world-class Space Human Factors Engineering & Human Systems Integration expertise and facilities have been shaped by over 50 years of human spaceflight research, design, and operations in the uniquely complex, challenging, and highly constrained spacecraft environment. These capabilities are co-located offering a unique combination of proven processes, design, testing, and evaluations of human-centered product designs and hardware.

- **Human Integration Design Handbook and Human System Integration Processes.** JSC's unique integrated space "human-centered" skills, knowledge, processes, and products developed over 50 years of human spaceflight includes Space Human Factors Engineering (SHFE) requirements, rationales, supporting information, and processes. These capabilities are used to verify effective implementation of systems and operations that enable optimal human space health and performance in extreme environments such as space. These complement the NASA Spaceflight Human Systems Standards and serve as a how–to guide of best practices.
- **Human-Centered Design (HCD).** JSC provides one-of-a-kind space products such as spacecraft crew systems designs, prototypes, and evaluation-based human factors recommendations for operating in extreme/harsh environments. The Habitability Design Center (HDC) is a unique human spaceflight conceptual "human-centered" design studio leveraging specialized expertise and knowledge in industrial design, architecture, and systems engineering to solve the unique challenges of living and working in the extreme space environments. The HDC specializes in concept design, rendering of design concepts, full scale and part scale mockups and models, and rapid delivery of functional prototypes.
- **Anthropometry and Biomechanics Facility (ABF)**. JSC's anthropometry and biomechanics facility and expertise is the human spaceflight's gold-standard in testing to identifying human ergonomic and occupational biomechanical problems and recommending solutions to improve passenger's safety, comfort, and injury protection. ABF has the capability to perform high-resolution laser scan measurements of humans and other complex or irregular objects, and perform multi-joint motion tracking of operators in complex environments such as cockpits. The ABF spaceflight Anthropometry Database includes measurements of both suited and unsuited crewmembers, which is beneficial to spacecraft designers.

- **Usability Analysis and Testing**. JSC's usability analysis and testing expertise, research, and facilities offers a world-class capability for human spaceflight usability analysis, evaluation, and testing of human and human-machine interfaces for spacecraft work areas and equipment. The analysis and test includes specialty subjective measures for workload and handling qualities as well as instrumentation, including eye-tracking and portable computing.
- **Lighting Design Evaluations**. JSC's lighting design expertise, research, technologies, and facilities offers capabilities to assess crews' spacecraft direct and indirect viewing, including characterization of existing lighting systems and graphical, math model based prediction of lighting.
- **Graphics Research and Analysis**: JSC's graphics research and analysis lab expertise, research, technologies, and facilities offers world-class spaceflight research capability performing computer-aided human spaceflight factors analysis and simulation that address human engineering issues for human system designs and analyses such as lighting and viewing, habitable volume and ergonomics of human occupied spacecraft.

For more information concerning Human Factors Engineering and Human Systems Integration, please visit our website.

b. <u>Space Food Systems</u> <back to index>

JSC's Space Food Systems expertise, processes, research, technologies, and facilities offer unique capabilities to support development of spaceflight advanced food products that could be used for private and Commercial Crew spaceflight as well as terrestrial applications. Applications include:

- Military uses;
- Evaluations of food concepts, menus, and nutrition pertaining to new space mission endeavors such as an orbiting commercial venture and space tourism;
- Operational challenges such as working and living in extreme environments like ocean exploration; and
- Optimized human nutritional performance.

These world-class Space Food Systems expertise and facilities are co-located making this a unique capability offering the combination of proven processes, research, and development of human-centered food systems.

- **Advanced Food Technology.** JSC's advanced food technology group has world-class space food development expertise, research, and facilities offering the capability to perform research with new technologies that extend the shelf life of processed foods, including emerging food processing technologies and packaging materials that are lightweight and can be easily and efficiently disposed of, thereby minimizing the use of limited resources such as mass and volume.
- **Spaceflight Food**. JSC's spaceflight food expertise and facilities produces, tests, and certifies all food for its spaceflight missions and ensures appetizing, nutritious food systems that are safe and easy to prepare on-orbit.
- **Food Production**. JSC's space food production expertise and facilities offers unique research, technologies, and knowledge to produce thermally stabilized pouched foods and freeze-dried packaged foods.

- **Food Packaging**. JSC's space food packaging expertise, technologies, and facilities has a variety of packaging equipment, with capabilities including heat sealing, vacuum packaging, and labeling, all in a space qualified clean room environment. We can provide expertise in space-rated high barrier flexible packaging materials and headspace testing.
- **Food Stowage**. JSC's space food stowage expertise and facilities has the unique knowledge in efficiently packing and stowing space foods to minimize mass and volume, while protecting the food packages from a harsh environment.
- **Menu Development**. JSC's space food menu development expertise, research, and knowledge has the unique capability to create nutritionally complete menu design for extreme environments utilizing shelf stable foods.
- **Food Characterization**. JSC's space food characterization expertise, research, and world-class facilities has the capability to test physical space food properties such as texture, color, and viscosity; expertise in accelerated shelf life testing; the capability to test water activity including moisture isotherms; and sensory evaluation and analysis.

For more information concerning Space Food Systems, please visit our website.

c. <u>Extreme Environment Medical Capabilities</u> **<back to index>**

JSC's unique human spaceflight expertise, processes, research, technologies, and facilities in the Extreme Environment Medical Capabilities are available to support the development of advanced medical systems and operations for both commercial and military applications to: 1) aid in development of new medical capabilities for commercial crewed flights; 2) aid other, novel space mission endeavors such as an orbiting commercial venture and space tourism; 3) transition expertise and technologies towards terrestrial populations working and living in extreme or austere environments; and 4) transition expertise and technologies towards ocean vessel and facilities operations to optimize human health and performance in extreme environments. These world-class Space medical expertise, research, technologies and facilities are co-located making this a unique capability offering the combination of proven spaceflight medical systems and support of human-centered spaceflight operations.

- **Human Spaceflight Medical Operations**. JSC's one-of-a-kind human spaceflight medical operational expertise and knowledge offers capabilities in providing medical support for human spaceflight missions; creating crew health standards for a specific population in an extreme environment; medical contingency planning and support; manifesting new medical devices and protocols; medical training of non-physician astronauts, flight surgeons and other flight controllers which may be leveraged by commercial and space tourism efforts, extreme environment operations such as oil & gas exploration, and ocean vessel and facilities operations.
- **Medical Informatics and Health Care Systems**. JSC's one-of-a-kind space Biomedical Informatics expertise, processes, and technologies is offered as a capability that can be used to define the study, invention, and implementation of informatics structures and algorithms to improve communication, understanding and management of medical data and information.
- **Medical Hardware Development**. JSC's space medical hardware development expertise, rigorous processes, research, and technologies offers a one-of-a-kind capability in space hardware and software development expertise, producing systems designed to operate in extreme (space) environments. These space medical

technologies are ruggedized to withstand radiation, vibration, and temperature extremes associated with flight. JSC also possesses expertise in developing technologies that can function in reduced gravity environments.

- **Biomedical Engineering for Exploration Space Technology**. JSC's space biomedical engineering expertise, research, and technologies offers the unique capability of developing advanced space biomedical technologies that utilize a wide variety of one-of-a-kind, customized test beds and cell/tissue models within a fully functional tissue culture/tissue engineering lab.
- **Biostatistics**. JSC's space biostatistics expertise, research, and technologies offers expertise in analyzing data gathered on small numbers of human spaceflight subjects under non-standard—space—environments and test regimens.
- **Clinical Risk Modeling**. JSC's space medical and clinical risk modeling expertise, research, and technologies offers unique spaceflight clinical and biostatistical expertise required to model medical conditions of concern in space flight. From identification of the medical conditions in a healthy, medically screened population in a space environment to probabilistic model development, JSC's unique expertise provides determination of likelihood of a medical event, probability of loss of life, and an indirect measure of crew health.
- **Telemedicine**. JSC's space telemedicine expertise, research, and technologies offers the capability to practice remote medicine and maintain crew health for short and long duration excursions over significant geographic distances via the application of space-rated hardware and software solutions and medical operations that effectively extend the diagnostic and treatment capabilities of clinicians into the remote environment. Based on 50 years of spaceflight experience, JSC has developed new processes and technologies such as unique expertise in remote ultrasound guidance of non-physicians, yielding diagnostic-quality imagery.

For more information concerning Extreme Environment Medical Capabilities, please visit our website.

d. <u>Biomedical Laboratories</u> <back to index>

JSC's specialized biomedical laboratories include space-related expertise, processes, research, technologies, and facilities. This uniquely co-located capabilities offers development of advanced biomedical systems that could be utilized for Army and Navy operations; aid in development of new biomedical capabilities for Commercial Crew; aid in new space mission endeavors such as an orbiting commercial venture and space tourism; aid in terrestrial operational challenges of working and living in extreme and harsh environments; used in medical research and development; and used to optimize for human health and performance. These world-class space biomedical expertise and facilities are co-located; making this an unique suite of laboratory capabilities offering the scientific evaluation, validation, and certification of optimal countermeasures that are necessary to maintain human health and performance in the isolated, confined and extreme environment of space.

- **Microbiology Expertise and Lab**. JSC's space focused microbiology expertise, rigorous processes, research, technologies, and facilities offers a one-of-a-kind co-located capability of highly skilled interdisciplinary team which serves as a NASA-wide resource for microbial issues associated with living and working in extreme closed environment operations; requirements development; environmental monitoring (including enumeration, microbial characterization and identification); potable water analysis; crew

diagnostics; food analysis; crew training; bio-safety review of payloads; and hardware and technology development. This one-of-a-kind specialized Microbiology Lab has the capability to address space microbial research issues associated with living and working in extreme closed environments through operational monitoring and investigative research.

- **Neuroscience**. JSC's space focused neuroscience expertise, processes, research, technologies, and facilities offers specialized capabilities to perform human subject data collection and analyses for ground-based and spaceflight studies pertaining to functional neurological assessments that provide an objective test of neurosensory re-adaptation to Earth's normal gravity following prolonged weightlessness.
- **Nutritional Biochemistry**. JSC's space focused nutritional biochemistry expertise, research, technologies, and laboratory offers an integrated one-stop capability to perform nutritional assessment techniques, including analyses of blood and urine samples for biochemical endocrine, and other physiological markers, in addition to detailed dietary intake assessment.
- **Immunology**. JSC's space focused immunology expertise, processes, research, technologies, and laboratory offers an integrated one-stop capability to investigate and recommend countermeasures for the effects of extreme space environment on human physiology including effects on the human immune system and on kidney stone formation.
- **Pharmacotherapeutics**. JSC's space focused pharmacotherapeutics expertise, processes, research, technologies, and laboratory offers an integrated one-stop capability to perform clinical space-related pharmacology research and operations, conduct therapeutic drug monitoring, perform pharmaceutical stability assessments, maintain therapeutic database analysis and maintenance, and provide pharmacy information services and documentation.
- **Extra-Vehicular Activity (EVA) Physiology**. JSC's space focused EVA physiology expertise, processes, research, technologies, and laboratory offers an integrated one-stop capability in pre-breathe exercise prescriptions, ability to analyze and graphically present metabolic data rates for use by mission flight surgeons during EVAs, and ability to support hypobaric testing and simulations.
- **Cardiovascular Physiology**. JSC's space-related cardiovascular physiology expertise, processes, research, technologies, and laboratory offers an integrated one-stop capability to identify risks associated with human spaceflight, conduct cardiovascular research using state-of-the-art technologies and methods including echocardiography, vascular imaging, Holter monitoring, orthostatic tolerance measures, muscle volume testing, time series data analysis, and virtual guidance ultrasound.
- **Behavioral Health Research.** JSC's space-related behavioral health expertise, processes, research, technologies, and laboratory offers an integrated one-stop capability and research environments used to simulate extreme environmental conditions such as altered day and night cycles, heavy workloads, social isolation, and close living quarters that provide insight into the impact of these conditions on human behavior and performance.

For more information concerning Biomedical Laboratories, please visit our website.

e. <u>Environmental Monitoring, Analysis, and Data Assessment</u> <back to index>

JSC's space-focused Environmental Monitoring, Analysis, and Data Assessment expertise, processes, research, technologies, and facilities offer unique capabilities in the development of

spacecraft environmental requirements, environmental analyses and planning, and monitoring and evaluation of internal environmental conditions. Unique space-related environmental factors include physical/chemical realities of the environmental (e.g., lack of convective dispersion, air/water separation phenomenon), and practical realities (e.g., minimal allowance for use of harmful reagents in monitoring, reality of lower sample sizes for returned archived environmental samples). Research activities include the development of advanced environmental monitoring technologies that could be utilized in military operations and human spaceflight endeavors such as development of capabilities for Commercial Crew, orbiting commercial ventures and space tourism. The capabilities are also applicable to environmental challenges here on Earth; particularly those situations that require working and living in extreme and harsh environments; that require environmental monitoring research and development; or must optimize for human health and performance. These world-class Environmental Monitoring, Analysis, and Data Assessment expertise and facilities are co-located making this a unique capability offering the combination of proven processes, research, development, and testing of human-centered spacecraft environmental monitoring systems.

- **Acoustics and Noise Control Lab**. JSC's space-related acoustics and noise control expertise, processes, research, technologies, and facilities offers the capabilities that ensures safe, healthy, and habitable acoustic environments in which humans can live, communicate, and work. These world-class capabilities include acoustics modeling, requirements allocation, and implementation of appropriate noise controls using flight-certified acoustics materials, acoustic testing, and noise remediation assistance.
- **Toxicology**. JSC's space-related toxicology expertise, processes, research, technologies, and facilities offers the capabilities that protects spaceflight crews from toxic exposures during extreme environment operations by setting limits to protect crew health; assessing health hazards of system chemicals based on composition, concentration, and volume; evaluating air quality real-time; and performing off-gas material testing of hardware.
- **Water and Food Analysis**. JSC's space food and water lab has expertise, rigorous processes, and facilities in environmental chemistry, analytical quality assurance, toxicology, the development of space qualified water quality monitors, and water quality engineering. Capabilities exist to assess, monitor and evaluate water quality, and analyze macro-nutritional content of food.
- **Advanced Environmental Health**. JSC's space-related advanced environmental health expertise, processes, research, technologies, and facilities offers the capabilities to conduct research by monitoring the physical environment in which spaceflight crews live and work—setting limits for the amount of crew exposure to chemicals, bacteria, fungus, and contaminants (unknown environment (planetary) soils). The world-class co-located one-stop Environmental Health Lab provides integrated analyses of personal and area samples for possible workplace exposure to solvents and other organic chemicals, metals (in coated surfaces and air), asbestos (in air and building materials) and any other potential workplace health hazards including mold and fungi.

For more information concerning Environmental Monitoring, Analysis and Data Assessment, please visit our website.

f. <u>Radiation Monitoring, Assessments, and Protection</u> **<back to index>**

JSC's human spaceflight radiation monitoring, assessments, and protection expertise, processes, research, technologies, and facilities offer unique capabilities unlike any other in that we monitor

its effect on humans. This capability includes development of radiation monitoring techniques, assessment tools and assessment, and protection of humans during spaceflight operations. These space-related capabilities could be used in nuclear power plants; military operations; development of spaceflight radiation hazard detection and protection (e.g., Commercial crew, orbiting commercial venture and space tourism) and any human operations in harsh environments that may be exposed to radiation, require human health protection, and involve human-machine interactions. These world-class radiation monitoring, assessments, and protection expertise and facilities are co-located making this a unique capability offering the combination of proven processes, research, development, testing, and operations of human-centered spacecraft systems.

- **Space Radiation Biophysics**. JSC's space-related radiation biophysics expertise, processes, research, technologies, and facilities offers capabilities that provide analysis of cellular and molecular damages in humans due to [space] radiation exposure.
- **Space Radiation Dosimetry Lab.** JSC's space radiation dosimetry expertise, processes, research, technologies, and lab offers capabilities to provide radiation dosimetry support through the measurement of human radiation exposures and characterization of extreme environments.
- **Space Radiation Operations Support**. JSC's space radiation operations expertise, processes, research, technologies, and facilities offers capabilities to provide, via the Space Radiation Analysis Group (SRAG), 24/7/365 solar radiation environmental monitoring and human spaceflight operations support.
- **Space Radiation Measurement and Analysis**. JSC's space radiation measurement and analysis expertise, processes, research, technologies, and facilities offers capabilities to assess extreme radiation environment operations, dosimetry, radiation measurement, design and shielding analysis with *very* strong information technology (I/T) reliance and 47 years of operational spaceflight history.
- **Space Radiation Research**. JSC's space radiation research expertise, processes, technologies, and facilities offers capabilities in radiobiology and physics tools for predicting the biological effects of radiation exposures, and shielding recommendations for habitats, vehicles, and storm shelters.

For more information concerning Radiation Monitoring, Assessments, and Protection, please visit our website.

2. Robotics – Development, Test, Management and Engineering Support

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The suite of JSC's robotics technologies is vast, ranging from robotic vehicles and mobile systems to dexterous robots. JSC has accelerated development for the next generation of robots and related technologies for use in the aerospace industry. Many industries, spanning from logistics and industrial robotics to medical, can benefit from incorporating these technologies into their existing products and processes.

There are a number of discrete technologies in the robotic portfolio that will advance the state of the art and provide a competitive advantage for both robotic and non-robotic applications and industries. Robotic applications include: logistics and distribution, service robots, real-time grasp planning, robot task commander, increased dexterity, joint and arm sensors, etc. In the

non-robotic arena, these advanced technologies could benefit health and diagnostic system tools, force and position sensing, and could streamline and simplify communications, actuators, etc. Specific capabilities are described below.

Robotic Development Capabilities

JSC has unique capabilities for rapid prototyping, analysis, design, assembly, integration and testing of dexterous robots and subsystems, rovers, vehicles, and mobile robotic systems. The focus of the JSC dexterous robots is humanoids, robotics for human assistance, and robots which operate safely with humans in their workspace. JSC's robotic development includes vision systems, image recognition systems, sensor integrations, tendon hands, control algorithms, and much more. The mobile systems technology focus is high maneuverability, safety, redundancy, and by-wire systems. As a result of past development in these areas, JSC has exceptional skills in the following technologies (demonstrated by nearly 50 patent and patent pending) related to robotic systems:

- Compact gear trains including highly integrated motors, reduction and motor drives;
- Custom high power motor drives;
- Packaging of battery cells and battery management into state-of-the-art performance lithium-ion batteries; safety focused, high voltage, power and dense energy capacity, and liquid cooled;
- Vehicle active suspension, both mechanical/electrical design and algorithms to operate the active suspension;
- Active liquid cooling and development of motors and motor drivers;
- Algorithm development and implantation for non-traditional driving kinematics;
- Sensor integration and remote/autonomous driving;
- High strength to mass, yet human-safe robotic limbs;
- Unique, anthropomorphic robotic hands with miniature, integrated force sensors;
- State-of-the-art force control manipulators for dealing with a range of activities; and
- Wearable robotic systems for fatigue reduction, strength enhancement, exercise, rehabilitation, ergonomic stress reduction.

Robotic Test Capabilities

JSC's one-of-a-kind robotic test capabilities include an array of simulation-following hydraulic and electromechanical systems and a team of engineers with the unique skills to integrate simulations with the robotic control system and payload, and when appropriate, human interfaces. The robot will move the payload as directed by the simulation as long as the command does not violate the motion constraints of the system.

Unique robotic test capabilities include:

- A Stewart platform with a payload capacity of 3000 lbs and a stroke of 10 feet;
- A 60-foot manipulator with a 500 lb payload capacity adjacent to a 6,860 sq-ft flat floor;
- Two smaller robots, designed for fine positioning, with 240 lb payload capacities; and
- A gravity offload hoist, with a 750 lb payload capacity, that relieves up to 100% of an object's weight and allows it to move freely within a 17 X 36 foot area.

Robotics Systems Management and Engineering Support

JSC's unique capabilities include a full range of end-to-end human rated robotic systems management and engineering support, including expertise analyzing resultant data and operations. JSC has extensive experience in the understanding and utilization of robotics systems, including remote operations in harsh environments such as the International Space Station (ISS) Mobile Servicing System (MSS), test labs, and tools. A distinguishing benefit to these capabilities is the access to engineers and technicians who test systems to meet the stringent NASA certification requirements (human rated testing) on a daily basis, as well as support continuous astronaut training and mission operations.

Specific capabilities include analysis of robotic tasks such as capture, maneuvering and berthing analysis for vehicles arriving at ISS, robotic user interface display development, software integration, and robotic camera systems.

The JSC core capabilities for prototyping, design, analysis, fabrication, testing, and integration include:

- Kinematic and dynamic robotic simulation capability;
- Human Graphical User Interface development for robotic control systems;
- System engineering and expertise in complex robotic operations; and
- Cameras, targets and vision systems for manipulation and berthing.

More details concerning JSC's unique Robotics capabilities can be found on the following websites:

JSC Robotics Fact Sheet
Robotic Systems Technology
Robonaut
Space Exploration Vehicle

3. Counterfeit Parts Detection <back to index>

JSC's Counterfeit Parts Detection unique attributes include a world-class facility with a broad range of testing capabilities and expertise including: X-Ray Fluorescence Spectroscopy; Optical Emission Spectroscopy; Destructive Physical Analysis; Scanning Electron Microscopy; and Real-Time Radiography. Our facility is an AS9100 registered laboratory and holds the most stringent ISO/IEC17025 accreditation from the American Association for Laboratory Accreditation (A2LA). Our engineers and technicians have a wealth of experience dealing with hardware destined to operate in hostile and unforgiving environmental conditions. The team can also provide a conduit to partners seeking additional problem-solving expertise resident in other organizations at the Johnson Space Center.

More details of JSC's Counterfeit Parts Detection unique capabilities are available on our website

4. Fastener and Material Testing <back to index>

Fasteners are used throughout industry to hold our world together. Their function under extreme conditions is dependent on the correct chemistry of the material, condition of the material, and

quality manufacturing processes. JSC technicians can certify that fasteners meet all the appropriate specifications. We test to the applicable military and industry standards, such as ASTM F 606/F 606M; NASM1312-18; NASM1312-8; ASTM E8. Our capabilities include:

- Fractography
- Scanning Electron Microscope (SEM)
- Real-Time Radiography
- Microhardness Testing
- X-Ray Fluorescence Spectroscopy
- Optical Emission Spectroscopy
- Bend Test
- Metallographic Preparation
- Double Shear
- Hardness Testing
- Tensile Testing

More details of JSC's fastener and material testing capabilities are available on our website.

5. Workmanship Training <back to index>

Special processes require superior skills, knowledge, experience and hands-on application. For over 15 years, JSC has provided NASA Workmanship Standards compliance trainings, issuing 1200 - 1500 training certificates annually. Workmanship Standards provide uniform engineering and technical requirements for processes, procedures, practices, and methods that have been endorsed as standard for NASA programs and projects. Training services include “hands on” training to engineers, technicians, and inspectors.
Available Workmanship Training Courses include:

· Through-Hole Soldering	40 hours
· Cable, Harness & Crimp Training/Inspection	40 hours
· Conformal Coating & Staking Training/Inspection	24 hours
· Electrostatic Discharge Control (ESD) Training	4 hours
· Surface Mount (SM) Soldering Training/Inspection	40 hours
· Fiber Optic Terminations Training	24 hours
· Lithium Battery Handling Familiarization	2 hours
· Wire Wrapping	8 hours
· NASA Workmanship Standards Familiarization	8 hours
· Soldered Electrical and Electronic Assemblies (IPC J-STD-001E/S)	40 hours

More details of JSC's Workmanship Training Courses are available on our website

6. Estimating Risk & Performance during System or Project Design
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NASA's unique tools and associated expert analytical capabilities, utilized to evaluate the performance and characteristics of vehicles and missions early in their design phases, can be applied to assess the relative benefits and drawbacks of system design or architecture in industries operating in extreme or hazardous environments. JSC is currently integrating two analysis tools. These tools enable the rapid evaluation of performance measures, such as mass and power, and provide accompanying operational risk metrics. The tools are used early in the design process to inform architecture decisions. Results from the analysis assists with architecture development efforts, regardless of the architectural destination. This capability involves the use of Excel software modules (visual BASIC) and the use of advanced Excel functions and operations.

JSC's extensive knowledge of the tool's inner workings and algorithms, in combination with event tree analysis process and system reliability/availability discipline knowledge, provides the necessary platform for application of the tool to other industries.

For more information please visit website:
http://www.nasa.gov/centers/johnson/partnerships/index.html (click on Safety and Risk Assessment)

7. Simulation <back to index>

JSC's unique simulation capabilities include a full range of high-fidelity, real-time graphical simulations that support both engineering analysis and crew training. This capability includes simulation software developed by JSC engineers – the distinction of these simulation packages is that each is reconfigurable.

The JSC simulation capabilities support development and operations for simulation prototyping, design, analysis, testing, integration and real-time operations. The capabilities can be tailored for use in many industries—ranging from companies interested in fluid dynamics simulation (e.g., oil and gas, medical, water, aerospace) to those companies interested in auto code generation and virtual reality simulation.

First, the individual simulation tools are unique because they can be tailored to multiple domains. Second, the integrated use of these simulation tools provides a one-of-a-kind platform for simulation application development. Third, JSC's capabilities are distinct, in that they integrate these simulation tools with the expertise to provide a simulation infrastructure and simulation applications. Once a simulation package is developed for a partner, it can be tailored for other applications.

Several of the simulation software packages created by JSC's engineers are described below.

JSC's simulation architectures and tools include "Trick." Trick is a simulation toolkit used for engineering analysis, hardware in the loop applications and training. Trick can be used as a standalone framework for any simulation application or in conjunction with other JSC core products to build specific space and robotics applications.

JSC has developed a simulation software toolset called GUNNS (General Use Nodal Network Solver). GUNNS is a flow system modeling software package that combines nodal analysis with hydraulic-electric analogy to simulate fluid, electrical and thermal systems. GUNNS has the following capabilities:

- Allows math model developers to graphically build a nodal network system with attributes. GUNNS generates the code and solvers for the network in a C++ class design. GUNNS also provides an aspect and model driven architecture to integrate dependent network systems such as fluids and gasses, power, and thermal.
- Provides capability for rapid simulation development, ease of maintenance and cost savings.

JSC's Virtual Reality (VR) and mass handling robotics simulation and graphics software capabilities include:

- OpenGL based 3D rendering and a VR software package named DOUG (Dynamic Onboard Ubiquitous Graphics) that executes on Windows/Linux PC platforms including laptops and is optimized for Nvidia GeForce graphics boards. DOUG is unique in that it provides highly reconfigurable 3D graphical rendering support for a diverse set of applications including out-the-window displays, dome projection displays, desktop dynamic skills training system displays, on site situational awareness and training displays, and the capability to develop and review procedures remotely and on site;
- VR helmet and laptop optics technologies for ground and space (onboard) VR training;
- Immersive capability which includes custom built, high-resolution helmet mounted displays; and
- Mass handing robotics that is integrated with human-in-the-loop to provide a high fidelity simulation. The system includes force feedback simulations and VR graphics.

For more information on JSC's unique Simulation capabilities, please visit the following webpages:

Dynamic Systems Testing

Simulation and Graphics

Systems Engineering Simulator

Dynamic Onboard Umbiquitous Graphis Software

Mini AEROCam

8. Software <back to index>

JSC possesses unique integrated resources that can be used to create software solutions for challenges here on Earth. These capabilities, which include prototyping, design, analysis, testing and integration, can be tailored to diverse industries—particularly those that require high reliability, fault tolerant architectures, are concerned with process control, operate remotely or in harsh environments, require just-in-time training or need systems where both humans and computers share and trade control (e.g., energy, medical, aerospace and the DoD).

Software capabilities encompass software architectures, command and data handling, communications and tracking, electronic procedures, crew procedure automation (XML procedure representation language with integrated development environment, translation, execution and display); shared and traded control (human interfaces for variable levels of autonomy); vehicle systems management; and advanced R&D in the following areas:

- Augmented reality technology combined with electronic procedures;
- Intelligent systems for semantic search / Aerospace ontology;
- System modeling for fault management; and
- High reliability / fault tolerant architectures.

Distinctive benefits to these capabilities include access to engineers who develop software that meets NASA's stringent certification requirements and work with humans-in-the loop testing on a routine basis. JSC's software reliability and fault tolerant architectures are robust enough to fly in the unforgiving environments of space.

For more information, please visit JSC's Space Craft Software webpage located >**here.**

9. Crew Exercise Systems <back to index>

JSC has extensive experience in designing highly reliable, lightweight, low volume and low power exercise systems for astronauts' use in space. This expertise can be used to develop similar exercise systems for Earth applications, where weight, volume, and power are limited or high reliability and functionality are required.

The JSC core capabilities for prototyping, design, analysis, fabrication, testing, and integration which are tailored to the environments for humans living and working in space are:

- Development of mechanical and electrical systems for microgravity environment within tight power, thermal, mass, and volume constraints;
- Development of Vibration Isolation and Stabilization systems;
- Advanced treadmills;
- Advanced resistive exercise devices;
- Human-machine integration;
- Integration of actuators and diagnostics sensors;
- Integration of physiological monitoring equipment with feedback capabilities;
- Reliability and flight-certification testing; and
- Management of teams with a wide variety of stakeholder disciplines.

Although these exercise systems were developed for humans in space, potential Earth applications include rehabilitation centers, physical therapy centers, medical facilities, or locations where space, power, or system weight is limited.

JSC has developed a suite of exercise equipment that meets NASA stringent certification requirements ("human-rated"). This equipment is used daily by astronauts onboard the International Space Station and includes an advanced resistive exercise device and a treadmill and ergometer with vibration isolation and stabilization.

JSC's experience and expertise is now being applied to the next generation of exercise systems--driven by the need to reduce mass, volume, and power requirements while improving reliability and functionality.

In addition to physiological benefits, exercise also provides psychological benefits such as stress relief. To enhance the physical and psychological benefits of exercise, the next generation activity will include research into existing exercise studies, evaluation of commercial products, data collection to compare physiological and psychological benefits from use of various exercise systems and regimes, and development of advanced hardware and software

Future concepts include integrating augmented reality, virtual reality, dynamic feedback, improved user control interface, integrated user workout prescriptions, and provide variety and motivation for improved user performance and prescription compliance. Concepts include identifying and developing physiological monitoring devices that provide reliable data collection and insight into exercise effectiveness (e.g. heart rate monitors, BP/ECG devices, exercise form recording and feedback, pulse oximetry, etc).

For more information concerning JSC's unique capabilities in Crew Exercise Systems, please visit our webpage located >here.

10. Structural & Manufacturing Testing, Analysis and Engineering Capability <back to index>

JSC has numerous unique capabilities to design, analyze, manufacture and test material and structural elements supporting safety critical flight hardware. Additionally, we have a full range of end-to-end structural test labs that conduct acoustic, environmental, vibration and direct load application, as well as technical expertise to analyze test results. Our manufacturing capability consists of end-to-end design and manufacture requiring tight tolerances while meeting the safety critical rigor of the flight hardware rated process.

The end-to-end structural engineering capabilities include:

- Testing and analyzing exotic materials and composites in extreme environments;
- Integration of materials into novel new structural designs such as inflatable structures;
- Design of systems and subsystems for aircraft and space flight vehicles;
- Research and development of new advanced manufacturing techniques;
- Rapid prototyping and fabrication of components and systems for aircraft and spaceflight vehicles, and structures, requiring high precision and tight tolerances; and
- Structural, thermal vacuum and environmental testing of flight components and vehicles.

The core capabilities available at JSC that are essential to structures are:

- Metallic spacecraft structures (potential for non-aerospace applications);
- Composite spacecraft structure (potential for non-aerospace applications);
- Inflatable spacecraft structure (potential for non-aerospace applications);
- Spacecraft windows (potential for non-aerospace applications);
- Pressure integrity of habitats, enclosures, or structures; and

- Seismic floor, load frames, multi-axis load control system, thermal chambers.

For more information please visit our website

11. Imaging Science <back to index>

JSC's Imaging Science encompasses imagery acquisition planning and comprehensive imagery analysis employing expertise in photogrammetry, high-precision motion tracking, and imagery enhancement techniques. JSC's Image Science and Analysis Group built and honed expertise in scientific and engineering analysis of photographic and video imagery to assess space vehicle performance, dynamic events, and anomalies. These capabilities include:

- Imagery acquisition planning, utilizing the application of modeling and calibration tools to define camera system sensors, placement, fields of view, lighting needs, lens and camera settings (e.g. exposure, frame rates, depth of field), in order to fulfill engineering data or situational awareness needs;
- Applying photogrammetric techniques to acquire 2 and 3-dimensional measurements from imagery for analysis of clearances and dynamic motion (position, velocity, and acceleration);
- Custom software tools created for analyzing imagery not originally intended for study. These tools account for variability in camera positions and orientations relative to the subject and inconsistency in the camera complement, which often represents technology that spans multiple decades, variable film and digital formats, poor image quality and varying photographic skills;
- High-precision motion analysis of objects or structure using software to track the 2-dimensional coordinates of pixels in an image sequence. Expertise is used in analysis of system performance, structural loads and jettison trajectories; and
- Rigorous and systematic imagery screening utilizing enhancement and restoration image processing methods to correct for degradation issues such as poor exposure, distance, motion blur or camera focus.

For more information concerning our Image Science and Analysis Laboratory, please visit our website.

12. Battery Design, Development and Testing and Cell Analysis and Testing <back to index>

JSC possesses a suite of tools, test equipment, and test chambers to meet most any battery and cell testing need. The co-location of these assets makes JSC unique and able to perform any performance, abuse or environmental testing desired.

JSC has extensive expertise within its battery and cell technology group. These experts can provide consultancy with the following unique capabilities:

- Expertise in various battery chemistries for space and ground applications:
    - Primary Lithium battery chemistries such as LiBCX, Li-thionyl chloride, Li-sulfuryl chloride, Lithium-sulfur dioxide, $LiCF_x$, $LiFeS_2$ and $LiMnO_2$;

- Rechargeable lithium-ion chemistry including li-ion pouch/polymer cell designs;
- Rechargeable Nickel metal hydride (NiMH), Nickel cadmium (NiCd) battery chemistries, primary and rechargeable Silver-Zinc (AgZn) and primary alkalines;

- Expertise in battery chemistry selection and battery sizing/trade studies for various applications based on experience with commercial-off-the-shelf (COTS) and custom designed cells and batteries;
- Expertise in safety of batteries for human-rated applications that include habitable and non-habitable volumes;
- Extensive experience in designing and testing batteries for human-rated safety that includes space vehicle main power;
- Extensive experience in problem solving cell and battery issues through cell and battery surveillance work;
- Experience in conducting classes on battery safety and battery certification for space and ground applications. Classes have been conducted at the European Space Agency and NASA-JSC for test engineers, technicians, project managers, and project engineers for more than ten years; and
- Experience and expertise in areas such as weld analysis, analysis of cell components, i.e., electrodes and electrolytes, as well as gas analysis.

The battery and cell test capabilities include:

- Test equipment with a range of voltage and current capability (from -5.0 V to 446 V and ±10mA to ±4000 A) used to test cell and battery performance in different thermal environments, vacuum and vibration environments;

- Cell and battery safety test chambers that can withstand up to 100 psig and a diameter of up to 2 feet used to test cell and battery safety under conditions such as overcharge, over discharge, external short circuit, and heat-to-vent. The chambers have capability to obtain gas samples from vent products for post-test gas analysis;

- Cell and battery non-chambered safety test for simulated internal short, drop, vent and burst pressure determination testing;

- Thermal chambers with a temperature range from -73 to 190 °C;

- Long-term cold storage with walk-in freezer;

- Vacuum chambers with capability down to 10^{-5} Torr with Pyrex see-thru design (important for li-ion pouch cell vacuum tolerance studies) and protective blast barrier;

- Laboratories with spectrometers, glove box, gas chromatographs, infra-red spectrometers, high-performance liquid chromatographs, vent hoods, etc. to carry out destructive physical analysis of fresh and cycled cells and capabilities for analysis of electrolyte liquids as well as vent gases; and

- Associated infrastructure to accomplish the above includes trained, experienced personnel, approved procedures, safety equipment, test chambers, etc.

NASA JSC has other capabilities on-site that provide support to the battery team in the areas of cell and component analysis using Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDS), optical microscopy, high resolution X-ray and CT scanning.

The co-location of these assets makes JSC unique and able to perform any performance, abuse or environmental testing desired.

More details of JSC's battery design, development and testing and cell analysis and testing unique capabilities are available at website

13. Large Scale Underwater Testing in Controlled Environment (Neutral Buoyancy Laboratory) **<back to index>**

JSC's Neutral Buoyancy Laboratory (NBL) is one of the world's largest indoor pools and can support multiple large scale operations utilizing both underwater and topside assets simultaneously. The NBL is utilized for mission planning, procedure development, hardware verification, astronaut training, and refinement of time-critical operations necessary to ensure mission success during spacewalks.

The Pool

- Length: 202 ft (61.5 m)
- Width: 102 ft (31.1 m)
- Depth: 40 ft (12.2 m)
- Volume: 6.2 million gallons
- Water composition: Chlorinated fresh water
- Water temperature: 84°-86° F (28.9°-30° C)

NBL Facility Capabilities

- Multiple integrated control rooms
- Clean climate controlled environment
- Extensive video and audio capabilities
- Multiple crane systems for equipment handling
- Professional dive support and dive systems
- On-site engineering and technical services
- Co-located logistics and manufacturing facility
- Multiple classroom, meeting, and high-bay work areas
- Time-critical, mission success ready and experienced workforce
- World class safety culture

Diver Support

With an experienced and certified professional diving staff, the NBL offers operations support, reconfiguration, camera operations and safety diving functions. The NBL utilizes Self-Contained Underwater Breathing Apparatus (SCUBA) and surface supplied dive systems, with Nitrox and air and has an on-site Hyperbaric Chamber. There is an ISO Level 8 Clean Room supporting maintenance and repair capabilities.

Buoyancy

The NBL has extensive experience manipulating buoyancy to simulate full or partial gravity and to make mass handling in the water more manageable.

Logistics and Mockup Facility (LMF)
The LMF consists of a large high bay, a series of workshops for building and maintaining equipment, and a cadre of highly skilled and certified personnel. LMF services include welding, machining, sewing, assembly, woodworking, and multi-disciplinary engineering.

Site Support
The NBL is conveniently located next to the Houston Ellington Airfield with access to a taxiway. The NBL has outdoor space to support training activities along with covered and uncovered areas to store hardware. Within the facility, the NBL has a hyperbaric chamber, a hypobaric altitude chamber, a medical treatment room and locker room facilities.

For more information please visit our website

14. Environmental & Life Support Systems, Air/Water Monitoring & Recycling, Active Thermal Control & Extreme Environment Protective Suites **<back to index>**

JSC's unique capabilities in this critical area include a full range of end-to-end human rated environmental and thermal simulation chambers, test labs, and tools as well as technical expertise associated with analyzing resultant data and operations. A distinguishing benefit to these capabilities is the access to engineers and technicians who work with human rated testing on a daily basis, as well as support continuous astronaut and cosmonaut training and mission operations.

These unique end-to-end human rated capabilities include:

- Design of environmental control and life support subsystems and complete systems for orbital space flight vehicles with critical requirements for long duration cabin pressure, oxygen management, carbon dioxide and trace contaminant removal, and humidity control;
- Rapid prototyping and fabrication of custom tailored components and systems for environmental control, thermal control, and protective suits;
- Thermal vacuum and environmental testing and analyzing systems, assemblies, and entire vehicles, with humans in the loop, in extreme environments;
- Thermal technology development, design, analysis, and test of active thermal control systems (ATCS) for orbital spacecraft and space flight systems (The traditional functions of ATCS include heat acquisition, transport, storage and rejection, and physical components may include cold plates, heat exchangers, pumped fluid loops, thermal transport fluids, heat pipes, evaporative systems, radiators, and thermal storage media. Primary unique development interests include mass reduction, system efficiency, reliability, fluids performance, variable heat rejection capability, phase management, and system architecture.); and
- Evaluation of textile material properties for use in extreme or hazardous environments.

The JSC core capabilities for prototyping, design, analysis, fabrication, testing, and integration which are uniquely tailored to the environments for humans living and working in low-earth orbit and beyond are:

- Environmental control and life support systems;
- Air and water filtration and monitoring systems;
- Active thermal control systems;
- Extra-Vehicular Activity (EVA) and Launch/Entry Suit (LES) systems;
- Advanced clothing systems;
- Habitation and crew provisioning systems;
- Payload and sample-return cold stowage systems; and
- Custom gloved-hand tools and work aides.

For more information please visit our website.

15. Crew Interface Rapid Prototyping Lab **<back to index>**

The Crew Interface Rapid Prototype Lab (RPL) offers the capability to quickly create cockpit mockups and prototype vehicle-crew interfaces. The RPL has a small team of developers led by experienced shuttle and space station astronauts. The RPL is dedicated to providing quick and accurate solutions to challenges in human spaceflight vehicle interfaces. The RPL is used to:

- Evaluate spacecraft cockpit displays and user interface elements;
- Provide generic cockpit development and simulation software (already in use with several major human space vehicle programs); and
- Provide low-cost cockpit mockups and prototypes of spacecraft crew interfaces.

Partners can benefit by using our generic designs as a starting point for their own designs, and are free to adapt our designs in whole or in part. Our capabilities, which may be applied to other industries, include our electronic procedures system which integrates procedures directly with displays ‘on the glass’ to achieve an all-glass, paperless cockpit while significantly reducing crew workload. Over the past decade, the RPL has prototyped, evaluated, or helped define glass cockpits for the Shuttle Cockpit Avionics Upgrade (CAU), the X-38, the Boeing CST-100 and the Orion Multi-Purpose Crewed Vehicle (MPCV).

The close proximity, direct participation, and leadership by the astronauts are essential ingredients for the RPL’s effectiveness. Our unique capabilities include the following:

- Prototyping avionics suite for spacecraft glass cockpits;
- Building and integrating MATLAB, ANTARES, and other models to drive the suite;
- Constructing functional prototypes of cockpit components and integrate them with physical and mathematical models to allow “flying” the cockpit;
- In close collaboration with JSC’s Mission Operations, Human Health & Performance human factors, and Engineering personnel, using the test bed to perform representative tasks for each phase of flight to evaluate displays and user interface elements; and
- Providing hands-on capability for customer project staff to exercise their designs.

Because of its access to the expertise of flown astronauts and the operational community of the Johnson Space Center, the RPL offers unique capabilities not available commercially. These include the ability to perform crew evaluations quickly, and to access forty years of human spaceflight experience at JSC. Additionally, the RPL has an existing code base of government-developed display and simulator software which can be directly applied to user interface challenges.

16. Propulsion System Design, Development, and Test <back to index>

JSC has led the development and certification of the majority of NASA's in-space on-board human spacecraft propulsion systems and is actively engaged in the development and demonstration of advanced propulsion system technologies. Expertise is available to support development of cold gas, warm gas (e.g. Tridyne), monopropellant, bi-propellant, and cryogenic propulsion systems from concept definition to flight. The co-location of these assets makes JSC unique and able to perform most any propulsion system testing desired.

The following Design and Analysis services are available:

- System design including vehicle integration of propulsion systems;
- In-house tools for rapid parametric propulsion system sizing;
- Thermal fluid network modeling;
- Water hammer and gas dynamics analysis;
- Thermal modeling including cryogenic systems;
- Rocket engine performance modeling including combustion kinetics and nozzle design;
- Computational Fluid Dynamics (CFD);
- Thermal mechanical design & analysis; and
- Mechanical design and solid fuel modeling.

The design and analysis services described above are complemented with JSC's unique propulsion test capabilities including:

- **Liquid Oxygen/Liquid Methane Mobile Test Platform (CryoCart):** CryoCart provides a flexible test platform for the screening and evaluation of small components and systems. CryoCart was built in-house to leverage test set up with minimal reconfiguration between tests and minimal operational overhead. CryoCart is fully mobile and portable with on-board data acquisition, and the separate LO2 and Methane carts have on-board helium pressurization and can be operated individually or as a pair with minimal operational overhead (2 operators). The carts are capable of providing propellant flow rates to support <1 lbf to 100 lbf class thruster hot-fires.

- **Integrated Cryogenic Propulsion System Thermal Vacuum Chamber Testing:** 15 ft diameter high vacuum (10^{-05} torr) test chamber with a modular cryogenic propulsion system test bed for integrated system testing to support technology development and demonstration for space storable cryogenic propulsion systems.

- **LO2-Methane Terrestrial Free Flyer Test Bed (Morpheus):** Morpheus was built in-house and provides a versatile platform to support integrated vehicle-level test and demonstration of spacecraft systems including non-toxic propellant technologies, integrated propulsion/avionics/GN&C architectures, and Autonomous Landing Hazard Avoidance Technology (ALHAT). It has the ability to fly analog trajectories such as Lunar descent using LO2/Methane propulsion for low-cost testing with rapid recycle time. Morpheus also provides a unique capability to test cryogenic hardware in an integrated flight environment.

- **Advanced Propulsion Physics Laboratory (Eagleworks):** Eagleworks Laboratories is equipped with a low thrust torsion pendulum capable of measuring single digit micro-Newton forces real-time with no signal averaging. The torsion pendulum is in a vacuum chamber located on a seismic isolation table. A Philtec optical displacement sensor collects data. The facility has the capability of providing high voltage DC power (up to 40,000V), and 500W of RF input power from 10kHz to 200MHz.

  Eagleworks is also equipped with a warp field interferometer that is finishing commissioning to measure spatial distortions at $1/100^{th}$ a wavelength of a He-Ne laser. The interferometer is located in a seismically isolated room, utilizing advanced software algorithms coupled with high fidelity physical lab setup to accomplish this sensitivity. The algorithms are capable of improving raw image quality significantly (removing diffraction and lens blemish artifacts) prior to passing the imager data to the advanced mathematics algorithms. An enhanced interferometer is being developed to measure spatial distortions at specific discrete points in space as well.

Specific testing parameters, component and system processing capabilities, available test fluids, and other services are described below:

- Environmental Testing
  - Vacuum to $1x10^{-6}$ torr
  - Thermal vacuum to $1x10^{-6}$ torr and -300 F to +300 F
  - Vibration (Random, Sinusoidal, Shock) of pressurized components
  - Combined Environment
- Component and System Processing
  - Precision Cleaning
  - Hydrostatic and Pneumatic Pressure Testing
  - Refurbishment
  - Battery Maintenance
  - Leak Testing including helium mass spec
- Available Fluids
  - Helium – 10,000 psi gas; atmospheric liquid
  - Nitrogen – 20,000 psi gas; 400 psi liquid
  - Oxygen – 2,000 psi gas; 350 psi liquid
  - Methane – 2,000 psi gas; 350 psi liquid
  - Hydrogen – 2,000 psi gas
  - Water – 60,000 psi
- Specialty Services
  - Super high-speed video

- Hypergolic and propulsion altitude simulation testing available at the WSTF

17. Space Vehicle Mockup Facility <back to index>

JSC's Space Vehicle Mockup Facility (SVMF) consists of mockups of the International Space Station, Orion, and commercial module providers in addition to part-task trainers and engineering tools. The SVMF is utilized for procedure development, hardware verification, high-fidelity training for space flight crews, and real-time mission support. Extensive engineering and mission operations evaluations for multiple space flight programs are supported within the facility.

SVMF Facility Capabilities

- Clean climate controlled environment
- Extensive video, audio and network capabilities
- Multiple crane systems for handling hardware up to 10 tons
- Extensive material handling equipment
- On-site engineering and technical services
- Rapid prototyping and fabrication of components
- Multiple classroom, meeting, and high-bay work areas
- Time-critical, mission success ready and experienced workforce
- World class safety culture

Partial Gravity Simulator (POGO)

The Partial Gravity Simulator consists of servos, air bearings and gimbals to provide accurate simulations of reduced gravity for both human subjects and hardware.

Precision Air Bearing Floor (PABF)

The Precision Air Bearing Facility's 32-ft by 24-ft (10-m by 7-m) stainless steel surface provides a two-dimensional simulation (three degrees of freedom) of a weightless environment. The PABF is useful as an engineering tool and crew training device, particularly in developing and teaching mass handling techniques by floating objects on a thin cushion of air.

18. Space Mission and Hardware Integration <back to index>

JSC's unique Space Mission and Hardware Integration capabilities include a seasoned cadre of mission and payload integration managers, with extensive experience from almost 30 years of Space Shuttle flights and 15 years of ongoing International Space Station operations. JSC intends to share this extensive experience and lessons learned in end-to-end mission development and integration of the human and cargo aspects for spaceflight. Our unique capability is end-to-end human/cargo spaceflight planning ranging from concept development to integrated architecture assessments to mission integration, and flight certification. These JSC capabilities will be of interest to the emerging commercial space industry, individuals and companies whose goal is to fly humans and cargo on commercial space vehicles. JSC specific goals are to advance Human Exploration and to share our knowledge base so as to increase the likelihood of success

for new commercial spaceflight companies focusing on human/cargo complements. Capabilities include:

Mission Concept Development

- Concept of Operations development
- Functional Systems Analysis and Capability Derivation
- Integrated Architecture Assessments

Mission Integration

- Mission requirements definition
- Mission production process definition and execution
- Mission complement and mission performance analysis
- Mission Systems Engineering and Integration
- Integrated Performance Assessments (e.g., loads & dynamics, thermal. EMC, acoustics, environments)
- Mission Flight Safety process development and compliance
- Certification of Flight Readiness process definition and execution
- Integrated Risk Assessments and Mitigation Plans
- Pre-flight and real-time Mission Management

Hardware Integration

- Hardware integration template and schedules
- Requirements definition and review milestones (e.g., hardware interfaces, integration hardware, operations, launch and recovery sites flight processing services)
- Product delivery milestones and responsibilities (e.g., safety data, flight hardware)
- Hardware Flight Safety process development and compliance
- Hardware operational and malfunction pr0cedures development
- Hardware physical integration and interface testing
- Hardware Flight Readiness process development and execution

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Response to Johnson Space Center **Announcement of Unique Capabilities** **NNJ13ZBH014L** Statement of Interest – One Page Summary
RESPONDENT INFORMATION
Company Name:
Company address:

Response to Johnson Space Center

Announcement of Unique Capabilities

NNJ13ZBH014L

Statement of Interest – One Page Summary

City:	State:	ZIP Code:
U.S. Subsidiary of International Company (Yes/No):		
If Yes, Company Headquarters Country of Origin:		
Website:		
Company Size (Personnel; Gross Revenue/Yr):		
Company Product or Service Line:		
PRIMARY POINT OF CONTACT (POC)		
Name/Title:		
Email:		
Phone (office):	Phone (cell):	
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Response to Johnson Space Center **Announcement of Unique Capabilities** **NNJ13ZBH014L** Statement of Interest – One Page Summary
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