

National Aeronautics and
Space Administration

A collage of space-related images including Mars, a rocket launch, the Moon, and Earth from space, all set against a dark blue grid background with a white orbital path.

Dual-Use Technology Development at NASA George C. Marshall Space Flight Center Cooperative Agreement Notice (CAN) Overview

MPCSC Bi-Monthly

16 July 2020

Scott Hutchins
NASA MSFC CS02
256-544-0225
256-520-3363 (mobile)
scott.hutchins@nasa.gov



EXPLORE MARSHALL

Dual-Use Technology Development @ Marshall Space Flight Center

Cooperative Agreement Notice (CAN)

Enhance Marshall's ability to partner with U.S. universities and industry to advance a technology development objective of the Partner as well as help meet a specific NASA/MSFC mission need

Solicit, competitively select, establish and support the accomplishment of collaborative, resource-sharing Cooperative Agreement projects where:

- 1. The Partner is developing a technology primarily for its own public purposes**
- 2. The proposed technology complements the technology development interests of Marshall**
- 3. NASA/Marshall can provide financial support and/or other in-kind assistance**



NATIONAL AERONAUTICS AND SPACE
ADMINISTRATION (NASA)

George C. Marshall Space Flight Center
Office of Strategic Analysis and Communications (OSAC)

Dual Use Technology Development at Marshall Space Flight Center
2020

COOPERATIVE AGREEMENT NOTICE (CAN)

ANNOUNCEMENT NUMBER: 80MSFC19N0001

CATALOG OF FEDERAL DOMESTIC ASSISTANCE
(CFDA) NUMBER: 43.009

ANNOUNCEMENT TYPE:

Initial announcement of this funding opportunity

Issued: September 12, 2019
(Amendment 2 issued June 22, 2020)

KEY DATES:

This CAN is effective until **September 30, 2020**
Other Key Dates are found on pages 4 and 23 of this CAN

- **2020 Marshall CAN release date: 12 September 2019 w/ Amendment 2: 22 June 2020**
 - **2020 MSFC CAN Solicitation number: 80MSFC19N0001**
 - **Released annually: Typically in August or early September of each year**
- **Posted on NASA NSPIRES and FBO (beta.SAM.gov) soliciting U.S industry and university responses**
- **2 Step Process**
 - **Step-1: White Paper submittal** **Step-2: Invited full Proposal submittal**
- **MSFC resource contributions to the Partner range from \$10K - \$250K in value for each awarded project**
 - **Cash contribution or in-kind contributions (MSFC labor, facility use, materials, etc.), or both**
- **Partner in-kind resource contributions must match or exceed the MSFC contribution to the project**
- **Project Period of Performance – up to 1 year. No-cost extensions (NCE) for additional project duration**
- **Multiple Cooperative Agreement awards are available**
- **CAN Award Selection Official: MSFC Associate Director, Technical**
- **2 independent opportunities for Step-1 White Paper submissions in each annual CAN**
 - 2020 CAN Due dates: Period 1: October 16, 2019 (completed)**
 - Period 2: May 6, 2020 (underway)**

- **~ 6.0 months from Step-1 White Paper submittal to Cooperative Agreement project start**
- **Includes evaluation/selection of submitted White Papers, development & evaluation/selection of invited Proposals, establishment of Cooperative Agreements for selected Projects**

Marshall Dual-Use Technology Development
Cooperative Agreement Notice (CAN)

Advancing technologies with commercialization potential that also enable or benefit upcoming MSFC programs and projects.

- Innovative/Advanced Propulsion Systems Technologies (launch vehicles, in-space, landers)
- Technologies Supporting Advanced Manufacturing, Structures and Materials
- Habitation Systems and Supporting Technology Development
- Technologies Supporting Environmental Control and Life Support Systems (ECLSS)
- Technologies Supporting Spacecraft Systems (Avionics, Power, Comm, GN&C, etc.)
- Technologies Enabling Science Research (Earth, Solar, Lunar/Planetary, Space Wx & Environments)



**Marshall Dual-use Technology Development CAN
Technology Interest Areas**

Collaboration between the candidate partner PI and Marshall POCs / Subject Matter Experts is permitted and encouraged during White Paper and Proposal development

- Free and open communication & collaboration during:
 - Development of initial collaborative project ideas
 - Advice and relevant MSFC input during the submitting Partner's development of the White Paper and the invited Proposal
- Limited, coordinated communication during:
 - The MSFC evaluation phase of submitted White Papers and invited Proposals
 - Occurs between the White Paper / Proposal submittal date and the MSFC official notification to the offering PI of section/non-selection results
 - Can be initiated and arranged by MSFC POCs but must be coordinated with MSFC Procurement
 - Typically occurs via a telecom with the submitting PI to clarify or address potential concerns with the White Paper or Proposal regarding technical content, cost items, or resource contributions



**Marshall Dual-use Technology Development CAN
Pre-Award Collaboration**

1. Relevance to NASA/MSFC Need

- Does the proposed project provide a satisfactory solution to a specific NASA MSFC need?

2. Technical Quality & Appropriateness

- Technical approach including anticipated partner & MSFC project roles/tasks, the clarity of the expected outcome, the anticipated accomplishments, and the level of technical challenges versus projected benefit

3. Appropriateness of Cost Projections

- Appropriateness and suitability of the total project cost projections.
- Appropriateness and suitability of the proposed MSFC and partner resource sharing contributions to the total project cost

4. Recommendation

- Is it recommended to invite the Step-2 full project proposal?



Step 1 White Paper Assessment Criteria

1. Technical Merit and Feasibility (40%)

- Project merit, approach, deliverables / personnel & facilities / Technical Schedule & Milestones

2. Business Plan (20%)

- Commercial potential of the technology
 - Industry Partner's commercial objectives for the investment
 - University Partner's research priorities and vision for eventual application to commercial use

3. Cost Plan (40%)

- Cost Plan elements are clearly described and complete for the scope and tasks of the project
- Total estimated resources needed for the project are adequate, and the cash & in-kind resources contributions of MSFC & the CAN project partner are appropriate for each

4. Recommendation

- Is the Proposal recommended to select for a Cooperative Agreement project?

Step 2 Proposal Assessment Criteria

13 cycles of Cooperative Agreement selections completed in 7 annual CAN releases 2014 - 2020

- CAN 2014; CAN 2015 - Period 1, 2 & 3; CAN 2016 - Period 1 & 2; CAN 2017- Period 1 & 2; CAN 2018 Period 1 & 2; 2019 CAN Period 1 & 2
- CAN 2020 Period 1 completed. CAN 2020 Period 2 evaluation and selection process is now underway
- **Total of 132 Cooperative Agreement projects selected for awards from 278 White Papers submitted**
 - **96 university projects and 36 industry projects**
- **~ \$19.6 M in combined university / industry Partners & Marshall project resources**
 - **Total MSFC resource contribution value ~ \$8.9M**
 - Cash contribution to partner and/or MSFC labor, materials, test facility/equipment use or other in-kind contributions
 - MSFC / NASA resource contributions have ranged from \$9K to \$152K per awarded CAN project (up to \$250K max limit as of 2020)
 - MSFC funding is provided by multiple sponsors (MSFC Technical Director, ED, various MSFC Projects, and NASA HQ and other NASA centers, etc)
 - **Total university and industry Partner matching resource contributions: ~ \$10.7M**
 - Labor, materials, facility and equipment use, and/or other in-kind contributions by the Partner to the project
 - Partner individual project resource contributions range from \$9K to \$648K per CAN project
- The current 2020 MSFC CAN is closed for new submissions. Anticipate release of the 2021 MSFC CAN opportunity in August or September 2020



Summary of Marshall Dual-use Technology Development Cooperative Agreement Projects 2014 - 2020

- **58 White Papers submitted in response to the MSFC CAN opportunity (2019 CAN Period 2 + 2020 CAN Period 1)**
 - (+5.5% from previous CAN year: 2018 CAN Period 2 + 2019 CAN Period 1)
- **34 NASA Cooperative Agreement projects for collaborative technology development partnerships awarded by MSFC.**
 - (+ 26%)
- **29 University partnership projects** supporting university faculty principle Investigator research that matches MSFC technology development interests and needs (+ 53%)
 - **Includes 9 projects with MSI universities** (+ 125%)
 - **39 university students** across all academic levels have directly participated in and supported the faculty PI in these collaborative research projects with MSFC (+ 26%)
 - many of these students have used our MSFC CAN project effort as the basis for their Master's or PhD thesis.
 - 10 undergraduate students
 - 9 master's degree candidates
 - 18 PhD candidates
 - 2 Post-doc researchers
- **5 Industry partnership projects** supporting company IRAD project efforts that match MSFC technology development interests and needs (8 last year: - 38%)

Total NASA project resource contributions	= \$2.66 M	(+ 33% from previous year)
Total CAN partner project resource contributions	= \$2.73 M	(+ 15%)
<hr/>		
Total value of combined NASA/partner CAN Project investments	= \$5.40 M	(+ \$23%)

- **Over \$2.66M in MSFC CAN resource funding has been provided by 17 different MSFC and NASA sponsor sources** (+42%. Up from 12 sponsor sources last year)
 - **Sources include MSFC Center IRAD resources, Engineering Directorate resources, various Marshall major program to small project office sponsors, and NASA HQ funding sources**
 - **Occasionally, even funding from project office sponsors at other NASA centers**



2019 CAN Period 2 + 2020 CAN Period 1

5 Industry partners: • C3 Propulsion • CFD Research Corporation • Geoplasma, LLC • Skyre, Inc • Qualtech Systems Inc.

24 university partners including 8 Minority Serving Institution (MSI) universities:

- Auburn • BYU • CalTech • Dillard (MSI) • FAMU (MSI) • FIT • FIU (MSI) • GaTech • LSU • MSU • OSU • Purdue • Rowan • Southern (MSI)
- TennTech • UAH • UofA • UCal Irvine • UF • UNLV (MSI) • UNM (MSI) • Puerto Rico –Mayagüez (MSI) • UTK

MSFC Technology Development areas supported by the 34 CAN Projects for the 2019/2020 award year (some projects cross multiple priority areas)

- **Space Launch System (SLS) - 4 projects**
 - (Verification support tools, Friction Stir Welding advancements)
- **Advanced Manufacturing/Materials - 9 projects**
 - (AM relevant to various applications: ionic liquids for ECLSS & in-situ regolith steelmaking, ultra/supercapacitors, ISM, 3D sensor printing, space structures, thermal control materials, polymers)
- **Propulsion and In-space transport - 7 projects**
 - (Small s/c propulsion (Lunar Flashlight risk reduction), RCS systems, IL mono prop, solar sail, NTP, AM projects targeting LRE Propulsion systems)
- **ECLS Systems - 5 projects**
 - (ECLSS specific applications)
- **Habitat Systems - 1 projects**
 - (AM projects with specific habitat radiation protection applications)
- **Lander Systems - 1 project**
 - (Precision rendezvous guidance)
- **Science - 1 project**
 - (Microwave sensors for global ocean wind research)
- **Crosscutting or supporting - 6 project**
 - (Inertial sensors, engineering modeling/analysis capability, vibration isolation, wireless power, wireless comm)

NATIONAL AERONAUTICS AND SPACE
ADMINISTRATION (NASA)

George C. Marshall Space Flight Center
Office of Strategic Analysis and Communications (OSAC)

Dual Use Technology Development at Marshall Space Flight Center
2021

COOPERATIVE AGREEMENT NOTICE (CAN)

ANNOUNCEMENT NUMBER: 80MSFC20N0001 (TBD)

CATALOG OF FEDERAL DOMESTIC ASSISTANCE
(CFDA) NUMBER: 43.009

ANNOUNCEMENT TYPE:

Initial announcement of this funding opportunity

Issued: Late August or Early September 2020 (TBD)

KEY DATES:

This CAN is effective until September 30, 2022
Other Key Dates are found on pages 4 and 23 of this CAN

- **2021 Marshall CAN release date: late August or early September 2020**
 - **2021 MSFC CAN Solicitation number: 80MSFC20N0001 (TBD)**
 - Released annually: Typically in August or early September of each year
- Posted on NASA NSPIRES and FBO (beta.SAM.gov) soliciting U.S industry and university responses
- 2 Step Process
 - Step-1: White Paper submittal Step-2: Invited full Proposal submittal
- MSFC resource contributions to the Partner range from \$10K - \$250K in value for each awarded project
 - Cash contribution or in-kind contributions (MSFC labor, facility use, materials, etc.), or both
- Partner in-kind resource contributions must match or exceed the MSFC contribution to the project
- Project Period of Performance – up to 1 year. No-cost extensions (NCE) for additional duration
- Multiple Cooperative Agreement awards are available
- CAN Award Selection Official: MSFC Associate Director, Technical
- **2021 CAN may have only 1 opportunity for Step-1 White Paper submissions (instead of the usual 2)**
2021 CAN Due dates: Period 1: ~~October 7, 2020~~ February 3, 2021 (TBD target date)
Period 2: ~~May 5, 2021~~

~ 6.0 months from Step-1 White Paper submittal to Cooperative Agreement project start

- Includes evaluation/selection of submitted White Papers, development & evaluation/selection of invited Proposals, establishment of Cooperative Agreements for selected Projects

Marshall Dual-Use Technology Development
Cooperative Agreement Notice (CAN)

Back up charts



**Marshall Dual-use Technology Development
Cooperative Agreement Notice**

Project Areas of Interest	Engineering Directorate Point of Contact	Contact Information
1. Innovative/Advanced Propulsion	ER64/Jarvis Caffrey	jarvis.a.caffrey@nasa.gov (256) 544-8464
<ul style="list-style-type: none"> - Propulsion systems technologies for launch, in-space transportation, surface landers, and small spacecraft/satellites - In-Space chemical propulsion - Nuclear-Thermal Propulsion systems technologies - Components and systems for engines and reaction control systems - Advanced Manufacturing for Propulsion Elements 		
2. Advanced Manufacturing: Structures and Materials	EM01/DeWitt Burns	dewitt.burns@nasa.gov (256) 544-2529
<ul style="list-style-type: none"> - Additive Manufacturing Technologies - Digital Manufacturing Technologies - In-Space Advanced Manufacturing and Repair 		
3. Technologies supporting Environmental Control and Life Support Systems	ES62/Jay Perry	jay.l.perry@nasa.gov (256) 544-2730
<ul style="list-style-type: none"> - Atmosphere revitalization and/or recovery, including ionic liquids-based processes - Novel structured or pelletized sorbent purification/conditioning of atmosphere - Novel water purification technology 		
4. Technologies supporting Test Capabilities - general	ET01/Ray Shaughnessy	ray.shaughnessy@nasa.gov (256) 544-3622
- Propulsion subsystems and component testing	ER64/Jarvis Caffrey	jarvis.a.caffrey@nasa.gov (256) 544-8464
- Materials testing, Space environments testing	EM01/DeWitt Burns	dewitt.burns@nasa.gov (256) 544-2529
- Avionics systems testing	ES50/Deanna Whitehead	deanna.j.whitehead@nasa.gov (256)544-8787
- Structural testing	ET01/Ray Shaughnessy	ray.shaughnessy@nasa.gov (256) 544-3622

Marshall Dual-use Technology Development CAN Marshall Engineering POC's for Project Area Interest

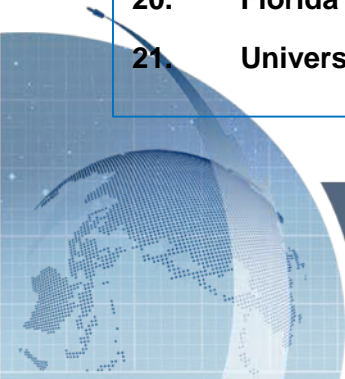
Project Areas of Interest	Engineering Directorate Point of Contact	Contact Information
5. Technologies supporting Spacecraft Systems	ES01/Leigh Anne McMahon	leigh.anne.mcmahon@nasa.gov (256) 544-6768
- Miniaturized low-power subsystems	ES34/Garrick Merrill	garrick.merrill@nasa.gov (256)544-4409
- Guidance, Navigation and Control (GN&C) systems	EV41/John Rakoczy	john.m.rakoczy@nasa.gov (256) 544-1512
- Low Mass and Volume Power-harvesting Technologies and Energy Storage Solutions	ES43/Terry Rolin	terry.d.rolin@nasa.gov (256) 544-5579
- Vehicle Management Systems	EV43/Dwight England	dwight.england@nasa.gov (256) 544-7644
- Wireless Instrumentation and Data Systems	ES33/Ian Small	IAN.K.SMALL@NASA.GOV (256) 544-5398
- Lander subsystems and components	ES12/Matt McSavaney	Matt.mcsavaney@nasa.gov (256)544-8316
- Human In-Space Habitation subsystems	EV74/Charles Dischinger	charles.dischinger@nasa.gov (256) 544-9526
- Advanced Manufacturing: electronic systems	ES33/Ian Small	IAN.K.SMALL@NASA.GOV (256) 544-5398



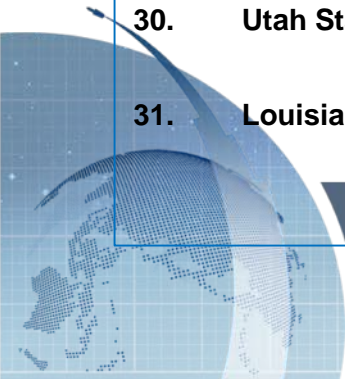
Marshall Dual-use Technology Development CAN Marshall Engineering POC's for Project Area Interest

1.	Mississippi State University	Additive Manufacturing Process for Fabrication of Large Aerospace Structures
2.	Mississippi State University	Improving Inter-laminar Shear Strength of “Out of Autoclave (OOA)” Composites
3.	University of Alabama	LOX Expansion Cycle
4.	University of Alabama in Huntsville	Optimization of Ultra-capacitors for Energy Storage
5.	University of Florida	Cryogenic Transfer Line Chillover Correlations in Generalized Fluid System Simulation Program (GFSSP)
6.	University of Alabama in Huntsville	Low-Cost Plasma Micropropulsion Using 3-D Printing and Off-the-Shelf Components
7.	Utah State University	Vacuum Test and Plume Contamination Measurements of Novel Green-Propellant Thruster for Small Spacecraft
8.	University of Alabama in Huntsville	Development of the Ultrasonic Stir Weld (USW) Process
9.	Alabama A&M University	Development and Characterization of Semiconductor Materials for 3D Printing of Electronic Components
10.	Rice University	SNAP-IMS: A snapshot hyperspectral imager for Earth Remote Sensing
11.	Purdue University	Characterizing mission and system architectures via analysis of operational and developmental interdependencies

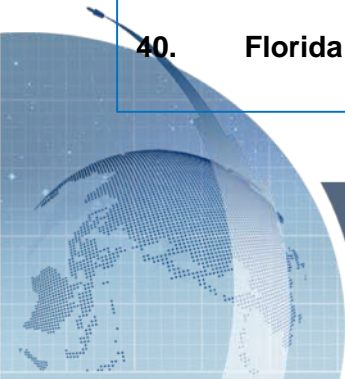
96 University Cooperative Agreement Projects Completed and Active

- 
- | | | |
|-----|---------------------------------------|--|
| 12. | Massachusetts Institute of Technology | Dual Mode Green Propulsion Proof of Concept: Providing Both Innovative Green Propulsion and Micro Propulsion for Small Spacecraft |
| 13. | Missouri University of S&T | Multi-Mode Micro-Propulsion for Small Spacecraft |
| 14. | Navaho Tribal University | Hydrocracking Biomass for Rocket Fuel |
| 15. | Auburn University | Octocopter Testing of Low-Cost Automotive Sensors for Lunar and Planetary Landing |
| 16. | University of Alabama in Huntsville | A Variable Step-size Control for Long Time Transient Simulation of Cryogenic Heat Transfer Problems Using Generalized Fluid System Simulations Program (GFSSP) |
| 17. | Virginia Tech University | Supersonic Testing of a Neutral Wind/Drag Detector for LEO |
| 18. | Auburn University | Chaos Baseband Transmitter and Receiver |
| 19. | University of Alabama | LOX Expander Cycle (LEC) |
| 20. | Florida Institute of Technology | SVGS-Based Navigation of RINGS onboard ISS |
| 21. | University of Alabama in Huntsville | Fatigue Behavior of Free Form, Additively Manufactured Inconel 718 |

**96 University Cooperative Agreement Projects
Completed and Active**

- 
22. Rutgers University Wireless, Multi-coil Readers for Structural Health Monitoring
 23. The George Washington University μ CAT Thruster Technology for Attitude Control and Primary Propulsion for Small Spacecrafts and Cubesats
 24. University of Alabama in Huntsville Spark Plasma Sintered (SPS) Ultracapacitors for Space Applications
 25. University of Louisville Process Characterization for Lightweight Geometries Using PBF Additive Manufacturing
 26. University of Maine Wireless Deflection Sensor System for Ground Structural Tests
 27. Mississippi State University A balloonsat service bus for the Rice U snapshot hyperspectral imager
 28. University of Arkansas Characterization of LTCC-manufactured Electrostatic Thruster (LTCC-ET)
 29. University of Alabama in Huntsville Advanced processing techniques to produce tooling materials for friction stir welding
 30. Utah State University Performance Optimization of 3-D Printed Hybrid Rocket Fuel Materials
 31. Louisiana State University Technology Development for Advanced Gravitational Radiation and Electromagnetic Counterpart Searches

**97 University Cooperative Agreement Projects
Completed and Active**



32.	Utah State University	Heterogeneous Strain Measurement during Hot-Fire Testing of Carbon-Carbon Rocket Nozzles
33.	Auburn University	Additive Manufacturing of Durable Mission-Critical Components by Establishing Process-Structure-Property-Performance Relationships
34.	University of Alabama in Huntsville	Processing-Structure-Property Relationship in Additively Manufactured Lattice Structure Alloys
35.	University of Alabama in Huntsville	Optimization of Ferroelectric Ultra-Capacitors for Energy Storage - Phase 2
36.	University of Utah	Space Debris Identification and Tracking System Based on a Real-time, Adaptive Motion Processing Algorithm
37.	Massachusetts Institute of Technology	Thermally Stable Nanocrystalline Nickel Alloys by Powder Metallurgy
38.	University of Alabama	Numerical Analysis Tool to Predict Fatigue and Failure of Friction Stir Weld Pin Tools for SLS Production
39.	Univ of Tennessee Space Institute	Ionic Liquid Propellants for Micro-propulsion
40.	Florida Institute of Technology	Redeployment of SVGS for Rendezvous and Docking in Space Applications

**96 University Cooperative Agreement Projects
Completed and Active**

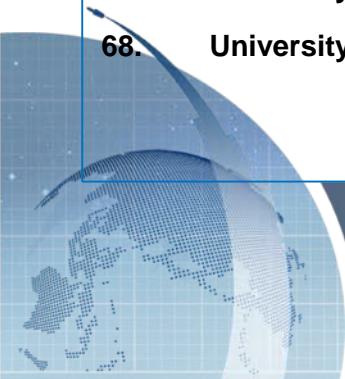
41.	Univ of Alabama in Huntsville	Quantifying Bi-metallic Joints Formed Using a Free-form, Hybrid Process to Improve the Reliability and Increase the TRL for an Additive Manufactured Rocket Component
42.	Arizona State University	Preliminary Investigation into Dissolvable Supports for Additively Manufactured Inconel 718 Components.
43.	University of Alabama	Advanced Polymer Materials to Support NASA Technology Needs
44.	Univ of Alabama in Huntsville	Evaluation of Intelligent Sensor Platforms for 3D Printed Electronics for Space Applications
45.	Iowa State University	Novel High Power-to-Weight Ratio Solar Cell on Flexible Polyimide Substrates For Space Power Applications
46.	Alabama A&M University	Feasibility Study on the Recycling Method for Material Preparation for the In-Situ 3D Printing of Electronics
47.	Auburn University	Improving Dielectric Strength to Achieve a Giant Energy Storage Density in Ferroelectric Based Ultra-capacitors
48.	Univ of Louisiana Lafayette	Development of Material Properties of Inconel, Titanium, and Nickel Alloys for Process Optimization of Selective Laser Melting Additive Manufacturing
49.	Wichita State University	Study on Development of New Detector Technology for Solar-neutrino Spacecraft

96 University Cooperative Agreement Projects Completed and Active



50.	Cornell University	Design, Analyze, and Verify the Performance of a 5N Water-Electrolysis Small-Sat Propulsion System
51.	University of Alabama in Huntsville	Engineering robust Friction Stir Welds by Using Digital Manufacturing Technologies
52.	University of Tennessee Knoxville	Printed Metallic Sensors Based on 3D Printing and Laser Sintering of Al Nanoinks
53.	University of Texas at El Paso	Advanced Additive Manufacturing for 1N and 5N Green Propellant Thrusters
54.	Auburn University	Enabling the Digital Twin for Additively-Manufactured Metallic Parts via Defect-Sensitive Mechanical Models
55.	University of Alabama in Huntsville	A Low-Profile, Reconfigurable Wideband Wireless Antenna for Structural Health Monitoring Sensor Applications
56.	University of Mississippi	Developing a Novel Method to Bond Planetary Regolith to Form Rigid Structures for Space Based Habitats
57.	Alabama A&M University	Damage Tolerance Characterization and Environmental Sensitivity of Custom 465 Alloy
58.	University of Alabama in Huntsville	Evaluation of Alternative Nickel-based Superalloys for Additive Manufacturing of Liquid Rocket Engine Components

96 University Cooperative Agreement Projects Completed and Active



59.	University of Texas at El Paso	Additive Manufacture of Porous Zirconium-Carbide for Nuclear Thermal Propulsion
60.	Iowa State University	Non-Contact Creep Characterization of High Temperature Materials for Nuclear Thermal Propulsion
61.	Colorado School of Mines	Process Development of Rapid Powder Removal for Additively Manufactured GRCop Copper Alloys
62.	University of Massachusetts Amherst	Understanding of Thermophysical Properties Towards Advanced Manufacturing of High Entropy Alloys
63.	University of Alabama in Huntsville	Fatigue Strength and Behavior of Additively Manufactured Lattice Structures
64.	Oklahoma State University	Ionic Liquid-Assisted Extractive Distillation for the Removal of Dimethylsilanediol
65.	Tennessee State University	Cognitive Work Analysis for Manual Steering of Highly Automated Systems
66.	Wichita State University	Pinned Joints of Composite Honeycomb Sandwich Panels
67.	University of Alabama in Huntsville	Subscale Magnetic Nozzle For Fusion Propulsion Plasma Deflection
68.	University of Washington	A High Repetition Rate, Scalable, Pulsed PPU for Electric Propulsion Applications

**96 University Cooperative Agreement Projects
Completed and Active**

69.	Purdue University	Integrated Green Propulsion Reaction Control System Module for Spacecraft and Small Launch Vehicle Applications
70.	Dillard University	Computational Approaches to Understanding the Shape Memory of Ionic Polyimides for Additive Manufacturing
71.	Auburn University	Flexible Ultracapacitor Energy Storage Devices for Wearable Crew Health Sensor Platforms
72.	Mississippi State University	Towards Steelmaking from Martian Regolith Metals Recovered Using Ionic Liquids
73.	University of Alabama in Huntsville	Compact Green Sensors for Electromagnetic Power Harvesting Applications
74.	University of Alabama	Utilizing Synthetic and In Situ-Generated Materials for Additive Manufacturing
75.	University of Florida	Measurement of Interfacial Tension of Additive Materials using the Electrostatic Levitation System (ELS)
76.	University of Nevada, Las Vegas	Designing Ionic Liquids Based Adsorbent for Treating Dimethylsilanediol Contaminated Water in International Space Station
77.	Georgia Institute of Technology	Ionic Liquid Interactions with Functionalized Carbon Nanotubes for Supercapacitors
78.	Brigham Young University	Developing Microwave CubeSat Sensors for Global Ocean Wind Vectors for Eventual Use in a Constellation Providing Near-hourly Revisit

96 University Cooperative Agreement Projects Completed and Active

79.	University of Alabama	Development of Metasurface Reflectors to Enable Future Solar Sail Mission
80.	Georgia Institute of Technology	Configurable Propulsion System Controller for Lunar Flashlight
81.	University of New Mexico	Quantum Limits of Inertial Sensors
82.	University of Alabama in Huntsville	Advanced Tooling Demonstration for Friction Stir Welding of Heat Resistant Materials
83.	California Institute of Technology	Printable Molecularly Imprinted Polymers for Cortisol Sensing
84.	University of Alabama in Huntsville	Critical Flow Performance and Mechanical Property Evaluation of Additively Manufactured Thin-Wall Copper-Chrome-Niobium Alloys
85.	Florida International University	Multi-Functional Boron Nitride Nanotube-Reinforced Titanium-Based Metal Matrix Composites For Space Vehicles And Structures With Improved Wear Resistance And Radiation Shielding Property
86.	University of Alabama in Huntsville	Interface Mixing Mechanisms in the Additive Manufacturing of Copper and Nickel Based Alloys and their Influence on Repeatability and Reliability
87.	Missouri Univ of Science & Technology	Characterizing the Performance of Ultra-High Temperature Ceramic Fuels for Nuclear Thermal Propulsion Technology

**96 University Cooperative Agreement Projects
Completed and Active**

- | | | |
|-----|---|---|
| 88. | Florida Agriculture and Mechanical University | Viability Assessment of Printed Powerless Sensors Structures for Aerospace Environment |
| 89. | University of Tennessee, Knoxville | Enhanced Equipment Isolation in Extreme Vibratory Environments using Rotational Inertial Devices |
| 90. | Rowan University | Wireless SmallSat Interface Technology for Rapid Mission Integration and Post-Deployment Reconfigurability |
| 91. | Florida Institute of Technology | Precision Landing of a Hexacopter Drone by Smartphone Video Guidance Sensor |
| 92. | University of Puerto Rico -Mayagüez | Low Melting Point Metallic Suspension Nano-composite PCM as a Thermal Solution for More-Electric Systems |
| 93. | Ohio State University | Mechanical Properties Evolution During Friction Stir Welding of SLS Space Launch System (Artemis) Relevant Alloys Al-alloy for Enhanced Process Capability in Structural Aerospace Applications |
| 94. | University of California, Irvine | Polymer Coatings with Glass Bubbles for Thermal Radiation Control in Space |
| 95. | Tennessee Technological University | Quasi-Wireless Capacitive (QWiC) Surface Power for Adaptive and Reconfigurable Sensor Elements on Space Infrastructure |
| 96. | Southern University | Investigating Autonomous Healing of Cracks in Lightweight, Aerospace-Grade Materials Systems |




96 University Cooperative Agreement Projects Completed and Active

1.	Moog Inc.	Orbital Maneuvering Vehicle (OMV) for ESPA-Based NASA R&T Platform
2.	Ball Aerospace Corporation Technologies	Road Mapping for the Technology Infusion of Storable Green Propellant
3.	Innovative Scientific Solutions, Inc. (with Univ of Alabama)	Enabling Fast Responding Pressure-Sensitive Paint Systems in B/D Wind Tunnels
4.	ai-one, inc (with ISC Consulting Group)	NASA Topic-Mapper
5.	Arctic Slope Technical Services	Electrical Ignition of Green Monopropellants
6.	Draper Laboratory	Interplanetary Radiation and Fault Tolerant Mini-Star Tracker System
7.	Siemens	Immersive Decision Making Environment for Mission Driven Technology Alignment
8.	The Software Shop, Inc.	Concept Analysis using Natural Language Understanding (NLU)
9.	Analytical Mechanics Associates, Inc.	Green Propellant Management for Small Satellites
10.	Volunteer Aerospace, Inc.	Characterizing Effects of Potential Build Induced Defects in SLM Components
11.	Masten Space Systems, Inc.	Electric Pump for 5,000 lbf Class LOX/Methane Engine
12.	Rocketstar, LLC	Additive Manufactured Throttleable Pintle Injector

36 Industry Cooperative Agreement Projects Completed and Active

- 
13. **NeXolve Corp** Atomic Oxygen Resistant Nanocomposite Coating for Replacement of Cover Glass Coatings on Solar Cells
 14. **nScript Inc.** A Carbon Nanotube Composite Strain Sensor for use in Aerospace Structures
 15. **Hamilton Sundstrand, Inc. (UTAS)** Water Condensation and Separation for Closed-Loop Life Support Water Extraction Pump (WExPump)
 16. **Scroll Labs, Inc.** Gas Compression for Closed-Loop Life Support Water Extraction Pump (WExPump)
 17. **Busek Co. Inc.** BGT-X5 Green Prop Thruster for Small Spacecraft and Cubesats
 18. **Plasma Processes, LLC** Electrodeposition of Platinum Group Metals (PGM) from Low Temperature Molten Salts
 19. **Pickens Innovations** 3-way/2-position Valve for Cryogenic Applications
 20. **Veloxint Corporation** Transformational Nanocrystalline Metal Alloys for Lightweight Components
 21. **DM3D Technology** Free Form Fabrication of a Demonstration RS25 Jacket Part using Large Scale Direct Metal Deposition (DMD) Additive Technique
 22. **Castheon Inc.** Additive Manufacturing of Refractory Metal Nb Alloy C103 for Propulsion Applications
 23. **Creative Technology, LLC** Exploration for Space Applications of Write Once, Read Forever (WORF) Gamma-ray Impervious Data Storage System

36 Industry Cooperative Agreement Projects Completed and Active

- 
- | | | |
|-----|--|--|
| 24. | EOS North America | Ultra-Fine Metal Lattice Structure Produced With DMLS Process on EOS M100 Machine |
| 25. | CFD Research Corporation | Computational Fluid Dynamics (CFD) Modeling of the Self-Reacting Friction Stir Welding (SR-FSW) Process |
| 26. | AGILE Space (formerly AMPT) | Additively Manufactured Advanced Space Engines |
| 27. | Techmer PM | Polymer Based Metal Replacement Materials |
| 28. | Frontier Aerospace Corporation | Development of a Low Cost, Low Pressure, Light Weight, MON/MMH Bi-prop 100lb Thruster with 300 Isp. |
| 29. | Von Braun Center for Science & Innovation | Eureka - Model Based Systems Approach for Space Architecture Definition |
| 30. | GE Additive | Large-Scale Direct Metal Laser Melting (DMLM) Development for RS-25 Block IV Application |
| 31. | Formalloy LLC | Laser Metal Deposition of Copper-Alloys for Commercial Space Heat Exchanger Applications |
| 32. | C3 Propulsion | Novel Ionic Liquid Monopropellant Development |
| 33. | Qualtech Systems Inc. | Function Propagation Probing Enhancements in TEAMS |

36 Industry Cooperative Agreement Projects Completed and Active

- | | | |
|-----|---------------------------------|---|
| 34. | Geoplasma, LLC | Design and Testing of Advanced Composites and Coatings for Radiation Environment Shielding (ACCRES) Applicable to Crew Vehicles, Habitats, and Avionics |
| 35. | CFD Research Corporation | Computational Fluid Dynamics (CFD) Modeling of Lightweight Alloy Self-Reacting Friction Stir Welding (SR-FSW) to Correlate Thermal, Mechanical, and Viscoplastic Flow Phenomena with Weld Quality and Hardness |
| 36. | Skyre, Inc | Development of Non-Platinum Group Metal (PGM) Catalysts for Hydrogen Resource Recovery (HRR) |



**36 Industry Cooperative Agreement Projects
Completed and Active**