National Aeronautics and Space Administration

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

## SBELT Bi-Monthly

***28 July 2020***


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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**

**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)

## 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

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

# Step 2 Proposal 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 decribed 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?

**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 CAN Metrics for the 2019/2020 CAN Year (1 of 3)

- **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%) |
| **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**

## Summary CAN Metrics for the 2019/2020 CAN Year (2 of 3)

# Summary CAN Metrics for the 2019/2020 CAN Year (3 of 3)

**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**
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  - **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**

Back up charts

| 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 |
| - Propulsion systems technologies for launch, in-space transportation, surface landers, and small spacecraft/satellites<br>- In-Space chemical propulsion<br>- Nuclear-Thermal Propulsion systems technologies<br>- Components and systems for engines and reaction control systems<br>- Advanced Manufacturing for Propulsion Elements | | |
| | | |
| 2. Advanced Manufacturing: Structures and Materials | EM01/DeWitt Burns | dewitt.burns@nasa.gov (256) 544-2529 |
| - Additive Manufacturing Technologies<br>- Digital Manufacturing Technologies<br>- 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 |
| - Atmosphere revitalization and/or recovery, including ionic liquids-based processes<br>- Novel structured or pelletized sorbent purification/conditioning of atmosphere<br>- 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 |
| | | |

| | | |
|---|---|---|
| 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 Chilldown 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 | µCAT Thruster Technology for Attitude Control and Primary Propulsion for Small Spcecrafts 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. | nScrypt 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

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| 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

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| 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