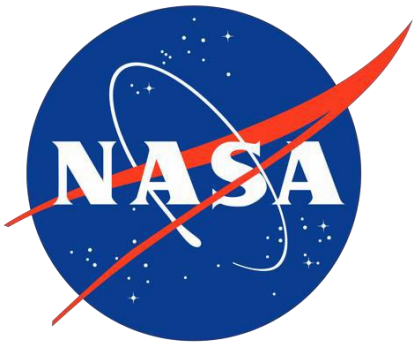

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA) HEADQUARTERS
AERONAUTICS RESEARCH MISSION DIRECTORATE
300 E STREET, SW
WASHINGTON, DC 20546-0001

RESEARCH OPPORTUNITIES IN AERONAUTICS – 2023

(ROA- 2023)

NASA RESEARCH ANNOUNCEMENT (NRA): NNH23ZEA001N

SOLICITING BASIC AND APPLIED RESEARCH PROPOSALS

Assistance Listing Number:43.002

ISSUED: November 01, 2022

PROPOSALS DUE
STARTING NO EARLIER THAN November 01, 2022
THROUGH NO LATER THAN January 31, 2024

OMB Control Number: 2700-0092

RESEARCH OPPORTUNITIES IN AERONAUTICS (ROA) – 2023

EXECUTIVE SUMMARY

This NASA Research Announcement (NRA), entitled *RESEARCH OPPORTUNITIES IN AERONAUTICS (ROA) – 2023*, solicits foundational and system-level research in support of the Aeronautics Research Mission Directorate (ARMD), National Aeronautics and Space Administration (NASA). This NRA covers a variety of topics in aeronautics fundamental research that are being pursued by NASA personnel. Specific research thrusts are outlined in the Appendices. A major focus of this NRA is to encourage collaboration between other organizations and NASA to help advance ARMD strategic goals. Details for award scope are provided for each project task area listed in the Appendices. Awards will be made as grants, cooperative agreements, or contracts, depending on the nature of the work proposed. It is anticipated that the majority of awards will be cooperative agreements or grants due to the expected collaborative nature of the work specified in the technical appendices. *NASA Guidebook for Proposers Responding to a NASA Funding Announcement* (hereafter referred to as the *NASA Guidebook for Proposers* found at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
provides a discussion regarding funding mechanisms. The typical period of performance for an award is three years, although a few programs may specify shorter or longer (maximum of five years) periods. Note that it is generally NASA's policy to conduct research with non-U.S. organizations based on no exchange of funds. Details of the solicited program elements along with any changes or modifications to any of these guidelines will be specified in the descriptions in the Appendices of this solicitation. Proposal due dates are given in Tables 5 and 6 which are located at the end of this NRA.

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SUMMARY OF SOLICITATION

I. FUNDING OPPORTUNITY DESCRIPTION

(a) Strategic Goals of NASA's Research Program

The National Aeronautics and Space Administration's (NASA) Mission,

> *"Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and bring new knowledge and opportunities back to Earth, support growth of the Nation's economy in space and aeronautics, increase understanding of the universe and our place in it, work with industry to improve America's aerospace technologies, and advance American leadership."*

draws support from NASA's world-class capability for aeronautical research founded on a tradition of expertise in aeronautical engineering and core research areas. The Aeronautics Research Mission Directorate (ARMD) contributes to NASA Strategic Goal 3: Address national challenges and catalyze economic growth. The Strategic Objective (3.2) of ARMD to meet this Goal is to "Transform aviation through revolutionary technology research, development and transfer". To help achieve this objective, NASA Aeronautics maintains and advances U.S. global leadership in aviation through applications of new concepts and technologies pioneered by NASA and developed in partnership with U.S. Industry that led to transformative improvements in mobility, efficiency, and safety.

In addition, the ARMD research plans directly support the National Aeronautics R&D Policy and accompanying Executive Order 13419 signed by the President on December 20, 2006, and the National Plan for Aeronautics R&D and Related Infrastructure that was released in December 2007 and updated in February 2010. A Technical Appendix to the National Plan was approved on December 22, 2008, and contains additional technical content on Aeronautics R&D goals and objectives and a preliminary assessment of current relevant Federal Aeronautics R&D activities. Specifically, ARMD conducts high-quality, cutting-edge research that includes foundational research across a breadth of core aeronautics competencies that supports aeronautics and space exploration activities; research in key areas related to the development of advanced aircraft technologies and systems, including those related to aircraft safety, environmental compatibility, and fuel efficiency; systems-level technology assessments in relevant environments; and research that supports the Next Generation Air Transportation System (NextGen) in partnership with the Federal Aviation Administration. In addition, ARMD is pursuing a coordinated approach to managing the Nation's research, development, test, and evaluation (RDT&E) infrastructure with other agencies, particularly the DOD. Additional information about ARMD can be found at https://www.nasa.gov/aeroresearch

An important goal of the ARMD NRA is to generate knowledge that can benefit the Nation. Therefore, it is expected that award recipients will publish their work and will utilize peer-reviewed publications to the greatest practical extent.

Further valuable, in-depth insight into NASA's strategic plan and supporting aeronautical research areas may be found in the updated *2019 NASA Strategic Implementation Plan* available at https://www.nasa.gov/sites/default/files/atoms/files/sip-2019-v7-web.pdf

The NASA strategic goals from *the 2019 NASA Strategic Implementation Plan* are shown in Table 1.

(b) NASA's Aeronautics Research Mission Directorate Programs

NASA Aeronautics guides its research efforts using a strategic vision that consists of Mega-Drivers which address research needs within three overarching trends affecting future aviation. Within these Mega-Drivers, ARMD research focuses on six strategic thrust areas that align to be responsive to a growing demand for mobility, severe challenges to sustainability of energy and the environment, and technological advances in information, communications, and automation technologies. These Mega-Drivers and Strategic Thrusts areas are shown in Tables 3 and 4 and can also be found in more detail at https://www.nasa.gov/aeroresearch/strategy

ARMD addresses the above objectives in four programs: The Advanced Air Vehicles Program, the Airspace Operations and Safety Program, the Integrated Aviation Systems Program, and the Transformative Aeronautics Concepts Program. The Advanced Air Vehicles Program (AAVP) conducts cutting-edge research that will generate innovative concepts, technologies, capabilities, and knowledge to enable revolutionary advances for a wide range of air vehicles. The Airspace Operations and Safety Program (AOSP) performs revolutionary research and technology development to enable the transformation of the National Airspace System (NAS) to safely accommodate a growing number of diverse new vehicles, operational concepts and missions. The Integrated Aviation Systems Program (IASP) conducts research at an integrated system-level on promising concepts and technologies and explores/assesses/demonstrates the benefits in relevant environments. The Transformative Aeronautics Concepts Program (TACP) cultivates multi-disciplinary, revolutionary concepts to enable aviation transformation and harnesses convergence in aeronautics and non-aeronautics technologies to create new opportunities in aviation. The goal of TACP is to knock down technical barriers and infuse concepts into all six ARMD strategic thrusts.

Appendices A-D provide a detailed description for each of the research programs listed above. Each of these appendices is prefaced with an Overview section that provides an introduction to the research program content that all interested applicants to this NRA are encouraged to read. Proposals in response to this NRA should be submitted to the most

relevant aeronautics program elements described in Appendices A-D (see also the *Table of Contents* that prefaces this NRA). Table 5 lists these programs in the order of their calendar deadlines for the submission of proposals, while Table 6 lists them in the order in which they appear in the appendices of this NRA. Questions about each specific program should be directed to the Program Officer(s) identified in the *Summary of Key Information* subsection that concludes each program description.

These appendices also provide clarifications or modifications, if any, to the general guidelines contained in this *Summary of Solicitation* for the individual program elements.

(c) References to Unique NASA Capabilities

NASA's Aeronautics Research Mission Directorate uses a variety of specialized test and high-end computational facilities to achieve its mission. Any need for these specific facilities for the proposed research must be explicitly described in the proposal, including the asset, rationale, and justification of the need, how it supports the investigation, and when during the proposed period the resource will be required. Proposals selected for funding will be considered for an allocation of the requested NASA resources needed for their investigation, but availability of the resource to support the fully requested level cannot be guaranteed.

(d) NASA Safety Policy

Safety is the freedom from those conditions that can cause death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment. NASA's safety priority is to protect the public, astronauts and pilots, the NASA workforce (including employees working under NASA award instruments), and high-value equipment and property.

(e) Availability of Funds for Awards

There is no funding associated with this umbrella solicitation. All funding will be associated with the relevant Appendix. The Government's ability to make awards is contingent upon the availability of appropriated funds and the receipt of proposals that NASA determines are acceptable for award under this solicitation.

(f) Proposal Submission

The electronic proposal must be submitted in its entirety by 5:00 p.m. Eastern Time on the appropriate proposal due date

II. AWARD INFORMATION

(a) Funding and Award Policies

The Summary of Key Information section in each Appendix provides the anticipated total amount of funds available, any funding limitations and potential number of proposal awards for each topic area. While the Summary of Key Information provides estimates for funding and the number of awards, these amounts may vary depending on the merit of proposals submitted and the funding available at the time of selections.

Any deviation from the usual maximum duration for awards of three years will also be noted (some programs may specify only one year for activities of limited scope to a maximum of five years for extensive, comprehensive studies).

ARMD's goal is to initiate new awards as quickly as possible after the selection of proposals is announced. However, NASA may take longer to make the awards, based on workload, availability of appropriated funds, and any necessary post-selection negotiations with the proposing organizations. To help expedite the processing of awards, proposers are reminded to submit all required information, including full and detailed explanations for the requested budget.

Awards made through this NRA will be in the form of grants, cooperative agreements, or contracts depending on the nature of the work proposed. The type of award to be offered to selected proposers will generally follow the policies in the *NASA Guidebook for Proposers*, although in a few cases only one type of award may be offered as specified in the individual appendices.

In cases where an appendix indicates the possibility of multiple award instrument types, a NASA official will determine the appropriate award instrument for the resulting selections.

As applicable, grants and cooperative agreements will be subject to the provisions of 2 CFR 200, 2 CFR 1800 and the Grant and Cooperative Agreement Manual (GCAM) (all found at https://www.nasa.gov/offices/procurement/gpc). Contract awards will be subject to the provisions of the Federal Acquisition Regulations (FAR) and the NASA FAR Supplement https://www.hq.nasa.gov/office/procurement/regs/NFS.pdf Depending upon the Technical, Scientific and Research requirements (i.e., by Project or Thrust Area) ARMD may make Multiple Year Awards under this NRA. Multiple Year Awards will be managed in accordance with *NASA Guidebook for Proposers*.

(b) Successor Proposals and Resubmissions

Generally, recipients holding previous awards selected through any of the programs offered through earlier NRAs are welcome to submit "successor" proposals that seek to continue a previously funded line of research (see *NASA Guidebook for Proposers*). However, in order to ensure equitable treatment of all submitted proposals, NASA does not extend any special consideration to such successor proposals in terms of preferential handling, review, or priority for selection. Note that the instructions regarding successor proposals in the *NASA Guidebook for Proposers* may have changed from past years.

Proposers are strongly encouraged to review them.

Applicable proposals that were submitted but not selected for any previous NASA solicitation(s) may be submitted either in a revised or original form. Such submissions will be treated as a new proposal and will be subjected to a full peer review.

Funds provided as a result of instruments awarded under this NRA cannot be applied as contributions under Space Act Agreements that NASA may execute in support of related programs.

(c) Increasing Access to the Results of Federally Funded Research

As a Federal Agency, NASA requires prompt public disclosure of the results of its sponsored research to generate knowledge that benefits the Nation. Thus, it is NASA's intent that all knowledge developed under awards resulting from this solicitation be shared broadly. In keeping with the *NASA* Plan: Increasing Access to the Results of Scientific Research https://www.nasa.gov/aeroresearch/strategy, new terms and conditions about making manuscripts and data publicly accessible may be attached to awards that derive from this ROA. All proposals to ROA-2023 must include a data management plan (DMP) or a statement that one is not necessary given the nature of the work proposed. The kind of data that requires a DMP is described in the NASA Plan: Increasing Access to the Results of Scientific Research and in the ROA-2022 General Q&A. Also see *NASA Guidebook for Proposers*.
The individual appendices of this ROA may give specific information concerning data archiving and management for those research elements, so please read the individual program solicitations carefully. Unless otherwise stated in individual appendices, the requirement for a DMP supersedes the data sharing plan mentioned in the *NASA Guidebook for Proposers.*

Award recipients will be required to ensure that any Final Peer-Reviewed Manuscripts are submitted for inclusion into NASA PubSpace. This requirement should be completed within one year from the publication by a journal. NASA's instructions for completing the submission process are available at http://sti.nasa.gov/submit-to-pubspace (scroll down for instructions for "External NASA Grantees, Contractors and Cooperative Agreement Holders," the external submission link, and "Additional Help" links).

(d) Intellectual Property and Data Resulting from Awards

Ownership of subject inventions is governed by the authorities listed below:

- Domestic small businesses and nonprofits (including educational institutions): Pursuant to the terms and conditions of the Bayh-Dole Act (35 U.S.C. Section 200, et seq.), domestic small businesses and nonprofits (including educational institutions) may elect to retain title to their subject inventions.

• Large Businesses and all others: Pursuant to the terms and conditions of Section 20135 of the National Aeronautics and Space Act (51 U.S.C. § 20135(b)), title to subject inventions vests in the U.S. Government. Large business and all others not subject to the Bayh-Dole Act, do not have an automatic right to elect to retain title to their subject inventions; however, they may request a waiver under the NASA Patent Waiver Regulations, 14 CFR Part 1245, Subpart 1, to obtain title to subject inventions. Such a request may be made in advance of award (or 30 days thereafter) for anticipated subject inventions and/or classes of invention, or within 8 months from the first disclosure of a subject invention to NASA.

Regardless of invention ownership, all awardees are required, under the appropriate patent rights clause, to report inventions made under an award to NASA.

In the case of contract awards, intellectual property provisions (patent and data rights) are subject to the FAR and the NFS. Intellectual property provisions applicable to grants and cooperative agreement awards are subject to the provisions identified in 2 CFR 200 and 2 CFR 1800 as applicable. See also

for more information on grant and cooperative agreement awards and intellectual property. The following Table II.d.1 identifies certain specific intellectual property clause references for contracts and grants/cooperative agreements.

TABLE II.d.1 Intellectual property clause references

	Small Businesses and Non-Profits (including Educational Institutions)	Large Business and All Others
Contracts	• FAR clause 52.227-11 as modified by NFS 1852.227-11 and FAR clause 52.227-14 as modified by NFS 1852.227-14 • Offerors shall complete FAR Provisio 52.227-15 Representation of Limited Rights Data and Restricted Computer Software and include with proposal.	• NFS clause 1852.227-70 and FAR clause 52.227-14 as modified by NFS 1852.227-14 • Offerors shall complete FA Provision 52.227-15 Representation of Limited Rights Data and Restricted Computer Software and include with proposal.
Grants/ Cooperative Agreements	GCAM	GCAM

Title and Rights in Intellectual Property. A stated purpose of NASA under the National Aeronautics and Space Act is to seek and encourage the commercial use of space. During

negotiations, offerors should identify any barriers that the appropriate set of intellectual property clauses would present to achieving commercialization efforts. Where such barriers have been identified, the parties will use reasonable efforts to negotiate to ensure that commercialization efforts can be realized, consistent with the above applicable authorities.

(e) International Traffic in Arms Regulations (ITAR) and Export Administration Regulations (EAR) Requirements

It is incumbent upon the recipient to assure the protection and nondisclosure of relevant technical data, including requirements of the Export Administration Regulations (EAR) and International Traffic in Arms Regulations (ITAR). U.S. recipients are required to know when hardware, software, or related materials and services, including technical data, are subject to U.S. export control laws, including the U.S. Export Administration Act, the Arms Export Control Act, and their associated regulations. It is incumbent upon the U.S. recipients to strictly comply with all U.S. export control laws, and when applicable, assume the responsibility for obtaining export licenses, or other export authority, as may be required.

Under U.S. law and regulations, spacecraft and their specifically designed, modified, or configured systems, components, and parts are generally considered "Defense Articles" on the United States Munitions List and are, therefore, subject to the provisions of the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120-130. It is the recipient's responsibility to determine whether any proposal information is subject to the provisions of ITAR, and to comply with the provisions of ITAR. Information about U.S. export regulations is available at http://www.pmddtc.state.gov/ and http://www.bis.doc.gov/

(f) Award Reporting Requirements

Required reports for contract awards will be negotiated with the contractor, subject to the terms and conditions of the FAR and NASA FAR Supplement. Required reports for grants and cooperative agreements are covered in 2 CFR 200 (see 2 CFR 200.327-329), the *NASA Guidebook for Proposers*, and Appendix F, "Required Publications and Reports" of the GCAM. Grants and cooperative agreements typically require annual and final technical reports, financial reports, and final technology reports. The reporting requirements in 2 CFR 180.335 and 2 CFR 180.350 are also applicable to awards issued under this NRA.

(g) Environmental Statement

Awards of proposals related to this Notice of Funding opportunity (NOFO) must comply with the National Environmental Policy Act (NEPA); thus, proposers are encouraged to plan and budget for any anticipated environmental impacts. While most

research awards will not trigger action-specific NEPA review, some activities (including international actions) will.

The majority of grant-related activities are categorically excluded as research and development (R&D) projects that do not pose any adverse environmental impact. A blanket NASA Grants Record of Environmental Consideration (REC) provides NEPA coverage for these anticipated activities. The NSPIRES award application cover page includes questions to determine whether a specific proposal falls within the Grants REC and must be completed as part of the proposal submission process. Activities outside of the bounding conditions of the Grants REC will require additional NEPA analysis. Examples of actions that will likely require NEPA analysis include but are not limited to suborbital-class flights not conducted by a NASA Program Office, activities involving ground-breaking construction/fieldwork, and certain payload activities such as the use of dropsondes.

Questions concerning environmental compliance may be addressed to the NASA NEPA Manager via the NASA program official listed in the appropriate Appendix.

III. ELIGIBILITY INFORMATION

(a) Eligibility of Applicants

Unless noted otherwise in the relevant appendix, participation in this program is open to all categories of U.S. and non-U.S. organizations, including but not limited to, educational institutions, industry, and not-for-profit institutions. Historically Black Colleges and Universities (HBCUs), Other Minority Universities (OMUs), small disadvantaged businesses (SDBs), veteran-owned small businesses, service-disabled veteran-owned small businesses, HUBZone small businesses, and women-owned small businesses (WOSBs) are encouraged to apply. Except where noted otherwise in individual appendices, participation by eligible non-U.S. organizations in this program is welcome but subject to NASA's policy of no exchange of funds, in which each government supports its own national participants and accounts for associated costs (further information on foreign participation is provided in paragraph (e) below and the *NASA Guidebook for Proposers*.

(a i) NASA's Commitment to Diversity and Inclusion

NASA recognizes and supports the benefits of having diverse and inclusive scientific, engineering, and technology communities and fully expects the reflection of such values in the composition of all panels and teams, including peer review panels, proposal teams, science definition teams, and mission and instrument teams. Per Federal statutes and NASA policy, no eligible applicant shall experience exclusion from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving financial assistance from NASA on the grounds of their race, color, creed, age, sex, national origin, or disability. NASA welcomes proposals from all qualified and eligible sources, and strongly encourages proposals from Historically Black Colleges and Universities (HBCUs), Minority Serving Institutions (MSIs), small disadvantaged businesses (SDBs), veteran-owned small businesses, service-disabled veteran-owned small businesses (SDVOSB), HUBZone small businesses, and women-owned small businesses (WOSBs), as eligibility requirements allow.

Appendices will identify specific eligibility requirements that apply to that opportunity. Additional information on collaboration opportunities may be found in appendices (A-D). Questions regarding NASA roles under cooperative agreements should be sent to the designated Point of Contact listed in the appropriate technical appendix (A-D).

(b) Number of Proposals and Teaming Arrangements

Unless Appendices specify additional information or provide limitations, there is no restriction on the number of proposals that an organization may submit to this solicitation or on the teaming arrangements for any one proposal. However, each proposal must be a separate, stand-alone, complete document for evaluation purposes. The NRA is structured in a way that facilitates responses to individual topic or subtopic areas. However, some program, thrust, or project areas provide special instructions for addressing more than one subtopic in a single proposal. The proposer is responsible for

reviewing any additional information that may be provided in those instructions.

NASA recognizes and supports the benefits of having diverse and inclusive scientific, engineering, and technology communities and fully expects that such values will be reflected in the composition of all panels and teams including peer review panels (science, engineering, and technology), proposal teams, science definition teams, and mission and instrument teams.

(c) Cost Sharing or Matching

For contracts, criteria, and procedures for the allowability and allocability of cash and non-cash contributions shall be governed by FAR Parts 30 and 31, and NFS Parts 1830 and 1831as they describe the policies and procedures for applying the Cost Accounting Standards and pricing principles.

For an institution of higher education, or other non-profit organization seeking to receive a grant or cooperative agreement, cost-sharing is not required; however, NASA can accept cost sharing if it is voluntarily offered. See 2 CFR 200.306 and 2 CFR 1800.306 for more information on cost sharing.

(d) Other Eligibility Criteria

Proposing to more than one Appendix simultaneously or with overlapping timeframes is permitted, provided the proposed efforts are appropriate for the solicitations and the recipient can carry out all proposed efforts, if selected. Appendices may also identify other eligibility restrictions such as limitations on the number of proposals that a PI or key participant may submit.

Ineligibility of Proposals That Include Participation of China or Chinese-Owned Companies

Proposals involving bilateral participation, collaboration, or coordination in any way with China or any Chinese-owned company, whether funded or performed under a no-exchange-of-funds basis, shall be ineligible for award.

(e) Foreign Participation

Participation by eligible non-U.S. organizations is also permitted, but subject to NASA's policy of no-exchange-of-funds, in which each government supports its own national participants and accounts for associated costs (further information on foreign participation is provided in NASA Guidebook for Proposers). NASA's policy is to conduct research with foreign entities on a cooperative, no-exchange-of-funds basis (see NPD 1360.2B, Initiation and Development of International Cooperation in Space and Aeronautics Programs, http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPD&c=1360&s=2B). Should a foreign proposal or a U.S. proposal with foreign participation be selected, NASA's Office of

International and Interagency Relations will arrange with the sponsoring foreign agency or funding/sponsoring institution for the proposed participation on a no-exchange-of-funds basis, in which NASA and the non-U.S. sponsoring agency or funding/sponsoring institution will each bear the cost of discharging their respective responsibilities.

For grants and cooperative agreements, NASA policy on research with foreign organizations is covered in 2 CFR 1800.3.

For contracts, NASA policy on research with foreign organizations is covered in paragraph (l) Additional Guidelines Applicable to Foreign Proposals and Proposals Including Foreign Participation of NFS provision 1852.235-72, Instructions for Responding to NASA Research Announcements (https://www.hq.nasa.gov/office/procurement/regs/NFS.pdf)

(f) China Funding Restriction

Proposals must not include bilateral participation, collaboration, or coordination with China or any Chinese-owned company or entity, whether funded or performed under a no-exchange-of funds arrangement. As stated in the GCAM Section 5.4, NASA requires Certifications, Assurances, and Representations, including Certifications and Assurances to implement restrictions in Appropriation Acts, that are applicable to all awards. By submission of a proposal, proposers are certifying that the proposing organization has read and is in compliance with all the Certifications, Assurances, and Representations.

NASA anticipates this restriction will be contained in future appropriation acts. Active Procurement Class Deviation (PCD) 12-01A instructs Contracting Officers to add certification NFS 1852.225-72 entitled “Restriction on Funding Activity with China – Representation” as well as NFS clause 1852.225-71entitled “Restriction on Funding Activity with China” in all contract awards.

IV. APPLICATION AND SUBMISSION INFORMATION

(a) Proposal Instructions and Requirements

All information needed to respond to this solicitation is contained in this ROA NRA and in the latest edition of the companion document, the NASA Guidebook for Proposers, located at
https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
and proposers are responsible for understanding and complying with its procedures for the successful, timely preparation and submission of their proposals. Proposals that do not conform to its standards may be declared noncompliant and rejected without review. Where this solicitation and the NASA Guidebook for Proposers are in conflict, this solicitation takes precedence. In addition, the provisions in any Appendix will apply to that specific opportunity and will supersede any conflicting provisions in this solicitation or in the NASA Guidebook for Proposers.
The introductory material, as well as the appendices, of the NASA Guidebook for Proposers provide additional information about the entire NRA process, including NASA policies for the solicitation of proposals, guidelines for writing complete and effective proposals, and NASA's general policies and procedures for the review and selection of proposals and for issuing and managing the awards to the institutions that submitted selected proposals.

Questions regarding this NRA or its program elements should be directed to the cognizant Program official listed in the program element's description. Clarifications or questions and answers will be posted on the relevant program element(s)'s web page(s).

A group of Frequently Asked Questions provides additional miscellaneous information about a variety of the NASA proposal and award processes, policies, and procedures. The Frequently Asked Questions with general applicability to the majority or all of the solicitation are posted on the ARMD ROA page on NSPIRES. In addition, each Project or program Element may post additional *Frequently Asked Questions* in their respective pages on NSPIRES.

Data Management Plan (DMP)
All proposals submitted under this Notice of Funding Opportunity (NOFO) are required to submit a Data Management Plan (DMP) in accordance with the *NASA Plan for Increasing Access to the Results of Scientific Research* located at http://www.nasa.gov/sites/default/files/files/NASA_Data_Plan.pdf.

(b) Registration

In order to submit a proposal, all team members and their institutions must be registered in NASA's proposal data system: NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) (http://nspires.nasaprs.com). Therefore, every organization that intends to submit a proposal to NASA in response to this solicitation, whether submitting through Grants.gov or the NSPIRES system must also be registered in NSPIRES. Every organization that intends to submit a proposal through Grants.gov must be registered in both Grants.gov and NSPIRES.

Details of the multi-step registration process for Grants.gov, which takes 3 business days (or up to four weeks if all steps are not completed in a timely manner) to register a new institution, are described in the Applicant FAQs (https://www.grants.gov/web/grants/applicants/applicant-faqs.html)

Registration in NSPIRES cannot be accomplished until each applicable institution obtains a Unique Entity Identifier (UEI) and registers in the System for Award Management (SAM). Once the UEI and SAM steps are complete, the institutions and each team member shall then register with NSPIRES and with Grants.gov, if that submission process will be used.

Unique Entity Identifier UEI) and system for award management (SAM)

Each applicant for NASA funding (unless the applicant is an individual or is excluded per 2 CFR 25.110) is required to:

- Be registered in SAM before submitting an application
- Maintain an active SAM registration with current information, including information on a recipient's immediate and highest-level owner and subsidiaries, as well as on all predecessors that have been awarded a Federal contract or grant within the last three years, if applicable, for all times during which it has an active Federal award or an application or plan under consideration by NASA; and
- Provide its UEI in each application or plan it submits to NASA. UEIs may be obtained by registering in SAM.gov

NASA may not issue an award or financial modification to an existing award to an applicant or recipient entity until the entity has complied with the requirements to provide a valid UEI and maintain an active SAM registration with current information. At the time of issuing an award, if the intended recipient has not complied with the UEI or SAM requirements, NASA may determine that the applicant is not qualified to receive an award and use that determination as a basis for making an award to another applicant.

Registration in NSPIRES is required in order to complete transfer of the Grants.gov proposal to NASA for review. Linking a team member's registration with their institution will automatically associate all required information (UEI, CAGE, EIN) with the proposal.

Registration for either proposal submittal system must be performed by an organization's Authorized Organizational Representative (AOR). To identify the AOR, the PI should contact his or her Sponsored Research Office (SRO) or Electronic Business Point of Contact (E-Biz POC). The NSPIRES Help Desk can also determine who the AOR is from the SAM system. If an institution is not registered in the SAM database, then the point of contact from the Office of Sponsored Research or the E-Biz POC shall register it on the SAM webpage sam.gov

(c) Content and Form of the Proposal Submission

(i) Electronic Proposal Submission

All proposals submitted in response to this solicitation must be submitted in electronic form by the AOR at the proposal principal investigator's (PIs) organization who is authorized to make such a submission; electronic submission of the proposal by the AOR serves as the required original signature by an authorized official of the proposing organization. No hard copy of the proposal will be accepted.

Appendices to this solicitation will indicate whether proposers may submit proposals via one or both of the electronic proposal submission systems: NSPIRES (http://nspires.nasaprs.com) or via Grants.gov http://www.grants.gov Offerors submitting through Grants.gov must register in NSPIRES in order for proposals to be transferred by NASA to the NSPIRES system for review.

NSPIRES will provide a list of all elements that make up an electronic proposal, and the system will conduct an element check to identify any item(s) that is (are) apparently missing or incomplete. Proposers are encouraged to begin their submission process early. Tutorials and other NSPIRES help topics may be accessed through the NSPIRES online help site at http://nspires.nasaprs.com/external/help.do. For any questions that cannot be resolved with the available on-line help menus, requests for assistance may be directed by E-mail to nspires-help@nasaprs.com or by telephone to (202) 479-9376, Monday through Friday, 8:00 a.m. – 6:00 p.m. Eastern Time.

The proposal submission process is complex and involves multiple steps to be carried out by all participants in the proposal. Therefore, offerors are strongly encouraged to familiarize themselves with the system and begin the submittal process early, well in advance of the deadline. While every effort is made to ensure the reliability and accessibility of submission systems and to provide a help center via e-mail and telephone, difficulties may arise at any point, including the user's own equipment. Difficulty in registering or using proposal submission systems (either NSPIRES or Grants.gov) is not a sufficient reason for NASA to consider a proposal submitted after the deadline. It is especially important to note that every individual named on the proposal's electronic Cover Page form (see below) as a proposing team member in any role, including co-investigators and collaborators, must be registered in NSPIRES and that such individuals must perform this registration themselves; no one may register a second party, even the Principal Investigator of a proposal in which

that person is committed to participate. This data site is secure, and all information entered is strictly for NASA's use only.

Any organization requesting NASA funds through the proposed project must be listed on the Proposal Cover Page. NASA will not fund organizations that do not appear on the Proposal Cover Page.

- Each individual team member (e.g., PI, co-investigators, collaborators), including all personnel named on the proposal's electronic cover page, must be individually registered and affiliated with their organization in NSPIRES. This registration requirement applies equally for proposals submitted via Grants.gov. Such individuals must perform the registration themselves; no one may register a second party, not even the PI of the proposal on which that person is committed to participate. Proposals that are submitted through Grants.gov may be deemed non-compliant and rejected without review if the above NSPIRES registration requirements are not completed prior to the proposal submission deadline identified in the relevant Appendix.
- Each individual team member (e.g., PI, co-investigators, collaborators), including all personnel named on the proposal's electronic cover page, must specify an organizational affiliation. The organizational affiliation specified on the cover page must be the organization through which the team member would work and receive funding while participating in the proposed effort. If the individual has multiple affiliations, then this organization may be different from the individual's primary employer or preferred mailing address. Team members are asked to ensure that their contact information in NSPIRES is up-to-date. Changes can be made using the "Account Management" link on the "NSPIRES Options" page.
- Submission of proposals via either NSPIRES or Grants.gov requires action by both the PI and the AOR. First, the PI must complete all required electronic forms, and upload the required PDF file(s). Second, the AOR must submit the electronic proposal on behalf of the PI. Coordination between the PI and his/her AOR on the final editing and submission of the proposal materials is facilitated through their respective accounts in NSPIRES and/or Grants.gov. Note that if one individual is acting in both the PI and AOR roles, he/she must ensure that all steps in the process are taken, including submitting the proposal from the organization.
- Offerors should be sure to allow adequate time for coordination between the PI and AOR. Depending on the organization and its internal review process, this can take several days. The PIs are encouraged to begin this coordination at the outset of the proposal preparation.

All team members identified on the NSPIRES proposal cover page may indicate their commitment to the proposed work via NSPIRES.

All proposals submitted via NSPIRES in response to this NRA must include a required electronic Cover Page form that is accessed at http://nspires.nasaprs.com. This form is comprised of several distinct sections: a Cover Page that contains the identifier information for the proposing institution and personnel; a Proposal

Summary that provides an overview of the proposed investigation that is suitable for release through a publicly accessible archive should the proposal be selected; and a Budget Summary of the proposed research effort. Unless specified in the program description itself, no other forms are required for proposal submission via NSPIRES. See the NASA Guidebook for Proposers.

The required elements of the proposal, including the science/technical/management section, must be submitted as one or more PDF documents that are attached to the Cover Page using the tools in NSPIRES. It is possible that the complete proposal is submitted as a single, searchable, unlocked PDF document, that contains the complete proposal, including the science/ technical/ management plan and Budget Narrative and Budget Details (but not the Total Budget), assembled in the order provided in the NASA Guidebook for Proposers and uploaded using the tools in NSPIRES.

The Total Budget must be uploaded as a separate attachment in a file named "totalbudget.pdf". One advantage of submitting the proposal as one PDF document as described above is that it is easier for the proposer to create a table of contents that will be correct. If separate files are uploaded, there may be slight differences in page numbering due to the concatenation process. Any mismatch with the table of contents caused by this process does not impact the evaluation of the proposal.

For proposals submitted through Grants.gov, instructions for NASA-specific forms and NASA program-specific forms may be found in the application package. For any questions that cannot be resolved with the available on-line help menus and documentation, requests for assistance may be directed by E-mail to support@grants.gov or by telephone to (800) 518-4726, twenty-four hours a day, seven days a week, except Federal holidays when the support center is closed.

(ii) Proposal Format and Contents

All proposals submitted in response to this NRA must include the appropriate required electronic forms available through either of two proposal submission systems, NSPIRES or Grants.gov.

The required sections of the proposal must be submitted as one searchable, unlocked PDF file that is attached to the electronic submission using one of the proposal submission systems. Offerors must comply with the format and page limit requirements specified in the Appendices. The provisions in each Appendix will apply to that specific opportunity and will supersede any conflicting provisions in this solicitation.

Important note on creating PDF files for upload: It is essential that all PDF files generated and submitted by the offeror meet NASA requirements. This will ensure that the submitted files can be ingested by NSPIRES regardless of whether the proposal is submitted via NSPIRES or Grants.gov. At a minimum, it is the

responsibility of the offerors to: (1) ensure that all PDF files are unlocked and that edit permission is enabled – this is necessary to allow NSPIRES to concatenate submitted files into a single PDF document; and (2) ensure that all fonts are embedded in the PDF file and that only Type 1 or TrueType fonts are used. In addition, any offeror who creates files using TeX or LaTeX is required to first create a DVI file and then convert the DVI file to Postscript and then to PDF. See http://nspires.nasaprs.com/tutorials/PDF_Guidelines.pdf for more information on creating PDF documents that are compliant with NSPIRES. PDF files that do not meet NASA requirements shall be declared noncompliant and not submitted to peer review for evaluation.

It is each offeror's responsibility to verify the accuracy and completeness of his/her proposal, including all text, figures, tables, and required forms. NSPIRES allows applicants to verify before submission that all information contained in proposal PDF file(s) being provided to NSPIRES is complete and accurate.

There is a 20 MB file size limit for proposals of the NASA Guidebook for Proposers. In order to meet the 20 MB file size limit, you should crop and compress any embedded photos and graphic files to an appropriate size and resolution. Only attachments that are specifically requested either in this solicitation or in Appendices to this solicitation should be submitted.

Note that some of the program elements in the Appendices of this NRA may specify different page limits for the main body of the proposal; if so, these page limits will be prominently given in the *Summary of Key Information* subsection that concludes each program element description. In the event the information in this NRA is different from or contradictory to the information in the *NASA Guidebook for Proposers*, the information in this NRA takes precedence.

A detailed Work Plan delineating how the Recipient/Awardee will accomplish the Goals and Objectives of the proposed Program, Thrust or Project Area (including applied Research Methodologies, Processes, and Resources, etc.) shall be included as part of the proposal. For entities seeking contracts, a Statement of Work (SOW) should be included as part of the proposal for the award of a contract. The SOW should include the following in the order listed: (1) Scope (2) Objectives (3) SOW tasks organized in a Work Breakdown Structure (WBS) (4) Program Schedule & Milestones (5) Measurable metrics, and (6) deliverables, which should be defined and described under the applicable task / WBS portion of the SOW. The SOW does not count against the page limit and should be inserted at the end of the proposal.

(iii) Budget Format

Both electronic systems require budget figures on the Proposal Cover Page. Offerors need to include budget figures for all years of the proposed project on the Proposal Cover Page including subawards. Offerors should refer to section NASA Guidebook

for Proposers and additional budget instructions provided in the relevant Appendix.

The uniform policy concerning the review of proposals submitted in response to this ROA NRA against the cost evaluation criterion is described in Appendix D of the *NASA Guidebook for Proposers*. Peer reviewers will provide input on cost realism and cost reasonableness to ensure that the proposed technical work is feasible. NASA program personnel will conduct the complete evaluation of cost the proposed technical work is feasible. NASA program personnel will conduct the complete evaluation of cost including cost realism, cost reasonableness, total cost, and comparison of the proposed cost to available funds.

In order to allow this division of review responsibilities, NASA will provide limited but sufficient proposal budget information to the peer review (work effort and personnel, other direct costs including procurements and sub-awards/subcontracts) while reserving certain proposal budget details for NASA's use (costs of direct labor, indirect costs, total costs).

In addition to the budget summary information provided in the NSPIRES or Grants.gov Cover Page forms, all proposers are required to include more detailed budgets and budget justifications, including detailed subcontract/sub-award budgets. For this NRA, this additional budget must be divided into three parts: the "Budget Justification: Narrative"; the "Budget Details," both as described in NASA Guidebook for Proposers; and the "Total Budget," a requirement specific to this ROA NRA.

The Budget Narrative includes the description of facilities and equipment, as well as the rationale and basis of estimate for all components of cost including procurements, travel (destination, purpose and number of travelers), publication costs, and all sub-awards/subcontracts.

The Budget Details must include the detailed proposed budget including all of the Other Direct Costs and Other Applicable Costs specified in the NASA Guidebook for Proposers. For this NRA, the Budget Narrative and the Budget Justification: Details should not specify the cost of Direct Labor or any Administrative Costs (e.g., overhead).

While the appropriate award instrument will be determined by the Government for appendices with multiple potential award instrument types, offerors must indicate the assumed type of award used during budget preparation. If a contract is assumed, offerors must indicate the type of contract proposed (i.e., cost plus fixed fee, cost sharing, fixed price, etc.). Note that some topics described in Appendices A-E may specify an expected award type.

The Total Budget file must specify the complete set of cost components including all costs discussed in the Budget Narrative and Budget Details, as well as the Total Estimated Cost, cost of Direct Labor, and Administrative Costs (overhead). The Total Budget document will not be provided to the non-government peer review but will be

used by NASA in the evaluation of total cost and comparison of the proposed cost to available funds. Proposers may also choose to include any data they consider to be sensitive financial information in the Total Budget file required by this Section of the ROA NRA. However, if any such information is excluded from the Budget Narrative and Budget Details sections, a note should be included in the applicable section of the Budget Narrative or Budget Details section to clarify where the information is located in the Total Budget file.

The required Budget Narrative and Budget Details section of the proposal may be incorporated into the proposal document as these will be provided to the peer review (for submission via NSPIRES, the Budget Narrative and Budget Details must be incorporated into the single proposal PDF file). Regardless of whether the proposal is submitted via NSPIRES or Grants.gov, proposers to the ROA must provide the Total Budget in a file called "totalbudget.pdf," which is uploaded as a separate attachment in either NSPIRES or Grants.gov.

(iv) Table of Personnel and Work Effort

The Table of Personnel and Work Effort must include the names and/or titles of all personnel (including postdoctoral fellows and graduate students) necessary to perform the proposed investigation regardless of whether these individuals require funding from the current proposal. The number of person-months each person is expected to devote to the project must be given for each year.

(v) Notice of Intent to Propose

Appendices will indicate whether a notice of intent (NOI) to propose is required, requested, or not requested for a particular opportunity. The information contained in an NOI is used to expedite the proposal review activities and is, therefore, of value to both NASA and the offeror. To be of maximum value, NOIs should be submitted to NSPIRES by the date given in each Appendix. Note that NOIs may be submitted within NSPIRES directly by the PI; no action by an organization's AOR is required to submit an NOI.

Within NSPIRES, space is provided for the PI to provide the following information:

- A short title of the anticipated proposal;
- A full title of the anticipated proposal (which should not exceed 254 characters and is of a nature that is understandable by a scientifically trained person).
- A brief description of the primary research area(s) and objective(s) of the anticipated investigation.
- The names of any Co-Investigators and/or Collaborators as may be known by the time the NOI is submitted. In order to enter such names, such team members must have previously accessed and registered in NSPIRES themselves; a PI cannot do this for them.

Grants.gov does not provide NOI capability; therefore, NOIs must be submitted via NSPIRES regardless of whether the proposal will be submitted via NSPIRES or Grants.gov. Interested proposers must register with NSPIRES before it can be accessed for use; see Section IV (b) (i) above. Since NOIs submitted after the deadline may still be useful to NASA, late NOIs may be submitted by E-mail as directed in *NASA Guidebook for Proposers.*

For most of the programs advertised through this solicitation, a brief Notice of Intent (NOI) to propose is encouraged, but not required, for the submission of proposals to this solicitation. The information contained in an NOI is used to help expedite the proposal review activities and, therefore, is of considerable value to both NASA and the proposer. To be of maximum value, NOIs should be submitted by the proposal principal investigator to NSPIRES, NASA's master proposal data system located at http://nspires.nasaprs.com, by the dates given in Tables 5 or 6 below for each program in the Appendices. Note that NOIs may be submitted within NSPIRES directly by the proposal principal investigator; no action by an organization's AOR is required to submit an NOI.

(vi) Conflict of Interest Check Information

In order to ensure that all proposal evaluations are conducted as fairly as possible, it is important to ascertain whether prospective reviewers may have conflicts of interest that might affect their capacity to function with impartiality. To facilitate the process of identifying potential conflicts of interest, it is necessary to collect information about the organizations participating in each proposal. A NASA program-specific form will be used to collect this information. This form will be part of a submission to the NSPIRES system. Proposers using Grants.gov will have to ensure that they complete the NASA program-specific form as described in section I (b) (iii). Failure to submit this form via the NSPIRES system shall result in the proposal being deemed nonresponsive to the NRA.

(d) Proposal Submission Dates, Time, and Location

For each program in Appendices A through D of this NRA, the electronic proposal must be submitted in its entirety by 5:00 p.m. Eastern Time on the appropriate proposal due date given in Tables 5 or 6 below. All proposals must be submitted electronically using NSPIRES or Grants.gov (see Sections IV (b) (iv), above).

Proposals that are late will be handled in accordance with NASA's policy as given in the *NASA Guidebook for Proposers* and returned without review. If a late proposal is returned, it is entirely at the discretion of the proposer whether or not to resubmit it in response to a subsequent appropriate solicitation.

(e) Funding Restrictions

In addition to the funding restrictions and requirements given in the NASA *Guidebook for Proposers* and the GCAM, the following restrictions are applicable to this ROA

NRA. All costs charged to awards covered by this NOFO must comply with the Uniform Administrative Requirements in 2 C.F.R. 200 and 1800, unless otherwise indicated in the NOFO, the terms and conditions of the award, and the Grants and Cooperative Agreement Manual (GCAM)

- The estimated funding and number of proposals anticipated to be funded, as shown in the *Summary of Key Information* at the end of each program element, are subject to the availability of appropriated funds, as well as the submission of a sufficient number of proposals of adequate merit.
- The construction of facilities is not an allowed activity for any of the programs solicited in this NRA unless specifically stated. For further information on the allowability of costs, refer to the cost principles cited in 2 CFR 200 Subpart E.
- Typically travel, including foreign travel, is allowed as may be necessary for the meaningful completion of the proposed investigation, as well as for publicizing its results at appropriate professional meetings.
- Profit for commercial organizations is not allowable under grant or cooperative agreement awards but is allowable under contract awards. Costs for managing the project may be allowed under grant or cooperative agreement awards. These costs, whether direct charges or part of the indirect cost agreement, must be consistent with 2 CFR 200 Subpart E.

- U.S. research award recipients may directly purchase supplies and/or services from non-U.S. sources that do not constitute research, but award funds may not be used to fund research carried out by non-U.S. organizations. However, subject to export control restrictions, a foreign national may receive remuneration through a NASA award for the conduct of research while employed either full or part time by a U.S. organization of the *NASA Guidebook for Proposers*.

- All proposed funds must be allowable, allocable, and reasonable. Funds may only be used for the project. All activities charged under indirect cost must be allowed under 2 CFR 200 cost principles.
- Grants and cooperative agreements shall not provide for the payment of fee or profit to the recipient.
- Unless otherwise directed in 2 CFR 200, for changes to the negotiated indirect cost rate that occur throughout the project period, the recipient must apply the rate negotiated for that year, whether higher or lower than at the time the budget and application was awarded.
- Proposals must not include bilateral participation, collaboration, or coordination with China or any Chinese-owned company or entity, whether funded or performed under a no-exchange-of-funds basis.
- Any funds used for match or cost sharing must be allowable under 2 CFR 200.
- The non-Federal entity must use one of the methods of procurement as prescribed in 2 CFR 200.320, Methods of procurement to be followed.

(f) Proposal Requirements for Relevance

Proposals for all NASA sponsored research programs are usually evaluated on three criteria: intrinsic merit, relevance to NASA's objectives, and cost realism and reasonableness (see *NASA Guidebook for Proposers*). These criteria may be modified in the Appendices of this NRA. Each program element includes a specific description of how it is relevant to the NASA Strategic Plan. Therefore, unless otherwise stated in the program element, it is not necessary for individual proposals to show relevance to NASA's broader goals and objectives. The proposal should instead focus on demonstrating relevance by discussing how the proposed investigation addresses the goals and objectives of the specific program element.

Note that this NRA references the strategic goals and objectives in the 2019 NASA Strategic Plan (see Section I (a) and Table 1).

V. APPLICATION REVIEW INFORMATION

(a) Application Evaluation Criteria

Each proposal will be evaluated by peers of the proposing personnel to assess the proposal's intrinsic scientific and technical merit, its relevance to NASA's stated objectives, and its cost realism and reasonableness. The evaluation criteria are:

1) Intrinsic Merit of the Proposal
2) Relevance to Objectives Stated in ROA 2023
3) Cost

The three evaluation factors will be equally weighted. See Appendix D of the *NASA Guidebook for Proposers* for further discussion of these criteria and their relative weights. Some of the projects in the attached Appendices contain additional or tailored evaluation criteria. If any criteria in Appendices A-D conflicts with any other part of the NRA, the criteria identified in the Appendices take precedence over this and other sections of the NRA. The evaluation factors include factors evaluated by peer reviewers, as well as factors evaluated by NASA program personnel. Note the following specific points:

- As evaluation panels review the intrinsic merit of the proposed investigation, they will be asked to consider the realism and reasonableness of the request for unique NASA capabilities and whether it is an appropriate utilization of a highly constrained asset.
- Some of the programs discussed in the Appendices will provide specific factors, based on the solicited research objectives, which will be considered when evaluating a proposal's technical merits and/or its relevance to program objectives.
- As discussed in Section IV (e) above, relevance will be judged in part by the proposal's focus on specific objectives for the ARMD program element.
- Opinions on a proposal's cost may be offered by peer review (for cost realism and cost reasonableness), but NASA personnel will conduct the complete cost evaluation (for cost realism, cost reasonableness, total cost and comparison to available funds). Proposers must follow the budget format requirements in Section IV (b) (iii).
- The selection official may take program balance into account when selecting proposals for funding.
- The Work Plan shall be evaluated in accordance with the requirements set forth in each of the applicable Appendices.
- The specific program element in the Appendices will identify how the DMP will be evaluated, i.e., as part of the peer review or internally by NASA staff.
- Cost sharing is generally not considered as part of the evaluation (see Section III(c) above). However, cost sharing may become a factor at the time of selection when deciding between proposals of otherwise equal technical merits.
- The peer reviewers only have access to the Budget Narrative and Budget Details, and will not have access to the Total Estimated Cost, the cost of Direct Labor, and Administrative Costs (e.g., overhead). Therefore, failure to provide sufficient

budget justification and data in the Budget Narrative, Budget Details and the Table of Personnel and Work Effort, will prevent the peer review from appropriately evaluating the cost realism of the proposal. A finding by the peer review of "insufficient information to properly evaluate cost realism" will be considered a weakness of the proposal. Inconsistent budget information between the budget descriptions will also be considered a weakness of the proposal.

(b) Review and Selection Processes

(i) Proposal Review and Selection

Review of proposals submitted to this NRA will be consistent with the evaluation criteria and the general policies and provisions given in Appendix D of the *NASA Guidebook for Proposers*.

For grants and cooperative agreement awards, the NASA Grant Officer will conduct a pre-award review of risk associated with the proposer as required by 2 CFR 200.205. For all proposals selected for award, the Grant Officer will review the submitting organization's information available through the Federal Awardee Performance and Integrity Information System (FAPIIS) and the System for Award Management (SAM) to include checks on entity core data, registration expiration date, active exclusions, and delinquent federal debt.

Unless otherwise specified, the Program Director responsible for a thrust area is the final Selecting Official. In cases where a conflict of interest exists, the Selecting Official will be designated by the Associate Administrator for Aeronautics.

(ii) Review of Applicants in the Federal Awardee Performance and Integrity Information System (FAPIIS)

NASA, prior to making a Federal award with a total amount of Federal share greater than the simplified acquisition threshold (currently $250,000), is required to review and consider any information about the applicant that is in the designated integrity and performance system (currently the Federal Awardee Performance and Integrity Information System—FAPIIS) accessible through the System for Award Management (SAM), https://www.sam.gov (see 41 U.S.C. 2313).

An applicant, at its option, may review information in FAPIIS and comment on any information about itself that NASA previously entered and is currently in FAPIIS.

NASA will consider any comments by the applicant, in addition to the other information in FAPIIS, in making a judgment about the applicant's integrity, business ethics, and record of performance under Federal awards when completing the review of risk posed by applicants as described in 2 CFR 200.205 Federal awarding agency review of risk posed by applicants.

(iii) Limited Release of Proposers' Confidential Business Information

(a) For proposal evaluation and other administrative processing, NASA may find it necessary to release information submitted by the proposer to individuals not employed by NASA. Business information that would ordinarily be entitled to confidential treatment may be included in the information released to these individuals. Accordingly, by submission of this proposal the proposer hereby consents to a limited release of its confidential business information (CBI).

(b) Except where otherwise provided by law, NASA will permit the limited release of CBI only pursuant to non-disclosure agreements signed by the assisting contractor or subcontractor, and their individual employees who may require access to the CBI to perform the assisting contract.

(iv) Risk Analysis

NASA Grant Officers will conduct a pre-award review of risk associated with the proposer as required by 2 CFR 200.206, Federal awarding agency review of risk posed by applicants. For all proposals selected for award, the Grant Officer will review the submitting organization's information available through multiple government-wide repositories such as the System for Award Management (SAM.gov), Federal Awardee Performance and Integrity Information System (FAPIIS), the Contractor Performance and Assessment Reporting System (CPARS), the Federal Audit Clearinghouse (FAC), USAspending.gov, and Grant Solutions Recipient Insight.

Risk Review

For any Federal award, if NASA anticipates that the total Federal share will be greater than the simplified acquisition threshold (currently $250,000) over the period of performance:

i. Prior to making a Federal award with a total amount of Federal share greater than the simplified acquisition threshold, NASA is required to review and consider any information about the applicant that is in the designated integrity and performance system accessible through SAM (currently FAPIIS) (see 41 U.S.C. §2313);

ii. An applicant, at its option, may review information in the designated integrity and performance systems accessible through SAM and comment on any information about itself that a Federal awarding agency previously entered and is currently in the designated integrity and performance system accessible through SAM;

iii. NASA will consider any comments by the applicant, in addition to the other information in the designated integrity and performance system, in making a judgment about the applicant's integrity, business ethics, and record of performance under Federal awards when completing the review of risk posed by applicants as described in 200.206, Federal awarding agency review of risk posed by applicants.

(c) Partial Awards and Participation with Others

NASA reserves the right to select only a portion of a proposed investigation, usually at a level of support reduced from that requested in the original proposal or may also offer tentative selections in which NASA requests investigators to team in a joint investigation. Additionally, NASA may decide to award an effort for less than the full period of the proposal. In these cases, the proposer will be given the opportunity to accept or decline such selection. If the proposer accepts such an offer, a revised budget and statement of work may be required before funding action on the proposal can be initiated. If the proposer declines the offer of a partial selection, or participation in a joint investigation, the offer of selection may be withdrawn in its entirety by NASA.

(d) Selection Announcement and Federal Award Dates

NASA's stated goal is to announce selections as soon as possible. However, NASA does not usually announce new selections until the funds needed for those awards are approved through the Federal budget process. Therefore, a delay in the budget process for NASA usually results in a delay of the selection date(s). After 150 days past the proposal due date for which a proposal was submitted, proposers may contact the responsible Program Officer listed at the conclusion of that program description in the appendices for the status of the selection activity.

Those proposers not selected will be notified by postal or electronic mail and offered a debriefing consistent with the policy in the *NASA Guidebook for Proposers*.

(e) Process for Appeals

(i) Ombudsman Program

The NASA Procurement Ombudsman Program is available under this NRA as a procedure for addressing concerns and disagreements. The clause at NASA FAR Supplement (NFS) 1852.215-84 ("Ombudsman") is incorporated into this NRA. The cognizant ombudsman is

William Roets
Deputy Assistant Administrator for Procurement
Office of Procurement
NASA Headquarters
300 E Street SW Room 5L14
Washington DC 20546-0001
Telephone: (202) 358-4483
Email: agency-procurementombudsman@nasa.gov

(ii) Protests

Only prospective offerors proposing to appendices specifying contracts as the anticipated award instrument have the right to file a protest, either at the Government Accountability Office (GAO) or with the Agency, as defined in FAR 33.101. The provisions at FAR 52.233-2 ("Service of Protest") and NASA FAR Supplement (NFS) 1852.233-70 ("Protests to NASA") are incorporated into this NRA. Under both of these provisions, the designated official for receipt of protests to the Agency and copies of protests filed with the GAO is

William Roets
Deputy Assistant Administrator for Procurement
Office of Procurement
NASA Headquarters Mail Stop 5L14
Washington, DC 20546
Telephone: 202-358-4483

(iii) Requests for Reconsideration

An offeror whose proposal has been declined may request a debriefing from the Program Officer. Following the debriefing, dissatisfied PIs may submit in writing a Request for Reconsideration to the Selecting Official. Details on this process may be found in Appendix H of the NASA Guidebook for Proposers.

VI. Federal Award Administration Information

(a) Notice of Award

Notification of both the selected, as well as the non-selected proposers, will be consistent with the policy given in the *NASA Guidebook for Proposers* and, for contracts, the Federal Acquisition Regulation and NASA FAR Supplement.

NASA will notify successful grant recipients of funding via a Notice of Award (NASA Form 1687) signed by the Grant Officer. This Notice of Award is the authorizing document and will be sent to the offeror's business office via electronic delivery. For selected proposers, the offeror's business office will be contacted by a NASA Awards Officer, who is the only official authorized to obligate the Government. All expenses incurred on grant activities prior to the period of performance start date listed on the Notice of Award are at the risk of the non-Federal entity until the Notice of Award is received and period of performance commences.

(b) Administrative and National Policy Requirements

This solicitation does not invoke any special administrative or national policy requirements—2 CFR 200.300, 2 CFR 1800, and the GCAM will apply to any grant and cooperative agreement awards that derive from this NRA, as applicable. All award requirements are posted at
https://www.nasa.gov/offices/procurement/gpc/regulations_and_guidance
Please note that it is expected that proposers will comply with Homeland Security

Presidential Directive/ HSPD-12. HSPD-12 applicability will be determined during negotiation for award for selected proposals.

Additionally, award recipients that have individuals working under the award who need access to NASA facilities and/or systems must work with NASA program staff to ensure proper credentialing. Such individuals include U.S. citizens, lawful permanent residents ("green card" holders), and foreign nationals (those who are neither U.S. citizens nor permanent residents).

In addition to the requirements in this section and in this NOFO, NASA may place specific terms and conditions on individual awards in accordance with 2 C.F.R. Part 200. Recipients of NASA grant funding shall adhere to requirements set forth in 2 CFR 200, 2 CFR 1800, 2 CFR 170, 2 CFR 175, 2 CFR 182, and 2 CFR 183.

Research Terms and Conditions

Awards from this funding announcement that are issued under 2 CFR 1800 are subject to the Federal Research Terms and Conditions (RTC) located at http://www.nsf.gov/awards/managing/rtc.jsp In addition to the RTC and NASA-specific guidance, three companion resources can also be found on the website: Appendix A—Prior Approval Matrix, Appendix B—Subaward Requirements Matrix, and Appendix C—National Policy Requirements Matrix.

(c) Reporting

The reporting requirements for awards made through this NRA will be consistent with the NASA Guidebook for Proposers and the GCAM Appendix F. Any additional requirements will be specified in the program description.

Award recipients may also be subject to reporting requirements under the NASA Plan for Increasing Access to Results of Federally Funded Research. Any such requirements will be identified in the Notice of Award.

Award recipients are subject to additional reporting requirements specified at 2 CFR 200 Appendix XII—Award Term and Condition for Recipient Integrity and Performance Matters, if the total value of the award recipients currently active grants, cooperative agreements, and procurement contracts from all Federal awarding agencies exceeds $10,000,000 for any period of time during the period of performance of the Federal award. (https://www.ecfr.gov/cgi-bin/text-idx?SID=4b63b1740bdb186d3bf5d346f5ddf42c&mc=true&node=ap2.1.200_1521.xii&rgn=div9)

Federal Financial Reporting

Recipients of NASA funding must submit quarterly financial reports. Financial reports must be submitted via the Payment Management System (PMS):

- Quarterly Federal Cash Transaction Reports (FCTR) are due no later than 30 days past the reporting period end date
- Final Financial Status Reports/Final Federal Financial Report (FSR/FFR) are due no later than 120 days after the end of the period of performance

Performance Reporting

Refer to Individual Appendix

All reports shall include the following data elements on the report's cover page:

- Federal agency (i.e., NASA) and program office to which the report is submitted.
- Award number.
- Project title
- Principal Investigator name, title, and contact information (e-mail address and phone number).
- Name of submitting official, title, and contact information (e-mail address and phone number), if other than PI.
- Submission date.
- Unique Entity Identifier (UEI) number and EIN number.
- Recipient organization name and address.
- Recipient identifying number or account number, if any.
- Period of performance start and end date.
- Reporting period end date.
- Report term or frequency (annual, semi-annual, quarterly, other).
- Final Report? Indicate "Yes" or "No"
- Signature of submitting official (either handwritten or electronic)

In addition to the data elements above, all NASA performance reports **shall** report on one mandatory reporting category, "accomplishments."

Accomplishments data element:
1. What were the major goals and objectives of this project?
2. What was accomplished under these goals?
3. What opportunities for training and professional development has the project provided?
4. How were the results disseminated to communities of interest?
5. What do you plan to do during the next reporting period to accomplish the goals and objectives?

For further details on reporting project performance, please refer to the Post-Award Phase Section of the GCAM.

Access to Research

Awards issued under this NOFO must comply with the provision set forth in the NASA Plan for Increasing Access to the Results of Scientific Research (http://www.nasa.gov/sites/default/files/files/NASA_Data_Plan.pdf) including the responsibility for:

1. Submitting as-accepted peer-reviewed manuscripts and metadata to a designated repository and
2. Reporting publications with the annual and final performance reports.

FFATA Reporting Requirements

Per 2 CFR 170, Reporting Subaward and Executive Compensation Information, award recipients that issue first-tier subawards above $30,000 shall report those subawards in the Federal Award Accountability and Transparency Act (FFATA) Subaward Reporting System (FSRS). 2 CFR 170 provides detailed guidance as to what information needs to be reported in these systems and the deadlines for submitting this information. Recipient information that is reported to FSRS is ultimately transferred to USAspending.gov for public display.

Suspension and Debarment Disclosure

This reporting requirement pertains to disclosing information related to government-wide suspension and debarment requirements. Before a recipient enters into a grant award with NASA, the recipient must notify NASA if it knows if it or any of the recipient's principals under the award fall under one or more of the four criteria listed at 2 CFR Part 180.335:

i. Are presently excluded or disqualified;
ii. Have been convicted within the preceding three years of any of the offenses listed in2 C.F.R. § 180.800(a) or had a civil judgment rendered against it or any of the recipient's principals for one of those offenses within that time period;
iii. Are presently indicted for or otherwise criminally or civilly charged by a governmental entity (federal, state or local) with commission of any of the offenseslisted in 2 C.F.R. § 180.800(a); or
iv. Have had one or more public transactions (federal, state, or local) terminated withinthe preceding three years for cause or default.

At any time after accepting the award, if the recipient learns that it or any of its principals falls under one or more of the criteria listed at 2 C.F.R. § 180.335, the recipient must provide immediate written notice to NASA in accordance with 2 C.F.R. § 180.350.

Additional Reporting Requirements

NASA recipients must conform to all reporting requirements outlined in the Required Publications and Reports section of the GCAM, currently Appendix F.

VII. NASA CONTACT INFORMATION

General questions and comments about the policies of this NRA may be directed to:

Neal Nijhawan
Integration and Management Office
Aeronautics Research Mission Directorate
NASA Headquarters
E-mail: NASA-roa@nasa.gov

Note: Proposals shall not be submitted to this E-mail address. Proposals shall be submitted electronically as described in Section IV above.

Specific questions about a given program element in this NRA should only be directed to the Program Officer(s) listed in the *Summary of Key Information* subsection that concludes each program description.

No communication concerning this NRA may be made to any other NASA official other than those specifically listed in this NRA.

Inquiries about accessing or using the NASA proposal data base located at http://nspires.nasaprs.com should be directed by an E-mail that includes a telephone number to nspires-help@nasaprs.com or by calling (202) 479-9376. This help center is staffed Monday through Friday, 8:00 a.m. – 6:00 p.m. Eastern Time.

Inquiries about accessing or using Grants.gov located at http://www.grants.gov should be directed by an E-mail to support@grants.gov or by calling (800) 518-4726. This customer support contact center is staffed twenty-four hours a day, seven days a week, except Federal holidays when the support center is closed.

Contact and Resource Information

Refer to Individual Appendix

Program Office Contact

Refer to Individual Appendix

VIII. ANCILLARY INFORMATION

(a) Announcement of Updates/Amendments to Solicitation

It is possible that additional programmatic information for any of NASA's programs may develop before their proposal due dates. If so, such information will be added as a formal amendment to this NRA as posted at its homepage at http://nspires.nasaprs.com. It is the responsibility of the prospective proposer to check this NRA's homepage for updates concerning the program(s) of interest.

Any clarifications or questions and answers that are published will be posted either with the summary ROA NRA information or on the relevant program element(s)'s web page(s) at http://nspires.nasaprs.com.

Access to NASA Facilities/Systems

All recipients shall work with NASA project/program staff to ensure proper credentialing for any individuals who need access to NASA facilities and/or systems. Such individuals include U.S. citizens, lawful permanent residents ("green card" holders), and foreign nationals (those who are neither U.S. citizens nor permanent residents).

Limited Release of Proposers' Confidential Business Information

(a) For proposal evaluation and other administrative processing, NASA may find it necessary to release information submitted by the proposer to individuals not employed by NASA. Business information that would ordinarily be entitled to confidential treatment may be included in the information released to these individuals. Accordingly, by submission of this proposal the proposer hereby consents to a limited release of its confidential business information (CBI).

(b) Except where otherwise provided by law, NASA will permit the limited release of CBI only pursuant to non-disclosure agreements signed by the assisting contractor or subcontractor, and their individual employees who may require access to the CBI to perform the assisting contract.

(b) Electronic Notification of NASA solicitations

NASA Headquarters maintains an electronic notification system to alert interested parties of program announcements. Subscription to this service is free to all registered users of the NASA proposal data base system at http://nspires.nasaprs.com/. To add or change a subscription to the electronic notification system, users should login to the data base system and select "Account Management", then "Email Subscriptions."

This e-mail service will notify all subscribers of:
(1) All NASA Headquarters research program solicitations (within a given Directorate)
(2) Amendments to those solicitations
(3) Special information that NASA Headquarters wishes to communicate to those interested in proposing.

Regardless of whether or not this service is used, all NASA Headquarters research announcements and amendments may be accessed at http://nspires.nasaprs.com/ (select "Solicitations" then "Open Solicitations") as soon as they are posted.

(c) Collection of Demographic Information

NASA is implementing a process to collect demographic data from grant applicants for the purpose of analyzing demographic differences associated with its award processes. Information collected will include name, gender, race, ethnicity, disability status, and citizenship status. Submission of the information is voluntary and is not a precondition of award.

IX. CONCLUDING STATEMENT

Through this ROA NRA, NASA encourages the participation of the aeronautics communities in its Aeronautics Research Mission Directorate research and technology programs. Comments about this NRA are welcome and may be directed to the point of contact for general questions and comments identified in Section VII above.

Robert A. Pearce
Associate Administrator
Aeronautics Research Mission Directorate

James Heidmann
(Acting) Director
Advanced Air Vehicles Program

Akbar Sultan
Director
Airspace Operations and Safety Program

Lee Noble
Director
Integrated Aviation Systems Program

John Cavolowsky
Director
Transformative Aeronautics Concepts Program

TABLE 1. NASA STRATEGIC GOALS[2]

Strategic Goal 1:	Expand human knowledge through new scientific discoveries.
Strategic Goal 2:	Extend human presence deeper into space and to the moon for sustainable long-term exploration and utilization.
Strategic Goal 3:	Address national challenges and catalyze economic growth
Strategic Goal 4:	Optimize capabilities and operations

TABLE 2. NASA's ARMD Goals, Objectives, Performance Goals

Strategic Goal 3: Address national challenges and catalyze economic growth
Objective 3.2: Transform aviation through revolutionary technology research, development, and transfer.
○ *Performance Goal 3.2.1: Develop solutions that will advance decision-making ability for improving air traffic management to accommodate future growth in air travel, and for increasing aviation safety under hazardous conditions.*
○ *Performance Goal 3.2.2: Demonstrate the ability to reduce sonic booms, enabling future industry innovation in commercial supersonic aircraft.*
○ *Performance Goal 3.2.3: Advance airframe and engine technologies to enable the development of future generations of ultra efficient air vehicles that minimize environmental impact including electric aircraft propulsion concepts.*
○ *Performance Goal 3.2.4: Advance airframe and propulsion technologies to enable the development of vertical take-off and landing (VTOL) vehicles that minimize noise and maximize safety.*
○ *Performance Goal 3.2.5: Significantly increase the ability to anticipate and resolve potential safety issues, and to predict the health and robustness of aviation systems.*
○ *Performance Goal 3.2.6: Contribute toward the safe introduction of on-demand Urban Air Mobility (UAM) and other emerging operations by developing, applying, demonstrating, and validating advanced autonomy and automation technologies and providing methods or research results that support certification of autonomous systems.*

The Updated 2019 NASA Strategic Plan, available at https://www.nasa.gov/aeroresearch/strategy

TABLE 3. ARMD MEGA- DRIVERS

Mega- Driver 1:	Global Growth in Demand for High Speed Mobility
Mega- Driver 2:	Affordability, Sustainability, and Energy Use
Mega- Driver 3:	Technology Convergence

TABLE 4. ARMD STRATEGIC RESEARCH THRUSTS

Strategic Thrust 1:	Safe, Efficient Growth in Global Operations
Strategic Thrust 2:	Innovation in Commercial Supersonic Aircraft
Strategic Thrust 3:	Ultra-Efficient Subsonic Transports
Strategic Thrust 4:	Safe, Quiet, and Affordable Vertical Lift Air Vehicles
Strategic Thrust 5:	In-Time System-Wide Safety Assurance
Strategic Thrust 6:	Assured Autonomy for Aviation Transformation

TABLE 5. SOLICITED RESEARCH PROGRAMS (IN ORDER OF PROPOSAL DUE DATES)

APPENDIX	PROGRAM	NOI DUE DATE	PROPOSAL DUE DATE
D.2	Transformational Tools and Technologies Project (TTT)	December 9, 2022	January 13, 2023, 5PM EST
D.6	Future Aviation Maintenance Technical Challenges	April 21, 2023	May 31, 2023
A.8	Advanced Air Vehicles Program (AAVP) Fellowship Opportunities	N/A	May 31, 2023, 5PM ET

Note: It is expected that additional project areas will be added in future amendments.

Notes:

TABLE 6: SOLICITED RESEARCH PROGRAMS (IN ORDER OF APPENDICES A–D)

APPENDIX	PROGRAM	NOI DUE DATE	PROPOSAL DUE DATE
A.8	Advanced Air Vehicles Program (AAVP) Fellowship Opportunities	N/A	May 31, 2023, 5PM ET
D.2	Transformational Tools and Technologies Project (TTT)	December 9, 2022	January 13, 2023, 5 PM EST
D.6	Future Aviation Maintenance Technical Challenges	April 21, 2023	May 31, 2023

Note: It is expected that additional project areas will be added in future amendments.

Notes:

APPENDIX A: Advanced Air Vehicles Program

A.1 Program Overview

The Advanced Air Vehicles Program (AAVP) develops knowledge, technologies, tools, and innovative concepts to enable safe new aircraft that will fly faster, cleaner, and quieter and use fuel far more efficiently than in the past. All major modern U.S. aircraft incorporate NASA research and technology. The type of research performed by AAVP will prime the technology pipeline, enabling continued U.S. leadership, competitiveness, and high-quality jobs in the future. These advanced, integrated technologies and capabilities improve vehicle performance by reducing fuel consumption, noise, and emissions without adversely affecting vehicle safety. Fuel efficiency and environmental factors will play an increasingly significant role as the aviation market grows in capacity and as airlines, manufacturers, and regulators commit to new environmental targets and explore new markets.

AAVP develops a broad range of technologies that help ensure continued U.S. industrial leadership that will benefit both the economy and the environment. Specifically with respect to subsonic transport aircraft and as part of NASA's leadership of the Sustainable Flight National Partnership, AAVP accelerates development of key subsonic technologies to ensure they will be ready by the mid- to late-2020s to transition into U.S. industry's next generation single-aisle transport aircraft. Across the program, NASA will continue to engage partners from industry, academia, and other government agencies to maintain a broad perspective on technology solutions to these challenges, to pursue mutually beneficial collaborations, and to leverage opportunities for effective technology transition.

The AAV Program directly supports three of the ARMD Strategic Thrusts (Thrust 2: Innovation in Commercial Supersonic Aircraft, Thrust 3: Ultra-efficient Subsonic Transports, and Thrust 4: Safe, Quiet, and Affordable Vertical Lift Air Vehicles) covering five projects:

The Advanced Air Transport Technology (AATT) Project explores and develops technologies and concepts for improved energy efficiency and environmental compatibility for fixed wing subsonic transports.

The Revolutionary Vertical Lift Technology (RVLT) Project develops and validates tools, technologies, and concepts to overcome key barriers, including noise, efficiency, and safety for vertical lift air vehicles.

The Commercial Supersonic Technology (CST) Project develops and validates tools, technologies and concepts to overcome the barriers to practical supersonic commercial aircraft.

The Hybrid Thermally Efficient Core (HyTEC) project will develop small core turbofan engine technologies aimed at achieving a 5-10 percent fuel burn reduction compared to

2020 best-in-class turbofan engines and up to 20 percent power extraction at altitude, culminating in an advanced core demonstration in the 2026 timeframe.

The Hi-Rate Composite Aircraft Manufacturing (HiCAM) project will demonstrate manufacturing approaches and associated technologies for large composite primary airframe structures that enable high-rate production (up to 80 aircraft per month) with reduced cost and no weight penalty versus 2020 technology for composite structures.

In addition to research that directly aligns with specific Strategic Thrusts, ARMD conducts foundational research on crosscutting ideas and technologies that provide critical support across multiple Strategic Thrusts. Fundamental research on reducing the barriers to reusable hypersonic systems provides one example of incorporating advancement across multiple disciplines to support an application. Within the AAV Program, the Hypersonic Technology project focuses on hypersonic propulsion systems, reusable vehicle technologies, high-temperature materials, and systems analysis.

Work within the AAV Program directly benefits the public through the development of techniques and concepts for air vehicles that are cleaner, quieter, faster, safer, and more energy efficient. Research efforts in revolutionary aircraft configurations, lighter and stiffer materials, improved propulsion systems, high-speed flight, and advanced concepts for high-lift and drag reduction all target the efficiency and environmental compatibility of future air vehicles. The program also helps the country develop and maintain excellence in the aeronautics workforce by providing significant research opportunities in all of its projects.

The awards from this NRA will support U.S. leadership in aerospace through its commitment to identify and advance innovative ideas, concepts, technologies, and approaches to the aeronautics challenges described below.

For more information, please see http://www.aeronautics.nasa.gov/programs-aavp.htm

A.2 Advanced Air Transport Technology (AATT) Project

A.2.1 Project Overview

The Advanced Air Transport Technology project enables revolutionary advancements in future aircraft performance. As part of the NASA-led Sustainable Flight National Partnership, research explores solutions to advance knowledge, technologies, and concepts, enabling major steps in energy efficiency and environmental compatibility and resulting in reductions to fuel burn, harmful emissions, and noise around airports. The research also benefits U.S. industrial competitiveness in the subsonic transport aircraft market, as well as, potentially opening new markets for U.S. entrants in the regional jet and smaller size classes. The knowledge gained from this research in the form of experiments, data, system studies, and analyses, is critical for conceiving and designing more efficient, quieter aircraft. Advanced air transport research directly supports ARMD

Strategic Thrust 3 and focuses on developing advanced technologies and tools for future generations of commercial transport – including the emerging area of electrified aircraft propulsion and the supporting engine core research needed to develop new engines that will ultimately power the new vehicles. Although this project focuses on the long-term technology timeframe, it also contributes to both near- and mid-term development by demonstrating interim technology advancements.

A.2.2 Description of Solicited Topics

The AATT Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

A.2.3 Summary of Key Information

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD

NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

A.3 Revolutionary Vertical Lift Technology (RVLT) Project

A.3.1 Project Overview

The NASA Revolutionary Vertical Lift Technology (RVLT) project develops and validates tools, technologies, and concepts to overcome key barriers to the expanded use of vertical lift configurations in the nation's airspace. The ability of vertical lift vehicles to hover provides a unique capability that has great potential in the civil market for human and cargo transportation, delivery systems, inspection and surveillance missions, oil and gas exploration, disaster relief, and many more critical operations. RVLT research advances technologies that will increase speed, range, payload, and safety and decrease noise, weight, and fuel burn. The research is accomplished through advanced computer-based multi-fidelity prediction methods, use of unique NASA facilities, and state-of-the art experimental techniques. RVLT considers current and future vertical lift vehicles of all classes and sizes, with particular focus on revolutionary new electric and hybrid-electric advanced air mobility concepts. The new concept vehicles that are targeted by RVLT are identified by various descriptors, including "urban air taxi", "urban air mobility" and "eVTOL" (electric vertical take-off and landing) which are all a subset of the larger set of advanced air mobility vehicles.

A.3.2 Description of Solicited Research

The RVLT Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

A.3.3 Summary of Key Information

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD

General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

A.4 Commercial Supersonic Technology (CST) Project

A.4.1 Project Overview

Supersonic vehicle research includes tools, technologies, and knowledge that will help eliminate today's technical barriers to practical, commercial supersonic flight. These barriers include sonic boom noise, supersonic aircraft fuel efficiency, airport community noise, high-altitude emissions, vehicle aeroservoelastic design, supersonic operations, and the ability to design vehicles in an integrated, multidisciplinary manner.

The Commercial Supersonic Technology (CST) project directly supports ARMD Strategic Thrust 2: Innovation in Commercial Supersonic Flight. CST leverages the X-59 Low-Boom Flight Demonstrator to gather data on the human responses to low-level sonic booms. This human community response data informs national and international regulatory organizations' efforts to define certification standards that commercial aircraft manufacturers can follow to create new supersonic aircraft markets.

In preparation for the use of the X-59, CST research will establish the necessary approaches and techniques for objectively measuring the level of supersonic overflight

noise acceptable to communities living near future commercial supersonic flight paths. These approaches, techniques, and resulting data will be the foundation for establishing the sonic boom acoustic limits as part of the international certification standards.

A.4.2 Description of Specific Solicited Research

The CST Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

A.4.3 Summary of Key Information

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

A.5 Hypersonic Technology (HT) Project

A.5.1 Project Overview

NASA focuses on fundamental research that explores key challenges in hypersonic flight and maintains unique, specialized facilities and experts. The Hypersonic Technology project focuses on hypersonic propulsion systems, reusable vehicle technologies, high-temperature materials, and systems analysis. NASA applies its expertise to support and evaluate the potential for future commercial hypersonic markets. In addition, this project coordinates closely with partners in the Department of Defense (DoD), so NASA can leverage DoD investment in ground and flight activities to develop and validate advanced physics-based computational models. At the same time, DoD benefits from NASA expertise, analyses, testing capabilities, and computational models. NASA can support U.S. industry's emerging interest in commercial hypersonic vehicles, while also supporting DoD needs.

A.5.2 Description of Specific Solicited Research

The Hypersonic Technology Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

A.5.3 Summary of Key Information

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.

Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

A.6 Hybrid Thermally Efficient Core (HyTEC) Project

A.6.1 Project Overview

The Hybrid Thermally Efficient Core (HyTEC) project will develop small core turbofan engine technologies aimed at achieving a 5-10 percent fuel burn reduction compared to 2020 best-in-class turbofan engines and up to 20 percent power extraction at altitude, culminating in an advanced core demonstration in the 2027 timeframe. As part of this effort, HyTEC will advance design capabilities for small core combustors for effective and efficient operability on high blend (80-100 percent) sustainable aviation fuels. Within the Sustainable Flight National Partnership, NASA will collaborate with industry in a cost-sharing arrangement on key technologies and will accelerate these key technologies to strengthen the U.S. industry position on small core-enabling technology and integrated systems for a future single aisle aircraft. HyTEC primarily supports ARMD Strategic Thrust 3.

A.6.2 Description of Specific Solicited Research

The HyTEC Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

A.6.3 Summary of Key Information

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD

General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.

Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

A.7 Hi-Rate Composite Aircraft Manufacturing (HiCAM) Project

A.7.1 Project Overview

The Hi-Rate Composite Aircraft Manufacturing (HiCAM) project will demonstrate manufacturing approaches and associated technologies for large composite primary airframe structures that enable high-rate production (up to 80 aircraft per month) with reduced cost and no weight penalty versus 2020 technology for composite structures. The project focus will be airframe structural components for single-aisle transport aircraft expected to enter service in the early to mid-2030s. HiCAM will develop model-based engineering tools to rapidly mature, optimize, and transition high-rate composite manufacturing and assembly methods. NASA will team with partners to share expertise, facilities, and resources to accelerate technology maturation efforts. As part of the Sustainable Flight National Partnership, the HiCAM project technologies will enable advanced vehicle concepts that require composite structures and will introduce manufacturing considerations into future vehicle designs. HiCAM primarily supports ARMD Strategic Thrust 3. However, the findings and techniques developed will generally advance manufacturing technology applicable to a variety of composite structures, including aircraft engine applications, urban air mobility vehicles, and space

launch vehicle applications. The findings and techniques may also contribute to future in-space construction and assembly of composite structures.

A.7.2 Description of Specific Solicited Research

The HiCAM Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

A.7.3 Summary of Key Information

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the Summary of Solicitation of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the Summary of Solicitation of this NRA and Chapter 3 of the NASA Guidebook for Proposers.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

A.8 Fellowship Opportunities

Advanced Air Vehicles Program (AAVP) goals and objectives are provided in Appendix A.1. A detailed description of Projects within AAVP can also be found in the preceding Appendices A.2 – A.7. Below is an amendment to the Appendix A focused on AAVP Fellowship Opportunities (Appendix A.8)

For more information, please see http://www.aeronautics.nasa.gov/programs-aavp.htm

For a Table of Content version of Appendix A.8, please see the Amendment Documents section.

A.8.1 AAVP Fellowship Overview

This NASA Notice of Funding Opportunity (NOFO) is administered by Aeronautics Science Mission Directorate's (ARMD) Advanced Air Vehicles Program (AAVP) and titled the AAVP Fellowship Opportunities (also referred to as Fellowship Opportunity in the document) .

The AAVP Fellowship Opportunities includes the use of program elements, which allows greater flexibility in meeting the activity goals and objectives. Program elements are tied to projects or sub-projects within AAVP. Additional program elements may be added as new section to this Appendix to be issued later in the year. This approach provides flexibility, so that each program element has its unique expectations and selection criteria. Contingent upon available federal funding, AAVP will administer the fellowships until closeout, thereby fulfilling NASA's responsibilities to its Fellows.

The announcement solicits proposals from accredited U.S. institutions for research training grants to begin the academic year. This NOFO is designed to support independently-conceived research projects by highly qualified graduate students, in disciplines needed to help advance NASA's mission, thus affording these students the opportunity to directly contribute to advancements in STEM-related areas of study. AAVP Fellowship Opportunities are focused on innovation and the generation of measurable research results that contribute to NASA's current and future science and technology goals.

Unique to this research and development fellowship, the program structure establishes a Professional Learning Community (PLC) consisting of active Fellowship cohorts, institutional faculty advisors as the grant Principal Investigators (PIs), NASA researchers, scientists, and subject matter experts (SMEs). The PLC is designed to provide a network of mentors committed to the successful completion of the proposed research. This fellowship includes the following benefits and allowances: Stipend, Tuition Offset and Fees, Center Based Research Experience Allowance, Health Insurance Allowance, Faculty Advisor Allowance, and Fellow Professional Development Allowance.

A.8.2 Solicitation Overview

A.8.2.1 Purpose of Fellowship

The fellowship opportunity is designed to provide US academic institutions the ability to enhance graduate-level learning and development. Institutions are provided funds that support graduate students at a level that allows the students to fully concentrate on academic and research proficiency without the need to seek employment.

The goals are to:

- Enhance research and development capacity of institutions and promote greater diversity in addressing AAVP priorities;
- Recruit a diverse set of students through by partnering with academia, non-profit organizations, and institutions; and
- Expand connections with institutions by enhancing their research capabilities through NASA's unique people, facilities, and content.

A.8.2.2 Fellowship Description

The fellowship opportunity provides financial awards to institutions to support development and training of graduate researchers. Furthermore, this activity leverages the capabilities of academic research at institutions of higher education and includes professional development components, designed to provide experiences that enhance the Fellows with NASA's best and promising practices for STEM workforce development.

Proposed Research

The candidate and the faculty advisor are encouraged to connect with the NASA Technical Advisor in advance to discuss the scope of proposed work. NASA Technical Advisor Points of Contact (POCs) are listed in the Program Elements of this NOFO. The institution's candidate will independently conceive a research hypothesis or an engineering design project concept in response to one of the graduate research opportunities listed in the NOFO. The institution's candidate, guided by a Faculty Advisor, shall develop a proposal in coordination with the NASA Technical Advisor in order to assure institutional capability and capacity, ensure relevance to AAVP priorities, and secure NASA's technical support for use of its unique facilities, content and/or subject matter experts (SMEs). The institution shall submit the proposal on behalf of a graduate student. If a NASA research training grant is awarded, the Faculty Advisor shall serve as the Principal Investigator (PI) under the awarded grant.

An institution may submit proposals on behalf of multiple candidates; however, each individual candidate is permitted to have only one proposal submitted on his or her behalf.

NOTE: Entities shall not submit duplicate proposals. If more than one proposal is submitted on behalf of an institution's candidate, then all proposals will be deemed

ineligible for that student and will not be forwarded for peer review.

On-Site Experience

If the proposal is selected and awarded a grant, the NASA Technical Advisor becomes an integral part of the team and an additional member of the research cohort. The NASA Technical Advisor promotes NASA's innovation-oriented culture and provides entry into NASA-unique facilities; access to specialized equipment, and exposure to NASA's partners and collaborators. NASA Fellows shall be mentored by the NASA Technical Advisor at a host NASA Center during an annual mandatory 10-week Center-Based Research Experience (CBRE). The CBRE occurs in the summer months, in order to benefit from the dynamic Federal research and development (R&D) environment and other related professional development activities. However, a possible unavailability of needed specific Center test facility and/or equipment due to its commitment to on-going NASA mission-related work may necessitate off-summer CBRE at the affected Center. Through the CBRE, Fellows will advance their STEM education through gaining relevant research experience, expanding their professional networks, learning best practices, developing and strengthening research ethics, and cultivating an understanding of specific research processes.

Period of Performance and Optional One-Year Extension

The fellowship opportunity is a 2-year award for a Master's Fellow and a 4-year award for a Doctoral Fellow. Both are dispersed annually consistent with the renewal process. This NOFO is designed to provide an extension for an optional third year of funding for a Master's Fellow and an optional fifth year of funding for a Doctoral Fellow. Additional details regarding the renewals process can be found in Section A.8.7 of this NOFO. Details and instructions for applying for an additional year extension can be found in Section A.8.8 of this NOFO.

Professional Networking Opportunity

NASA Fellows will be able to participate in annual prestigious conferences during which they will have the opportunity to network with their cohort of Fellows, meet prospective recruiters, and participate in professional development sessions.

Requirement to Notify NASA of Other Funding Submissions/Selections

Each proposal shall clearly indicate if it is being submitted to more than one NASA office at the same time. For example, proposal submission to EONS (Engagement Opportunities in NASA STEM) and AAVP Fellowship Opportunities, this information shall be included in the program specific data section of the proposal. NASA will make appropriate determinations in the selection process if the same proposal is recommended for award to multiple NASA offices. In other words, the same proposal cannot be selected for an award to more than one NASA office.

A.8.2.3 Relevance to NASA and AAVP

Each proposed research/engineering project is to be developed in response to one of the fellowship opportunities. A letter of support is required if NASA resources (such as

laboratory equipment, computational hours, test facilities, etc.) are requested in the proposal and it needs to be coordinate in advance with the Technical Advisor listed in the solicitation. Additionally, the Technical Advisor's letter shall indicate concurrence from the Center's Office of STEM Engagement to support tasks associated with on-boarding and/or off-boarding the fellow. The NASA Technical Advisors are identified in the opportunities posted under Program Elements of this NOFO. In addition, the NASA Technical Advisor shall document the agreed-upon collaboration, including a communication plan, specific equipment, and/or facility use and other investments. Both the Faculty Advisor and the NASA Technical Advisor's proposed collaboration shall be included, with areas of collaboration interests and potential outcomes clearly documented. Coordination with the potential NASA Technical Advisor is mandatory. The NASA Technical Advisor associated with the opportunity will provide review and guidance on the activities in his or her lab. Also, proposals shall clearly and concisely describe:

- The relevance of the proposed work to NASA's currently funded research priorities as described in the funding opportunity;
- The relevance of the proposed work to the interests and abilities of the Institution's candidate; and
- How the work will increase the capacity of executing cutting-edge research at the institution.

A.8.3 Award Information

Type of Award
Research training grants.

Available Funding for the NOFO
Funding is subject to NASA's receipt of proposals of adequate merit and to the availability of Congressional appropriations in each FY. Please refer to the Program Elements for award details.

Projected Number of Awards
Awards are subject to NASA's receipt of proposals of adequate merit and to the availability of Congressional appropriations in each FY. Please refer to the Program Elements for award details.

Maximum Award Amount
Award amount varies by degree. Please refer to the Program Elements for award details.

Cancellation of Announcement
NASA reserves the right to not make any awards under this NOFO and/or to cancel any or all aspects of this NOFO at any time. NASA assumes no liability (including proposal preparation costs) for canceling this NOFO or for an entity's failure to receive an actual notice of cancellation.

Anticipated Period of Performance

All awards are disbursed annually and may be renewed pending availability of Congressional funds and a successful annual review of the effort. Fellows shall justify extended third- and fifth-year requests (Master's and PhD, respectively). Annual renewals are contingent upon NASA's acceptance of the renewal application, which includes satisfactory progress (as reflected in the Fellow's academic performance and research progress, recommendation by the Faculty Advisor, recommendation by the NASA Technical Advisor, and effective costing of the annual budget).

Requests for deferment of awards are not encouraged and will only be considered in emergency situations. Approvals for deferments are not guaranteed. Institutions seeking renewals shall submit a Renewal Proposal Applications Package in May of each year. Specific details will be released to Fellowship awardees upon acceptance of the award.

Additional details regarding the renewals process can found in Section A.8.7 of this NOFO.

Funding Instrument Type(s)

The fellowship funding is issued to the awardee's institution by NSSC in the form of a NASA research training grant.

Applications for renewal or supplementation of existing projects are handled separately from yearly release of the NOFO.

A.8.3.1 Funding Information

The fellowship will be awarded as a non-portable research training grant to accredited U.S. institutions on behalf of Fellows selected under this NOFO. As such, this award cannot be transferred to another institution. If a Fellow transfers to a different institution during the award's period of performance, the Fellow shall reapply to the activity and follow the guidelines for a new Institution's candidate, submit a new proposal, and compete for any future AAVP Fellowship Opportunity. If the PI transfers to another institution, the award remains with the institution that received the initial award funding, and not with the PI (or any other individual(s)). For each Fellow, their institution receives up to a $64,000 annual award ($59,000 for Master's student and $64,000 for Doctoral student), with the following annual maximums per budget category:

TYPE OF FUNDING	FUNDING AMOUNT
Fellowship Stipend	$35,000 (Master's) $40,000 (Doctoral)
Tuition Offset and Fees	$8,000
Center-Based Research Experience (CBRE) Allowance	$6,000

Health Insurance Allowance	$3,000
Faculty Advisor Allowance	$5,000
Fellow Professional Development Allowance	$2,000

Refer to Section A.8.3.2 for detailed information on each of the above funding categories.

NOTE: Institutions are allowed to transfer Tuition Offset and Fees funds to health insurance and professional development allowance, upon approval from the Fellowship program and the NASA Grants Officer. Students are exempt from paying any tuition differences (i.e., the difference between the tuition and fees allowance and the actual tuition and fees.) A statement should be provided by the institution during acceptance of the award that the students are exempted from paying any tuition differences.

A.8.3.2 Allowances Explained

Fellowship Stipend: A stipend offsets the Fellow's living expenses. Stipend payments shall be prorated evenly across a twelve-month academic school year.

Tuition Offset and Fees: Permissible up to the maximum value. While the student is funded as a result of selection for the AAVP Fellowship Opportunity, the institution shall exempt the student from paying the difference between the tuition and fees allowance and the actual tuition and fees.

Center-Based Research Experience (CBRE) Allowance: This allowance is to be used to support travel and other expenses associated with the CBRE experience. CBRE funds are to be released from the institution to the Fellow in two incremental payments. The first payment shall be released within a month of the planned CBRE, and the last payment shall be released after the successful completion of the 5th week of the CBRE. In accordance with the NASA research training grants reporting process, all institutions shall submit receipts for all financial transactions to the Fellowship program.

Health Insurance Allowance: Permissible up to a maximum value, only to the level of the actual expected cost.

Faculty Advisor Allowance: This allowance is designated to support and facilitate a collaborative research team. Faculty Advisors are significant contributors to the execution of the training grant's research goals. This allowance supports on-site visit(s) during the Fellow's CBRE to discuss various research-related topics with the team and to explore additional research opportunities with NASA.

Fellow Professional Development Allowance: This allowance may be used in direct support of training, attendance at technical and scientific conferences, and publication needs of the Fellow. This allowance may be used in concurrence with the Faculty Advisor Allowance to cover the Fellow's approved domestic travel to technical and

scientific meetings. Each Fellow shall attend at least one technical conference (in person or virtual) to present the work he or she is conducting under the awarded research proposal. All technical conferences shall follow procedures for approval by the Fellowship program. Conferences are to be attended after the first year of the research training grant. Fellows presenting their research papers at conferences shall have advanced written approval to do so from their NASA Technical Advisors and NASA's export control office.

Allowable expense details for attending professional research, conferences, symposiums, and workshops are as follows:

1. Registration Fees.
2. Accommodation - maximum three nights in a fire safe hotel* per event (per diem 3 full days and two ½ days).
3. Travel costs to and from event.
4. Publication costs for conference presentation materials, related research papers, thesis, and dissertation.
5. Training for professional required skills such as software training, etc.

Details to fire safe hotels and property selection criteria and cost of travel can be found on U.S. General Services Administration rates. *NOTE: Shared homes, including Airbnb are not included in the list of acceptable lodging.

NASA funds must not be used to purchase equipment such as computers, furniture, and non-related research equipment.

The NASA Fellowship supports graduate research training and development and does not provide funding for institutional overhead/indirect costs.

Pre-award costs are not allowable.

Tax questions should be directed to the Internal Revenue Service. Refer to IRS publications on "Scholarships and Fellowships."

A.8.3.3 Transfer of Award

The PI and the institution's AOR shall provide a timely statement to the fellowship management advising of any changes in the Fellow's enrollment status. If the Fellow withdraws within the first half of the award year, the institution may submit a request for replacement of a graduate student with similar achievement and research objectives to complete the remaining months of the current award. Since this is a highly competitive program, replacement Fellows will be subject to Technical Advisor's concurrence.

A.8.3.4 Cost Sharing

NASA may consider voluntary cost sharing options, as deemed appropriate. Submitting

institutions shall describe in their proposals any such cost-sharing that is offered.

A.8.4 Eligibility Information

A.8.4.1 Candidate Eligibility

Institutions are submitting research ideas on behalf of their respective candidates. To be eligible to apply for receipt of a fellowship, the candidate shall satisfy all of the following criteria:
Be a U.S. citizen or a U.S. national on the date of proposal submission. The term "national" refers to native residents of a possession of the United States such as American Samoa.
Hold a Bachelor's degree earned before August 31 of the academic year for the grant award.
Have a minimum GPA of 3.0 on a 4.0 scale on the most recent transcript. (All college level transcripts are required. Unofficial transcripts are acceptable at the time of proposal submission. However, once selected official transcripts shall be submitted.)
Be enrolled in a full-time Master's or Doctoral degree program in a STEM-related field no later than September 1 of the academic year for the grant award.
Have a projected degree plan for continuous full-time enrollment equating to the period of performance of the grant award. Candidates shall be no later than in the first academic year of their Master's degree program, or no later than in the second academic year of their doctoral degree program. (Students should not plan to graduate before the end of the period of performance of the grant award.)

A.8.4.2 Degree and/or Field of Study

Fellowships are awarded for graduate studies leading to research-based Master's and Doctoral degrees in a NASA-specific STEM discipline.

A.8.4.3 Institutional Eligibility

Accredited U.S. institutions of higher education, offering graduate level degrees in STEM fields, and having a physical campus located in the U.S. or its territories are eligible for this NOFO.

Proposals involving bilateral participation, collaboration, or coordination in any way with China or any Chinese-owned company, whether funded or performed under a no-exchange-of-funds arrangement, shall be ineligible to receive an award.

A.8.4.4 Faculty Advisor / PI Eligibility

The PI shall be a tenured or tenure-track faculty member at an eligible accredited U.S. institution (if a tenure system is established). Eligible institutions that do not have a tenure track instead shall submit a letter of commitment to comply with the rule that any proposed change to the PI under the agreement is subject to NASA's advance written approval. The PI shall have a Ph.D. or equivalent in an engineering, computer science, technology, mathematics, or science discipline that is relevant to NASA's research needs. The PI shall be a U.S. citizen or a U.S. national on the date of proposal submission. The

term "national" refers to native residents of a possession of the United States such as American Samoa.

A.8.5 Proposal Submission

The institution's candidate shall be the principal author of the submitted research proposal, except for the impact statement, which is written in collaboration with the faculty advisor. By submitting the proposal for consideration, the institution's candidate and the Faculty Advisor/PI certify that the institution's candidate is the principal author of the proposal.

The NASA civil servants listed in Program Elements of this NOFO as potential Technical Advisors, shall not assist in the development or any formal pre-submission review of specific proposals. This restriction begins on the release date of this NOFO. Additionally, any NASA civil servants who will serve as proposal reviewers for this NOFO shall not "pre-read" any proposals nor provide letters of support (with exceptions being letters of support relating to the use of NASA resources, see Section A.8.2.3) to an entity/entity that plan(s) to submit a proposal. However, submitters shall contact the potential NASA Technical Advisors (as identified in Section A.8.2.3) for information regarding a review of the work currently being performed in the respective lab. The proposed research idea shall align with the research opportunity listed in the Program Elements and shall be approved by the NASA Technical Advisor for that specific research opportunity.

Proposals that do not comply with these requirements will be deemed ineligible for award.

A.8.5.1 Notice of Intent to Propose

Notices of Intent (NOIs) are not required for this solicitation.

A.8.5.2 Fellowship Proposal Submission Guidelines

Unless otherwise noted below, all proposals submitted in response to this solicitation shall be in accordance with Chapter 2 Proposal Preparation and Organization and Chapter 3 Proposal Submission of the NASA *Proposer's Guide*, *Edition: February 2023*. Proposals that do not follow the formatting requirement are subject to rejection during administrative screening.

All proposals shall be submitted via NSPIRES in electronic format by the institution's Authorized Organization Representative (AOR) by 5PM Eastern Time. Proposals received after this deadline are considered "LATE" and will be deemed ineligible for award. NASA does not pre-approve the submission of late proposals. If a late proposal is submitted, it is within NASA's sole decision to decide whether to accept it. If NSPIRES is available for proposal submissions, the site automatically captures the time the system received the proposal. Proposals submitted later than 5PM Eastern Time on the proposal due date are considered "LATE." The NSPIRES system may prevent the submission of

proposals after the deadline. Extensions will not be given to accommodate late or partial submissions. No hard copy proposals will be accepted. Incomplete proposal packages will be deemed non-compliant and ineligible for further review.

Proposers are strongly encouraged to access the NSPIRES electronic proposal submitting system well in advance of the proposal due date. Proposers are also required to coordinate all submission steps with the institution's AOR to ensure timely proposal submissions.

Proposals shall include all the items listed below, appropriately labeled, in the exact order specified below:

1. Proposal Cover Page (including Project Summary, Program Specific Data and Data Management Plan)
2. Impact Statement
3. Faculty Advisor/PI Curriculum Vitae (CV)
4. Project Description
5. Candidate's Degree Program Schedule
6. Candidate's Curriculum Vitae (CV)
7. Personal Statement
8. Candidate's Transcripts
9. Letters of Recommendation
10. Letter of Support for use of NASA resources

Proposals shall not include extraneous information nor materials that are not specifically requested or outlined in this NOFO. The proposal shall not include any additional information provided by way of links to web pages, except as part of citations in the "References Cited" section. Images may be included in the page limits. Review of the proposal is based solely on those materials received by the proposal deadlines. The proposal shall be submitted using the following format:

- Standard 8.5" x 11" page size
- 12-point, Times New Roman font
- 10-point font may be used for citations, references, footnotes, figure captions, and text within figures
- 1" margins on all sides
- Single-spaced

A.8.5.3 Proposal Submission Requirements

Refer to Chapter IV Application and Submission Information of Research Opportunities in Aeronautics (ROA) 2023.

A.8.5.4 Proposal Submission Checklist

Below is the proposal submission information and checklist.

			Page Limit
☐	**NSPIRES Registration Information:** The institution shall be registered with NSPIRES through the Electronic Business Point of Contact (EBPOC) listed in the *System for Award Management (SAM)* database. Step-by-step instructions for proposal submission can be found in NSPIRES in "Other Documents" under the NASA Fellowship Activity.		N/A
	AOR	Each registered institution shall have a designated AOR, who shall submit the Institution's proposal for graduate-level research support.	
	PI	The Faculty Advisor (PI) shall be registered in NSPIRES and affiliated with the registered institution. (Please see "NOTE" below if the candidate has not been accepted or has not selected the institution of their choice yet and thus does not have a PI.)	
	Institution's Candidate	The institution's candidate shall be registered in NSPIRES and activate his/her account.	
	Deadline	**Proposal Submission Deadline (See appropriate appendix for each specific program element)** Extensions will not be granted to accommodate late proposals or partial proposal submissions.	
a). NSPIRES-generated Proposal Cover Page: The cover page to be completed online includes a **Project Summary** to be titled in the proposal as "Project Summary." This summary shall be a clear, concise, cohesive paragraph of approximately 1,000 characters. Also, this summary shall be a complete synopsis of the proposed project description stating the purpose, methodology, findings, and the conclusion or expected outcome of the project. The cover page also includes responses to the Program Specific Data Questions and Data Management Plan.			
The following elements are not part of the NSPIRES Proposal Cover Page form and shall be combined into a **single PDF** document and uploaded on NSPIRES for submission.			
	Format	• Standard 8.5" x 11" page size • 12-point, Times New Roman font • 10-point font may be used for references, footnotes, figure captions, and text within figures • 1" margins on all sides • Single-spaced	
NOTE: The following elements (b – k) are not part of the NSPIRES Proposal Cover Page and shall be combined into a single PDF document and uploaded on NSPIRES for submission. **b). Impact Statement:** This proposal section shall be titled "Impact Statement" and shall be jointly written by the Institution's candidate and Faculty Advisor (PI).			

The Impact statement shall address the following:			
	Pages	Shall not exceed two pages in length.	2
	Content	1. State the research gap and identify how the candidate's research proposal addresses the research gap within their STEM field in the scientific literature. 2. Discuss the impact of NASA partnership on the institution's capacity and capabilities. 3. Explore the potential for commercialization – possible technology transfer. 4. Consider scientific impact of the proposed effort on NASA and the larger scientific society, with a focus on the candidate's specific field of study. 5. The statement shall have specific information on the need for NASA participation in the research due to NASA-unique facilities, personnel, and institutional knowledge. To expand on the impact statement, the candidate shall state how their prior experience will enhance the proposed NASA research.	
c). Faculty Advisor/PI Curriculum Vitae (CV)			
	PI	• The PI shall be a tenured or tenure-track faculty member at an eligible institution (if a tenure system is established). • Eligible institutions that do not have a tenure track shall submit a letter of commitment to comply with the rule that any proposed change to the PI under the agreement is subject to prior written NASA approval. • The PI shall have a Ph.D. or equivalent in an engineering, computer science, technology, mathematics, or science discipline that is relevant to NASA's research needs.	
	Pages	Shall not exceed three pages in length.	3
	Content	1) Name 2) Current position 3) Title 4) Department 5) Institution address 6) Institution phone number 7) Principal publications (within the last three years) 8) Relevant career experience 9) Research 10) Awards 11) Scholarships 12) Other relevant accomplishments	
d). Project Description: This proposal section shall be titled "Project Description." This Project Description shall provide a clear description of the			

candidate's proposed research and shall be written in response to a specific Research Opportunity listed under "Other Documents," and with the support of a NASA Technical Advisor. The Project Description follows the order below and shall contain all the following technical elements:			
	Pages	Shall not exceed six single-spaced pages in length	6
	Content	1. Abstract 2. A statement of the problem to be addressed 3. A description of the science background and relevance to previous work in the field 4. General methodology 5. Project Schedule / Timeline 6. Explanation of new or novel techniques 7. Expected results and their significance or application 8. Literature citations	
e). Candidate's Degree Program Schedule: This section shall be titled "Degree Program Schedule," and shall include the following information:			
	Pages	Shall not exceed two pages in length.	2
	Content	1) Proposed start and completion dates. 2) Anticipated candidate degree program milestones, such as candidacy exams.	
f). Candidate's Curriculum Vitae (CV)			
	Pages	Shall not exceed two pages in length.	2
	Content	1. Name 2. Current Academic Level 3. Title 4. Department 5. Institution address 6. Institution phone number 7. Relevant career or Academic experience 8. Research or Significant Projects 9. Awards and Recognition 10. Other relevant accomplishments	
g). Candidate's Personal Statement: How does graduate school prepare the candidate for a career contributing to the expansion of scientific understanding and the alignment of proposed research with NASA's mission?			
	Pages	Shall not exceed two pages in length.	2
	Content	1. Describe personal motivation to pursue advanced NASA- related STEM research. 2. Include specific examples of any relevant research, class project and/or professional activities in which the candidate has participated. 3. Chronicle STEM graduate school preparation activities and the results. 4. Describe the contributions of the candidate's activity to advancing knowledge in STEM fields, as well as the potential impacts to NASA Missions.	

h). Candidate's Transcripts: Include all undergraduate and graduate transcripts. The candidate shall have a minimum GPA of 3.0 on a 4.0 scale on his or her most recent official transcript. (All college-level transcripts are required, however, only the GPA from the most recent institution is required to be a minimum GPA of 3.0 on a 4.0 scale. While official and unofficial transcripts are acceptable at the time of the application, official transcripts will be required following selection.)			N/A
	Format	Shall be legible and unaltered.	
	Note	Redact the candidate's social security number and date of birth, if they appear on the transcript, prior to submission (These two redactions are the only permitted alterations to a transcript.)	
	Foreign Transcripts	Transcripts from institutions outside of the United States also have the option to be accompanied by an international credential evaluation from a third party, such as, but not limited to, the *World Education Services* (WES). Explanatory statements regarding transcripts are optional and shall be used to explain special cases, such as non-English Language transcripts. Adding a simple reference/link to an institution's website in order to explain the credit allocation and conversion of grades to the U.S. system or websites that translate from foreign languages into English is not an explanatory statement since websites may not work. The necessary explanatory text shall be fully contained within the supplemental transcript explanation.	
i). Letters of Recommendation			
	Content	Each institution's candidate shall submit three current letters of recommendation as part of the proposal by the proposal due date on an organization's official letter head.	N/A
	Restrictions	Recommenders shall not be family members of the candidate. If a NASA civil servant or JPL employee provides a Letter of Recommendation for a proposal, then they **cannot** provide the Letter of Support for that proposal.	
	Details	Each letter shall contain the recommender's contact information. One letter shall be from (and signed by) the candidate's proposed Faculty Advisor/PI on official institution/organization letterhead. It shall include the following information: name and title of the letter writer, department, and institution or organization. **It shall include a statement indicating the level of assistance provided to the candidate during the preparation of the project description**. (**NOTE:** If a candidate has not yet been accepted into their institution of choice, then they shall submit a letter of recommendation from his or her current academic advisor.) *The identified PI is not permitted to be a family member. The other two letters shall be written by individuals (e.g.,	

		teachers, professors, STEM professionals, advisors, mentors, work supervisors) with detailed knowledge of the candidate's abilities.	
	Requirement	All letters of recommendation for the proposed candidate shall be submitted as part of the proposal by the proposal due date and the letters shall be on the organization's letter head with the recommender's name, title, organization, and contact information.	
j). Letter of Support			N/A
	Technical Advisor	The contributing NASA Technical Advisor shall: (1) be a NASA civil servant; and (2) provide a letter on the organization's letterhead stating his/her support relating to the use of NASA resources. Additionally, the Technical Advisor shall obtain concurrence of support from the Center's Office of STEM Engagement for tasks associated with onboarding and offboarding the fellows.	
	Content	A statement of support shall be included for any research expenses not covered by the research training grant and identified as an in-kind contribution from NASA.	
	Restriction	A NASA civil servant providing a Letter of Support for the proposal **cannot** also provide a Letter of Recommendation for the proposal. *The identified NASA Technical Advisor should not be related to any proposers on this effort.	

A.8.6 Proposal Review and Evaluation Information

A.8.6.1 Proposal Review and Selection

The evaluation criteria in Chapter IV and Appendix D of the NASA *Proposer's Guide*, *Edition: February 2023* are superseded by the following criteria.

All eligible proposals will be reviewed by NASA subject matter experts (SMEs) via online reviews. These reviewers will be identified by NASA, ensuring they are experts in the STEM subjects closely related to the candidate's field of study. The selection process

will ensure that reviewers have no conflicts of interest with the submitting institution, the institution's candidate, and/or the proposal team. Reviewers shall be required to sign a nondisclosure/conflict of interest form prior to being granted access to the proposals. NASA technical experts will complete a technical review of proposals and submit their findings and results to the selection officials for final award decisions.

The following criteria shall be used to evaluate proposals: Academic Merit and Distinction, Broader Impact, and Scientific Merit. The weights and a description of these areas are provided below.

Academic Merit and Distinction (30%)
Based upon the review of the Institution's candidate's transcripts, degree program schedule, personal statement, impact statement, letters of recommendation and candidate's CV, reviewers shall analyze the applicant's potential to conduct NASA relevant research based upon the following criteria:

1. The applicant's ability to synthesize and evaluate original thoughts into a clear and concise document;
2. The applicant's previous experiences conducting research and/or desire/potential to conduct research in an authentic lab setting; and
3. The applicant's intrinsic motivation and determination to complete an advanced degree.

Broader Impact (10%)
Based upon the review of the applicant's "Project Description," reviewers shall analyze the proposed research's potential to benefit society or advance desired societal outcomes. These include activities that are directly related to the specific research projects or activities that are supported by and are complimentary to the project. Examples include participation by an underrepresented and/or underserved community, enhancement of STEM education and educator development, improved well-being of individuals, increased partnership between academia and industry, and improved national security.

Scientific Merit of the Proposed Research (60%)
Based upon the review of the applicant's Project Description, reviewers shall analyze the quality of the proposed NASA relevant research based upon the following:

1. The proposal's ability to address research gap in the scientific literature;
2. The proposal's ability to clearly describe a collaborative approach to conducting research within NASA;
3. The proposal's ability to clearly describe the connection between the proposed research area and the academic discipline that the Institution's candidate is pursuing; and
4. The proposal's ability to clearly describe the uniqueness of their proposal against the goals described in the Fellowship solicitation.

A.8.7 Annual Renewal Process

The Annual Renewal Process is contingent upon satisfactory progress, as reflected in the academic performance, research progress, recommendation by the faculty advisor, NASA Technical Advisor and the availability of funds. Fellows seeking renewal shall submit a Renewal Application Package to fellowship management and the grant management at the NASA Shared Services Center (NSSC) for each Academic Year. The Renewal Application Package includes the Annual Progress Report that is a comprehensive summary of significant accomplishments during the reporting period or for the duration of the grant. The purpose of the Annual Report is to provide an update on the progress of the Fellow's research and/or degree progression. The submission of the Renewal Application Package is required before the Activity Grants Officer can release funding for additional years. The responsible parties for submitting the documentation for renewals are the Fellow and the PI; this documentation is submitted to fellowship management.

Annual Progress Report for Renewal

The *NASA Grant and Cooperative Agreement Manual (GCAM)* - Exhibit E, identifies the publications and reports required for submission. Technical Publications and Reports should be submitted in accordance with the terms and conditions at 2 CFR 1800.902.

Grant recipients shall comply with 2 CFR 180.335 and 2 CFR 180.350 of the reporting requirements. In addition to the annual progress report, recipients are also required to submit quarterly and final Federal Financial Reports (SF-425s) per the award terms and conditions (see *NASA Grant and Cooperative Agreement Manual*, Appendix D, Section D6, pg. 59) via the HHS Payment Management System.

NOTE: Any changes in academic status shall be reported and submitted with the renewal application. It is the PI's responsibility to ensure that all documents are submitted prior to 5PM ET on June 30 of each Government fiscal year, which runs from October 1 to September 30. Failure to meet this deadline will result in non-renewal of the AAVP Fellowship. Annual Progress Packages shall be sent to the following email address: GRC-AAVP-Fellowships@mail.nasa.gov

The Annual Progress Package includes the following:

- Annual Progress Report, Faculty Advisor Evaluation and NASA Technical Advisor Evaluation Form (templates will be provided at least 30 days in advance of the due date);
- Certification of Compliance (PDF Form NF1206) completed by the AOR (Not required if a Certificate of Compliance has been completed at the time of proposal application submission);
- Budget Report (All budgeted items shall be fully justified)

A.8.8 Additional Year Extension Process

Fellows may apply for a one-year extension during their final year of the period of performance, pending availability of Government funds. For Doctoral Fellows, the additional year extension is an opportunity to ask creative questions related to research from the previous years. It is intended to provide teams with the chance to apply their findings in new settings or build upon discoveries not previously outlined in the original proposal. For Master's Fellows, the additional year extension is an opportunity to receive consideration for a revised proposal that describes specific differences from the original proposal.

NOTE:
Those interested in an additional year extension should seek guidance at least 6 months in advance. Proposals based heavily on the need for more time to complete the initially proposed work or the Fellow's graduation date will not be considered.

A.8.9 Points of Contact for Further Information

Please note that the following information is current at the time of publishing. See activity website for any updates to the points of contact.

Proposal Submission Assistance Contact:
NASA Research and Education Support Services (NRESS)
Email: GRC-AAVP-Fellowships@mail.nasa.gov

Proposal Submission Help Desk (NSPIRES):
NSPIRES Help Desk
202-479-9376 from 8 am to 6 pm Eastern Time, Monday to Friday (except on federal holidays).
Email: nspires-help@nasaprs.com

NASA Shared Service Center (NSSC):
NSSC Customer Contact Center
1-877-677-2123 (1-877-NSSC123)
Email: nssc-contactcenter@nasa.gov

A.8.10 Summary of Key Information

Expected annual program budget for new awards	Between $0.4M - $0.6M will be awarded in 2023
Number of new awards pending adequate proposals of merit	8 or more
Maximum duration of awards	2 years for Masters and 4 years for Doctoral student (with a possibility of a one year extension)
Due date for Notice of Intent to propose (NOI)	Not required
Due date for proposals	May 31, 2023, 5PM ET
Award announcement date	Approximately 2 months after the proposal due date
General information and overview of this solicitation	See the *Summary of Solicitation* in the ROA.
Detailed instructions for the preparation and submission of proposals	See the NASA *Proposer's Guide*, *Edition: February 2023*
Page limit for the central Science-Technical-Management section of proposal	See Section 2.7 of the NASA *Proposer's Guide*, *Edition: February 2023* and refer to Section A.8.5.4 of this document
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of the ROA and Chapter 3 of the NASA *Proposer's Guide*, *Edition: February 2023.*
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected award type	Research Training Grant
Funding opportunity number	NNH23ZEA001N-AAVP
NASA technical point of contact concerning this program	Email questions to: GRC-AAVP-Fellowships@mail.nasa.gov Written responses will be provided individually via email, and posted online on NSPIRES Technical POC: Manan A. Vyas Fellowship POC: Tamra K. Ross
NASA Procurement point of contact concerning this program	Steven C. Linn Email: steven.c.linn@nasa.gov

Element One – Advanced Air Transport Technology (AATT) Project

Award Information

Anticipated Type of Award	Research Training Grant
Number of Years of Support	Proposals seeking Master's support shall request at least 2 years of support (with a possibility of a one year extension); Proposals seeking Doctoral support shall request at least 4 years of support (with a possibility of a one-year extension).
Total Funding **Estimated Number of Awards**	Approximately $192,000 Fellowship Opportunity anticipates awarding 3 Graduate Research Fellows per fiscal year (FY) under this element, pending the availability of funds. **NOTE:** If opportunities for cost sharing become available, this estimate may increase.

Fellowship Opportunities

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
AATT-GRC-001	Innovative Research to Advance the Development of Sustainable Subsonic Transport Aircraft	NASA seeks innovative research endeavors relevant to advancing the development of sustainable subsonic transport aircraft and technologies to meet the goal of the U.S. 2021 Aviation Climate Action Plan to achieve Net-Zero Greenhouse Gas Emissions from the U.S. Aviation Sector by 2050. This includes, but is not limited to, development of technologies in the areas of aerodynamics, propulsion, materials and structures, energy/thermal management, and alternative fuels.	Master's/Ph.D.	Technical Advisor Eric Hendricks eric.hendricks@nasa.gov 216.433.6612 Co-Technical Advisor Ty Marien ty.marien@nasa.gov 757.864.6139

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
		Additionally, development of methods and models for systems analysis and systems-of-systems/lifecycle analysis are sought to enable evaluation of sustainable aircraft technologies and concepts.		
AATT-GRC-002	Innovative Research to Advance the Development of Engines for Subsonic Commercial Air Transport	NASA seeks innovative research endeavors relevant to the broad scope of enabling technologies for next generation engines for subsonic commercial transport. This includes, but is not limited to, the technical disciplines of Aerodynamics, Fluid Dynamics, and Heat Transfer for Internal Flows, Airbreathing Propulsion, Mathematical Modeling (characterizing the spatial and temporal domains) and associated Computational Fluid Dynamic algorithms (RANS and LES), Energy/Thermal Management, and Fluid-Structure Interactions. The intent is to address key engine technologies for sustainable subsonic commercial air travel.	Master's/Ph.D.	Technical Advisor Sameer Kulkarni Sameer.kulkarni@nasa.gov 216.433.6504 Co-Technical Advisor Julia Stephens Julia.e.stephens@nasa.gov 216.433.8674
AATT-LaRC-003	Active Flow Control for Subsonic Aircraft	NASA seeks research endeavors that integrate active flow control (AFC) for improving the efficiency of commercial transports. To develop the next generation of ultra-efficient commercial vehicles, technologies such as AFC are needed to help in reducing fuel burn. Areas of interest include AFC actuator development, AFC design tool development, closed-loop AFC system development, and experimental and/or computational studies focused on novel AFC	Master's/Ph.D.	Technical Advisor Latunia Melton Latunia.p.melton@nasa.gov 757.864.1618

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
		concepts for improving vehicle efficiency. This opportunity is recommended for students with an interest in fluid mechanics, experimental techniques, and computational fluid dynamics.		

Element Two – Commercial Supersonic Technology (CST) Project

Award Information

Anticipated Type of Award	Research Training Grant
Number of Years of Support	Proposals seeking Master's support shall request at least 2 years of support (with a possibility of a one year extension); Proposals seeking Doctoral support shall request at least 4 years of support (with a possibility of a one-year extension).
Total Funding **Estimated Number of Awards**	Approximately $192,000 Fellowship Opportunity anticipates awarding 3 Graduate Research Fellows per fiscal year (FY) under this element, pending the availability of funds. **NOTE:** If opportunities for cost sharing become available, this estimate may increase.

Fellowship Opportunities

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
CST-GRC-001	Innovations in Aeroacoustics for a Quiet Fast Future	NASA seeks innovative research endeavors relevant to aeroacoustics of high-speed aircraft. Predicting and mitigating the noise produced by fans and exhaust jets for high-powered propulsion involves the advanced disciplines of fluid mechanics and acoustics. Skills needed include applied mathematics, scale-resolving computational fluid dynamics including acoustic simulations, experimental techniques, and statistical	Master's/Ph.D.	Technical Advisor James Bridges James.E.Bridges@nasa.gov 216.433.2693 Co-Technical Advisor David Stephens david.stephens@nasa.gov 216.433.2355

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
		modeling. Application of skills to real-world problems and ability to learn from prior work to propose creative new solutions is required.		
CST - LaRC-002	Estimating Sonic Boom Exposure from Supersonic Aircraft Overflight	This opportunity is for acoustics research on estimating sonic boom exposure from community overflight of supersonic aircraft. In order to enable the development of a new generation of civil supersonic aircraft, NASA is pursuing its Quesst mission to gather data on human responses to the sound generated from supersonic overflight, and to deliver that dataset to U.S. and international regulators. To aid in these efforts, research is sought to extend procedures to improve estimations of the sonic booms from new aircraft designs that produce non-traditional, low-noise signatures and to aid in planning of community tests with NASA's X-59 low-boom vehicle. Areas for improvement may include: acoustic propagation through real, complex atmospheres and clouds; noise in the region around the lateral extent of the boom carpet; noise in the focused boom region; and secondary sonic booms (initially propagated upward, but refracted downward by the atmosphere). Application of the improved methodology to the analysis of conceptual aircraft designs and to estimation of community noise exposure through fusing measurements and predictions,	Master's/Ph.D.	Technical Advisor Alexandra Loubeau a.loubeau@nasa.gov 757.864.2361 Co-Technical Advisor Sriram Rallabhandi Sriram.Rallabhandi@nasa.gov 757.864.9554

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
		including assessment of noise metrics relevant to certification standards development, is also desired. Visualization of the phenomena and resulting ground sonic boom noise exposure could be an additional component of the research. Recommended for students with an interest in nonlinear acoustics and meteorological effects on acoustic propagation. Computer programming skills required.		
CST - LaRC-003	Innovative Research Toward Making Commercial Supersonic Flight a Reality	NASA seeks innovative research proposals to enable efficient and practical commercial supersonic flight. Currently the Commercial Supersonic Technology (CST) project is preparing the necessary tools and procedures to test, fly and collect sonic boom related data from the X-59 low boom flight demonstrator. Knowledge and data from this work will inform the efforts of both national and international regulatory organizations in the development of design and certification standards for future supersonic commercial aircraft. The research proposals being sought are in support of this critical commitment. The CST Project's current focus is on sonic boom prediction and reduction methods. The project's scope includes analysis and design tools for vehicles with low sonic boom and defines the necessary approaches and techniques for objectively assessing the levels of sonic	Master's/Ph.D.	Technical Advisor Sriram Rallabhandi Sriram.Rallabhandi@nasa.gov 757.864.9554 Co-Technical Advisor Melissa Carter melissa.b.carter@nasa.gov 757.864.8606

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
		boom acceptable to communities living in the vicinity of future commercial supersonic flight paths. The intent of this call is to address several key aspects which are required to enable practical commercial supersonic flight that are complimentary to existing tools and build upon the research advances that have already been accomplished. These include: application of advanced numerical schemes for solving underlying mathematical models using efficient computational techniques; ability to understand complex mathematical models, develop computational tools and deliver solutions that can be integrated into existing models/tools; application of novel computational methods that can improve the efficiency and robustness of sonic boom prediction and mitigation; and leveraging existing research to propose creative alternate solutions/implementations to supersonic aircraft analysis/design.		

Element Three – Hypersonic Technology (HT) Project

Award Information

Anticipated Type of Award	Research Training Grant
Number of Years of Support	Proposals seeking Master's support shall request at least 2 years of support (with a possibility of a one year extension); Proposals seeking Doctoral support shall request at least 4 years of support (with a possibility of a one-year extension).
Total Funding **Estimated Number of Awards**	Approximately $128,000 Fellowship Opportunity anticipates awarding 2 Graduate Research Fellows per fiscal year (FY) under this element, pending the availability of funds. **NOTE:** If opportunities for cost sharing become available, this estimate may increase.

Fellowship Opportunities

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
HTP-GRC-001	Development of High Temperature, Wear-Resistant Coatings for Seals and Thermal Barriers	Future high-speed vehicles will require high temperature, dynamic seals and thermal barriers around movable surfaces to minimize the ingestion of hot gases through sealed interfaces and protect underlying temperature-sensitive structures. The seals must operate in high heat flux, oxidizing environments and restrict the flow of hot gases at extreme temperatures that can exceed 2000 °F. They must be flexible enough to accommodate distorted sealing	Master's/Ph.D.	Technical Advisor Patrick Dunlap patrick.h.dunlap@nasa.gov 216.433.3017 Co-Technical Advisor Joshua Finkbeiner joshua.r.finkbeiner@nasa.gov 216.433.6080

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
		surfaces while remaining in contact with them to create an effective seal. In some locations, they may also have to limit applied loads against sealing surfaces that are fragile or covered with protective coatings. The seals must also be sufficiently durable to meet required life goals. They must resist damage as they are rubbed over rough, distorted sealing surfaces without incurring excessive increases in leakage due to wear. In some locations the seals may have to seal against rough thermal protection system (TPS) materials without sticking to their surfaces. High temperature seals and thermal barriers are often fabricated out of flexible, oxide-based ceramic fibers and fabrics, and previous testing has shown that coatings on those materials can improve seal durability. The objective of this opportunity is to identify and/or develop high temperature, wear-resistant coatings for seals and thermal barriers and evaluate their durability under representative operating conditions.		
HTP-GRC-002	Development of High Temperature Elastomer for Use in Seal Applications at 700+°F	Future high-speed vehicles will require high temperature, low leakage seals to minimize the ingestion of hot gases through sealed interfaces and protect underlying temperature-sensitive structures. Low leakage seals such as O-rings are often made of elastomers because these materials exhibit little plastic flow and rapid,	Master's/Ph.D.	Technical Advisor Patrick Dunlap patrick.h.dunlap@nasa.gov 216.433.3017 Co-Technical Advisor Joshua

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
		nearly complete recovery from an extending or compressing force. However, even the most heat-resistant elastomers have maximum continuous use temperature limits of about 600°F. The objective of this opportunity is to identify and/or develop a high temperature elastomer that can be formed (e.g., molded, extruded) into various seal geometries for use at temperatures of 700°F or greater. Upon successful identification/development of the elastomer, test specimens will be fabricated and evaluated under representative operating conditions.		Finkbeiner joshua.r.finkbeiner@nasa.gov 216.433.6080
HTP-GRC-003	Packaging Materials for Reliable On-Chip Integrated Temperature Silicon Carbide Pressure Sensors	NASA high speed vehicle technology development in hypersonic regime would require robust and reliable pressure and temperature sensors that would support ground and flight experimental tests. These sensors are to be used to validate the computational fluid dynamics codes that are used in the predictive modeling and future production of the flight vehicle. The validation of these codes, and subsequent improvements, would result in the reduction of cost-prohibitive and time-consuming iterative processes that characterize current production of vehicles and related components. NASA Glenn Research Center has demonstrated silicon carbide (SiC) pressure sensors with integrated temperature sensors operational at	Master's/Ph.D.	Technical Advisor Robert Okojie robert.s.okojie@nasa.gov 216.433.6522 Co-Technical Advisor

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
		800 oC. Further development is underway to extend operation to 1000 oC, which would allow the insertion of these device closer to the combustion chamber of the vehicle where the prediction models still have high uncertainties. To accomplish this goal, however, requires fundamental research in the following enabling areas: sensor packaging to quantify the level of tolerable parasitic resistance, ohmic contact metallization that is robust and stable at high temperature, and sensor sensitivity characterization to achieve high signal to noise ratio. Among the primary causes of failure is the residual stresses in the thin film metallization that can be observed as tensile or compressive stress driven delamination, cracks, or tears. In addition, temperature induced current conduction within the package also inhibits reliable device performance due to the introduction of undesirable parasitic current transmission paths. These problems are even more severe at the extremities of temperatures where these devices are designed to operate. Prospective candidates can be from electrical engineering, mechanical engineering, chemical engineering, materials science and engineering, applied math and physics, modeling and simulation, etc. Multidisciplinary knowledge in the above areas, and in micro-		

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
		or nano-electromechanical systems are highly desired.		
HTP-GRC-004	High Temperature (>500 C) Integrated MEMS Temperature/ Shear Stress Sensors	Successful mode transitions from low- speed to hypersonic regime is greatly affected by shear forces, shock-shock interactions, and temperature/pressure transients. These states also impact vehicle health and survivability within the prescribed flight window. The quantification of these states by computational fluid dynamic (CFD) models is currently characterized by high degree of uncertainties, particularly at high Mach numbers (>4) and high enthalpy (>600 oC) flows. The lack of robust high temperature (>500 oC) shear stress sensors technology to validate the accuracy of these models is categorized by the hypersonic research community as an existing technology gap. NASA Glenn Research Center has demonstrated MEMS-based 4H-SiC semiconductor piezoresistive pressure/temperature sensors operating at 800 C, thereby making it possible to insert the sensors further into higher temperature sections of test articles without the need for cooling. Similarly, a new boundary layer MEMS shear stress sensor is being actively developed for a wide range of flow speeds and enthalpies. This project is to simulate and implement a silicon carbide shear stress sensor concept that would provide high fidelity	Master's/Ph.D.	Technical Advisor Robert Okojie robert.s.okojie@nasa.gov 216.433.6522 Co-Technical Advisor

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
		quantification of boundary layer frictional forces during ground and flight test experiments. Prospective candidates can be from electrical engineering, mechanical engineering, chemical engineering, materials science and engineering, applied math and physics, modeling and simulation, etc. Multidisciplinary knowledge in the above areas, and in micro- or nano-electromechanical systems are highly desired.		
HTP-LaRC-005	Boundary-layer transition physics relevant to hypersonic flight	Complex flow physics phenomena relevant to boundary-layer transition on hypersonic vehicles (shock-boundary layer interaction, fluid-structure interaction, multi-mode boundary layer transition, receptivity, etc.) can have a negative influence on hypersonic vehicle performance via increased aeroheating, increased drag, boundary layer separation, and decreased control surface effectiveness. Furthermore, these phenomena can create harmful thermal and acoustic loads and increase the uncertainty in the predictions of boundary layer transition and separation. Proposals are invited for experimental investigations focusing on one or more elements of this subject, including a better understanding of the physical mechanisms behind the laminar-turbulent transition process and high-quality experimental measurements. Based on the findings of recent research, the	Master's/Ph.D.	Technical Advisor Rudolph King rudolph.a.king@nasa.gov 757.864.5727 Co-Technical Advisor Scott Berry scott.a.berry@nasa.gov 757.864.5231

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
		impact of freestream disturbance environment on these phenomena is a topic of particular interest. In general, the proposed experimental research should encompass several measurements for an appropriate geometry and setup, providing a comprehensive perspective on the dynamics of important flow features.		
HTP-LaRC-006	Efficient Cavity Flameholders for Ramjet, Dual Mode Scramjet, and Scramjet Applications	In high-speed propulsion applications, characterized by short combustion residence times, cavities are commonly used as flame holding devices that pilot the main combustor flow by supplying heat and species radicals which reduce the ignition delay time when mixed into the main combustor flow. An ideal cavity should be designed to burn robustly over a relevant range of main combustor flow conditions, while simultaneously be as small as possible to minimize combustor size and potentially high heat loads, which would require excessive cooling. The objective of the current opportunity is to identify various physical mechanisms that play a role in how a particular cavity design operates robustly and interacts with the main combustor flow to generate flame holding effect under relevant high-speed flow conditions, AND to utilize this information to propose an approach to the optimal design of a cavity.	Master's/Ph.D.	Technical Advisor Andrew Norris Andrew.T.Norris@nasa.gov 757.690.3179 Co-Technical Advisor Tom Drozda tomasz.g.drozda@nasa.gov 757.864.2298
HTP-	Hypersonic	Two anticipated challenges for	Master's/Ph.D.	Technical

NASA Center	Opportunity Title	Opportunity Description	Desired Student Academic Level	NASA Technical Advisor and Co-technical Advisor
LaRC-007	Power and Thermal Management Systems	reusable hypersonic vehicles include both thermal management and power generation systems. First, extended duration and reusable hypersonic vehicles will require active thermal management of vehicle components including, but not limited to, the high-speed engine. Second, on board power will need to be generated for an extended period, and hypersonic aircraft may require the use of alternative power generation architectures to make up for the deficit of available power from any on board turbojet or turbofan systems during cruise. Power and thermal management architectures that address these challenges in a synergistic manner represent opportunities for improved system and vehicle efficiencies. The objective of the current activity is to identify novel and feasible approaches for hypersonic power and thermal management systems. Efforts including, but not limited to, fundamental trade studies of new cycles, evaluation and development of working fluids, and hardware demonstration are solicited under this opportunity.		Advisor Erik Axdahl Erik.L.Axdahl@NASA.gov 757.864.8318

APPENDIX B: Airspace Operations and Safety Program

B.1 Program Overview

The Airspace Operations and Safety Program (AOSP) performs revolutionary research and technology development to enable the transformation of the National Airspace System (NAS) to safely accommodate a growing number of diverse new vehicles, operational concepts and missions. The envisioned future NAS must accommodate: a greater diversity of vehicles, operations, missions, and vehicle systems; increased complexity of diverse operations and levels of performance; and a higher density and volume of operations in highly integrated and more heterogenous airspace. AOSP aims to:

- Develop capabilities for an integrated transformed air traffic system to enable safe and efficient airspace access across all users, vehicles, and missions
- Simultaneously reduce operator workload, fuel consumption, and environmental impacts while identifying and mitigating safety risks under all-weather constraints in a manner that is scalable to meet operational growth over time
- Enable safe operation of emerging aviation markets, including low altitude remotely piloted and autonomous vehicles representing a variety of use cases such as: small autonomous Unmanned Aircraft Systems (UAS), wildfire/disaster response operations, Advanced Air Mobility (AAM) regional passenger and cargo operations, passenger-carrying autonomous urban air taxis; high altitude long endurance UAS; and short/thin haul aviation.
    - Achieve safe and efficient high density, high frequency operations from many more access points in current low-density airspace (e.g., Class G, Class E (including upper E))
    - Achieve safe integration of traditional and emerging market operations
- Enable more proactive system-wide "in-time" safety assurance management
    - Develop tools and technologies to support in-time detection and mitigation of safety hazards
    - Integrate more predictive safety technologies to enable adaptive in-time safety management

AOSP is currently comprised of four projects: Air Traffic Management – Exploration (ATM-X), Advanced Air Mobility (AAM), System-Wide Safety (SWS) and a new project under formulation Advanced Capabilities for Emergency Response Operations (ACERO). Key to the success of this research is integration, evaluation, and testing of more mature concepts and technologies in an environment that faithfully emulates real-world complexities, and analyses conducted on the program's research concepts to identify the system benefits or impacts.

For more information, please see http://www.aeronautics.nasa.gov/programs-aosp.htm

B.2 Air Traffic Management - Exploration (ATM-X) Project:

B.2.1 Project Overview

The Air Traffic Management - eXploration (ATM-X) project will transform the air traffic management system to accommodate the growing demand of new entrants with their new mission requirements while also allowing established, large commercial aircraft operators to fly more user-preferred routes with improved predictability. ATM-X will provide early demonstration of emerging market operations by simulating higher levels of industry-provided services to validate the potential for more rapid modernization by incorporating innovations at "industry" speeds.

ATM-X will demonstrate, through an open architecture approach, the integration of air traffic technologies, system-wide digital data, and advances in human-machine teaming to enable flexible, user-preferred, predictable, and robust operations. The project will validate and transfer key concepts and technologies to the FAA and industry stakeholders. The project aims to:

- Develop and transfer an airspace architecture and service requirements to enable Advanced Air Mobility operations in support of ARMD National Campaign.
- Enable the transformation to an extensible UTM-inspired, service-oriented airspace management system by developing and evaluating airspace management concepts for multiple domains and mission types.
- Design a digital information architecture that enables easy access to relevant NAS data, integrates that data into operationally relevant information, and enables effective dissemination of data to airspace users.
- Enable remotely-operated and increasingly autonomous vehicles to gain normalized operational access to the NAS.
- Demonstrate integrated trajectories optimized for environmental benefit

B.2.2 Description of Solicited Research

The ATM-X Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

B.2.3 Summary of Key Information:

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD

Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

B.3 System-Wide Safety (SWS) Project:

B.3.1 Project Overview

The System-Wide Safety (SWS) project will perform research to explore and understand the impact on safety of the growing complexity introduced by advances aimed at improving the efficiency of flight, the access to airspace, and/or the expansion of services provided by air vehicles. As part of this research, the project will develop and demonstrate innovative solutions that enable these advances, and the aviation transformation envisioned by NASA's Aeronautics Research Mission Directorate (ARMD), through the identification, monitoring, assessment, and proactive mitigation of risks in accordance with target levels of safety. The project will develop tools, methods and technologies to enable capabilities such as those envisioned by ARMD's Strategic Plan [1] and In-Time Aviation Safety Management Systems (IASMS) as described by the National Academies [2].

In both of these visions, system safety awareness and provision are expanded through:

- Increased access to relevant data
- Integrated analysis and predictive capabilities
- Improved real-time detection and alerting of domain-specific hazards
- Decision support, and in some cases, automated mitigation strategies

The SWS project also addresses the needs identified in [1] and [2] for safety-related advances in methods used for the verification and validation of complex ATM/avionics systems, including increasingly autonomous, non-deterministic systems.

B.3.2 Description of Solicited Research

The SWS Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

B.3.3 Summary of Key Information:

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD

Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

B.4 Advanced Air Mobility (AAM) Project:

B.4.1 Project Overview

The Advanced Air Mobility (AAM) project focuses on enabling emerging aviation markets for transformational local and intra-regional missions that will provide substantial benefit to the U.S. public and industry. Starting with an emphasis on Urban Air Mobility (UAM), the AAM project will enable these markets by being a community catalyst and developing and validating system-level concepts and solutions both within AAM and in coordination with other ARMD projects.

The AAM project will also conduct focused research in key areas such as autonomy that will be required to achieve NASA's vision for urban air mobility. One of the initial primary functions of the project is to execute a series of "National Campaigns" that will help the entire community better assess the advances of key technologies and systems and also help identify where future research must be focused. The AAM project aims to:

- Provide operational test and evaluation opportunities of candidate industry technologies, vehicles, airspace services, concepts and scenarios through the National Campaign series.
- Conduct research on vehicle automation systems that will enable UAM Maturity Level 4 operations (medium density and medium complexity operations with collaborative and responsible automated systems) and the National Campaign series.

B.4.2 Description of Solicited Research

The AAM Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

B.4.3 Summary of Key Information:

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD

Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

B.5 Advanced Capabilities for Emergency Response Operations (ACERO) Project:

B.5.1 Project Overview

The ACERO Project will pursue the inclusion of advanced aviation technologies to better assist emergency responders by making their interventions more efficient, more targeted, and better able to adapt to changing circumstances. The ACERO Project goals are to:

- Develop of an Interagency Concept of Operations, use case and technology roadmap, and system architectures that align with operational priorities, technology adoption strategies, and programmatic national needs.
- Mature concepts, requirements, and technologies to improve strategic planning, situation awareness, coordination, information exchange, and safety for wildland fire airspace management.

- Mature concepts, requirements, and technologies to extend the ability for wildland firefighters to execute aerial attack under low visibility conditions (e.g., heavy smoke, nighttime).
- Mature concepts, requirements, and technologies to improve safety for existing wildland fire aircraft operations and promote safe integration for non-conventional aircraft (e.g., UAS) in wildland fire operations.

B.5.2 Description of Solicited Research

The ACERO Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

B.5.3 Summary of Key Information:

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD

NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

APPENDIX C: Integrated Aviation Systems Program

C.1 Program Overview

The Integrated Aviation Systems Program (IASP) focuses on bridging the gap between the maturity level of technologies developed through fundamental research and the maturity requirement of infusion into future air vehicles and operational systems. The goal of IASP is to demonstrate integrated concepts and technologies at a maturity level sufficient to reduce risk of implementation in the aviation community. IASP focuses on the rigorous execution of highly complex flight tests and related experiments. These flight tests support all phases of ARMD research, not just the culmination of research activities. For technologies at low Technology Readiness Levels (TRLs), IASP flight research accelerates the development and/or determines the feasibility of those technologies. For more mature technologies, flight research will reduce risks and accelerate transition of those technologies to industry.

IASP is comprised of five portfolio projects as follows:

- Flight Demonstrations and Capabilities (FDC)
- Low-Boom Flight Demonstrator (LBFD)
- Electrified Powertrain Flight Demonstration (EPFD)
- Sustainable Flight Demonstrator (SFD)

The IASP projects are described in the sections below.

For more information on IASP and its focus, please visit the following website:
https://www.nasa.gov/aeroresearch/programs/iasp

C.2 Flight Demonstrations and Capabilities (FDC) Project

C.2.1 Project Overview

NASA's FDC Project validates benefits associated with critical technologies through focused flight experiments. As part of the FDC Project, NASA demonstrates the feasibility and maturity of new technologies through flight tests, utilizing collaborative partnerships from across the aeronautics industry. These demonstrations typically address technologies that have proven their potential merit through ground based or subscale testing and require results from a realistic flight environment for validation of the benefits.

Through the integrated use of appropriate flight test capabilities and assets, regardless of whether the capabilities and assets are available from NASA, through other Government agencies, or industry, the FDC Project validates benefits associated with critical selected technologies. The flight experiments are campaigns focused on aggressive, success-oriented schedules that utilize the most appropriate set of assets available to accomplish the experimental objectives. While

many of the technologies are at relatively high Technology Readiness Levels (TRLs), the FDC Project supports all phases of technology maturation.
In addition to the use of flight test support aircraft, NASA flight research and test capabilities necessary to address and achieve the ARMD Strategic Plan, and available to the FDC Project, include the Dryden Aeronautical Test Range, and the Simulation and Flight Loads Laboratories at the Armstrong Flight Research Center (AFRC). The project also utilizes flight research and test capabilities across the U.S. aeronautical industry and international partners as appropriate.

C.2.2 Description of Solicited Research

The FDC Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

C.2.3 Summary of Key Information

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD

NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

C.3 Low Boom Flight Demonstrator (LBFD) Project

C.3.1 Project Overview

Over the past decade, fundamental research and experimentation has demonstrated the possibility of supersonic flight with greatly reduced sonic boom noise. The LBFD Project demonstrates these advancements in flight by utilizing the purpose-built X-59 aircraft. It will provide validation of design tools and technologies applicable to low sonic boom aircraft and create a database of community response information supporting the development of a noise-based standard for supersonic overland flight.

The LBFD Project is being executed during the first two phases of the 3-phase Quesst Mission. Phase 1 includes the X-59 aircraft development activities, starting from detailed design, continuing through fabrication, and concluding with functional checkouts and supersonic envelope expansion. In Phase 2, a NASA-led team will perform low boom acoustic validation flights of the X-59 aircraft. These flights will characterize and evaluate the near-field, mid-field, far-field, and ground sonic boom signatures from the X-59 aircraft. Phase 2 will conclude with an initial community response overflight study to validate community test and survey designs and explore initial community acceptance of low-boom noise.

Subsequent to this work by the LBFD Project, a NASA-led team will utilize the X-59 aircraft for Phase 3 of the Quesst Mission where low-boom community response overflight studies will be conducted through multiple flight test campaigns over varied locations. The ultimate goal will be to develop a low-boom community response database that will be provided to U.S. and international regulators in support of their development of a noise-based standard for supersonic overland flight.

C.3.2 Description of Solicited Research

The LBFD Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

C.3.3 Summary of Key Information

Expected annual program budget for new awards	TBD

Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

C.4 Electrified Powertrain Flight Demonstration (EPFD) Project

C.4.1 Project Overview

The EPFD Project is focused on flight demonstrations that advance the state-of-the-art for subsonic transports to enable enduring leadership of the U.S. aviation industry for the benefit of the country and U.S. flying public. The initial focus of this project is on flight demonstration of more electrified propulsion system technologies to determine the benefit of enabling technologies to further advance industry's focus on more electrified aircraft. The initial flight experiments will be high power (1-megawatt) electrified powertrain demonstrations that evaluate

the performance of hybrid electric propulsion systems. The focus is on technologies and configurations that require integration and flight demonstration to validate technical feasibility and performance as well as economic benefit.

C.4.2 Description of Solicited Research

The EPFD Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

C.4.3 Summary of Key Information

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
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Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

C.5 Sustainable Flight Demonstrator (SFD) Project

C.5.1 Project Overview

The purpose of the Sustainable Flight Demonstration (SFD) Project is to engage with United States (U.S.) Industry to identify, select and mature key airframe technology(s) that have a high probability of transition to the next generation subsonic commercial transport in the 2030s. Specifically, in partnership with U.S. Industry, National Aeronautics and Space Administration's (NASA) SFD Project will:

- Develop and flight test an advanced airframe configuration and related technologies to dramatically reduce aircraft fuel burn and carbon dioxide (CO2) emissions
- Obtain ground and flight data that will be used by the NASA/industry teams to validate the configuration and associated technologies
- Inform industry decisions associated with next generation single-aisle seat class product [2030s Entry Into Service (EIS)] to maximize the potential to meet US environmental goals articulated in the US Aviation Climate Action Plan

C.5.2 Description of Solicited Research

The SFD Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

C.5.3 Summary of Key Information

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD

Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

APPENDIX D: Transformative Aeronautics Concepts Program

D.1 Program Overview

The Transformative Aeronautics Concepts (TAC) Program cultivates cross-cutting concepts and capabilities that inspire new solution paths to aeronautics technical barriers, enable innovative designs, and lead to breakthrough technologies that transform aviation. In this context, a "breakthrough" technology has a significant positive impact. For instance, it may greatly improve system performance or open up a new market. Because of its "seedling" nature within the NASA Aeronautics enterprise, the TAC Program impacts a wide variety of systems, subsystems, vehicles, operations, tools, and applications of technology within the aeronautics community.

The TAC Program objectives are:

1) Support and challenge strategic and tactical planning via early convergent innovation; and
2) Advance the strategic thrusts by providing transformative capabilities within single disciplines and at system-level.

The TAC Program supports all six of the ARMD Strategic Thrusts and consists of three projects:

The Transformational Tools and Technologies (TTT) Project advances state-of-the-art computational and experimental tools and technologies that enable aviation applications in the six strategic thrusts.

The Convergent Aeronautics Solutions (CAS) Project performs rapid feasibility assessments of early-stage innovations that challenge existing technical approaches, create alternate paths to solutions, or enable new strategic outcomes.

The University Innovation (UI) Project provides an opportunity for U.S. colleges and universities to demonstrate leadership by forming teams that explore novel solutions to complex aviation problems.

For more information on TACP, please visit http://www.aeronautics.nasa.gov/programs-tacp.htm

D.2 Transformational Tools and Technologies (TTT) Project

D.2.1 Project Overview

The Transformational Tools and Technologies (TTT) Project advances state-of-the-art computational and experimental tools and technologies that are vital to aviation applications supporting the six NASA Aeronautics strategic thrusts. The project enables fast, efficient design and analysis of advanced aviation systems from first principles by developing physics-based tools/methods and cross-cutting technologies. The project also provides new multi-disciplinary design, analysis and optimization (MDAO) and systems analysis tools and supports exploratory research with the potential to result in breakthroughs. These tools and technologies are intended to offer the potential for high payoff outcomes through their application within the mission programs/projects of the Aeronautics Research Mission Directorate (ARMD) toward completion of their Technical Challenges and toward progress in achieving the ARMD Strategic Implementation Plan (SIP) goals and objectives. The project strives to be relevant across all ARMD SIP Thrusts and a value-adding contributor toward the success of key outcomes and critical commitments.

To achieve its vision and objectives, the TTT Project has established an organizational structure that emphasizes two purposes: Enduring Disciplines to sustain NASA ARMD's leadership role for advancing the state of the art by supporting foundational research and technology development in the traditional core competency discipline areas and Subprojects to incentivize a more focused and inter-disciplinary approach for contemplating longer-term research and development solutions and the potential impact of these solutions on key challenges advocated in the NASA ARMD SIP and prioritized by ARMD.
TTT Project currently encompasses the following three focused Subprojects, each of which uniquely combines various disciplinary perspectives toward a NASA ARMD SIP key challenge.

1. **Foundational Electrified Aircraft Propulsion (FEAP) Subproject** which supports the enduring electrified propulsion research needs of the ARMD Mission Programs with the development of innovative materials, components, tools, and methods that enable the performance, reliability, and durability of these systems;
2. **Revolutionary Aviation Mobility (RAM) Subproject** which provides leading edge tools, technologies, and research findings to enable increasingly autonomous Advanced Aerial Mobility (AAM) transportation in the Urban Air Mobility (UAM) Maturity Level (UML)-4+ time frame; and
3. **Reduced Life Cycle Cost (RLCC) Subproject** which supports the reduction of the life cycle cost of aircraft to help the US aircraft industry stay competitive worldwide.

The TTT Project currently encompasses the following traditional core competency discipline areas: Aerosciences, Materials and Structures, Multi-disciplinary Design/Analysis/Optimization and Systems Analysis, Combustion, Flight and Propulsion Controls, Innovative Measurements, Communication, Navigation & Surveillance, and Autonomous Systems. Each discipline area encompasses one or more research elements

and lower-level task activities. Research elements embody the longer-term, important areas of research necessary to advance the state of the art.

The Revolutionary Computational Aeroscience (RCA) Discipline research portfolio includes development of high-order robust numerical methods, transition and turbulence modeling aided by AI/ML, direct numerical simulation, large eddy simulation, and canonical flow physics experiments. The main objective of the research is to develop high-fidelity analysis capability for aerodynamic and propulsion flows that provides orders-of-magnitude speed increases by exploiting emerging high-performance computing hardware. Research is focused on capturing the potential of emerging high-order scale-resolving methods and automated high-order mesh generation to impact the design and analysis of aircraft and turbomachinery flows. Efficient knowledge extraction from large scale simulations is another important area of research as is algorithmic development for exploiting the potential of emerging quantum computer technology.

The Materials and Structures (M&S) Discipline emphasizes improved multifunctional and high temperature materials for airframe and engine application, as well as integrated multiscale modeling and simulation tool development to improve validated first-principles materials and structural modeling. The investment in specific models and a cyber-physical-social ecosystem framework is consistent with the recently developed 2040 Vision study results. Three swim lanes of composites, metallic materials, and electric aircraft, as well as their respective major focus areas, underpin the M&S discipline portfolio. This portfolio constitutes a balanced computational modeling and experimental program, wherein fundamental advancements in physics-based and data driven modeling infrastructure development will be undertaken while at the same time pursuing specific complementary experimental material technology developments. This pushes the mechanistic understanding and validation of the associated modeling toolsets.

The Multi-disciplinary Design/Analysis/Optimization and Systems Analysis, (MDAO) Discipline develops MDAO and aircraft system-level tools to improve integration of discipline-based technologies and enable improved assessment of system-level benefits. An open-source framework is emphasized to better leverage external partners, increase interaction, and benefit the community.

The Combustion Discipline addresses several significant challenges that ultimately govern combustor performance and its influence on key overall propulsion/aircraft system performance. The scope of work includes: (1) non-volatile particulate matter (nvPM) emissions, (2) fully-coupled engine core (compressor-combustor-turbine) simulations, (3) reduced cooling and improved durability of engine hot section components, and (4) expanding unique experimental databases and direct numerical simulations of fuel spray atomization. These topics are important to both subsonic and supersonic aircraft.

The Flight and Propulsion Controls Discipline encompasses work across aircraft flight controls and advanced propulsion controls. Flight Controls research focuses on technologies and methods which concurrently develop models and control algorithms for

flight vehicles that result in dramatically shortened development and certification timelines, reduced costs, and potentially provide improved flight safety and reliability. Two key enabling technologies are real-time modeling and learning adaptive controls. Propulsion Control research focuses on the operability, performance, and safety of increasingly complex propulsion systems for advanced air vehicles. Research emphasizes the development of dynamic modeling and analysis tools that seek to inform the system designer about complex interactions between engine operability, power and energy management, thermal management, system integration, and their impact on vehicle performance.

The Innovative Measurements Discipline is responsible for the development of enhanced sensing and optical measurement techniques which are useful for a broad range of aerospace applications. The optical methods effort is sub-divided into two areas: surface measurements and flow field measurements. In surface measurements, research will seek to extend the temperature range of pressure sensitive paints. In flow field measurements, molecular-based high precision point techniques to simultaneously measure velocity and temperature will be developed. A luminescence-based thermal and environmental barrier coatings (TBCs/EBCs) method developed for turbine engine components will be investigated to map temperature and damage progression. A research effort will focus on a measurement technique to allow components with sub-optimal residual strain distributions to be screened before they reach service.

The Communication, Navigation and Surveillance (CNS) enduring discipline addresses the most challenging CNS technology gaps necessary for enabling UML-4+ operations. UAM aircraft will require multiple CNS services, including vehicle telemetry, command, pilot/passenger voice, cooperative separation assurance, navigation and timing sources, non-cooperative surveillance, and vertiport proximity CNS services to ensure safe landings and departures at high-volume vertiports.

The Autonomous Systems (AS) Discipline addresses capability gaps facing safe, increasingly autonomous operations for aviation. AS is focused on enabling urban air mobility (UAM) and designing its airspace infrastructure through foundational autonomy research. The AS discipline currently supports a variety of UML-4+ activities. UML-4+ signifies an intermediate to mature state where there are a hundreds to thousands of simultaneous operations in a given area; highly distributed networks; autonomous aircraft and remote fleet management; high weather tolerance; and high-volume manufacturing [1]. Activities fall into two primary categories: scalable management of many air vehicles by a small number of agents (m:N) and autonomous airspace coordination.

[1] Goodrich, K. H. and Theodore, C. R., “Description of the NASA Urban Air Mobility Maturity Level (UML) Scale,” AIAA SciTech Forum, January 2021, AIAA 2021-1627. https://doi.org/10.2514/6.2021-1627]

D.2.2 Description of Solicited Research

In this solicitation, TTT is seeking proposals for work in the development of uncertainty quantification for CFD and multidisciplinary analysis, high-fidelity structural modeling for complex aeroelastic vehicle design, industry-relevant application for analytic derivatives in multidisciplinary design analysis and optimization, responsibility designation in scalable m:N architectures, collective behavior of air mobility systems, and water drop impingement measurement capability.

The following list summarizes the specific topics for which proposals are sought. Details for each topic are provided in the following subsections.

D.2.2.1 TTT Proposal Topics

- D.2.2.1.1 – Uncertainty Quantification for CFD and Multidisciplinary Analysis
- D.2.2.1.2 – High-Fidelity Structural Modeling for Complex Aeroelastic Vehicle Design
- D.2.2.1.3 – Industry-Relevant Application for Analytic Derivatives
- D.2.2.1.4 – Responsibility Designation in Scalable m:N Architectures
- D.2.2.1.5 – Collective Behavior of Air Mobility Systems
- D.2.2.1.6 – Water Drop Impingement Measurement Capability

Topic D.2.2.1.1 – Uncertainty Quantification for CFD and Multidisciplinary Analysis

Objectives:

Develop efficient uncertainty quantification methods and tools for computational fluid dynamics and multidisciplinary analysis.

Scope of Research:

Uncertainty quantification (UQ) theory encompasses both aleatoric (e.g., stochastic/random processes) and epistemic (e.g., parameters as distributions, range of models, etc.) sources of uncertainty. The NASA sponsored study on aircraft certification by analysis (CbA) [1] highlighted the need for creating efficient uncertainty quantification methodology and characterized it as a key technical challenge toward enabling computational methods as a credible alternative for CbA in lieu of flight testing. Since analysis using computational fluid dynamics (CFD) is a computationally intensive task and UQ generally requires a large number of CFD solves, it is important to develop strategies that reduce the computational cost for UQ to be employed routinely in CFD and multidisciplinary analysis applications.

This subtopic focuses on both the forward propagation of epistemic sources of uncertainty and the inverse estimation of epistemic input model parameters using data obtained from state-of-the-art CFD simulations. Standard approaches include the estimation of statistics via dense- and sparse-tensored quadrature [2], chaos-like polynomials [3], random sampling [4], Bayesian statistics [5], and machine learning [6]. The computational cost of these approaches is often reduced by employing multilevel approximation, surrogate models, or partial differential equations (PDE) reduced-order

modeling. So that approaches developed under this subtopic can be routinely used in CFD calculations, the proposed approaches must enable very significant (perhaps, an order of magnitude) reduction in the overall computational effort for quantification of uncertainty and ideally be compatible with NASA CFD codes. In multidisciplinary analyses, CFD constitutes the most resource intensive element and, therefore, efficient UQ approaches for CFD should also enable quantification of uncertainty in high-fidelity multidisciplinary analysis.

The proposed approaches should address the outstanding deficiencies in current forward or inverse uncertainty propagation approaches, e.g., estimation of output probability density function (PDF) statistics for distributions that have a significant departure from a normal distribution. Computational fluid dynamics calculations often yield output quantity of interest uncertainty distributions that depart from a normal distribution due to: (1) nonlinearity of the underlying PDEs and (2) presence of shock wave discontinuities in the high Reynolds number limit. Distributions from these calculations may be multi-model (multiple peaks) and/or exhibit PDF slope discontinuities in the high Reynolds number limit.

The ultimate goal of the research effort is to develop a framework for uncertainty quantification for CbA, which requires building confidence in numerical simulations and establish their credibility on equal footing with flight testing. Such a framework will be all encompassing, ranging from the characterization of sources of uncertainty to the propagation of uncertainties through multidisciplinary simulations. As stated in Ref [1], the technical challenges of UQ for CbA include the ability to deal with large parameter spaces, techniques for interpolation and extrapolation from validation data, realistic assessment of the effect of model form uncertainties within large complex simulations, and rare statistical event predictions, which are paramount for safety considerations. Therefore, reliable methods must be developed to estimate errors present in numerical simulations. Model form error in turbulent flow simulations is among the key sources of uncertainties for such applications and needs to be considered.

In the longer term, treatment of output uncertainties that depend discontinuously with respect to input uncertainties is another area of research in UQ. Transonic and supersonic aerodynamic calculations at high Reynolds number often contain nearly discontinuous shock waves propagating through space and time. The position of these discontinuities may depend on input sources of uncertainty so that output quantities of interest have a discontinuous dependence in the limit of increasing Reynolds number. This can severely degrade the performance of classical uncertainty quantification methods that utilize global approximation, e.g., global chaos polynomials, global quadrature, etc. While this area of research is important in UQ for CFD, in general, our first priority is to develop and mature UQ capability for CbA applications (for aircraft in take-off and landing configurations). It was indicated in Ref. [1] that scale-resolving methods may be required to significantly improve predictive capabilities for separated flows associated with CbA applications. While this remains the ultimate goal, proposers can use RANS-based approaches to demonstrate the UQ capability provided they are extendable to scale-resolving methods. Proposers are referred to various presentations at the recently held AIAA High-Lift Prediction Workshop – 4 (Ref. [7]) for various methodologies used to compute aircraft maximum lift.

Expected Outcomes:

1. Computational methods and tools that reduce the cost of UQ by an order of magnitude.
2. The developed UQ approach will have a suggested path to allow incorporation of the technology in NASA CFD codes.

[1] T. Mauery et al., A Guide for Aircraft Certification by Analysis, NASA/CR-20210015404, 2021.
[2] T. Gerstner and M. Griebel, Numerical Integration Using Sparse Grids, Num. Alg., Vol. 18, 1998.
[3] N. Weiner, The Homogeous Chaos, Am. J. Math., Vol. 50, 1938.
[4] N. Metropolis and S. Ulam, The Monte Carlo Method, J. Am. Stat. Assoc., Vol. 44, 1949.
[5] P. Bessiere, Bayesian Programming, CRC Press, 2013.
[6] Z. Ghahramani, Probablistic Machine Learning and Artificial Intelligence, Nature, Vol. 521, 2015.
[7] https://hiliftpw.larc.nasa.gov/

Topic D.2.2.1.2 – High-Fidelity Structural Modeling for Complex Aeroelastic Vehicle Design

Objectives:

Develop structural finite element (FE) modeling tools aimed at realistic aerospace vehicle configurations. Research will be conducted to develop and utilize a FE capability that can handle complex structural nonlinearities, and efficiently couple to computational fluid dynamics (CFD) codes for scalable high-fidelity aeroelastic analysis.

Scope of Research:

Current state-of-the-art aeroelasticity tools typically combine high-fidelity CFD analysis with a linear mode-based structural analysis. The required modal data can be obtained, a-priori, from commercially available FE tools (NASTRAN, ABAQUS, etc.). The resulting coupled framework can be used for both static and dynamic aeroelastic analysis but is limited to small structural displacements.
The next generation aircraft of interest to the aerospace community will utilize highly flexible wing structures, which undergo large deflections and vibrations. These structural nonlinearities can be computed by the aforementioned FE codes, but robust and scalable time-domain analysis that can be utilized for in-core coupling to other disciplines, such as CFD solvers, is challenging. Available open-source FE tools may be more amenable to CFD coupling, but these tools are unlikely to accommodate the relatively large finite element library required by modern aerospace structural models.
Under this subtopic, research will be conducted to develop a highly scalable FE tool which can (1) accommodate the wide array of element types and solution methodologies

typically utilized in the aerospace industry; (2) compute complex structural geometric and material nonlinearities; and (3) demonstrate in-core coupling to an external CFD solver in an efficient manner, for both static and dynamic aeroelastic analysis. This tool will be made available for coupling with NASA CFD codes and will enable high-fidelity early-stage aeroelastic design of complex vehicle configurations, in addition to certification by analysis (CbA) efforts.
The final tool will be demonstrated on relevant aerospace configurations with large and complex finite element models. Example uses of the envisioned code include multidisciplinary wind up turn analyses or long duration simulations for transonic flutter and limit cycle oscillations of highly flexible aircraft such as the Transonic Truss-Braced Wing. To the extent possible, the input deck for the code will be compatible with the industry-standard NASTRAN code. Scalability of the FE analysis may be achieved with strong scaling or use of hardware accelerators such as GPUs. Finally, the work will be conducted in such a way as to enable downstream future efforts aimed at extending this framework towards the computation of coupled adjoint sensitivities for multidisciplinary design optimization (MDO).

Expected Outcomes:

1. Demonstration of a FE capability aimed at aerospace vehicle models composed of element types and solution methodologies typical of realistic industry applications.
2. Demonstration of a FE capability that can handle complex geometric and material nonlinearities.
3. Demonstration of an interface that can utilize in-core coupling with CFD solvers for static and dynamic aeroelastic simulations.
4. Demonstration of adequate scalability of the FE solver.

Topic D.2.2.1.3 – Industry-Relevant Application for Analytic Derivatives

Objectives:

The multidisciplinary design analysis and optimization (MDAO) research community has developed tools and techniques using analytic derivatives that drastically improve the efficiency of gradient-based optimization and widen its applicability to a new range of problems, but adoption of that research by the broader engineering community lags far behind the research itself. This topic solicits research aiming to close the adoption gap by identifying its root causes and then developing new techniques, tools, and demonstration problems that address them.

The outcomes of this research should demonstrably improve the ability of non-optimization-expert practitioners to apply state-of-the-art gradient-based optimization methods to their system-level design problems involving three or more distinct disciplines.

Scope of Research:

Modern research has already made some progress in improving the accessibility of state-of-the-art optimization techniques. Algorithmic differentiation tools have reduced the effort required to compute analytic derivatives and recently, due in part to a renewed interest from the machine learning community, they have become significantly more capable and widely available. At the same time, frameworks such as NASA's Open MDAO have made it possible to integrate 10's of different disciplines along with their analytic derivatives efficiently, even when using high-fidelity tools and high-performance computing environments with distributed memory.

Despite these advancements, multiple barriers remain. Two of the most serious are overly simple problem formulation, which make it hard to extend methods to practical design efforts and lack of analytic derivatives for low- or mid-fidelity analyses critical to industry design processes.

Proposals to this topic should include a collaboration between optimization researchers and design practitioners to identify a specific key barrier (i.e., a specific critical analysis missing derivatives, or a specific problem formulation that needs to be addressed) and propose a clear research path to reduce or eliminate that barrier.

One potential way this could be achieved would be through close collaboration with an industry partner providing formal input or help to define a challenge problem, specific boundary conditions, or context for how a specific analysis is used in practice. Although an industry partner might have proprietary tools and problems, the scope and aim of this topic is to advance the general ability for the broad community to adopt state-of-the-art gradient-based optimization techniques. Hence the primary outcomes of the work should be built on top of open-source tools, use publicly available data (e.g., grids, geometries, constraints), and generally be delivered in a widely distributable form.

Specific multidisciplinary areas of interest, based on known challenges in existing aircraft design capability, include (but are not limited to):

- Aero-structural-thermal design of ducted heat exchanger systems
- Aero-propulsive design of propulsion systems considering both internal-flow and external-flow
- Aero-structural-propulsive design of aircraft concepts such as boundary layer ingesting, distributed propulsion
- Aero-propulsive-acoustic design of propeller and/or rotors for eVTOL aircraft
- Electromagnetic-structural-thermal design for electric aircraft propulsion motor/drive systems (geared or direct-drive)
- Conceptual design for novel aircraft configurations including hybrid propulsion systems, all electric propulsion systems, and thermal management systems, or tight aero-propulsive integration

Expected Outcomes:

Proposals for this topic should aim to deliver one or more of the following research outcomes:

1. Novel optimization benchmark problems consisting of three or more disciplines; All analyses, geometry, and critical data should be included along with at least one solution approach
2. One or more new open-source low- or mid-fidelity analysis tools with analytic derivatives, along with a demonstration study (potentially including some other non-open-source analyses) showing how they are used to construct industry-relevant problem formulations and successfully solve them.
3. One or more new open-source tools to compute derivatives for existing close-source (i.e., commercial) analysis tools or to integrate close-source analysis tools with derivatives into a tightly coupled multi-disciplinary model, along with a demonstration study showing how they are used to construct industry-relevant problem formulations and successfully solve them.

Topic D.2.2.1.4 – Responsibility Designation in Scalable m:N Architectures

Objectives:

Explore the delegation of responsibility and authority between humans and increasingly autonomous aircraft in the context of Advanced Air Mobility (AAM) to achieve scalability through m:N operational architectures (i.e., a small number of humans [m] managing a larger number of autonomous vehicles [N]). There is a dearth of research on this topic, which needs to be explored using modeling and simulation techniques and/or human-in-the-loop experimentation.

Scope of Research:

The vision of Advanced Air Mobility seeks to introduce a range of missions that will expand the capacity to transport people and goods to locations in rural and urban environments. Using aircraft of all sizes, this vision will be achieved by leveraging higher levels of automation and increasingly autonomous technologies, with applications ranging from commercial transport and air taxi services (e.g., Urban Air Mobility [UAM]) to drone surveillance and inspection operations [1]. Yet an expansion of air transportation services will also exacerbate (or be limited by) a looming shortage of qualified pilots to support even current operational demands. To address this challenge, uncrewed aerial vehicle (UAV) concepts are being considered [2], with the goal of enabling fewer human operators to manage more increasingly autonomous vehicles (i.e., m humans-to-N vehicles, or m:N) to grow scalability potential. Studies in related fields indicate that humans can manage a limited number of vehicles before performance rapidly declines. This limit, however, is partially due to delegation of responsibility (and therefore authority) between human and automated components. This delegation is largely driven by regulatory constraints that ultimately require a human to be responsible for the safety and operation of aircraft (e.g., Pilot in Command). It is unlikely that the operational tempo or scale envisioned in AAM will be feasible if a shift in responsibility from the human to automation and increasingly autonomous systems is not addressed. Moreover, this implicit requirement may lead to operational architectures in which

humans monitor increasingly autonomous system components but are still held responsible for actions over which they have little authority. Although a monitor role allows responsibility to remain with the human, humans are inherently poor monitors with limited attentional resources. NASA's Transformational Tools and Technologies-Revolutionary Aviation Mobility (T^3-RAM) subproject has identified Human-Autonomy Teaming as a critical area of research required to enable m:N operations with scalability potential [2]. The concept of a human "teaming" with a technology fundamentally alters the assumptions of traditional human-automation interaction paradigms, as the technology is required to assume many of the responsibilities traditionally held by humans within the overall system.

Recommendations generated from this subtopic will inform critical areas where operation and vehicle autonomy must be mature and reliable, while also focusing Human-Autonomy Teaming efforts on architectures where human skills are appropriately employed. This topic is also directly related to the T^3-RAM m:N Technical Challenge [3] and its goal of increasing operations scalability. This subtopic seeks proposals that address one or more of the following topics to support the scalability potential in AAM by shifting responsibility and authority from the human to automation and increasingly autonomous systems in m:N architectures (N.B., this work is targeted at UAM, but open to other UAV operations more broadly within AAM):

- Narrow down possible m:N configurations that are feasible, given the delegation of responsibility and authority of human-autonomy teams.
- Identify tradeoffs associated with shifting responsibility from a human to automated and increasingly autonomous systems.
- Modeling and simulation and/or human-in-the-loop experimentation investigating m:N fleet management scenarios with varying delegation of responsibilities in human-autonomy teams.
- Identify candidate functions to remove from human oversight, given existing or projected technical capabilities and limitations.
- Generation of certification considerations/recommendations in scalable m:N architectures.

Proposers shall clearly describe the approach including the objectives, supporting research, method, proposed analyses, schedule, and expertise available for executing proposed work. Deliverables will include periodic reports and presentations, and electronic files of all work products generated (e.g., manuscripts).

Expected Outcomes:

1. Recommendations for assigning appropriate human-autonomy team responsibilities and authorities in a representative AAM m:N architecture
2. Documentation describing developed models, literature reviews, method, and results supporting human-autonomy teaming responsibility and authority delegations in an AAM m:N architecture
3. Plan for disseminating recommendations and enabling derivative work

References:
[1] National Academies of Sciences, Engineering, and Medicine, "Advanced Aerial Mobility: A National Blueprint," The National Academies Press, Washington, DC, 2020.
[2] J. B. Holbrook, L. J. Prinzel III, E. T. Chancey, R. J. Shively, M. S. Feary, Q. V. Dao, M. G. Ballin, and C. Teubert, "Enabling Urban Air Mobility: Human-autonomy teaming research challenges and recommendations," in *2020 AIAA AVIATION*, Virtual Meeting, 2020.
[3] V.V. Aubuchon, K.E. Hashemi, R.J. Shively, J.M.Wishart, "Multi-Vehicle (m:N) Operations in the NAS – NASA's Research Plans," in *2022 AIAA Aviation*, Chicago, 2022. https://doi.org/10.2514/6.2022-3758

Topic D.2.2.1.5 – Collective Behavior of Air Mobility Systems

Objectives:

Develop models of the emergent behavior of collective autonomous air mobility systems consisting of vehicles, operators of vehicles, and providers of airspace services operating in a closed network of ports and sharing the same airspace. Develop metrics that are useful to assess the performance of the collective autonomous mobility system, such as its ability to self-operate persistently in a safe, orderly, fair, and efficient manner, under high levels of uncertainty and complexity. Based on the models and metrics, develop methods for the dynamic coordination among the system agents to enable more persistent and effective self-operation. The methods may represent edge or cloud-based capabilities assuming high levels of autonomy with no human intervention. The models should be drawn from existing examples of distributed, collective, autonomous mobility systems that can be generalized to represent the future behavior of autonomous air mobility systems. Where data is available, develop data-science methods for analyzing historical data about such example systems to infer and learn their behavior into valid models for autonomous air mobility.

Scope of Research:

Air mobility is expected to undergo transformative changes that are needed to accommodate new markets enabled by new vehicle technologies, such as electric vertical takeoff and landing (eVTOL), supersonic, high altitude long endurance (HALE), among others, and advances in digital connectivity and intelligent computing. Autonomy is one key element of this transformation, as the current centralized, human-centric paradigms of operating the vehicles and the airspace do not provide the scalability needed for these new markets and demands. Unmanned aerial vehicles will become increasingly dominant, operated from the ground, with one operator managing increasingly higher numbers of vehicles, and, ultimately, able to fly autonomously with no human supervision. Airspace and traffic services will become increasingly distributed, depending largely on vehicle-to-vehicle coordination, with digital, cloud-based application support. While vehicles are able to fly most of their mission autonomously with only human supervision or oversight, the autonomous coordination among multiple heterogeneous autonomous vehicles sharing the same airspace is still a major challenge.

NASA is conducting research to advance autonomy in air mobility to support and unlock an increasing number of use cases. They include urban air mobility (UAM), firefighting, regional cargo delivery, among others. Initial entry of these new operations may be based on structured approaches such as isolating them from other traffic and with significant human role. However, large-scale operations will need to be supported by high levels of autonomy that feature less structure and less human intervention, enabled by highly automated and distributed schemes. This sub-topic is aimed at understanding such end-state high-autonomy paradigms and studying their viability and effectiveness:

- This research concerns the autonomous interaction among vehicles as opposed to the autonomous mission completion by a single vehicle.
- The system consists of vehicles, vehicle operators, and airspace services that self-operate persistently in a closed network of ports, thus ensuring an integrated perspective.
- This research assumes the human role is reduced to a minimum level of oversight without intervention and aims to identify the edge and cloud capabilities that enable this high level of autonomy.
- This research aims to enable autonomy to self-operate anywhere (autonomy level 5 [1]), under high to extreme levels of uncertainty and complexity in the environment not under a limited operational domain.

A major challenge in modeling and evaluating such a futuristic system is lack of precedence and supportive data and observations. The research should draw from existing examples of distributed, collective, autonomous mobility systems that can be generalized to represent the future behavior of autonomous air mobility systems. Examples of such systems include autonomous air traffic operations under visual flight rules without centralized air traffic control, where general aviation flights can see each other, avoid each other, follow each other, negotiate their landing sequence, among other coordination behaviors. Other examples include autonomous surface traffic, biological communities or swarms, the internet, among others. The research should identify and propose relevant models from different domains. A key interest of this research is to identify underlying utilities that drive the autonomous agents (vehicles, operators and services) behavior towards competing, colluding, or coordinating among each other and thus dynamically producing structure where and when needed, while affording as much flexibility as possible for individual mission objectives. These models can be useful to inform dynamic coordination and structure allocation mechanisms in the future autonomous air mobility, such as information sharing, negotiation of access, and convoy formation. Where data are available, this research should develop data-science methods for analyzing historical data about such example systems to infer and learn their behavior into valid models for autonomous air mobility.

<u>Expected Outcomes:</u>

1. Relevant examples of collective autonomous systems that can be representative and useful for identifying models for collective autonomous air mobility
2. Models of such collective, autonomous mobility systems

3. Metrics for assessing the performance of collective, autonomous air mobility and its emergent behaviors
4. Validation of the models and metrics against historical data and evaluation of their effectiveness in representing future autonomous air mobility use cases, such as urban air mobility, cargo delivery, firefighting, among others
5. Methods based on these models that can be used as edge- or cloud-based capabilities to enable persistent self-operation of the collective system of vehicles, operators, and services
6. Publication of the research in conference and journal venues

References:
[1] SAE International, ISO, "Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles," SAE J3016, SAE International/ISO, 2021.

Topic D.2.2.1.6 – Water Drop Impingement Measurement Capability

Objectives:

Design, build, test and verify an experimental measurement capability to quantify the distribution of water mass impinging on a aerodynamic surface. The source of the impinging water is a cloud of drops emanating from a spray system in an icing wind tunnel.

Scope of Research:

In the field of aircraft icing, a critical measurement is the amount of water that strikes the aerodynamic surface of interest during transit through a cloud of supercooled water. The ratio of water mass flux at a specific location on the surface to the mass flux available in the freestream is referred to as local collection efficiency or local catch efficiency. The integrated distribution of local collection efficiency is referred to as the total collection efficiency or total water catch. Determining the amount of water and its location that strikes a surface is an important consideration for ice protection systems and is a key step in the numerical prediction of ice growth. Computer simulation of ice accretion involves the tracking of water drops and prediction of their impact on the surface to determine the local collection efficiency. An experimental measurement capability is needed to quantify the local collection efficiency that supports validation of computer simulations and promotes further understanding of the surface water transport phenomena in the initial stages of ice growth on aerodynamic surfaces.

The importance of water drop impingement measurement was recognized in past research conducted by the National Advisory Committee for Aeronautics (NACA). Von Glahn et al. [1] and Gelder et al. [2] used a dye-tracer technique to create a collection efficiency database for aerodynamic surfaces including a set of NACA airfoil sections. In this method, the spray water was treated with a dye and impinged onto strips of blotter paper

attached to the aerodynamic surface. Very short durations of water spray were used to saturate the blotter paper which was subsequently removed for colormetric analysis. Segments of the blotter strip were removed and dissolved in distilled water. The concentration of the dye in the resulting solute was then measured through absorbance of light at a particular wavelength. The concentration of dye was then related back to the mass of impinging water.

The need for an expanded collection efficiency experimental database led to several studies conducted in the late 1980s, 1990s and early 2000s. Papadakis et al. (for example, Ref. [3], [4] and [5]) used a similar dye-tracer method, but employed a laser reflectance spectroscopy method to determine dye concentration on the blotter paper and hence the local collection efficiency. This approached was applied directly to the blotter strips and did not require segments of the paper to be dissolved in water. However, the method did rely on calibrations performed via the colormetric analysis. Papadakis et al. applied this method to over 20 different aerodynamic surfaces including airfoils, wings, engine inlets and other geometries. These databases cover a large range of drop sizes with the median volumetric diameter (MVD) of the distributions ranging from "standard icing" less than 40 μm to large drops with MVD up to 170 μm. The databases has been used in numerous icing simulation software development and validation efforts.

As these databases have been employed and analyzed over the years, questions have been raised about the uncertainty and applicability of the experimental results. For example, the dye-tracer method requires very short spray duration which led to questions about nozzle stabilization and cloud repeatability. The short spray duration combined with the need to add dye to the water resulted in the development of a dedicated spray system used for the testing. The installation and calibration of this spray system added time, complexity and cost to the impingement measurements. For tests with large-diameter drops, splashing on the surface can lead to mass loss, which was further complicated by a lack of understanding of blotter paper's ability to replicate a typical aircraft surface such as aluminum. A paper by Bodoc and Berthoumieu [6] suggests that drop splashing on a bare metal surface versus blotter paper shows important differences in secondary drop generation. This can affect the rate of water impingement and the resulting ice growth if not properly understood and modeled. In addition to this potential limitation, the previous databases were limited in terms of the median drop sizes investigated and freestream speeds.

Computer simulation tools for icing applications continue to be developed and advance in capability. New experimental data for water drop impingement are required to validate the computer simulation of drop impingement. The 1st Ice Prediction Workshop [7] emphasized the need for updated collection efficiency databases with complex three-dimensional geometries where the experimental uncertainties are well understood and quantified. NASA is currently developing an icing simulation tool called GlennICE [8] to predict water drop impingement and ice growth on three-dimensional aerodynamic surfaces and thus has an inherent interested in developing a corresponding experimental database for local collection efficiency.

This subtopic focusses on the development, fabrication, test and verification of new experimental methods for measuring local collection efficiency in icing wind tunnels. Offerors should consider and propose applicability to relevant icing conditions for a given aircraft segment. For example, fixed wing airplanes may encounter icing at speeds in excess of 200 knots in both standard icing conditions (e.g. Title 14 Code of Federal Regulations Part 25, Appendix C) and in freezing drizzle and freezing rain (Title 14 Code of Federal Regulations Part 25, Appendix O). Offerors should consider and address whether or not special spray systems are needed including additives to the spray water for the proposed measurement method. The ability or the proposed method to utilize existing water spray systems without any or minimal modification is desired. Offerors should describe an approach to quantify the experimental uncertainty in the proposed method. Offerors should consider and address the ability of the proposed method to investigate potential mass loss from the splashing events associated with large drops. Offerors should propose demonstration tests in an appropriate icing wind tunnel along with candidate test article(s).

Expected Outcomes:

1. Development of an experimental capability to quantify the distribution of water mass from drops impinging on an aerodynamic surface. This includes documentation of the theoretical basis for the methods, limitations of implementation and required calibrations.

2. Testing of a prototype system in an appropriate icing wind tunnel.

3. Characterization and quantification of the experimental capability in terms of the relevant variables such as cloud drop size, size distribution, liquid water content, temperature and flight speed.

4. Characterization and quantification of the experimental uncertainty in the measured local collection efficiency.

5. Publication of the research in appropriate conferences and journals.

References:

[1] Von Glahn, U. H., Gelder, T. F., and Smyers, W. H., "A Dye-Tracer Technique for Experimentally Obtaining Impingement Characteristics of Arbitrary Bodies and a Method for Determining Droplet Size Distribution," NACA TN 3338, March 1955.

[2] Gelder, T. F., Smyers, W. H., and Von Glahn, U. H., "Experimental Droplet Impingement on Several Two-Dimensional Airfoil with Thickness Ratios of 6 to 16 Percent," NACA TN 3839, December 1956.

[3] Papadakis, M., et al. “An Experimental Method for Measuring Water Droplet Impingement Efficiency on Two- and Three-Dimensional Bodies,” NASA CR 4257, November 1989.

[4] Papadakis, M., et al. “Experimental Water Droplet Impingement Data on Airfoils, Simulated Ice Shapes, and Engine Inlet and a Finite Wing,” NASA CR 4636, December 1994.

[5] Papadakis, M., et al, “Experimental Study of Supercooled Large Droplet Impingement Effects,” DOT/FAA/AR-03/59, September 2003.

[6] Bodoc, V. and Berthoumieu, P., “Experimental Investigation of High Speed SLD Impact,” SAE Technical Paper 2019-01-2006, 2019, doi:10.4271/2019-01-2006.

[7] Laurendeau, E., et al., “Summary from the 1st AIAA Ice Prediction Workshop,” AIAA Paper 2022-3398, June 2022.

[8] Wright, W.B., Porter, C.E., Galloway, E.T., and Rigby, D.L., “GlennICE 2.1 Capabilities and Results,” AIAA Paper 2022-3309, June 2022.

D.2.3. Programmatic Considerations

D.2.3.1 General Information

The Transformational Tools and Technologies Project anticipates investing a total of $1.5-$2.0M per year in the solicited subtopics over the next three years. The maximum period of performance will be three years, with nominal budgets in the range of $150K-$250K per year. The actual number and value of the awards will depend on the quality of the proposals received and the scope of the proposed work. There is no guarantee that an award will be made in each subtopic area. Multi-year awards are subject to funding availability in subsequent fiscal years. In some cases, only a portion of a proposal may be selected for award.

The intent of the NRA process is to seek and fund the best research proposed to the solicited topics from outside of NASA. NASA also seeks to collaborate with awardees in a manner that adds value towards the research and development of the innovative concepts. Therefore, proposed informal collaboration with NASA researchers is encouraged where it a) adds value towards achieving the research objectives of the topic area, and b) serves as a direct and beneficial form of technology transfer into NASA. The proposers may propose such informal collaborative activities, but without specifying NASA researchers’ names in the proposal. If a proposal is selected for negotiation towards a potential award, then and only then can the details of any proposed collaboration including time in residency at a NASA Center, if applicable, be discussed and finalized. Communications with NASA during the solicitation period can only occur through the designated POC (see Sections 5 and 6). There can be no direct or indirect communications with NASA researchers and managers from the time this solicitation is

posted to NSPIRES until proposal selections are final.
Annual oral presentations made as part of an open technical exchange meeting for purposes of technology transfer and knowledge dissemination are required. In particular, there will be a kick-off meeting at the beginning of the award period, and an annual review meeting. These meetings will be held at a NASA Aeronautics Center (NASA Ames Research Center, NASA Armstrong Flight Research Center, NASA Glenn Research Center, or NASA Langley Research Center), and must be attended by at least the principal investigator (or a designated representative) for the award. A written report that completely documents the approach and results shall be submitted for each year's effort (no later than 30 days before the end of the 12-month period), and quarterly written status reports shall also be provided. The information in the annual report will be one of the factors used to determine whether adequate progress has been made.
A final report documenting the approach, results, recommendations, and conclusions of the entire contract shall be submitted no later than 30 days before the end of the contract period of performance. This report shall be suitable for publication as a NASA Contractor Report (Reference: NFS 1852.235-73 Final Scientific and Technical Reports). Sensitive information may be provided to NASA in a proprietary appendix. Software developments and/or enhancements shall be developed in modular form and delivered in appropriate computer file formats.

D.2.3.2 Proposal Preparation Requirements and Organization

General Requirements
A competitive proposal will clearly and concisely: (1) describe the proposed innovation(s) and/or research approach(s) relative to the state-of-the-art; (2) address the scientific, technical merit and feasibility of the proposed activities, and (3) relevance and significance to NASA's stated needs.

Format Requirements
Unless otherwise noted, all proposals submitted in response to this solicitation shall be in accordance with Chapter 2 Proposal Preparation and Organization and Chapter 3 Proposal Submission of the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023*. Proposals that do not follow the formatting requirement are subject to rejection during administrative screening.

The technical section of the proposal is the most important for selection. The proposal must address a particular topic, identified from the above sections. It shall clearly describe: the background and objectives of the proposed research; the approaches to be considered; the workforce required; the anticipated results; and the contribution of the work. The proposal shall identify milestones with measurable metrics toward achieving the proposer's goal, with a minimum of one milestone per year. The proposal shall address requirements of the topic to which it is responding.

The following checklist describes the minimum information expected in the science-technical and management section of the proposal. It must clearly describe:

a. Topic area and challenge(s) the proposal is addressing
   - Objectives and technical approach
   - Targeted/anticipated result
   - Expected impact/benefits if successful
   - Quantifiable metrics to evaluate progress

b. Detail work plan
   - Schedule with milestones with success criteria
   - Technology transfer plan
   - Plan for oral presentations, interim reports, and a final report
   - Detail budget – level of effort, estimated costs, travel, etc.
   - Team members - qualifications and experience
   - Organization capabilities and resources
   - Computing requirements*

* If any NASA computational resource is proposed, include specific computing requirements (CPUs, hours, timeframe, etc.) and state its criticality to the proposed work (select from below):
   1) Require NASA computation resources as go/no go for proposed work
   2) Optional need for NASA computation resources to enhance research execution

NASA is committed to the dissemination of federally funded research, and is responsible for making data from awarded research activities as widely and freely available as possible, while also safeguarding the privacy of participants, and protecting confidential and proprietary data. To facilitate increased access to non-proprietary data, all proposals or project plans submitted to NASA for scientific research funding will be required to include a Data Management Plan (DMP) as described in the section entitled "Increasing Access to the Results of Federally Funded Research" (Section II.c of the ROA). If data will not be made available during the course of the research activity, the DMP shall explain why data sharing and/or preservation are not possible or scientifically appropriate. At a minimum, DMPs must describe how data sharing and preservation will enable validation of published results, or how such results could be validated if data are not shared or preserved.

Reasonable costs associated with the DMP (i.e., costs of sharing, preservation, etc.) may be included in the proposal budget. However, the DMP and its associated costs will not be measured according to the evaluation criteria in section 4. Furthermore, the DMP will not be subject to the page limitation given for the proposal. Specific questions regarding a DMP should be directed towards the POCs in Section 6 as they may provide guidance to proposers and awardees, in addition to their responsibility for compliance with DMPs.

D.2.3.3 Intellectual Property

A clear statement is required of what intellectual property is expected to be available to the Government, U.S. aeronautics community, and public at the conclusion of the work. It is NASA's preference that all deliverables under the contract be provided to NASA

with unrestricted/unlimited rights; thus, any restrictions must demonstrate a significant net benefit to the Government.

D.2.3.4 Proposal and Submission Information

Proposal Submission Site
Proposers must submit electronic proposals in response to this solicitation to the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES [3]; http://nspires.nasaprs.com). The NSPIRES system will guide proposers through submission of all required proposal information. The presentation *NSPIRES Organization Registration*, located in the "Tutorials and User Guides" section of this website, provides information on how to register an organization in NSPIRES.

In order to be able to submit a proposal all investigators must be preregistered in NSPIRES and have received a User ID and password. This includes the Principal Investigator, all listed Co-Investigators and Collaborators. NSPIRES registration can be done at the website https://nspires.nasaprs.com/external/aboutRegistration.do. Early registration is advised. A Help Desk is available at (202) 479-9376 or by E-mail at nspires-help@nasaprs.com.

Proposal Deadline Requirements

No late proposals will be accepted or reviewed.

Pre-award costs

Pre-award costs are not allowable.

Notice of Intent to Propose
Notices of Intent (NOIs) are encouraged but not required for this solicitation.

D.2.4. Evaluation Criteria and Basis for Award

The evaluation criteria in Chapter 4 and Appendix D of the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* are superseded by the following criteria.

The principal elements considered in evaluating a proposal are its relevance to NASA's objectives, technical merit, effectiveness of the proposed work plan (including cost and team qualifications), and technology transfer plan (a separate and distinct plan from the Data Management Plan described above). Failure of a proposal to be highly rated in any one of the following elements is sufficient cause for the proposal to not be selected.

1. Relevance to NASA's Objectives (weight 20%):

Evaluation of a proposal's relevance to NASA's objectives includes consideration of the potential contribution of the effort to the specific objectives and goals given in the solicitation. The proposer is required to:

- Identify the specific topic and subtopic to which the proposal is submitted and what specific challenge(s) within the subtopic is/are being addressed.
- Provide a discussion of the impact if the proposed research is successful.

2. Technical Merit (weight 40%):

- Overall scientific or technical merit of the proposal, including unique and innovative methods, approaches, or concepts.
- Evaluation will also include: credibility of technical approach, including a clear assessment of primary risks and a means to address them; techniques, or unique combination of these, which are integral factors for achieving the proposal's objective.
- The selection process will also assess the proposal against the state-of-the-art.

3. Effectiveness of the Proposed Work Plan (weight 30%):

- Comprehensiveness of the proposed work plan, effective use of resources, management approach, and proposed schedule for meeting the objectives.
- Proposed team qualifications and experience.
- Suitability of proposed computational and/or experimental facilities to meet the objectives.
- Proposed cost realism and reasonableness.
- Milestones or objectives with measurable metrics towards achieving those.
- Annual oral presentations made as part of an open Technical Exchange Meeting for purposes of technology transfer and knowledge dissemination are required.
- Documentation of approach and results in the form of final written technical reports is required.

4. Technology Transfer Plan (weight 10%)

- A plan for knowledge/technology transfer to NASA is required. Any proposed collaboration with NASA researchers (including synergistic research goals, residency at a NASA center, development of computer code modules compatible with NASA software, and potential use of facilities) should be discussed in this section. Collaboration is encouraged where it a) adds value towards achieving the research objectives of the topic area, and b) serves as a direct and beneficial form of technology transfer into NASA.

D.2.5 Proposed Use of Unique NASA Capabilities

Proposers are encouraged to carry out a substantial portion of the overall work objectives (experimental and computational) prior to using a NASA facility and consider NASA facilities for the final validation of concepts or models.

Proposers wishing to use NASA facilities should refer to Section I (c) of ROA- FY 2023 for general proposal requirements.

Each NASA facility is managed differently. If use of NASA facilities is proposed, prior to submitting proposals the proposers should have a general discussion with the facility manager – can they accommodate you, order of magnitude cost details, who pays etc. Only for tests at NASA facilities managed by Aerosciences Evaluation and Test Capabilities, if the proposal gets awarded then it will be a non-reimbursable test under the TTT Project, i.e., at a lower cost to the proposer.

If use of NASA facilities is proposed, the costs associated with fabricating test articles, fixtures, instrumentation, and testing required should be included in the proposed cost. Specific timeframe and duration of testing will be negotiated upon selection of a proposal. For use of a NASA facility, a letter of commitment from the facility manager, or equivalent, should be included in the proposal.

General information on NASA test and evaluation facilities, including points of contact, can be found using the websites given below.

Armstrong Flight Research Center

https://www.nasa.gov/centers/armstrong/capabilities/index.html
https://www.nasa.gov/aeroresearch/programs/iasp/fdc

Ames Research Center

Air Traffic Management Simulations:
https://aviationsystems.arc.nasa.gov/facilities/index.shtml

Ames Wind Tunnels:
https://www.nasa.gov/centers/ames/orgs/aeronautics/windtunnels/index.html

Glenn Research Center

https://www1.grc.nasa.gov/facilities/

Langley Research Center

https://researchdirectorate.larc.nasa.gov/facilities-capabilities/

Advanced Supercomputing

Information on NASA Advanced Supercomputing facilities can be found at
https://www.nas.nasa.gov/hecc/resources/
A letter of support for supercomputing is not possible during the proposal submission phase. If awarded, one can apply for supercomputing allocation under the TTT Project.

D.2.6 Summary of Key Information

Expected annual program budget for new awards	Between $1.5M - $2.0M will be invested annually in these NRAs over the next 3 years.
Number of new awards pending adequate proposals of merit	1 or more per topic
Maximum duration of awards	3 years
Due date for Notice of Intent to propose (NOI)	December 9, 2022
Due date for proposals	January 13, 2023, 5PM EST
General information and overview of this solicitation	See the *Summary of Solicitation* in the ROA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	See Section 2.7 of the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023*
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of the ROA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	Cooperative Agreement
Funding opportunity number	NNH23ZEA001N-TTT1
NASA technical point of contact concerning this program	Email questions to: LaRC-2023-TTT-NRA@mail.nasa.gov Written responses will be provided individually via email, and posted online on NSPIRES Technical POC: Joseph H. Morrison NRA Manager: Tracey M. Frisby
NASA Procurement point of contact concerning this program	Morris Hicks, morris.hicks@nasa.gov

D.3 Convergent Aeronautics Solutions (CAS) Project

D.3.1 Project Overview

The Convergent Aeronautics Solutions (CAS) Project uses short-duration activities to establish early-stage concept and technology feasibility for high-potential solutions. Internal teams propose ideas for overcoming key barriers associated with large-scale aeronautics problems associated with ARMD's six strategic thrusts. The focus is on merging traditional aeronautics disciplines with advancements driven by the non-aeronautics world to advance innovative solutions to these barriers to open and enable new capabilities in commercial aviation. The teams will conduct initial feasibility studies, perform experiments, try out new ideas, identify failures, and try again. At the end of the cycle, a review determines whether the developed solutions have met their goals, established initial feasibility, and identified potential for future aviation impact. During these reviews, the most promising capabilities will be considered for continued development further by other ARMD programs or by direct transfer to the aviation community. In the dynamic environment of new ideas, ARMD also gains significant value from the knowledge gained in activities that do not proceed.

CAS represents a change from the way ARMD has traditionally planned, managed, and implemented technology development projects. It seeks to identify targeted solutions to strategic "big questions" that will involve a more radical approach, taking greater technical risk, considering problems from a broader, more systemic frame of reference, exploiting the benefits afforded by synergy between convergent technologies, and more quickly and efficiently exploring multiple solution pathways.

CAS consists of a diversified portfolio of research activities aligned with the ARMD Strategic Thrusts pursuing novel concepts focused on system-level benefits with the potential to significantly outperform current solutions. These activities are intended to quickly determine whether the concept is feasible and justifies additional investment. This type of innovation is not based on taking the next logical step along an established path of development but involves identifying and exploiting new ideas and combinations of existing ideas to greatly outperform established products/services/solutions and create the potential for disproportionate advantages over the status quo.

These types of innovation cannot be managed using the same approaches commonly used for other types of research and technology development. It has attributes that are very different than the innovation that produces incremental improvement. It involves a different approach to the "big questions" than is being addressed by the mainstream research community. It often involves addressing persistent systemic problems that have defied solution using traditional methods and comes from identifying new opportunities created from a more holistic understanding of the needs, problems, and challenges in the current system and often combines technological innovation with new ways of creating and delivering value – new business models.

It also entails greater risk, uncertainty, and a longer time horizon partly due to the resistance to change and vested interests of the established players. With greater risk, uncertainty, and longer time horizons comes the need for patience, persistence, and trust and redefining success to focus more on learning, adaptation, and responding to weak signals rather than on more common measures associated with consistent systematic improvement within the current systems. Transformative solutions will appear to lag behind incremental improvements in the dominant paradigm but if the risks can be mitigated could have much greater impact.

While a project like CAS is intended to create innovative solutions, it is also an innovation in itself. CAS will be innovating the ARMD project model and requires alternative innovation management methods, the ability to better manage complexity and change (and the ambiguity and uncertainty that comes with it), willingness to pursue alternative approaches to overcoming systemic barriers to innovation, and the ability to embrace diversity to find new ways of doing things. The skill sets, infrastructure, systems, processes, and tools required to support this type of innovation are quite different from what is commonly practiced within NASA.

D.3.2 Description of Solicited Research

The CAS Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

D.3.3 Summary of Key Information

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* of this NRA.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD

Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of this NRA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected contract type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD

D.4 University Leadership Initiative

The University Leadership Initiative (ULI) is a portfolio item in NASA Aeronautics Research Mission Directorate's (ARMD) University Innovation (UI) Project.

D.4.1 ULI Overview and Goals

ARMD created ULI for universities to take the lead, build their own teams, and set their own research path. ULI seeks new, innovative ideas that can complement the NASA ARMD portfolio and support the U.S. aviation community.

ULI's strategic goals are:

- Assist in achieving aviation outcomes defined in the ARMD Strategic Implementation Plan ("Strategic Plan") [Ref. 1] through NASA-complementary research.
- Transition research results to an appropriate range of stakeholders that leads to a continuation of the research. Transition can occur in several ways, including the following:
  - Creates a new product line in U.S. industry or a new ARMD project,
  - Whole ULI concept is transitioned to U.S. industry/ARMD project,
  - Part of the ULI concept is transitioned to U.S. industry/ARMD project,
  - ULI findings impact direction of U.S. industry/ARMD.
- Provide broad opportunities for education and workforce development by targeting students at different levels, including K-12, community college, undergraduate, and graduate, to participate in aeronautics research and relevant educational opportunities.
- Promote greater diversity in aeronautics through increased participation of minority-serving institutions [Ref. 2] and underrepresented university faculties in ULI activities.

ULI provides the opportunity for university teams to exercise technical and organizational leadership in proposing unique technical challenges, defining interdisciplinary solutions, establishing peer review mechanisms, and applying innovative teaming strategies to strengthen the research impact. By addressing the most complex challenges associated with ARMD strategic thrusts, universities will accelerate progress toward achievement of high impact outcomes while leveraging their capability to bring together the best and brightest minds across many disciplines. In order to transition their research, Principal Investigators (PIs) are expected to actively explore transition opportunities and pursue follow-on funding from stakeholders and industrial partners during the award.

D.4.2 Description of Solicited Research

The ULI Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

D.4.3 Summary of Key Information

Expected program budget for new awards	TBD
Anticipated number of new awards pending adequate proposals of merit and funds availability	TBD
Maximum duration of awards	TBD
Applicant's Workshop	TBD
Due date for Step-A proposals	TBD
Due date for Step-B proposals	TBD
Start of Period of Performance	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* in the ROA
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement,Edition:February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Science-Technical-Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of the ROA and Chapter 3 of the *NASA Guidebook for Proposers*.

Web site for submission of proposal via NSPIRES	https://nspires.nasaprs.com (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected award type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD
NASA Facility POCs	TBD
Questions and Answers (Q&A)	TBD

D.5 University Student Research Challenge (USRC)

The University Student Research Challenge (USRC) is a portfolio item in TACP's University Innovation (UI) Project.

D.5.1 USRC Overview

USRC seeks to challenge students to propose new aeronautics ideas/concepts that are relevant to ARMD. Apart from this, the students also have the challenge of raising cost share funds through crowdfunding[1] platform. The process of creating and preparing a crowdfunding campaign act as a teaching accelerator - requiring students to act like entrepreneurs and taking action. Understanding the market, fundraising and execution are major skills for a future entrepreneur. Crowdfunding also raises awareness in the general public about students' research. Finally, crowdfunding is being used to excite and bring in non-traditional communities in relationship with ARMD.

USRC's strategic goals are:

- Provide broad opportunities for students at different levels, including undergraduate and graduate, to participate in aeronautics research;
- Assist in achieving aviation outcomes defined in the ARMD Strategic Implementation Plan ("Strategic Plan") [1] through NASA-complementary research.

USRC will provide students from accredited U.S. colleges or universities with grants for their aeronautics projects. It will support cutting-edge research on emerging aviation

[1] Crowdfunding is a method for individual citizens to pool their resources, usually via the Internet, to fund efforts initiated by other people or organizations. Crowdfunding campaigns can finance any type of effort, from design, to movies and disaster relief. Typically, the crowdfunding model has a project initiator (in this case, the student) who proposes the idea to be funded; a specified goal or target amount for funds to be raised (in this case, the cost share matching funds); individuals or groups (members of the public) support the project by donating funds; and a crowdfunding platform that brings the project initiator and the public together to launch the funding of the project. The crowdfunding platform may charge a fee for their service. In this manner, crowd funding allows the general public to directly engage in projects that interest them.

technologies and the education of new researchers in various fields of study. Additional beneficiaries are members of the aviation community who will receive new technology and concepts from USRC results.

D.5.2 Description of Solicited Research

The USRC Project is not soliciting research topics at this time. Please continue to monitor this solicitation for future amendments.

D.5.3 Summary of Key Information

Expected annual program budget for new awards	TBD
Number of new awards pending adequate proposals of merit	TBD
Maximum duration of awards	TBD
Due date for Notice of Intent to propose (NOI)	TBD
Due date for proposals	TBD
General information and overview of this solicitation	See the *Summary of Solicitation* in the ROA
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers Responding to a NASA Funding Announcement, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf
Page limit for the central Scientific/Technical/Management section of proposal	TBD
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of the ROA and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/(help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected award type	TBD
Funding opportunity number	TBD
NASA technical point of contact concerning this program	TBD
NASA Procurement point of contact concerning this program	TBD
Questions and Answers (Q&A)	TBD

D.6 Future Aviation Maintenance Technical Challenges

The University Innovation (UI) project enriches the Transformative Aeronautics Concepts Program (TACP) and Aeronautics Research Mission Directorate (ARMD) portfolio with university-led innovation to address system-level challenges, which are outlined in ARMD's Strategic Implementation Plan. UI seeks new, innovative ideas that can support the U.S. aviation community and ARMD portfolio.

In this Appendix, the UI project is soliciting for a new portfolio item, Future Aviation Maintenance Technical Challenges.

D.6.1 Background, Motivation, and NASA Relevance

NASA Aeronautics Research Mission Directorate's vision (in the Strategic Implementation Plan (see reference 1 in Section D.6.13) includes the safe and widespread use of piloted, remote-controlled, and fully autonomous aircraft of all sizes to move people and packages wherever they need to go – perhaps within a dense urban environment, out to a nearby international airport, or to a rural town on the prairie. With government, industry and academic partners, NASA Aeronautics is working to make real these new forms of air transportation with their new concepts of operations, vehicle designs, airframes, and propulsion systems – whether powered by electric, hydrogen, hybrid power, or other energy source. This program element focuses on these new forms of aviation.

NASA Aeronautics recognizes that to develop this new air transportation ecosystem, it has to focus not just on the new forms of aircraft but also on the wider system in which these aircraft will operate – looking at things like infrastructure, energy supplies, integration with ground transportation, etc. This program element focuses on one of those prominent issues likely to be faced by the future air transportation industry – Aviation Maintenance. Not only is it important to identify the new and unique maintenance issues that will crop up with these new forms of air transportation but also to develop the workforce for it – the Aviation Maintenance Technicians.

In response, the UI project has introduced the Future Aviation Maintenance Technical Challenges program element under ROA-2023 to support an initial set of competitively-selected investigations that will address key maintenance and training challenges facing the next-generation of air transportation.

D.6.2 Program Element Goals

The goal of Future Aviation Maintenance Technical Challenges is multi-fold:

a) First, perform a scientific inquiry into aviation's future maintenance technical challenges, both holistically and with some technical specificity; (this is the scope of this solicitation) and
b) Eventually, develop aviation mechanic standards, training curriculum, required equipment and materials based on the findings of the first phase.

The program element goals have been limited in this solicitation to convey the essence of the program element and is not meant to limit future expansions or need for fulfilling additional goals. A full range of activities and investments could also involve:

- Learning from related disciplines like automotive, space, medical, etc. on incorporation of new techniques,
- Investigating new or borrowed methods and techniques which could provide benefits in the existing framework and then extrapolating how these would be implemented for new technologies, and
- Developing new teaching technologies, that are easily updatable to address future aviation technologies, thereby more efficiently teaching Aviation Maintenance Technician Schools (AMTS) students.

These activities are not the primary scope of this solicitation.

Ultimately, the generated data, information, and curriculum should be useful towards establishing future curriculum requirements of FAA-certificated AMTS where gaining knowledge and proficiency becomes easier and more affordable for future aviation maintenance technicians.

D.6.3 Scope of Solicited Research within this Program Element

Hundreds of aviation companies are working on technologies that will enable greener flying with a wide range of future possibilities – Unmanned Aircraft Systems (UAS), electric vertical takeoff and landing (eVTOL) vehicles, all electric and electric-hybrid regional aircraft, hydrogen powered aircraft, etc. This has spurred a lot of excitement about the latest and greatest advances in these near-future technologies. Government agencies, including NASA, are working technologies to safely integrate these new-generation aircraft into the national airspace system.

These new paradigms indicate the near-future vehicles will most likely incorporate some fundamentally different requirements for system maintenance. This solicitation focuses on the unique aviation maintenance technical challenges of these near-future technologies that are different from those currently being studied in AMTS. The scope of this solicitation is for two-year investigations that fall within the scientific and technical scope of the program element goal (a) in Section D.6.2, and which have the prospect of analyzing the highest impact aviation maintenance technical challenges within the context of a focused, two-year effort.

Within the above mentioned solicitation scope, the UI project solicits investigations that will:

- Focus on either cross-cutting technologies (as an example, a common new technology, like new materials and structures, shared across multiple new vehicle designs that is not in conventional vehicles) or choose one impactful, near-future vehicle technology (as an example, megawatt electric propulsion systems).
- Partner with an applicable industry member who can provide sufficient information on the new technologies (as an example, in vehicle design) and differences of these new technologies from conventional technologies.

- Critically analyze the maintenance and repair requirements of the new technologies to assess the technical requirements/skills that are not covered in the current AMTS curriculum.
- Focus the research on impactful "gap" elements for the new technologies of either Airframe or Powerplant for the chosen technologies.
- With guidance from the industry partner, assess the unique maintenance and repair requirements for the technologies based on projected operational use.
- Investigate the state-of-science techniques available or needed to deliver AMTS-viable maintenance and repair techniques with potentially thorough certification.
- Ensure existing, available state-of-science techniques meet or exceed safety requirements.
- Develop a prioritized list of the new aviation maintenance technical challenges investigated.

Proposers are required to have a funded AMTS as a team member and have a funded or unfunded industry partner who could guide awardees with new maintenance challenge areas. Having an FAA advisor is optional but may be helpful to awardees in maintenance and certification/qualification requirements.

The proposed technical approach should discuss planned phases of research that would ensure a high probability of a successful outcome. Among selectable proposals, see evaluation criteria in Section D.6.9, proposals with higher potential impact will be prioritized for selection. It is not required for proposals to verify the practicality of maintenance and repair techniques via demonstrations to facilitate technology transfer into the AMTS community. However, a limited number of such demonstrations with the partner AMTS will be an added bonus.

Because of the limited funding available under this solicitation, the scope of this proposal opportunity is limited and should not be construed as representative of the full range of activities and investments that will be required to fully understand aviation's future maintenance and training challenges. Should this program be continued in future years, it is anticipated that the scope can be broadened in accordance with the highest priorities in this field.

D.6.4 Solicited Research Exclusions

This current solicitation narrowly focuses on identifying the state-of-the-science in aviation maintenance technical challenges of the near future. Consequently, proposals in the following categories are not solicited:

- Investigations where the focus is on the advancement of certifiable maintenance and repair techniques.
- The primary emphasis is on designing aviation mechanic curriculum or purchases of equipment and materials.
- Developing maintenance cost analyses or tradeoff analyses among different maintenance techniques.

D.6.5 Expected Outcomes

The following are the desired outcomes:

- Write a final report including a prioritized list of aviation maintenance technical challenges of the future for your focused area of examination that are currently not addressed in AMTS curriculum.
- For each listed challenge, identify either existing technique or a maintenance and repair technique need for the near-future, new aviation technologies.
- Publicly disseminate final report and research results so that future work can build on them. Disseminate results to a range of AMTS.
- Involve undergraduate, graduate, and AMTS students in meaningful ways while performing the research.

D.6.6 Funding Information and Projected Distribution of Awards

The UI Project anticipates that the total amount allocated for this program is approximately $900K/year for two years. Proposals are invited from eligible organizations (see Section D.6.7) for a 2-year duration and should have budgets $300K/year or less per award, with ~$50K/year directed towards a partner AMTS. The UI Project anticipates investing in three awards in this solicitation. It is expected that the majority of the Year 1 funding will be available in October 2023 for Year 1 performance and similarly Year 2 funding will be available in October 2024. Actual spending and timely invoicing by the awardees are important to NASA and proposed budgets must consider ramp ups within the team.

The actual number, value, and duration of the awards will depend on the quality of the proposals received, the scope of the proposed work, funding availability, and program needs. In addition, these projections represent the UI project's plans at the time of the release of this solicitation. These conditions are subject to change, and therefore there is no guarantee that the awards will be allocated as described above. Awards for multiple years of performance are subject to adequate performance during previous years and funding availability in subsequent fiscal years. In some cases, only a portion of a proposal may be selected for award.

D.6.7 Eligibility

For this solicitation, the proposing (lead) organization must be an accredited, degree-granting U.S. college or university. Community colleges are encouraged to participate as either as the lead organization or as team members. Proposing organizations are encouraged to include accredited AMTS as partners in their team, such that they can receive funds from the NASA award. Historically Black Colleges and Universities (HBCU) and other minority-serving institutions (MSI) are strongly encouraged to participate. Industry partners can be funded or unfunded team members.

Collaboration with FAA and other U.S. government agencies that adds value towards the research is encouraged. Collaborating U.S. government agencies will not receive funds from the NASA award.

Other eligibility criteria, not superseded by the above, are in Section III of this ROA. Proposals involving bilateral participation, collaboration, or coordination in any way with China or any Chinese-owned company, whether funded or performed under a no-exchange-of-funds basis, shall be ineligible for award.

D.6.8 Proposal Preparation

Notice of Intent (NOI) to Propose
NOIs are encouraged but not required for this solicitation.

General Requirements
A competitive proposal will clearly and concisely: (1) describe the proposed innovations and/or research approaches relative to the state-of-the-science; (2) address the scientific, technical merit and feasibility of the proposed activities, and (3) relevance and significance to this solicitation's stated needs in Sections D.6.2 to D.6.5.

Format Requirements
Unless otherwise noted, all proposals submitted in response to this solicitation shall be in accordance with Section 2 and 3 of the *NASA Proposer's Guide, Edition: February 2023* (see reference 2 in Section D.6.13). Proposals that do not follow the formatting requirement are subject to rejection during administrative screening.

Technical Section
The Scientific/Technical/Management Plan of the proposal is the most important for selection. The proposal must address a topic within scope of Section D.6.3. It must clearly describe: the background and objectives of the proposed research; the approaches to be considered; the workforce required; the anticipated results; and the contribution of the work. The proposal must identify milestones with measurable metrics toward achieving the proposer's goal, with a minimum of one milestone per year. The proposal must address all requirements of this solicitation.

The following checklist describes the minimum information expected in the Scientific/Technical/Management Plan of the proposal. It must clearly describe:

a. Topic area and challenges the proposal is addressing
    - Objectives and technical approach
    - Targeted/anticipated result and deliverables at the end of the period of performance
    - Expected impact/benefits if successful
    - Quantifiable metrics to evaluate progress
    - Assessment of what is innovative or novel in the proposal
b. Detailed work plan, that also includes the following
    - Schedule with milestones with success criteria
    - Team members - qualifications and experience
    - Strategy to involve students in the research
    - Technology transfer plan
    - Detailed budget – level of effort, estimated costs, travel, etc.

- Organization capabilities and resources
- Computing requirements: If any NASA computational resource is proposed, include specific computing requirements (CPUs, hours, timeframe, etc.) and state its criticality to the proposed work (select from below):
  i) Require NASA computation resources as go/no go for proposed work
  ii) Optional need for NASA computation resources to enhance research execution

  A letter of support for supercomputing is not possible during the proposal submission phase. If awarded, one can apply for supercomputing allocation under the UI Project.

Other Requirements

Please refer to Section IV of this ROA and the *NASA Proposer's Guide* for additional requirements on proposal content, format, budget details, and submission procedures. A budget justification, including justification for any foreign travel, is required in the proposal, but will not be counted toward the Scientific/Technical/ Management page limit; nor will other supporting information, such as the Data Management Plan, references, résumés and optional letters of support from partners and collaborators.

D.6.9 Proposal Evaluation Criteria

All proposals will be reviewed according to the evaluation criteria listed in this section.

- Relevance and Impact (weight 30%)
  - Relevance to specific goals and objectives in Sections D.6.2 to D.6.5
  - Expected significance and/or impact of the proposed work
  - Clear link between the proposed objectives, research products, and milestones to the expected outcomes
  - Value of the proposed dissemination of final report and transfer of research results
- Technical Merit (weight 30%)
  - Overall scientific or technical merit of the proposal, including unique and innovative methods, approaches, or concepts
  - Credibility of technical approach, including a clear assessment of primary risks and a means to address them
  - Comprehensiveness of work plan, effective use of resources, management approach, milestones and proposed schedule for meeting the proposed objectives
  - Facilities, instruments, equipment, and other resources or support systems presented in the proposal that will affect the likelihood of achieving the proposed objectives
  - Documentation of approach and results in the form of final written technical reports is required
- Teaming and Education (30%)
  - Proposed team qualifications and experience including AMTS
  - Integrated team contributes to overall proposal strength
  - Training of student team members
  - Value of the industry partner and FAA advisor
- Cost (weight 10%)

- Proposed cost realism and reasonableness. Appropriateness of proposed effort and proposed other direct costs with those required to accomplish the goals of the investigation.
- Value of the proposal - cost to NASA in time and budget relative to the expected impact
- Budget for AMTS and industry partner in research

E-mail debriefs of the review panel comments of proposals from NASA will be provided after reviews are completed.

Note that NASA reserves the right to offer selection of only a portion of a proposed investigation; in such a case, the proposer will be given the opportunity to accept or decline NASA's offer.

D.6.10 Source Selection

The Source Selection Official is the UI Project Manager. After review of proposals, the Source Selection Official has the option to consider program portfolio priorities, team disciplinary and expertise diversity, and budget constraints when making a final selection.

D.6.11 Reporting and NASA Oversight

NASA intends to conduct oversight through annual reviews and quarterly reports/meetings.

Awardees shall hold a kickoff meeting and annual reviews for NASA to assess the work effort's relevance, quality and performance. The location and medium for this review are at the discretion of the awardee with NASA concurrence. The review will also provide a forum to discuss the awardee's handling of issues and risks that have arisen during the year, as well as provide a mechanism for technology transfer and knowledge dissemination to NASA.

Awardees shall also conduct quarterly status reviews with NASA. These reviews shall provide an update on technical progress, completed milestones, notable accomplishments, and any changes to the plan that occurred during the quarter. This review discussion is expected to take place via video or teleconference. Quarterly status reviews will occur after the first, second, and third quarters of each fiscal year during the period of performance. No quarterly status review is required for the fourth quarter (i.e., the quarter preceding the annual review). Information from the fourth quarter can be incorporated into the annual review.

A written report that completely documents the approach and results shall be submitted for each year's effort.

All technical deliverables identified in the proposal, along with a final report documenting the approach, results, recommendations, and conclusions of the entire work effort shall be submitted no later than 90 days after the end of the period of performance.

Sensitive information may be provided to NASA in a proprietary appendix. Software developments and/or enhancements shall be developed in modular form and delivered in appropriate computer file formats.

D.6.12 Cost Monitoring

Cost monitoring is a part of performance monitoring. The awardees should have procedures for planning, budgeting, tracking, and reporting their costs from all partners. Although NASA understands that there will be a time lag between the institutions' use of funds and when funds are drawn down, invoicing should be timely and prompt.

Pre-Award Costs

Pre-award costs are allowable but at the grantee's own risk. Per 2 CFR § 1800.210, Pre-Award Costs, NASA has waived the requirement for award recipients to obtain written approval prior to incurring project costs up to 90 calendar days before NASA issues an award.

D.6.13 References

[1] NASA, "NASA Aeronautics Strategic Implementation Plan, 2019 Update" https://www.nasa.gov/aeroresearch/strategy, 2019.
[2] NASA. "NASA Proposer's Guide," https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf, Edition: February 2023

D.6.14 Summary of Key Information

Expected budget for new awards	Nominally $300K per award per year, depending on scope
Anticipated number of new awards pending adequate proposals of merit and funds availability	Nominally three awards
Maximum duration of awards	Up to 2 years
Applicant's Workshop	Wednesday April 26, 2023; 1:00-2:00 p.m. ET
Due date for Notice of Intent (NOI) to propose	April 21, 2023, 5 pm ET
Due date for proposals	May 31, 2023, 5 pm ET
Start of Period of Performance	Fall 2023
General information and overview of this solicitation	See the *Summary of Solicitation* in the ROA
Detailed instructions for the preparation and submission of proposals	See D.6.8 and the *NASA Proposer's Guide, Edition: February 2023* at https://www.nasa.gov/sites/default/files/atoms/files/2023_-_nasa_proposers_guide_-_final.pdf

Page limit for the central Science-Technical-Management section of proposal	15 pages
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *Summary of Solicitation* of the ROA and Chapter 3 of the *NASA Proposer's Guide*.
Web site for submission of proposal via NSPIRES	https://nspires.nasaprs.com (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Expected award type	Grants
Funding opportunity number	NNH23ZEA001N-UI
NASA technical point of contact concerning this program	Steven Holz, <steven.m.holz@nasa.gov>, (757) 864-9798
NASA Procurement point of contact concerning this program	DeLunzo Bartee, <delunzo.bartee@nasa.gov>, (228) 688-2781
Questions and Answers (Q&A)	Quickest way to resolve questions about this NRA is to e-mail questions to: HQ-UnivPartnerships@mail.nasa.gov Responses will be provided by e-mail. NASA will also post any general Q&A on-line in the NSPIRES website, so that all proposers will have access to the same information.