AMENDMENT No. 4 TO THE NASA RESEARCH ANNOUNCEMENT (NRA) ENTITLED "RESEARCH OPPORTUNITIES IN AERONAUTICS – 2023 (ROA-2023)," NNH23ZEA001N, RELEASED April 20, 2023

Changes are made to the following:

- Updated Table of Contents
- Table 5. Solicited Research Programs (in order of proposal due dates)
- Table 6. Solicited Research Programs (in order of Appendices A-D)
- Appendix D.4 - University Leadership Initiative (ULI)

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
D.4	University Leadership Initiative (ULI)	July 06, 2023 See note 1	See note 2

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

1. University Leadership Initiative will use a 2-step proposal process. Step-A proposals are required, in place of the Notice of Intent (NOI) and are due 07/06/2023.
2. University Leadership Initiative will use a 2-step proposal process. Step-B proposals will be due 60 days after the notification for Step-B proposals is issued.

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.4	University Leadership Initiative (ULI)	July 06, 2023 See note 1	See note 2
D.6	Future Aviation Maintenance Technical Challenges	April 21, 2023	May 31, 2023

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APPENDIX D: Transformative Aeronautics Concepts Program

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

D.4.2.1 Solicited Topics

In this solicitation, NASA's University Innovation (UI) Project is seeking proposals for work in the following six topic areas:

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

Each of the six topics correspond to an ARMD strategic thrust listed in parenthesis – see Section D.4.2.2. The UI Project continues to be interested in Zero-Emissions Aviation and are encouraging Zero-Emissions Aviation proposals be submitted under Strategic Thrust 3.

D.4.2.2 ARMD Strategic Thrusts and Outcomes

The six ARMD strategic thrusts are described further in the ARMD Strategic Implementation Plan [Ref. 1]. Research objectives for the strategic thrusts are provided in terms of community-based outcomes for three time periods: near-term (2015-2025), mid-term (2025-2035), and far-term (beyond 2035). These outcomes represent NASA's view of expected aviation community advancements within each strategic thrust. Achieving the outcomes will rely on research contributions from NASA and others in the aviation community, as well as the implementation of technologies and procedures onboard aircraft and ground-systems and throughout the National Airspace System.

In the two previous ULI solicitations (NNH21ZEA001N-ULI and NNH20ZEA001N-ULI), the UI project created a topic 7 addressing Zero-Emissions Aviation to focus new proposals in this area. Now that most proposers are aware of this topic and the project's continued interest in Zero-Emissions Aviation, proposals addressing this topic are to be submitted under Strategic Thrust 3. Zero-Emissions Aviation proposals, being submitted under strategic thrust 3, can be on any technology that provides a pathway to the eventual adoption of aircraft that do no environmental harm in all its modes of operations.

D.4.2.3 NASA-Complementary Research

Through this solicitation, NASA looks to introduce independent research paths toward achieving the strategic thrust outcomes. To support this goal, as well as avoid duplication of effort, proposers are encouraged to develop different technical challenges than those currently pursued by ARMD and its research partners. Reference 3 provides the current ARMD technical challenges and Reference 4 provides the list of existing ULI awards. ARMD does not claim these technical challenges to be all-inclusive of those needed to address the thrust outcomes, nor do they necessarily represent the most important barriers that must be overcome. NASA's research portfolio will be enhanced through the addition of new technical challenges brought in by awardees of this solicitation. Proposer-defined technical challenges will be evaluated based on their anticipated impact, without any effort to determine their compatibility with the current ARMD portfolio.

D.4.3 Funding and Eligibility

D.4.3.1 Funding Information and Projected Distribution of Awards

The UI Project anticipates investing in two 3-year awards and two 4-year awards, with one of those awards in Zero-Emissions Aviation and the other three awards in any of the six topics. Proposals should have nominal budgets in the $1-2M range per award per year. Maximum total budgets should range between $3-6M per award for a 3-year award and $4-8M per award for a 4-year award. Actual budget usage by the awardees is important to NASA and so proposed budgets must consider ramp ups within the team.

The actual number, value, duration, and topic 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 program'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.4.3.2 Eligibility

Lead Organization: For this solicitation, the proposing (lead) organization must be an accredited, degree-granting U.S. college or university.

Partners: Proposing organizations are invited to include partners as part of their team - a partner can receive funds from the NASA award. Partners may include other U.S. colleges and universities, U.S. companies, non-profit organizations, federally funded research and development centers (FFRDC), and any other public or private U.S. entity. Other government agencies and NASA centers are not eligible to participate as partners.

HBCU and MSI: Historically Black Colleges and Universities (HBCU) and other minority-serving institutions (MSI) are strongly encouraged to lead or participate.

Collaborators: Proposing organizations are invited to include other collaborators as part of their team - collaborators may not receive funds from the NASA award. Proposers may describe potential plans for collaboration with industry, U.S. government agencies or other organizations in their Step-A or Step-B ULI proposals. Focused but unfunded collaboration under ULI may take many different forms. Some examples may include, but are not limited to: technology convergence, where an idea previously developed for a different government agency is utilized for NASA aeronautics in a novel way; a partnership where the industrial collaborator that will eventually utilize the proposed concept works with the ULI team to ensure this possibility; and use of a collaborator's facilities, equipment, or research capabilities.

Collaboration with other U.S. government agencies that adds value towards the research and development of the innovative concepts, while preserving the university leadership

aspect of this initiative, is encouraged. Any proposed collaboration with a U.S. government agency must conform to the solicitation's instructions.

Collaboration with NASA is covered in Section D.4.5.4.

Ineligible: Foreign organizations are not permitted for this solicitation as partners, collaborators, peer reviewers, technology recipients, etc. However, the direct purchase of supplies and/or services, which do not constitute research or research data exchange, from non-U.S. sources with NASA-awarded funds is permitted.

Pursuant to The Department of Defense and Full-Year Appropriation Act, Public Law 112-10, Section 1340(a); The Consolidated and Further Continuing Appropriation Act of 2012, Public Law 112-55, Section 539; and future-year appropriations (hereinafter, "the Acts"), NASA is restricted from using appropriated funds to enter into or fund any agreement of any kind to participate, collaborate, or coordinate bilaterally with China or any Chinese-owned company, at the prime recipient level and at all subrecipient levels, whether the bilateral involvement is funded or performed under a no-exchange-of-funds arrangement. This restriction does not apply to the purchase from Chinese-owned entities of commercial items of supply needed to perform the agreement.

Partnering with Foreign-Owned U.S. Subsidiaries

The ULI policy for foreign-owned U.S. subsidiaries is intended to ensure that the ULI investment provided by the U.S. government is for the benefit of the U.S. and is not undermined and exported or otherwise transferred for the benefit of the foreign affiliates of the U.S. company.

For this solicitation, foreign-owned U.S. subsidiaries will be permitted to participate as partners, collaborators, peer reviewers, or technology recipients, subject to the requirements outlined below. In accordance with NASA's China funding restriction stated above, except for the purchase from Chinese-owned entities of commercial items of supply, participation by Chinese-owned entities, including Chinese-owned U.S. subsidiaries is prohibited here.

For proposals involving participation of a foreign-owned U.S. subsidiary:

- Proposers shall identify all relationships with foreign-owned U.S. subsidiaries and their roles as partners, collaborators, peer reviewers, or technology recipients.
- The PI and lead university shall attest in the proposal that ULI research results will not be transferred to foreign affiliates of team members and articulate the basis for the attestation.
- If awarded, the PI and lead university shall set up an organizational firewall or other mechanisms to ensure that ULI research results will not be transferred to the benefit of the foreign affiliates of any team member.
- If awarded, during the performance of the award and until 3 years after closeout of the award, the lead university shall annually provide an independent (third-party) verification that NASA research funding and results of ULI research has not been transferred to the benefit of foreign affiliates of any team member (see below).

The following requirements apply to the foreign-owned U.S. subsidiaries:

- Prior to award, shall develop and implement a ULI Technology Control Plan or implement an equivalent, existing control plan. The Plan shall prescribe all security and operational measures determined necessary to reasonably foreclose the possibility of inadvertent access to ULI research by their foreign affiliated companies and personnel. This plan has to be presented to NASA prior to award.
- Shall provide Technology Control Plan briefings to all employees working on ULI and they should sign a Non-Disclosure Agreement.
- Shall physically mark ULI information with appropriate markings to warn and inform holders of the desired protection.
- Shall store ULI information in an access controlled system that would prevent inadvertent access of the material by their foreign affiliated companies and personnel.
- Shall follow these procedures until 3 years after closeout of the ULI award.

If during the performance period, circumstances indicate a violation of the ban, or the likelihood that NASA research funding may indeed operate to the benefit of the foreign affiliates, then with the concurrence of the Transformative Aeronautical Concepts Program Director the Contracting Officer/Grant Officer may terminate the award.

Other eligibility criteria, not superseded by the above, including China Funding Restriction are in Section III of this ROA.

D.4.4 Information for Proposal Development

D.4.4.1 Research Topic and Technical Challenge Identification

When selecting a topic to address, proposers are encouraged to consider a distinct set of outcome needs in a single solicited topic area and then determine technical challenges and research activities that will meet those needs. Technical challenges are distinct barriers that must be overcome in order to achieve the topic outcomes. Research activities are limited-duration projects contributing the knowledge or capabilities needed to accomplish the proposer-defined technical challenges. While a given research product may be able to meet outcomes in more than one topic area, proposers must explicitly connect their research products to specific outcomes in a single topic area. Proposers may note compatibility with multiple topics but should avoid making general associations between their expected products and multiple topics (i.e., avoid stating, “This technology could also support topics X, Y, and Z.”). Alignment and focus are more important than breadth of applicability. This emphasis supports a “topic-driven” rather than “technology-driven” approach.

Through this announcement, proposers will have the opportunity to:

- Independently identify the most critical technical challenges that must be solved to achieve the topic outcomes;
- Propose independent, innovative research activities to solve the technical challenges, including developing the success criteria, progress indicators, and technical approach;
- Bring forward system-level, revolutionary concepts;

- Build a talented, diverse, and cross-disciplinary team to explore innovative, integrated solutions toward the technical challenges;
- Consider application of multi-disciplinary, multi-industry approaches, including those outside of traditional aeronautics disciplines (technology "convergence"); and
- Offer novel, high technical risk approaches that open avenues for accelerated progress.

Proposals offering integrated, multi-disciplinary solutions will be considered more favorably than a group of loosely connected single-discipline solutions, even if the single-discipline solutions address challenging problems in their own right.

D.4.4.2 Developing Technical Challenges

This section provides proposers with insight on developing technical challenges. The complete set of elements discussed below applies most directly to second stage ("Step-B") proposals. First stage ("Step-A") proposals may only require a sub-set of the information described. Please see Sections D.4.6.1.4 and D.4.6.1.6 for a complete list of required elements for Step-A and Step-B proposals, respectively.

Proposers shall identify one or more technical challenges corresponding to one of the solicited topics (Section D.4.2.1). Technical challenges have the following characteristics: they are stated in crisp, clear, and concise terms; a technical barrier or enabler is clearly defined; there is a quantifiable measure of success; and progress is measurable in discrete increments (progress indicators). To accomplish an outcome, the aviation community must address progressively more difficult challenges across a range of research themes. Each technical challenge represents an important step toward achieving the outcomes. Proposers shall provide technical challenge(s) they expect to be achievable through their own contributions within the research activity duration.

In developing the technical challenges, proposers are encouraged to review the solicited topic areas above (Section D.4.2.1), including the Strategic Plan [Ref. 1] and determine a topic to which they can contribute. Through their own analyses, proposers should determine the technical challenges they consider important. The technical challenges may correspond to the research themes provided in the Strategic Plan or may address different themes the proposer deems necessary to accomplish the outcome. To support this goal, as well as avoid duplication of effort, proposers are encouraged to develop different technical challenges than those currently pursued by ARMD and its research partners (see Section D.4.2.3, Ref. 3 and 4). This process is comparable to that used by NASA teams in developing the current ARMD portfolio.

A technical challenge includes the following elements: statement, duration, performance metric(s), and success criteria. The statement shall be represented as a research contribution that addresses a technical barrier. A well-written statement clearly reflects a barrier that can be overcome within the established timeframe. It should be an important step towards achieving the strategic outcome and not the research area's long-term goal. Duration of the technical challenge is measured in years from the start of award. Where required, proposers shall provide a small number (nominally 1-2) of key performance

metrics. These metrics will be used to determine progress and final completion of the technical challenge. Success criteria provide target levels of the performance metric upon completion of the technical challenge.

D.4.4.3 Progress Indicators

Awardees will be expected to plan and measure progress toward their technical challenges. Progress indicator charts are one such way to support this task. Reference 5 provides current or recent NASA examples for different types of research products, including tools, technologies, and concepts (Ref. 5 examples 1-3, respectively). Charts include the following elements: technical challenge statement, duration, technical performance plot, and technical maturity plot. Technical performance and technical maturity are represented in the upper and lower plots of each example, respectively. Technical performance indicates the expected interim and final performance of the research products contributing to the technical challenge. Performance is measured using the technical challenge performance metric(s). Approximate error bands may be included. Any bands are used for illustrative purposes only and are not intended to be precise. Performance can advance through improvement in the value itself and/or a reduction in its uncertainty. Technical maturity reflects the progress of research products on the way to achieving the technical challenge. Various means to assess technical maturity may be used.

Use of TRLs and MRLs: Where applicable, ULI recommends using Technology Readiness Level (TRL) or Manufacturing Readiness Level (MRL). These are helpful metrics for technologies and manufacturing, respectively. However, TRLs and MRLs may not relate well to a tool, method, or model, nor may it be applicable to software. The software community uses other measures to reflect maturity - see for example NASA Software Engineering Handbook (https://swehb.nasa.gov/). ULI recommends using the appropriate success criteria depending on the concepts or technologies being developed.

For both technical performance and maturity plots, performance and maturity are assessed at selected milestones. Proposers may note that the Reference 5 examples represent NASA work in progress and therefore include some features that are not applicable to the planning stage (e.g., completed and/or slipped milestones).

Proposers may apply different approaches to planning their technical challenges, provided they show expected advancements in technical performance and maturity as milestones are completed. Technical performance should culminate in the target established for the technical challenge.

D.4.4.4 Research Milestones

For each technical challenge, proposers shall develop an associated set of research milestones addressing the challenge. A fully defined milestone includes the following information: title, description, duration (year and quarter-year from start of award – see Section D.4.8 for Start of Period of Performance), exit criteria, and deliverables. The description should provide a few sentences on the research activity's objectives and technical approach leading to the milestone. Exit criteria include the metrics and target

levels used to determine that the milestone objectives have been achieved. They may or may not be the same as the corresponding technical challenge performance metric and success criteria. Deliverables are the research products and/or publications provided by the proposer that are associated with milestone completion. Proposers should include periodic research deliverables and/or milestones that can be used to assess research performance by non-advocate reviewers in annual meetings.

D.4.4.5 Expected Research Products

Proposers are expected to produce specific research products in the process of addressing their technical challenges. These products may include technologies, operational concepts, methods, design tools, models, or other technical advancements. Proposals should clearly indicate how the products will contribute to the chosen topic outcomes.

Research products developed over the course of the award period should demonstrate a growing level of validation, integration, and technical maturity. Strong proposals will build upon early-stage exploration and progress toward system-level solutions later in the award period. For these proposals, earlier research products will effectively converge to address increasingly more complex and multi-faceted problems as the work advances.

D.4.4.6 Intellectual Property

Ownership of subject inventions is governed by Section II (d) of ROA-2023.

D.4.4.7 Transition

Teams are expected to explore transition opportunities for their research products or technologies developed over the course of the award. The intent is to have a successful transfer of the technologies from a research environment to an operational environment that provides the U.S. aviation industry with the best possible technologies at the earliest possible dates.

In order to transition their research, the team is expected to actively explore transition opportunities and pursue follow-on funding from stakeholders and industrial partners during the award.

If new business models are proposed, then NASA will require risk management as part of the transition planning. This plan should include, but not be limited to, maturity, market, economic, and workforce risks.

D.4.4.8 Teaming

Subject to eligibility requirements (Section D.4.3.2), building and applying a diverse, multi-disciplinary team is part of the strategic leadership role entrusted to awardees of this solicitation. Proposers are expected to incorporate wide-ranging capabilities and apply innovative teaming methods that strengthen the proposal's overall contributions and promote education of the next generation of engineers. When putting together their teams, lead institutions are strongly encouraged to explore new partnerships in addition to leveraging those they have previously developed. Partnerships could include other

departments at the PI's institution, other colleges or universities, industry members, non-profit organizations, or other U.S.-based entities.

D.4.4.8.1 Diversity in Teaming

Diversity is a ULI strategic goal (see Section D.4.1). ULI strongly encourages broadly diverse groups to increase their participation in this solicitation (for example but not limited to female PIs, minority PIs, PIs from HBCUs and other MSIs, and new PIs). Each of these groups is crucial to making the national aeronautics research infrastructure healthy and reflective of the US.

HBCUs and MSIs are strongly encouraged to lead or participate in ULI.

Proposers are expected to consider partnerships with schools that may have less prior experience in working on NASA Aeronautics research projects and include underrepresented university faculties in ULI activities. Lead organizations can demonstrate leadership by creating mentoring opportunities, providing access to facilities or contacts, and otherwise helping to nurture and fully integrate the capabilities of less-established partners.

Diverse partnerships are expected to bring a wealth of talent and different perspectives that can contribute to novel, innovative approaches. These benefits notwithstanding, proposers should not add members solely for the purpose of lengthening their partnership list. Each partner should have a meaningful role.

D.4.4.9 Education and Workforce Development

Education and workforce development is a ULI strategic goal (see Section D.4.1). The university community is the ultimate source of the future aeronautics workforce needed to keep the U.S. industry and U.S. government in the position of aerospace global leadership.

ULI strongly encourages the use of undergraduate students, in addition to graduate students, by providing plenty of research opportunities in all its projects. It gives students a practical view of what many of them will be doing after they graduate – an opportunity for the next generation of engineers to see real-world problems being formulated, solved and implemented in agile, multi-organizational environments.

ULI strongly encourages proposing funded development of students in K-12 and community colleges by providing them relevant educational experiences to encourage future engineering candidates for colleges and universities. K-12, community college, and undergraduate education programs should be incorporated in the proposal. Proposers should allocate a minimum of $50K each year to providing a ULI-related research experience for community college students.

D.4.4.10 Risk Identification

The desire for increasing technical maturity notwithstanding, proposers are encouraged to bring forward revolutionary, high technical risk approaches that open avenues for

accelerated progress toward the strategic outcomes. Research results that do not ultimately meet their technical objectives will be readily accepted, provided the proposers openly share their findings and insight.

Proposals should identify credible primary risks and how the team will manage those risks.

D.4.4.11 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-2023 for general proposal requirements.

Each NASA facility is managed differently. If use of NASA facilities is proposed, prior to submitting Step-A 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 UI 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 Step-B 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 UI Project.

D.4.5 Management Information

D.4.5.1 Non-Advocate Peer Review

As part of the strategic leadership aspect of this initiative, proposers and the university-led teams must take primary responsibility for maintaining high levels of relevance, quality, and performance across their portfolio. Proposers should therefore establish their own methods for regular external peer review and reporting of the review results to NASA. Proposers have broad leeway to select external reviewers they believe will add value to their research efforts. These reviewers should be non-advocates – i.e., experts that are not otherwise involved in performing the team's research. Reviewers selected from industry should be from U.S. companies (see Section D.4.3.2 on Eligibility). To promote independence from NASA research activities and minimize NASA's role in technical oversight, proposers should not include current NASA employees on their review panels. Proposals can include a travel budget for peer reviewers.

During the research effort, awardees are encouraged to propose necessary course corrections to maintain continued relevance based on peer review recommendations and other interactions with key stakeholders.

D.4.5.2 Reporting and NASA Oversight

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

As part of the non-advocate peer review process, awardees are asked to hold an annual review to assess the work effort's relevance, quality and performance. The location and medium for this review are at the discretion of the awardee. 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 any technology transfer that has occurred. In addition, awardees will be asked to share results from peer assessments occurring during the prior year. NASA, who will be a participant at the annual meeting, will allow time for private caucus between the university team and its non-advocate reviewers, and will be an additional recipient of the peer review information.

Awardees shall also conduct quarterly status reviews with their peer reviewers and NASA. These reviews shall provide an update on technical challenge 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.

NASA's determination of adequate progress will consider results from the annual review, quarterly status reviews/reports, and additional insight gained from the non-advocate peer reviews. NASA reserves the right to discontinue funding if it determines the awardee has been unable to correct serious performance problems.

In addition to reviews and reports, there will be a kick-off meeting at the beginning of the award period. Annual oral presentations made as part of an open technical exchange meeting for purposes of technology transfer and knowledge dissemination are also required. Direct participation by contributing partners and collaborators is encouraged, especially for the kick-off meeting and annual reviews. NASA program and project personnel may also coordinate with the awardee to arrange informal visits to the awardee's institution or facilities.

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.4.5.3 Cost Monitoring

Cost monitoring is a part of performance monitoring. The ULI teams should have procedures for planning, budgeting, tracking, and reporting their costs from all partners. To enable the UI Project to optimize the use of available funds, a phasing plan (costing to NASA) for the first fiscal year shall be submitted within 30 calendar days of the award date and within 30 days of start of the following fiscal years of the award (by October 30th). NASA will provide the phasing plan templates for costing. Monthly and quarterly assessment of execution to phasing plans is the responsibility of the PI. 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.4.5.4 Collaboration with NASA

As noted in Section D.4.3.2, proposers may not include NASA centers or researchers as partners. NASA does seek to collaborate with awardees in a manner that adds value towards the research and development of the innovative concepts, while preserving the university leadership aspect of this initiative. Therefore, proposed informal collaboration with NASA researchers during the performance period is encouraged only where it a)

adds value towards achieving the research objectives of the topic area, b) promotes technology transfer into NASA or the broader aviation community, and c) preserves inherent differences in technical approach between proposer-led and NASA research activities. The proposers may propose such informal collaborative activities, but without specifying NASA researchers, Center, or Project names in the proposal. Only NASA management can assign NASA personnel to work on projects, so proposals including NASA names will be penalized appropriately. 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 with NASA management and finalized.

D.4.6 Proposal Process

D.4.6.1 Proposal Format and Submission Information

Proposals involving multiple cooperating organizations must be submitted by a single institution, which becomes the Lead Institution. The Lead Institution must be the PI's home institution. Proposals must be submitted by an official at the PI's organization who is authorized to make such a submission.

Proposals submitted in response to this solicitation are required to be clearly legible in both the body of the text and in the figure captions. Text within figures and tables may be smaller but must still be judged by the reviewers to be readable. Expository text necessary for the proposal may not be located solely in figures or tables, or in their captions.

D.4.6.1.1 Proposal Submission Site

Proposers must submit electronic proposals in response to this solicitation to NSPIRES (https://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 PI, all Co-Investigators (Co-Is) and Partners. It is optional for Collaborators and is not needed for Advisory Board members, Technical Panelists, or Peer Reviewers. 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.

D.4.6.1.2 Applicant's Workshop

An applicant's workshop will be held on the date and time given in Section D.4.8. The workshop will provide interested parties with the opportunity to better understand the intent, scope, and selection criteria of this solicitation. A presentation on the solicitation will be followed by a question and answer period. The briefing will be live streamed with participation available to anyone having Internet access.

Applicants are invited to register and learn more at https://uli.arc.nasa.gov/applicants-workshops/workshop7. Upon registering, you will receive an automatic e-mail with connection details to join the virtual ULI applicant's workshop. During the workshop, all participants will have the opportunity to ask and upvote questions while also using the chat. Interested parties can also submit their questions in advance to hq-univpartnerships@mail.nasa.gov.

A week after the event, links to the applicant's workshop charts and video recording will be posted on NSPIRES.

D.4.6.1.3 Two-Step Proposal Procedure

The information in Section IV of this ROA and the *NASA Proposer's Guide* is superseded by the following:

This solicitation will use a two-step proposal process in which a mandatory Step-A proposal is first submitted. A separate Step-A proposal must be submitted for each intended, and thus corresponding, Step-B proposal. Only proposers who submit a Step-A proposal and are invited to submit a Step-B proposal are eligible to submit a Step-B proposal. The submission of a Step-A proposal is not a commitment to submit a Step-B proposal.

D.4.6.1.4 Step-A Proposal Format and Contents

The Step-A proposal Scientific/Technical/Management section may not exceed five (5) pages in length, with a minimum 12-point font size and one-inch margins on all sides. Step-A proposals that exceed the five-page limit may be rejected without review. This section must cover the following topics:

- Title of proposed task
- Topic and outcome addressed
- Name and organization of PI
- List of partners known to date (may be changed if proposer is selected to submit a Step-B proposal)
- Research objectives
- Partially defined technical challenge(s) (to include only technical challenge statement and duration for each technical challenge submitted)
- Summary of technical approach for the effort
- Assessment of what is innovative or novel in the proposed concept and how it will contribute to the chosen strategic thrust outcome(s)
- Expected research products
- Anticipated transition opportunities of research products/technologies to the U.S. aviation industry or NASA
- Overall teaming and education strategy for workforce development.

Proposals may also include a list of references which will not count against the 5-page Scientific/Technical/Management section limit in Step-A proposals.

The period of performance will be an important consideration in the Step-A evaluation process – proposals will be evaluated from two pools, one for 3-year awards and another for 4-year awards. NASA will use the period of performance and total budget to ensure final selections can be supported by the anticipated ULI budget. The period of performance should remain the same between Step-A and Step-B, and proposers may only increase their total Step-B budget request as long as it stays within the limit as described in section D.4.3.1.

D.4.6.1.5 Other Step-A Proposal Submission Considerations

The NSPIRES proposal submission system requires certain information be input before proposal submission. Note that the Proposal Summary, Business Data, Program Specific Data, and Proposal Team are required Cover Page Elements even for a Step-A proposal. In Step-A, NASA will only review the five-page proposal. The other information (Proposal Summary, Business Data, Program Specific Data, Detailed Budget, Letters of Commitment, etc.) will not be reviewed.

Step-A proposals do not need to submit a Detailed Budget, but proposers are requested to provide an estimated yearly and total budget in the Cover Page Elements of the proposal. If the Step-A budget form is not available for NSPIRES entry, please add an extra page with the yearly and total budgets in your submission. This page will not count against the 5-page limit for the Scientific/Technical/Management section.

Note: Besides the budget, there may be other elements required by NSPIRES for submitting a Step-A proposal, otherwise the Step-A proposal will not be accepted by NSPIRES. Proposers need to complete these elements even though NASA may not review these elements.

D.4.6.1.6 Step-B Proposal Format and Contents

The Scientific/Technical/Management section may not exceed twenty-five (25) pages in length, with a minimum 12-point font size and one-inch margins on all sides. This section must cover the following topics:

- Title of proposed task
- Topic and outcome addressed
- Name and organization of PI, Co-Is, Partners and Collaborators
- Research objectives and overall strategy
- Fully defined technical challenge(s):
    - Statement
    - Duration (year from start of award)
    - Performance metric(s)
    - Success criteria
- Progress indicators for each technical challenge, including:
    - Statement
    - Duration (year from start of award)
    - Technical performance, using the proposer-defined performance metric

    - Technical maturity, using the proposer's preferred means to assess technical maturity

  Proposers may provide this information using progress indicator charts (modeled after the examples shown in Reference 5) or any other method that uses distinct events to mark improving performance and maturity on a path toward achieving the technical challenge. A legend should be provided as necessary to define any colors and symbols used.

  If applying the Reference 5 examples, proposers should use their own performance metric(s), success criteria, and interim and final milestones. Proposers are encouraged to use the examples as a general guide, adapting the content and style as needed to fit their technical challenges. If the required technical challenge elements are provided in full in the progress indicator depiction, they need not be repeated in a separate table or list. Further discussion on progress indicators is provided in Section D.4.4.3.
- Milestones (at least one per year):
    - Title
    - Description
    - Duration (year and quarter-year from start of award)
    - Exit criteria (metrics and expected performance levels)
    - Deliverables
    - Technical challenge supported (if more than one technical challenge proposed)
- Technical approach
- Assessment of what is innovative or novel in the proposed concept and how it will contribute to the chosen strategic thrust outcome(s)
- Expected research products and schedule during the period of performance
- Plans for peer review to assess relevance, technical quality, and performance on a quarterly and annual basis
- Anticipated transition opportunities of research products/technologies to the U.S. aviation industry or NASA. The ULI award should serve as a catalyst with stakeholder-funding taking over. Provide a roadmap for transitioning research with stakeholder requirements and increasing stakeholder involvement.
- Qualifications, capabilities, and experience of the team members, including PI, Co-Is, and other collaborators
- Teaming strategy, that also includes
    - Plans to include faculty and students from HBCU and/or MSIs in ULI research
    - Inclusion of underrepresented university faculties in ULI activities
- Education and Workforce Development
    - Strategy promoting relevant education and workforce development of the next generation of K-12, undergraduate (including community colleges), and graduate engineers.

    - Innovative training for U.S. citizen or permanent resident student team members in leadership, management, entrepreneurship and/or public policy. This would support the graduation of students who are trained to lead and would encourage partnership between engineering schools with other university departments.
- Proposers may include cost sharing in their proposals at their own discretion. Such offers will become binding and auditable resource commitments upon award. Cost sharing is not an evaluation criterion for peer review. However, cost sharing may be considered by the Selecting Official in the final selection of awards.
- Statement of what intellectual property is expected to be publicly available at the conclusion of the work
    - Note: It is NASA's intent to share knowledge developed under this solicitation, thus, any restrictions to this objective may impact the evaluation of the proposal. Securing intellectual property rights through the patent process is permitted. It is the responsibility of the investigator to secure desired protections prior to public briefings required by ULI.
- Test facilities to be used including proposed use of NASA facilities (see Section D.4.4.11)
- If any NASA Supercomputing resource usage is proposed, include specific computing requirements (CPUs, hours, memory, storage, timeframe, etc.) and state its criticality to the proposed work (select either one of two from below):
    - Require NASA computation resources as go/no go for proposed work
    - Optional need for NASA computation resources to enhance research execution
- For proposals involving team members participating from foreign-owned U.S. subsidiaries as partners, collaborators, peer reviewers, or technology recipients:
    - Proposers shall identify all relationships with foreign-owned U.S. subsidiaries and their roles in the Scientific/Technical/Management section.
    - The PI shall provide a separate letter for each foreign-owned U.S. subsidiary organization attesting that ULI research results will not be transferred to foreign affiliates of team members and articulate the basis for the attestation.
    - The Chair of the Department or the Dean of the School shall provide a letter attesting that their support of the PI and the organization's commitment to ensure that ULI research results will not be transferred to foreign affiliates of team members.

  Proposals that do not meet these requirements will not be reviewed and will be disqualified.

Please refer to Section IV of ROA-2023 for additional requirements on proposal content, format, budget details, and submission procedures. A budget justification, including justification for any foreign travel, is required for the Step-B proposal, but will not be counted toward the Scientific/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.4.6.1.7 Step-B Data Management Plan (DMP)

The requirements for DMP are in Section II (c) of the ROA. Reasonable costs associated with the DMP (i.e., costs of sharing, preservation, etc.) may be included in the proposal budget. Specific questions regarding a DMP should be directed towards the POCs in Section D.4.8 as they may provide guidance to proposers and awardees, in addition to their responsibility for compliance with DMPs.

D.4.6.1.8 Proposal Team and NSPIRES

Note that NSPIRES has a different interpretation than the ULI terminology for PI, Co-I, Partner, Collaborator, and Reviewer. It is not important how they are registered in NSPIRES, provided the technical part of the proposal identifies them and their role correctly.

Every funded Co-I and Partner is critical for the conduct of the investigation through the contribution of expertise and/or capabilities. They must demonstrate their commitment to participate in the proposed investigation by electronic confirmation in NSPIRES for the Step-A and Step-B proposal.

Collaborators and Reviewers need not confirm their electronic participation in NSPIRES. Letters of commitment from unfunded collaborators will suffice to show their intent to participate in the work. Advisory Board members, Technical Panelists, or Peer Reviewers do not have to confirm their participation either through NSPIRES or through letters of commitment.

D.4.6.2 Proposal Evaluation and Selection

All proposals will be reviewed according to the Selection and Evaluation Criteria listed in this section.

D.4.6.2.1 Selection Process

The following steps will be followed for this solicitation and selection process.

- NASA releases this solicitation.
- Proposers submit a Step-A proposal in NSPIRES.
- NASA will review and make the final selection decision on which Step-A proposals will be invited to submit a Step-B proposal. Through NSPIRES, NASA will also notify all proposers who are not selected.
- NASA will invite all the selected Step-A proposers to submit a Step-B proposal for this solicitation.
- Step-B proposals will be due at least 60 days from the issue date of the notification and/or invitation E-mail.
- Invited proposers submit a Step-B proposal in NSPIRES.
- Proposals are evaluated by a Technical Review Panel consisting of government subject matter experts.
- The Selecting Official is the ARMD Transformative Aeronautics Concepts Program Director.
- NASA will notify all Step-B proposers of the final award decisions.

E-mail debriefs of the review panel comments of Step-A and Step-B proposals from NASA will be provided after Step-A and Step-B are completed, respectively.

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.4.6.2.2 Step-A Proposal Evaluation Criteria

Step-A proposals will be evaluated against the criteria listed below. The evaluation criteria in the *NASA Proposer's Guide* are superseded by the following:

- Relevance to ULI objectives (weight 35%)
  - Relevance to ULI strategic goals of Section D.4.1.
  - Clear link between the proposed technical challenges and research products to the selected topic outcomes.
  - Viable transition path for the research products/technologies.
- Technical Merit (weight 35%)
  - Overall scientific or technical merit of the proposal, including unique and innovative methods (such as technology convergence), approaches, or concepts.
  - Technical challenges that represent complex, system-level problems.
- Innovative Teaming and Education (weight 30%)
  - Innovative and inclusive teaming methods that contribute to overall proposal strength, promote diversity, inclusion of faculty and students from HBCUs and/or MSIs.
  - Promoting relevant education and workforce development of the next generation of K-12, undergraduate (including community colleges) and graduate engineers.

Failure of a Step-A proposal to be highly rated in any one of the evaluation criteria is sufficient cause for the proposal to not be selected. Proposals without the appropriate involvement of HBCUs and/or MSIs will be rejected. Step-A proposals will be evaluated from two pools, one for 3-year awards and another for 4-year awards. The period of performance cannot change between Step-A and Step-B.

Proposers should be aware that even when selected to proceed to Step-B, there might be weaknesses in their proposals that could prevent them from being selected in Step-B. Fairness procurement rules prevents ULI from providing reviewer feedback on Step-A proposals selected to proceed to Step-B. ULI expects proposers to improve their proposals between Step-A and Step-B.

D.4.6.2.3 Step-B Proposal Evaluation Criteria

Step-B proposals will be evaluated against the criteria listed below. The evaluation criteria in the *NASA Proposer's Guide* are superseded by the following:

- Relevance to ULI objectives (weight 25%)
  - Relevance to ULI strategic goals of Section D.4.1.

  - Clear link between the proposed technical challenges, milestones, and research products to the selected topic outcomes.
  - Viable research transition roadmap for the research products/technologies. See ULI transition goals in Section D.4.1.
- Technical Merit (weight 25%)
  - Overall scientific or technical merit of the proposal, including unique and innovative methods (such as technology convergence), approaches, or concepts.
  - Proposal offers an integrated solution to a major barrier instead of a group of loosely connected solutions.
  - Technical challenges provide distinct research barrier and represent complex, system-level problems.
  - Demonstrated ability and technical breadth of proposed team.
  - Credible, integrated, multi-disciplinary technical approach, including a clear assessment of primary risks and means to address them.
- Innovative Teaming and Education (25%)
  - Integrated team contributes to overall proposal strength.
  - Innovative and inclusive teaming methods that promote diversity, inclusion of faculty and students from HBCUs and/or MSIs.
  - Inclusion of underrepresented university faculties in ULI activities.
  - Promoting relevant education and workforce development of the next generation of K-12, undergraduate (including community colleges), and graduate engineers.
  - Innovative training of student team members to become future leaders.
- Effectiveness of the Proposed Work Plan (weight 15%)
  - Comprehensiveness of work plan, effective use of resources, management approach, and proposed schedule for meeting the objectives.
  - Strong peer review process for assessing relevance, technical quality, and performance.
- 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. Phasing plans provided by teams on plans to meet the funding required at start up and during the rest of the years.
  - Value of the proposal - cost to NASA in time and budget relative to the expected impact.
  - Budget for HBCU and/or MSI participation in ULI research.
  - Budget for community college students' participation in ULI research
  - Budget set aside for K-12, undergraduate, including community college, educational opportunities.

Proposals with missing letters of attestation involving team members participating from foreign-owned U.S. subsidiaries as either partners, collaborators, peer reviewers, or technology recipients will not be reviewed and will be disqualified. Failure of a proposal to be highly rated in any one of the evaluation criteria is sufficient cause for the proposal to not be selected. Proposals without the appropriate involvement of HBCUs and/or MSIs will be rejected.

D.4.6.2.4 Source Selection

After the review of Step-B proposals, the Selecting Official has the option to consider program portfolio priorities, team diversity, new ULI investigators, cost sharing and budget constraints when making a final selection.

D.4.6.3 Contact with NASA during Solicitation Period

Except to obtain information about NASA facilities, communications with NASA during the solicitation period can only occur through the designated POC (see Section D.4.8). There can be no direct or indirect communications with NASA researchers and managers from the time this solicitation is posted to the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) until proposal selections are final. NASA personnel may not be involved in any aspect of proposal writing.

Communications with NASA facility POCs are permitted during the solicitation blackout period – solely to obtain facility capability, availability, and costs information for the proposed tests. Proposers may refer to Section D.4.4.11 for information on NASA facilities and points of contact.

D.4.7 References

[1] NASA, "NASA Aeronautics Strategic Implementation Plan, 2019 Update" https://www.nasa.gov/aeroresearch/strategy, 2019.

[2] U.S. Department of Education, "List of postsecondary institutions enrolling populations with significant undergraduate minority students," http://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst.html.

[3] List of ARMD Technical Challenge Statements

Program and Project Acronyms (as listed in technical challenge statements):

AAVP – Advanced Air Vehicles Program *AATT* – Advanced Air Transport Technology Project *CST* – Commercial Supersonic Technology Project *HT* – Hypersonic Technology Project *RVLT* – Revolutionary Vertical Lift Technology Project
AETC – Aerosciences Evaluation and Test Capabilities Portfolio
AOSP – Airspace Operations and Safety Program *AAM – Advanced Air Mobility Project* *ATM*-X – Air Traffic Management – Exploration Project *SWS* – System-Wide Safety Project
IASP – Integrated Aviation Systems Program *AAM – Advanced Air Mobility Project* *FDC* – Flight Demonstrations and Capabilities Project

TACP – Transformative Aeronautics Concepts Program
TTT – Transformational Tools and Technologies Project
UI – University Innovation Project

ARMD Technical Challenge Statements by Program and Project

(As of October 2022)

Program	Project	TC Name	TC Statement	FY Complete
AAVP	AATT	Focused Technologies for EAP Demo	Demonstrate representative hybrid electric powertrain having a total power of at least 3X the state-of-the-art that meets fault management, redundancy, and power quality requirements (TRL 4) and develop key components to TRL 6	FY24
AAVP	AATT	TTBW Technology Maturation	Enable fuel burn benefit of 5-10% by identifying and characterizing edge-of- envelope performance, safety, and environmental challenges and maturing the TTBW technology. (TRL 3)	FY26
AAVP	CST	Community Test Planning & Execution	Planning and Execution of overflight tests with the LBFD aircraft over large non-experienced communities within the U.S.	FY27
AAVP	CST	Improved Combustor Scaling	To improve current engine (1X) performance and enable engine scale-up to fully reusable vehicle scales (100X), NASA will develop and deliver mathematical models and associated validation test data with quantified uncertainty that support the design of high-speed combustors inclusive of green fuels. NASA will demonstrate such capability by reducing the length of the state-of-the-art cavity flameholder by 25%. (10% threshold, 25% goal cavity length reduction for HDCR with equivalent performance)	FY27
AAVP	CST	LBFD Prediction Validation (ProViT)	Develop and validate tools for prediction of sonic boom carpet loudness in test day conditions including uncertainties due to atmospheric and operational conditions	FY24
AAVP	CST	Prediction Uncertainty Reduction (PUR)	The technical challenge seeks to: • Improve CFD nearfield prediction capabilities to provide fast, robust solutions for signature validation • Incorporate full mission envelope and real atmospheric models into fast turn-around propagation codes • Perform multi-discipline, multi-fidelity total mission analysis under uncertainty for sonic boom loudness. • Develop an integrated tool for day of flight exposure planning	FY24
AAVP	CST	LBFD Flight Validation Data Measurement	Develop key flight systems for enhanced safety and operational efficiency, and transition these systems to the Low Boom Flight Demonstration (LBFD) Project. Develop and demonstrate techniques to collect high quality validation data from the LBFD aircraft in flight.	FY22
AAVP	HT	System Level UQ	In order to identify cost- effective ways to reduce hypersonic vehicle development time and budget, a novel and reliable methodology to quantify and propagate uncertainties to the system performance level will be developed and validated using ground and flight test data. This will significantly improve the prediction of highly sensitive operational performance and will provide improved insight for decision-making during the design process.	FY22
AAVP	HT	Turbine Based Combined Cycle (TBCC) Propulsion Mode Transition	Demonstrate autonomous control and establish performance/operability assessment methodologies for TBCC propulsion mode transition utilizing an off-the-shelve turbojet (TJ) integrated with an advanced dual- mode ramjet (DMRJ) to facilitate the development of affordable, robust, and reusable propulsion systems for civilian and military hypersonic vehicles.	FY24
AAVP	RVLT	Reliable & Efficient Prop. Comps for UAM	Because there is a lack of data for propulsion systems and thermal management systems for UAM vehicles, NASA will develop design and test guidelines, acquire data, and explore new concepts that improve propulsion system component reliability by several orders of magnitude over state-of the-art technology.	FY24
AAVP	RVLT	UAM Operational Fleet Noise Assessment	In order to address the need for a documented methodology for generating noise assessments of fleet operations of UAM eVTOL aircraft concepts, NASA will deliver validated tools and tool chain documentation at TRL=5, document best practices for fleet noise modeling, and demonstrate fleet noise assessments of representative UAM operations.	FY23
AAVP	RVLT	Tools for noise & performance for UAM	Because the community does not have the capability to accurately predict the noise and performance of multi-rotor UAM aircraft, NASA will develop, demonstrate, validate, and document a set of conceptual design tools capable of assessing the tradeoffs between UAM vehicle noise and performance.	FY26
AAVP	RVLT	UAM Crashworthiness	To address the need for crashworthiness requirements and onboard occupant crash and impact protection, NASA will deliver: 1) full-scale and component-level data to	FY26

Program	Project	TC Name	TC Statement	FY Complete
		and Occupant Protection	inform eVTOL standards development; and 2) test guidelines, modeling best practices, and vehicle technologies for crash mitigation that reduce predicted occupant compressive lumbar loads to less than 1500 lb for five load cases that represent expected eVTOL impact conditions for the RVLT Lift+Cruise reference configuration.	
AAVP	RVLT	Acceptable Handling & Ride Qualities for UAM	This Technical Challenge (TC) will define and validate appropriate HQ and RQ guidelines for UAM vehicle design and operations based on human subject testing. The HQ and RQ guidelines will be incorporated into new flight dynamics and control modeling tools suitable for conceptual design.	FY26
AOSP	AAM	Automated Flight and Contingency Management (AFCM)	Develop and evaluate an initial, integrated set of key vehicle functions for automation enabled piloting in urban operations, and propose recommendations to support requirements for certification and approvals for the selected concepts.	FY28
AOSP	AAM	High-Density Vertiplex (HDV)	Develop and evaluate a reference automation architecture that addresses scalable and efficient aircraft operations, flight and airspace management procedures, and vertiport operations in high density vertiplex environments.	FY28
AOSP	ATM-X	eXtensible Traffic Management	New extensible traffic management (xTM) services, such as UAS Traffic Management (UTM) and UAM, will allow emerging operations to coexist with conventional air traffic management (ATM) by sharing fully integrated and interoperable information.	FY28
AOSP	ATM-X	Pathfinding for Airspace with Autonomous Vehicles (PAAV)	Enable the development of requirements, procedures, and technologies to enable the integration of new vehicles and operations into the National Airspace System (NAS).	FY28
AOSP	ATM-X	Urban Air Mobility (UAM)	Develop technologies for airspace and vertiport management to enable UAM missions at user-specified tempo in lower-controlled airspace	FY28
AOSP	SWS	SAAFE	Develop and demonstrate cost-efficient V&V tools, methods and guidance that provide justifiable confidence in safety claims for designs of complex safety-critical ATM/avionics systems. This TC will seek to develop an increasingly effective path to approval for advanced software and systems that address the following barrier(s): • Existing methods and guidance do not support cost-effective paths to the safety assurance required to enable the introduction of highly reliable advanced avionics and future ATM systems. The success criteria for this TC are as follows: • Minimum success: Perform demonstrations of flight critical system V&V capabilities for selected case studies applied to realistic avionics systems • Full success: Complete a performance evaluation of the developed V&V capabilities and a technology transfer plan for at least one developed technology element • Stretch success: Demonstrate suitability of alternate approaches to software and systems assurance sufficient to provide a basis for industry consensus standards	FY22
AOSP	SWS	Terminal Area	Develop and demonstrate integrated risk assessment capabilities to monitor terminal area operations based on data analytics and predictive models.	FY24
AOSP	SWS	Emerging Risk	Develop and demonstrate integrated dependable monitoring, assessment and mitigation capabilities for safety-critical risks to low altitude urban beyond visual line-of-sight for small UAS operations.	FY25
AOSP	SWS	Complex Autonomous Systems Assurance (CASA)	Develop and demonstrate innovative V&V tools and methods to provide assurance of the safe operation of complex, increasingly autonomous, non-deterministic systems.	FY25
IASP	FDC	IEP	Demonstrate the performance of a complex, integrated Distributed Electric Propulsion system through manned flight test and collaborate with standards and certification agencies to develop a certification basis for electric aircraft.	FY23
IASP	FDC	ARMD Flight Data Portal (AFDP)	ARMD Flight Data Portal (AFDP) - Provide NASA civil servants, contractors, and partners secure, direct access to ARMD flight test data products along with the information required to interpret and use the data both during and after flight projects. The Aeronautics Research Mission Directorate (ARMD) Flight Data Portal (AFDP) Project is a Capabilities Challenge within the Flight Capabilities sub-project in the ARMD Flight Demonstrations and Capabilities Project. Capability challenges support ARMD Technical Challenges by developing needed flight research capabilities and improving operational efficiency or reducing costs.	FY27

Program	Project	TC Name	TC Statement	FY Complete
IASP	FDC	Mobility Operations Facility (MOF)	Develop, assemble, and demonstrate a Mobile Operations Facility (MOF) to support LBFD Phase III Community Response Testing deployments. The MOF will provide systems and space to support mission control and coordination functions at deployment locations. These functions will include: aircraft and ground team communication systems; situational awareness of aircraft location, speed, and altitude; and climate controlled workspace for the mission control team. The MOF will also provide space for storage and transport of ground based measurement systems required to acquire quantitative data on sonic boom strength and characteristics. The MOF will be contained in one or more van type semi-trailers as necessary to provide the necessary space for systems, storage, and operational areas.	FY24
IASP	FDC	LBFD Phase 2 Shock Measurements	Develop and demonstrate LBFD Mission Phase 2 capabilities to safely measure in-flight 1) near-field shock signature of the LBFD aircraft and 2) far-field shock signature above the atmospheric boundary layer. These measurements support LBFD Mission Phase 2 acoustic signature validation of the X-59 aircraft. The capabilities include - a Shock Sensing Probe to measure the near-field shock signature - airborne Schlieren imaging capability to capture images of the X-59 shock structure - the attendant systems to enable positioning the measurement carrier aircraft relative to X-59 and acquisition of the data - an airborne microphone and carrier aircraft to measure the far-field shock signature above the atmospheric boundary layer.	FY23
TACP	TTT	Modeling Tools	Advances in computational fluid dynamics (CFD) over the last several decades has fundamentally changed the aerospace design process. Advanced simulation capabilities not only enable reductions in ground-based and in-flight testing requirements, but also provide added physical insight, enable superior designs at reduced cost and risk, and open up new frontiers in aerospace vehicle design and performance. The NASA sponsored CFD Vision 2030 Study, while highlighting these accomplishments, brought out several challenges and deficiencies in the computational technology and developed a research roadmap for advancing the state-of-the-art required for enabling NASA missions in aeronautics and space applications. The recommended “swim-lanes” that require focused research efforts include: *High Performance Computing *Physical Modeling (transition and turbulence) *Numerical Algorithms *Geometry and Grids *Knowledge Extraction RCA has conducted research in some of these research areas under its TC TACP01 that expired May 31, 2018. Based on this research, it has become clear that unsteady flow simulation capability is needed for expanding the role of CFD across the entire flight envelope to enable design of future advanced aircraft and space vehicles. The new technical challenge TACP06 is aimed at further research in maturing eddy-resolving modeling tools, in their accuracy and efficiency, and demonstrating the tools for application to the prediction of aircraft maximum lift (CLmax). The goal is achieve CLmax prediction accuracy of the same level as in aircraft certification flight tests. This will require comparison of various modeling approaches against experimental results from the planned wind tunnel tests, downselecting an approach, further maturing the technology and validating against flight test data.	FY25
TACP	TTT	Multidisciplinary Design Analysis and Optimization (MDAO)	Develop advanced design and optimization tools for coupled multi-disciplinary analysis with a range of fidelities to shorten the design cycle of revolutionary new vehicles. Use X-Plane ground and flight test data to validate the implementation of critical physics required to model new concept aircraft.” Work under this TC transitions the NASA MDAO tool set from conventional “tube-and-wing” to enable design, analysis, and optimization of revolutionary N+3 aircraft from preliminary through detailed design stages. Accomplishing these goals and objectives requires research to fill gaps in the current models, development of frameworks that are capable of new execution techniques and model interactions, and validation of the new models and methods against real world test cases. High performance computing (HPC) will also play a role to enable computationally intensive operations required for high-fidelity coupled discipline optimizations. The end products of this TC will be several new tools that provide variable fidelity operations for low, medium, and high order operations. To the degree possible, where outputs from one tool must transition to a new format for input to another tool, the transition will be automated either through the tools themselves, or with supporting translation scripts. In parallel to the main body of work targeted for Thrusts 2, 3, and 4, other work is also being done within MDAO to support exploration of possible follow on Tech Challenges, such as that targeting Thrust 1 to translate concept aircraft into models that can support NAS-wide or human-in-the-loop simulation studies.	FY22

Program	Project	TC Name	TC Statement	FY Complete
TACP	TTT	Combustion Modeling	Predict the sensitivity of lean blowout and soot emissions to changes in fuel composition occurring with the use of alternative fuels (or blends) where the relative difference in fuel sensitivity between simulations and experiments is less than 20% The long term vision is to develop physics-based combustion models for the prediction of aircraft combustor operability, dynamics and emissions over a wide range of potential fuels, operating conditions and combustor designs. Combustion modeling is inherently multi-disciplinary and requires modeling of spray atomization and evaporation, chemical kinetics, soot formation and evolution, radiation heat transfer and the interaction of turbulence with all of these complex physical processes. It is important to note that significant levels of turbulence are desired and important to combustor designs to promote rapid mixing of fuel and air and to provide flame stability; thus, the interaction of turbulence with chemistry, spray, soot and radiation is important. This Combustion Modeling TC addresses one operability process (lean blowout) and one emission component (soot), with the additional challenge of predicting the sensitivity of lean blowout (LBO) and soot emissions to changes in fuel composition (which can change the combustion chemistry and key physical properties of the fuel). LBO modeling is beyond the current state-of-art and soot mass or size predictions are often more than an order of magnitude in error. Fuel sensitive models address goals of the National Jet Fuels Combustion Program, as well NASA and Federal goals for improving the scientific understanding of how sustainable alternative jet fuel composition impacts gas turbine combustion emissions and operability. Models developed under this TC will likely also improve the modeling of NOx and CO emissions, combustion dynamics and ignition processes. Also, the prediction of aircraft particulate emissions (volatile and non-volatile) requires accurate prediction of soot formed in the combustor.	FY23

[4] List of ULI Awards

University Leadership Initiative Awards

(As of Mar 10, 2023)

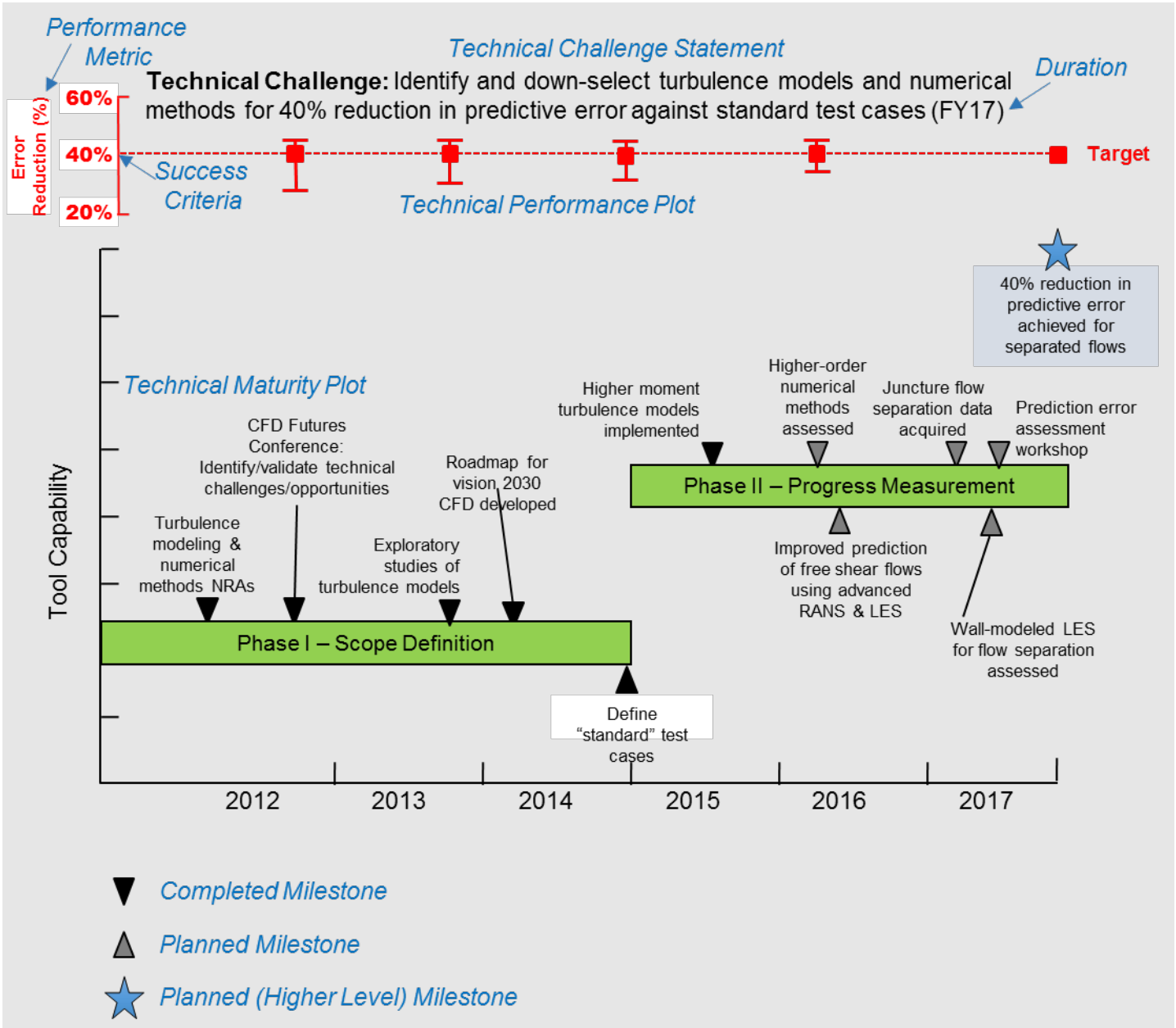
Program	Project	ULI Title	Summary	FY Complete
TACP	UI	Hyper-Spectral Communications, Networking & ATM as Foundation for Safe and Efficient Future Flight: Transcending Aviation	Communication capabilities for improving link/network capacity, reliability, security in support of new Air Traffic Management applications (Thrust 1)	FY21 (Work Completed)
TACP	UI	Adaptive Aerostructures for Revolutionary Civil Supersonic Transportation	Small real-time geometric outer mold line reconfigurations to minimize boom signatures and drag in response to changing ambient conditions (Thrust 2)	FY23 (Work Completed)
TACP	UI	Advanced Aerodynamic Design Center for Ultra-Efficient Commercial Vehicles	Develop slotted, natural laminar flow airfoil to reduce wing profile drag (Thrust 3)	FY23 (Work Completed)
TACP	UI	Electric Propulsion: Challenges and Opportunities	Advance electric power systems, battery and energy storage, thermal management supporting electric propulsion aircraft (Thrust 3, Transition to Alternative Propulsion and Energy)	FY23
TACP	UI	Information Fusion for Real-Time National Air Transportation System Prognostics under Uncertainty	System-wide, real-time prognostics framework with rigorous V&V for proactive health management of NextGen National Airspace System (Thrust 5)	FY23
TACP	UI	Development of an Additive Manufacturing Ecosystem for Qualification of Additive Manufacturing Processes and Materials in Aviation	Developing a scientifically sound basis for qualifying parts from additive manufacturing, as well as demonstrate facilities for the efficient large-scale production of these parts (Advanced Aviation Manufacturing)	FY23
TACP	UI	Effective Human-Robot Teaming to Advance Aviation Manufacturing	Explore new ways in which humans can use robotics to improve the efficiency and flexibility of aviation-related manufacturing processes in a manner that enhances the safety of human workers (Advanced Aviation Manufacturing)	FY23
TACP	UI	Center for Cryogenic High-Efficiency Electrical Technologies for Aircraft (CHEETA)	Produce several novel superconducting electrical system components that use liquid hydrogen in fuel cells to power an electric aircraft propulsion system (Thrust 3, Transition to Alternative Propulsion and Energy)	FY23

Program	Project	ULI Title	Summary	FY Complete
TACP	UI	Real-time Weather Awareness for Enhanced Safety Assurance in UTM	Prediction of low-level winds and turbulence in both natural and urban environments to improve safety of UAS and UAM operations (Thrust 5)	FY24
TACP	UI	Synthetic Design Synthesis of 'Thermoplastic UD Tape based, Fastener-free assemblies' for Urban Air Mobility vehicles	Develop Thermoplastic Unidirectional Tape based Fastener-free Assemblies without loss of material strength or need for adhesive or mechanical joining (Materials and Structures)	FY24
TACP	UI	Composite Manufacturing Technologies for Aerospace Performance at Automotive Production Rates	Science-based part/process design methodology for TuFF composites meeting aerospace performance at automotive manufacturing rates (Materials and Structures)	FY24
TACP	UI	Safe Aviation Autonomy with Learning-enabled Components in the Loop: from Formal Assurances to Trusted Recovery Methods	Design fault detection, isolation, and recovery methods for the machine learning components and develop framework for assuring machine learning components for UAS/UAM (Thrust 6)	FY24
TACP	UI	Secure and Safe Assured Autonomy	For UAS/UAM develop and integrate coordination and control algorithms, secure algorithms, and V&V procedures to support certification of these technologies (Thrust 6)	FY24
TACP	UI	Rapid Development of Urban Air Mobility Vehicle Concepts through Full-Configuration Multidisciplinary Design, Analysis, and Optimization	Create computational tools that would enable U.S. industry to rapidly develop electric vertical takeoff and landing vehicles that would fly as part of an Advanced Air Mobility environment (Thrust 4)	FY24
TACP	UI	Emission & Absorption Spectroscopy Sensors for Hypersonic Flight Control	Refine techniques and hardware associated with a particular set of optical and laser sensors that can be used in examining the surfaces of a hypersonic vehicle in a way that can help that aircraft maintain control in flight (Special Topic: Novel In-Flight and Ground Measurement Techniques for Hypersonic Flight)	FY24
TACP	UI	Innovative Manufacturing, Operation, and Certification of Advanced Structures for Civil Vertical Lift Vehicles	Improve accessibility, affordability, and safety by developing simulation tools and operational processes to optimize the cost, safety, and performance of civilian vertical lift air vehicles and transitioning successful research in advanced materials (Thrust 4)	FY24
TACP	UI	Autonomous Aerial Cargo Operations at Scale	Develop a theory and concept of operations that could be used by the Advanced Air Mobility community to help verify if their concept of autonomous cargo operation could work and if it makes economic sense to deploy on a large scale (Thrust 1)	FY25
TACP	UI	Leading Advanced Turbine Research for Hybrid Electric Propulsion Systems	Identify the optimal design of a gas turbine engine that could be used in a future single-aisle, medium- and short-haul aircraft that uses hybrid-electric propulsion (Thrust 3)	FY25
TACP	UI	Lowering Emissions and Environmental Impact from Civil Supersonic Transport	Overcome barriers to reducing the environmental impact of future civil supersonic transport through a tightly integrated program of low-emission combustor technology development, system-level design, and environmental impact assessment (Thrust 2)	FY25
TACP	UI	Robust and Resilient Autonomy for Advanced Air Mobility	Develop a robust and resilient autonomy framework that holistically integrates state-of-the-art technologies in control theory, machine learning, uncertainty quantification, formal verification, and distributed optimization (Thrust 6)	FY25
TACP	UI	Zero-Carbon Engine Core with Supercritical Carbon Dioxide Power Cycle for Onboard Power	For a 737-8 class aircraft, developing propulsion concepts and new components for jet engines using liquid ammonia as the fuel (Thrust 3, Zero Emissions Aviation)	FY27
TACP	UI	IZEA – Integrated Zero-Emission Aviation using a Robust Hybrid Architecture	Establish design requirements for and advance component technologies using a >100-passenger short-range aircraft with a 3000 nm mission profile to meet the zero-emission target (Thrust 3, Zero Emissions Aviation)	FY27
TACP	UI	Mobility-Energy-Coordinated Platform for Infrastructure Planning to Support AAM Aircraft Operations	Develop a mobility-energy-coordinated platform for efficient infrastructure planning. To achieve this goal, the project will (1) collect data from real-world flight tests and battery tests for model validation and calibration, (2) project electric charging demand by modeling flight energy consumption, battery dynamics, and trip requests, (3) assess energy cost, emission, and reliability from an electric grid perspective, and (4) develop a holistic optimization model for AAM portal siting by considering electric-grid readiness assessment. (Thrust 1)	FY26

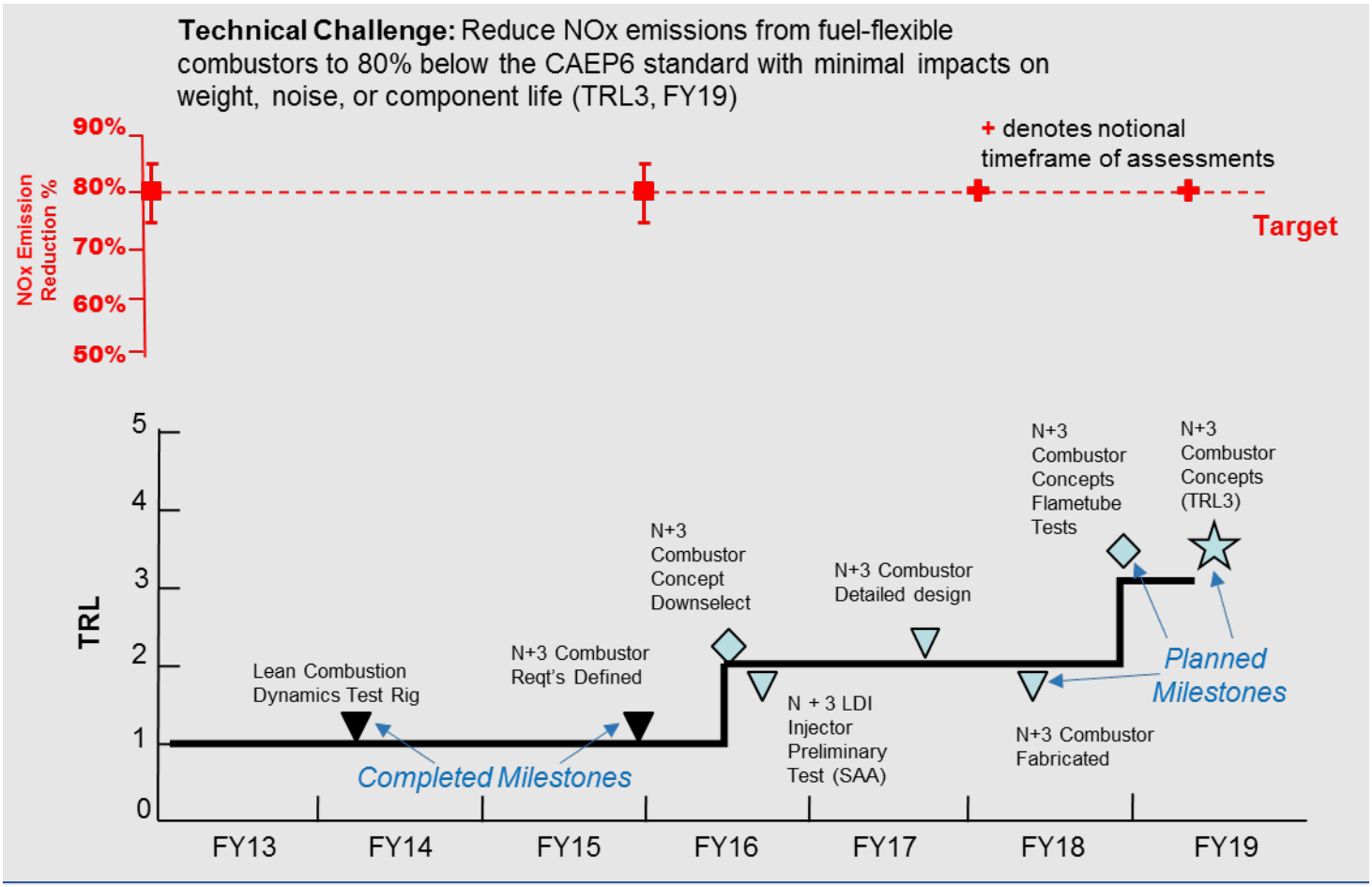
Program	Project	ULI Title	Summary	FY Complete
TACP	UI	Safe, Low-Noise Operation of UAM in Urban Canyons via Integration of Gust Outcomes and Trim Optimization	Develop critical knowledge and prediction methods for addressing a main barrier to the development and adoption of UAM: community noise. The proposed project will enable the development of validated simulation methods to assist with the design of low-noise multirotor vehicles and control strategies for operation in urban settings. Results will also provide guidance on suitable locations for vertiports that minimize the noise produced during take-off and landing. (Thrust 4)	FY26
TACP	UI	A Safety-Aware Ecosystem of Interconnected and Reputable sUAS	Develop a UTM-compatible Safety-Aware Drone Ecosystem (SADE) which supports fully automated authorization decisions for reputation-holding sUAS. This project will develop the infrastructure for deploying SADE in the physical world, provide a highly-scalable simulation environment for end-to-end testing, and a physical “proving ground” designed to independently validate sUAS capabilities without the need for any special equipment beyond that required by the general SADE environment. (Thrust 5)	FY26
TACP	UI	CarbonLess Electric AviatioN (CLEAN)	The project focuses on investigating, designing, and testing several components and subsystems that are required for a zero-emissions commercial passenger aircraft. The team has unique one-of-kind testing capabilities for SOFC technologies under actual flight conditions including pressurized operation with rapid changes in load, inlet temperatures for fuel and air for reproducing the perturbations and changing boundary conditions experienced during a flight. The SOFC technology will be tested directly on ammonia fuel at emulated flight conditions flight ambient conditions vary from -53°C to 30°C temperature and 24kPa to 101kPapressure. (Thrust 3, Zero Emissions Aviation)	FY27

[5] Progress Indicator Examples

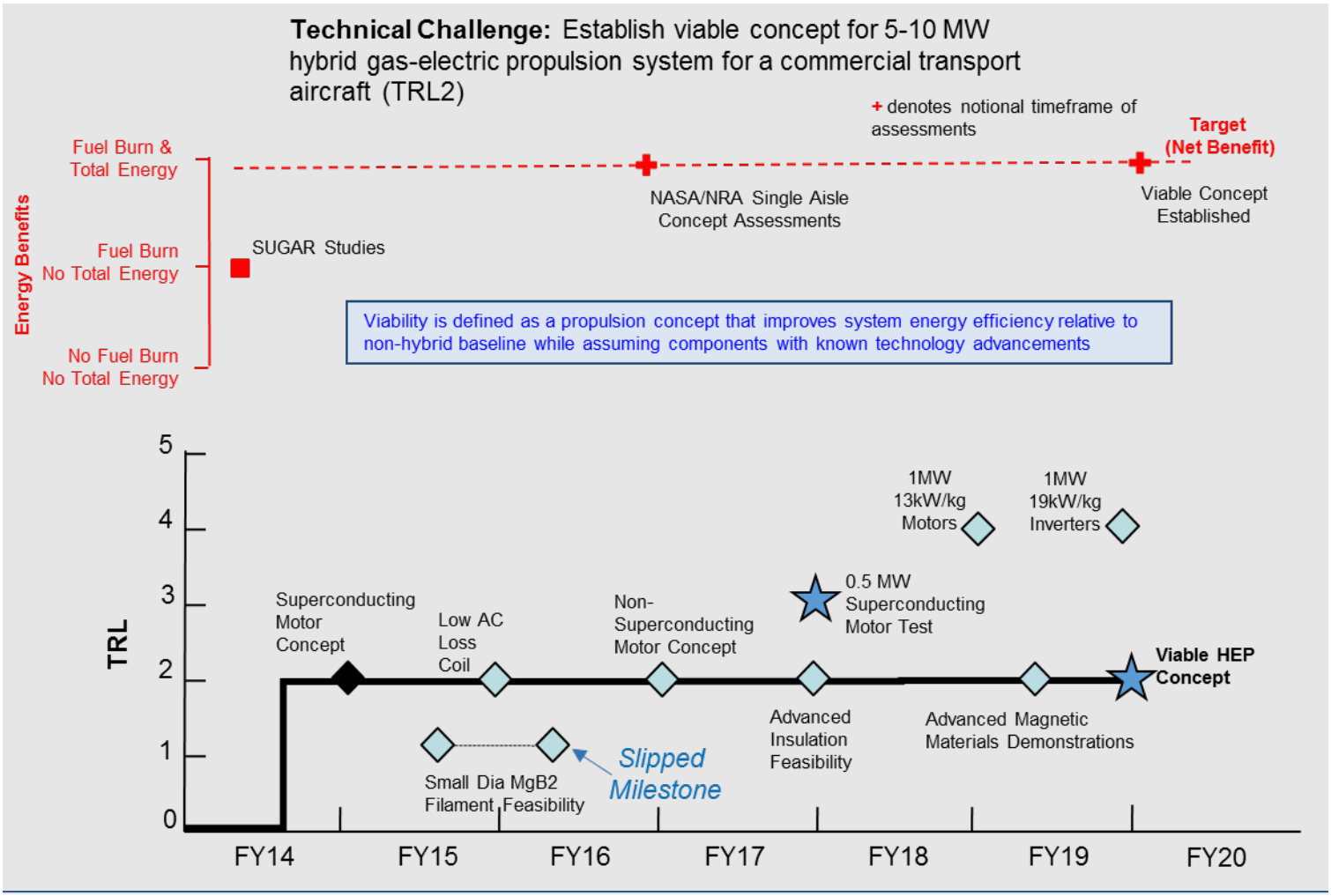
Example 1



Example 2


Technical Challenge: Reduce NOx emissions from fuel-flexible combustors to 80% below the CAEP6 standard with minimal impacts on weight, noise, or component life (TRL3, FY19)
NOx Emission Reduction %
90%
80%
70%
60%
50%
+ denotes notional timeframe of assessments
Target
TRL
5
4
3
2
1
0
Lean Combustion Dynamics Test Rig
N+3 Combustor Reqt's Defined
N+3 Combustor Concept Downselect
N + 3 LDI Injector Preliminary Test (SAA)
N+3 Combustor Detailed design
N+3 Combustor Fabricated
N+3 Combustor Concepts Flametube Tests
N+3 Combustor Concepts (TRL3)
Completed Milestones
Planned Milestones
FY13
FY14
FY15
FY16
FY17
FY18
FY19

Example 3


Technical Challenge: Establish viable concept for 5-10 MW hybrid gas-electric propulsion system for a commercial transport aircraft (TRL2)
+ denotes notional timeframe of assessments
Target (Net Benefit)
Energy Benefits
Fuel Burn & Total Energy
Fuel Burn No Total Energy
No Fuel Burn No Total Energy
NASA/NRA Single Aisle Concept Assessments
Viable Concept Established
SUGAR Studies
Viability is defined as a propulsion concept that improves system energy efficiency relative to non-hybrid baseline while assuming components with known technology advancements
TRL
5
4
3
2
1
0
1MW 13kW/kg Motors
1MW 19kW/kg Inverters
Superconducting Motor Concept
Low AC Loss Coil
Non-Superconducting Motor Concept
0.5 MW Superconducting Motor Test
Viable HEP Concept
Advanced Insulation Feasibility
Advanced Magnetic Materials Demonstrations
Small Dia MgB2 Filament Feasibility
Slipped Milestone
FY14
FY15
FY16
FY17
FY18
FY19
FY20

D.4.8 Summary of Key Information

Expected program budget for new awards	Nominally $1 - 2M per award per year, depending on scope
Anticipated number of new awards pending adequate proposals of merit and funds availability	Nominally two 4-year and two 3-year awards
Maximum duration of awards	3 to 4 years
Applicant's Workshop	Thursday May 11, 2023; 1:00-3:00 p.m. ET
Due date for Step-A proposals	July 6, 2023, 5 pm ET
Due date for Step-B proposals	60 days after request for Step-B proposals issued
Start of Period of Performance	Fall 2024
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.4.6.1 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	5 pages for Step-A; 25 pages for Step-B
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	Cooperative Agreements
Funding opportunity number	NNH23ZEA001N-ULI
NASA technical point of contact concerning this program	Gelsomina (Mina) Cappuccio, <mina.cappuccio@nasa.gov>, (650) 604-1313
NASA Procurement point of contact concerning this program	DeLunzo Bartee, <delunzo.bartee@nasa.gov>, (228) 688-2781
NASA Facility POCs	See Section D.4.4.11
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 ULI section of NSPIRES website, so that all proposers will have access to the same information.