

National Aeronautics and Space Administration

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Next Space Technologies for Exploration Partnerships -2 (NextSTEP-2)

Appendix E: Human Landing System Studies, Risk Reduction, Development, and Demonstration

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**NextSTEP-2 Appendix E: Human Landing System
Studies, Risk Reduction, Development, and Demonstration**

NextSTEP-2 Appendix E: Human Landing System Change Log

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1. Introduction and Background

1.1 Introduction

The President's Space Policy Directive-1 instructs NASA to "Lead an innovative and sustainable program of exploration with commercial and international Partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low-Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations." NASA has identified a variety of exploration, science, and technology demonstration objectives via Strategic Knowledge Gap analyses, NASA Decadal Surveys, and exploration architecture studies that could be addressed by sending instruments, experiments, and humans to the lunar surface.

To address these objectives, NASA will build on the public-private partnership model to create a Human Landing System (HLS) to deliver human crews to the surface of the Moon.

In addition to contributing to the establishment of the HLS, commercial and international partners will be able to leverage new capabilities developed through this initiative for the execution of multiple other missions over the coming decades, including the potential to participate in regularly-recurring hardware and services procurements by NASA.

NASA has performed Lunar architecture studies over the past year to derive a reference architecture for the HLS. This architecture divides the HLS into five Elements:

- Descent Element
- Transfer Vehicle Element
- Refueling Element
- Ascent Element
- Surface Suit Element

The scope of this appendix is limited to three of those Elements: Descent, Transfer Vehicle, and Refueling. The primary objective of this appendix is to enable rapid development and flight demonstrations of these three Elements by first requesting proposals for 6-month Phase A studies with potential partners. The overarching goals of these Phase A studies include:

- Refining the architecture, functional allocation options, and common interfaces required to enable the HLS to provide human landing capability
- Informing overall HLS requirements, as well as requirements for individual Elements and Inter-Element interface
- Understanding and refining Element designs, schedules, and costs
- Identifying key Element technology maturation areas and implement Element technology maturation plans
- Identifying any long-lead procurement items, as well as providing a plan for how proposers would acquire those items, including procurement during the 6-month period of performance of the Phase A effort

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1.2 Background

1.2.1 Applicable Initiatives by NASA Organizations

To enact the direction provided in Presidential Space Policy Directive-1 for returning to the Moon, NASA is implementing a multifaceted and coordinated approach across several organizations as outlined in Table 1 below:

Table 1. NASA’s Lunar Lander Related Activities

NASA Organization	Activity	Initiative
Human Exploration & Operations Mission Directorate (HEOMD)	Advanced Cislunar and Surface Capabilities (ACSC)	Development of HLS
		Lunar Cargo Transportation and Landing by Soft Touchdown (Lunar CATALYST) – partnership with three companies to help them mature their lunar lander designs
Science Mission Directorate (SMD)	Lunar Discovery and Exploration Program (LDEP)	Commercial Lunar Payload Services (CLPS) – procure lunar surface payload delivery services from commercial lander providers
		Payload development for lunar missions (various)
		Mid-sized lander and rover for missions in the mid-2020s
Space Technology Mission Directorate (STMD)	Innovation, maturation, and demonstration of technology through partnerships, contracts, and grants	Development of various HLS component technologies, subsystems, and demonstrations
		Development of various payload technologies for lunar missions

NASA is employing a capability-driven approach to its human spaceflight strategy by developing a suite of evolving capabilities that provide specific functions to solve exploration challenges. These investments in initial capabilities can continuously be leveraged and reused, enabling more complex operations over time and exploration of more distant solar system destinations. While NASA expects to utilize commercial landed services available in the near term for some early robotic missions, NASA also recognizes that it needs to foster the development of expertise and technologies required for reusable, human landers. In addition, NASA understands that investments by the private sector are expected to grow as market opportunities are identified and activities move from science and exploration to resource utilization for both industry and Government.

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Within HEOMD, the ACSC Activity will once again establish U.S. preeminence around and on the Moon. NASA is planning to develop a series of progressively more complex missions to the lunar surface, utilizing commercial participation to enhance U.S. leadership. The ACSC activity is focused on engaging with U.S. Industry Partners and will use innovative approaches to combine robotics, a cislunar presence, and lunar landing capabilities to ultimately return humans to the surface of the Moon. In addition to the HLS initiative, the Lunar CATALYST initiative has focused on leveraging NASA expertise to enable companies to develop commercial lander capabilities, which will inform the development of future cargo and human landers.

Within SMD, the LDEP activity also leverages NASA partnerships with U.S. Industry to rapidly develop new capabilities. The LDEP supports innovative approaches to achieve science and human exploration goals by funding commercial lunar delivery services and the development of science instruments and technology demonstration payloads. The CLPS initiative is the first implementation of that program. Visit the NASA website at www.nasa.gov for further details regarding LDEP and CLPS. Capabilities created as a result of the development and flight demonstration of human lunar landers could also be used by industry to enhance the commercial landers available for CLPS missions beyond 2021. SMD will lead the acquisition of the first mid-sized lander for missions in the mid-2020s.

STMD leads the maturation and demonstration of advanced technologies and capabilities to enable new capabilities that would reduce cost, risk, or complexity of priority NASA space mission objectives. STMD's portfolio of technology advancements relative to this solicitation include lunar lander components and technologies for pointing, navigation and tracking, fuel storage and transfer, autonomy and mobility, communications, propulsion, and power. STMD initiatives include competitively selected public-private partnerships to accelerate the demonstration and commercial infusion of new space capabilities. STMD also offers conventional contracts and grants to advance relevant technologies.

1.2.2 Human Landing System Reference Architecture

The reference architecture for the HLS employs a phased development approach starting with multiple flight demonstration missions. The first crewed human lunar landing is targeted for the third mission (see Attachment A for the reference architecture in the context of an overview of the three anticipated missions).

NASA is planning for the launch of the first HLS Element demonstration mission in 2024. The minimum objective of this mission is to demonstrate a lunar surface landing from the Gateway with a Descent Element capable of supporting a future human lander that includes both a Descent Element and an Ascent Element (for additional information on Gateway, please see the update presented to the NASA Advisory Council on December 7, 2018 at: <https://www.nasa.gov/sites/default/files/atoms/files/20181206-crusan-gateway-reduced-v4.pdf>). The design, development, test, and evaluation (DDT&E) of the Descent Element for the lander is expected to be led by a commercial partner. The requirements and operations concept for the overall HLS, as well as the top-level Element requirements are expected to be managed by NASA.

NASA plans to launch the second demonstration mission in 2026. The objectives of this mission are to demonstrate:

- Docking or berthing of the Ascent Element to the Gateway to support transfer of crew from Orion in a future mission
- Aggregation of Descent, Ascent, and Transfer Vehicle Elements at Gateway
- Transfer of the aggregated Elements to Low Lunar Orbit (LLO)

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- Lunar surface landing of the aggregated Descent and Ascent Elements
- Return of the Ascent Element to Gateway, including docking or berthing
- Return of the Transfer Vehicle to Gateway

NASA plans to launch the third demonstration mission in 2028. The objectives of this mission include those of the 2026 mission, as well as demonstrating:

- Refueling and Reusability of the 2026 Transfer Vehicle and Ascent Elements
- Transfer of Crew to and from the Ascent Element at Gateway
- Lunar surface extra-vehicular activity (EVA)

1.3 Human Landing System Acquisition Strategy

1.3.1 Acquisition Strategy Overview

For this appendix, offerors may submit proposals for a Phase A study and risk reduction effort focused on the following HLS Elements: Descent, Transfer Vehicle, and Refueling. Offerors may submit proposals for one or more Elements, with a separate proposal submitted for each Element being proposed. Offerors may only submit one proposal per Element. Note that proposals not aligned with the Elements of the HLS as described above, while potentially valuable to NASA, are outside the scope of this BAA. Phase A offerors are expected to have the ability to develop proposed Elements in subsequent phases. Designs for Elements used in earlier missions are expected to be robust enough to be used for later missions with only minor modifications. NASA intends to make multiple awards, with anticipated individual award values ranging from \$300K - \$9M, depending on milestones to be defined (additional details on award values are provided in section 4.1 Instructions for Proposals).

While proposals for Descent, Transfer Vehicle, and Refueling Elements will be reviewed in response to this BAA, Descent Element proposals are expected to receive a majority of overall funding since the Descent Element is planned to be the the first HLS Element to proceed to flight demonstration. NASA may release one or more additional BAA appendices in the future for subsequent Study Phases focused on further refining Ascent Element and Surface Suit Elements and to better inform procurement strategies for those Elements.

Below, Figure 1 is a notional timeline for acquisition of all HLS Elements.

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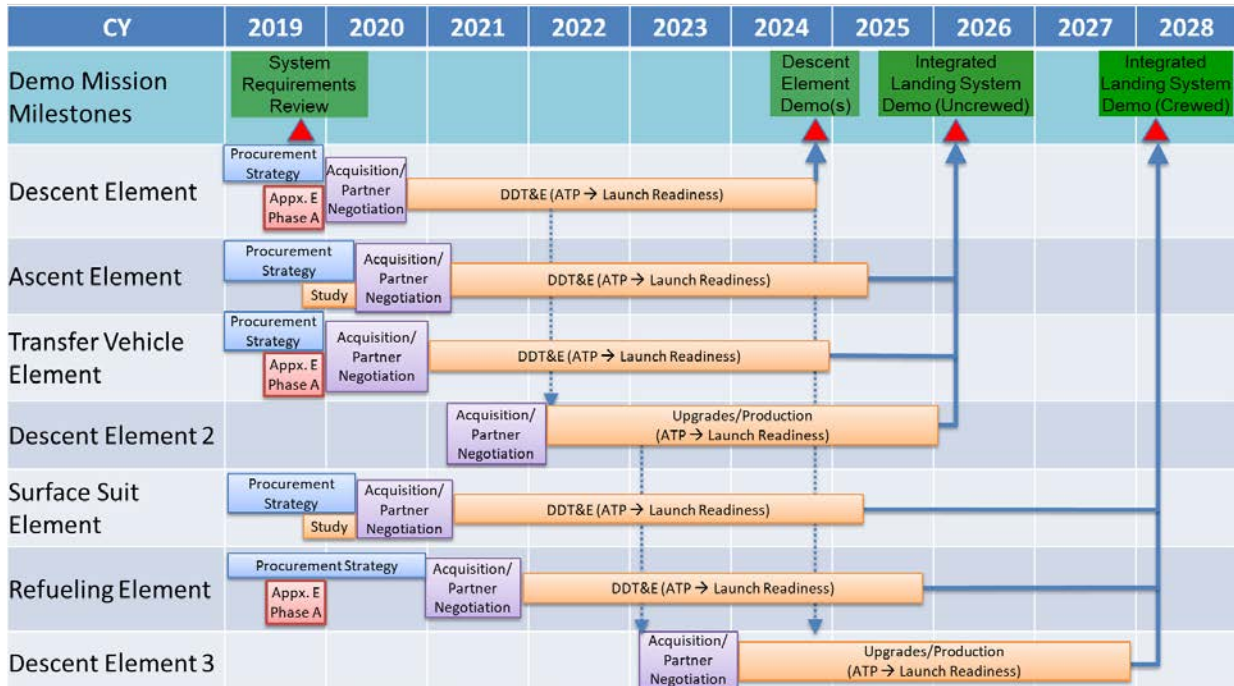


Figure 1: Notional HLS Acquisition Timeline

1.3.2 Descent Element Phase B

Following the Phase A study and risk reduction period, NASA currently intends to make zero, one, or two awards for the Design Development Test and Evaluation (DDT&E) and planned 2024 flight demonstrations of Descent Elements from among the Phase A participants. Each award is expected to be valued at multiple hundreds of millions of dollars. Potential Offerors that are interested in performing DDT&E and flight demonstration of their Descent Elements under contract at Phase B are strongly encouraged to and should propose Phase A Studies requested under this appendix. Following Descent Element Phase A award, NASA intends to publicize additional Phase B information, including applicable evaluation criteria. NASA reserves the right to revisit and modify its Descent Element DDT&E acquisition/partnership strategy at any time and will notify industry if and when it does so.

Note that all phases of Descent Element work subsequent to the Phase A studies, including work related to the planned 2026 and 2028 missions, may be awarded exclusively to one or more Offerors from among Descent Element Phase A awardees. NASA may also select awardees for each subsequent phase of Descent Element work from among the previous phase’s awardee(s). Therefore, Offerors who are interested in potentially performing later phases of Descent Element work, including production, are strongly encouraged to submit a proposal responsive to this solicitation for Descent Element Phase A studies. Alternatively, Descent Elements for 2026 or 2028 could also potentially be procured under a separate production contract or contracts. NASA reserves the right to revisit and modify its future Descent Element acquisition/partnership strategy at any time and will notify industry if and when it does so.

Note that NASA intends to initiate separate procurements or partnerships for DDT&E for all other Elements, including Transfer Vehicle and Refueling.

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1.3.3 Developing Commercial Capabilities

An important objective of this appendix is to stimulate the commercial space Industry through public-private partnerships. NASA uses the NextSTEP BAA to establish public-private partnerships where NASA shares development cost and risk with industry, while industry builds a viable commercial capability. A key component of the NextSTEP Partnership model is to provide an opportunity for NASA and Industry to collaborate in developing capabilities that meet NASA's space exploration objectives while also supporting industry's commercialization plans. The NextSTEP-2 BAA contract vehicle requires corporate resource contributions for research-and-development-type activities, including maturing unique technologies.

2. Funding Opportunity Description

2.1 Description of Solicitation Topic

This appendix seeks firm fixed-price, milestone-based proposal(s) to:

- Refining the architecture, functional allocation options, and common interfaces required to enable the HLS to provide human landing capability
- Informing overall HLS requirements, as well as requirements for individual Elements and Inter-Element interface
- Understanding and refining Element designs, schedules, and costs
- Identifying key Element technology maturation areas and implement Element technology maturation plans
- Identifying any long-lead procurement items, as well as providing a plan for how proposers would acquire those items, including procurement during the 6-month period of performance of the Phase A effort

NASA intends to award Phase A study and risk reduction contracts at a value not to exceed \$9M each. Offerors shall describe capabilities they can provide to meet the proposed Element needs.

2.2 General Information:

- **Agency:** National Aeronautics and Space Administration
- **Announcement Title:** NextSTEP-2 BAA, Appendix E: Human Landing System
- **Omnibus BAA:** NextSTEP-2, BAA NNH16ZCQ001K
- **Responsible Office:**
 - Advanced Exploration Systems Division
Human Exploration and Operations Mission Directorate
NASA Headquarters
Washington, DC 20546
- **Selection Official:**
 - Mr. Marshall Smith
Human Exploration and Operations Mission Directorate
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- **Industry Forum:** A NextSTEP-2 Partnership virtual forum will be held for this appendix that will provide Offerors with an opportunity to listen to a NASA HLS briefing and ask questions about this particular solicitation. The tentative date for the forum is **February 14, 2019**. The meeting agenda and related information will be posted on:
<https://www.nasa.gov/nextstep/humanlander>.
- **Requirements for Submissions to NASA.** All submissions to NASA that pertain to this appendix, including notices of intent, inquiries, and proposals, shall be received at the Point of Contact email address specified above and by the time and date(s) specified below for each type of submission. All submissions shall contain the following general information: name, address, telephone number, e-mail address, and institutional affiliation of the Offeror including full company name if applicable, as well as “BAA NNH19ZCQ001K_APP-E.” All submissions shall have “NextSTEP-2, Appendix E: Human Landing System” in the subject field along with other identifying information (e.g., “Notice of Intent”) as appropriate. Submissions that do not follow these and other terms specified in this appendix may, at NASA’s sole discretion, be disregarded.
- **Notice of Intent: Due February 21, 2019, 5:00 pm Eastern Time.** To assist in the planning of the proposal evaluation process, NASA strongly encourages the submission by email of a Notice of Intent (NOI) to propose by all prospective Offerors. The NOI shall identify which Element(s) and which Contract Line Item Numbers (CLINs) Offerors plan to submit proposals for (please see Section 4.1 for additional details on CLINs). **Please note that NOIs are strongly encouraged, but are not required. Not submitting an NOI will not affect the selection process.**
- **Inquiries: Due February 21, 2019, 5:00 pm Eastern Time.** Offerors may submit inquiries in response to this appendix. Inquiries shall not contain proprietary information nor require proprietary information in the response. NASA responses will not contain evaluations, opinions, or recommendations regarding any suggested approaches or concepts.
- **Proposals: Due March 25, 2019, 5:00 pm Eastern Time.** Offerors may submit proposals for a Phase A study and risk reduction effort for any or all of the following HLS Elements: Descent, Transfer Vehicle, and/or Refueling. Offerors may submit proposals for one or more Elements, with a separate proposal submitted for each Element being proposed. Offerors may only submit one proposal per Element.
- **Website for Reference Information:** <https://www.nasa.gov/nextstep/humanlander>

3. Eligibility Information

3.1 Eligibility of Applicants

This solicitation topic is open to non-Government U.S. institutions (companies, universities, nonprofit organizations). Foreign institutions, NASA civil servants, Jet Propulsion Laboratory (JPL) employees, national laboratories, and Federally Funded Research and development Centers (FFRDCs) shall not be proposed as a Prime Contractor on any effort associated with this announcement, but may participate as a team member. Offerors are advised that performance of Descent Element Phase B of this appendix will be subject to the eligibility and domestic sourcing requirements of both the Commercial Space Act of 1998 and the National Space Transportation Policy. Proposals including foreign organizations must comply with Section 3.2, Guidelines for International Participation, of the omnibus portion of this BAA. Other eligibility information is also included in the omnibus portion of this BAA.

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3.2 Corporate Resources

Offerors are required to show a minimum of 20% Corporate Resource Contribution of the total system/component development cost that is directly relevant to the proposed effort. Small Businesses must be able to show a 10% Corporate Resource Contribution. The definition of a Small Business, as defined by Small Business Innovation Research (SBIR) program small business eligibility, is posted here: <http://sbir.nasa.gov/content/nasa-sbirsttr-program-definitions>). Fifty-percent (50%) of the Corporate Contribution must be invested coincident with the period of performance of this effort for all Offerors, regardless of business size. Offerors shall describe how they intend to meet this eligibility requirement in Section II of their proposal. An attachment to the proposal shall provide documentation proof of corporate contribution (please see Attachment D to this BAA). No more than 50% of the required corporate contribution may be from foreign Partners.

Corporate Contribution may be in the form of direct labor, consumables or other in-kind contributions. Also, other reasonable forms of corporate contribution including travel directly related to achieving proposed objectives during the period of performance, investments in special facilities or equipment, tooling or other prior private investment, and internally funded technology maturation such as Independent Research and Development (IRAD) are deemed acceptable for this effort. For this appendix, state and local Government contributions may be included with private corporate resources.

The value of participation by federally funded participants funded by NASA as well as the use of federal Government facilities or NASA civil servants shall be added to the price to the Government for determining whether the required corporate contribution has been met.

Criteria and procedures for the allowability and allocability of cash and non-cash contributions shall be governed by Federal Acquisition Regulation (FAR) Parts 30 and 31, and NASA FAR Supplement (NFS) Parts 1830 and 1831. NASA reserves the right to hold due diligence discussions to make reasonable determinations regarding corporate contributions.

4. Proposal Submission Information

4.1 Instructions for Proposals

See omnibus NextSTEP BAA for general instructions. Where instructions are different, the specific instructions in this section are in addition to or supersede the general instructions in the omnibus BAA or in the NASA Guidebook for Proposers. Proposals must state the applicable HLS Element (Descent, Transfer Vehicle, or Refueling). Offerors may submit proposals for multiple Elements, with a separate proposal submitted for each Element being proposed.

Proposals shall structure the SOW tasks, associated activities, and deliverables into severable CLINs and sub-CLINs integrated with the priced milestones such that the Government can quickly negotiate and activate CLINs based on programmatic priorities and funding availability. Inclusion of “No Later Than” Start dates for each CLIN will facilitate Government decisions. Specific CLINs are:

- Base Study CLIN: All proposals are expected to include a Base Study CLIN. The Base Study CLIN includes all Phase A scope with the exception of scope included under Long-Lead and Prototype CLINs described below. NASA anticipates Base Study CLIN individual awards to be less than \$1M and not to exceed \$1.5M.

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- Long-Lead CLIN: If the contractor’s proposal includes procurement of long-lead items, the contractor shall include a separately priced CLIN for procuring these long-lead items. If there are multiple long-lead items, the contractor shall provide a sub-CLIN for each item.
- Prototype CLIN: If risk reduction prototype development and testing is proposed, offerors shall separate by CLIN each proposed prototype. Offerors shall include an option for a priced sub-CLIN to provide potential support for shipping of selected prototypes to a NASA center (see 4.3.2 Government Testing).

The total price of the sum of all proposed CLINs shall not exceed \$9M. Phase A activities shall not exceed 6 months from authorization to proceed (ATP). NASA reserves the right to grant a no-cost extension.

Payment milestones should be tied to significant program achievements, and not more frequently than monthly. Payment milestones must reference technical milestones accomplished for that payment. Offerors may use NASA NPR 7123 as reference/lessons learned on design review content. Offerors may propose optional fixed-price performance-based milestones that provide additional system maturation or risk reduction.

4.2 Proposal Format and Contents

The proposal format and content requirements as outlined in this section below are the same for all proposal volumes unless specifically noted otherwise. The required sections of the proposal must be submitted as one searchable, unlocked Portable Document File (PDF) with edit permission enabled. Applicants must comply with the format and page limit requirements described in the omnibus BAA, as well as any additional requirements specified in this appendix.

There is no file-size limit for proposals (This is an exception to Section 3.23 of the NASA Guidebook for Proposers). Offerors shall only include attachments as part of their proposals as specifically requested in this appendix. Descriptions of work breakdown structure and a description of the major tasks, activities and resources necessary to complete those tasks, and products linked to the milestone achievements may properly be addressed in detail in the Statement of Work (SOW) attachment, which is not page limited.

<u>Proposal Section</u>	<u>Page Limitations</u>
Title Page	1
Executive Summary (Section I)	3
Proof of Eligibility (Section II)	3
Technical Proposal (Section III)	23
Business Proposal (Section IV)	7
Price Proposal (Section V)	No limit
Attachments (see section 4.2.7 Attachments to Proposals):	No limit

A page is defined as one side of a sheet, 8 1/2" x 11" with at least one-inch margins on all sides, using not smaller than 12-point font, with the exception of tables and figures, which may use 8-point font. Pages in excess of the page limits for each section will not be evaluated.

Proposals received by the Government after the published date and time for receipt will not be accepted.

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4.2.1 Title Page:

- Include any Notice of Restriction on Use and Disclosure of Proposal Information.
- An optional graphic image may be included.
- The Proposer's name of the proposal or proposed project
- Date of the proposal
- The title, solicitation number and Appendix being responded to of this Announcement
- Organization name and address.
- Proposer Point of Contact name, title, e-mail address, and phone number.

4.2.2 Executive Summary:

- Describe the proposal's prominent and distinguishing features.
- The Executive Summary should provide an overview of the proposed effort that is suitable for release through a publicly accessible archive should the proposal be selected.

4.2.3 Proof of Eligibility:

- Provide information showing that the offeror and all team members are eligible participants as stipulated in Section 3 of the omnibus BAA and this appendix.
- Describe compliance with participation requirements as needed. Explain how the required corporate contribution resources will be satisfied by submitting Attachment D – Corporate Contribution Worksheet. Supporting details may be included as an Attachment (please see Section 4.2.7)

4.2.4 Technical Proposal:

4.2.4.1 Capability Concept:

The Offeror shall describe their proposed Element concept. Include how the objectives and requirements in this appendix are met. Include an assessment of the concept's maturity (Technology Readiness Level (TRL)) and technical challenges for development. Include launch vehicle assumptions. Proposers should describe how the proposed Element is able to support the overall HLS.

Additional evaluation merit will be accorded for Element reusability, recyclability, and extensibility. The concept of reusability is one of the principal means from which return on investment is obtained, strengthening the business case for commercial application of lunar lander technology. Reusability may be realized at the Element level by refueling, for example. Recyclability may be realized by using the empty tank of the Descent Element for other purposes such as habitats or for storing in-situ resource utilization (ISRU) products, for example. Extensibility is a system design principle where the implementation takes into consideration future growth. It is a systemic measure of the ability to extend a system and the level of effort required to implement the extension. Extensions can be through the addition of new functionality or through modification of existing functionality. The central theme is to provide for change while minimizing impact to existing system functions. The design of an avionics suite to readily support software changes from one lander to the next, more capable lander is an example. NASA will work with partners to develop a strategy that will enable efficient transitioning of reusable and extensible aspects of the architecture.

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Key preliminary minimum and goal Element performance requirements are outlined below, in the Tables 2-4. Note that these performance requirements are not inclusive of the full requirements set, but they do represent key functions expected to impact HLS design and should be addressed in offerors' technical proposals. Additionally, the performance requirements shown below are preliminary and may be modified in the future based on feedback received via this study and risk reduction effort or other factors.

Table 2. Descent Element Preliminary Requirements

Descent Element Requirement	Preliminary Minimum	Preliminary Goal
Design stability	Minimal changes needed from 2024 design to support 2026, 2028 missions	Not applicable (N/A)
Payload mass to lunar surface	At least 9 metric tons (mT) from LLO (100km) to support 2026 and 2028 missions. Note: For the 2024 demonstration mission, since there will not be a Transfer Vehicle, the Descent Element will be responsible for all propulsion after trans-lunar injection so actual delivered payload mass will be less.	12 mT or greater.
Reusability (Full reusability: ability to be refueled and reused on a subsequent mission)	N/A	Evolvable to be refuelable to support eventual full reusability
Schedule	Credible launch readiness in 2024	Credible launch readiness in 2023
Launch Vehicle considerations	Design to fit within 6.3m dynamic envelope diameter Wet mass at launch less than 16mT	Design to fit within 4.6m dynamic envelope diameter Wet mass at launch less than 15mT
Landing zone	Global access	N/A
Landing precision	100m	50m
Propulsion system effective deep throttling (accomplished with single or multiple engines)	4:1	6:1

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Table 3. Transfer Vehicle Element Preliminary Requirements

Transfer Vehicle Element Requirements	Preliminary Minimum	Preliminary Goal
Reusability (Full reusability: ability to be refueled and reused on a subsequent mission)	Evolvable to being fully reusable	Fully reusable
Number of reuses	N/A	10 uses
Mass transferred from Near Rectilinear Halo Orbit (NRHO) to 100km LLO (assuming ability to return to NRHO after transfer)	25mT	>25mT
Schedule	Credible launch readiness in 2026	Credible launch readiness in 2025
Launch Vehicle considerations	Design to fit within 6.3m dynamic envelope diameter Wet mass at launch less than 16mT	Design to fit within 4.6m dynamic envelope diameter Wet mass at launch less than 15mT
Propellant	Cryogenic or storable	Cryogenic

Table 4. Refueling Element Preliminary Requirements

Refueling Element Requirements	Preliminary Minimum	Preliminary Goal
Refueling capacity at NRHO	10 mT propellant	>10mT propellant
Propellant types	Cryogenic or storable	Cryogenic
Reusability	None	Some
Schedule	Credible launch readiness in 2028	Credible launch readiness in 2026 or earlier
Launch Vehicle considerations	Design to fit within 6.3m dynamic envelope diameter Wet mass at launch less than 16mT	Design to fit within 4.6m dynamic envelope diameter Wet mass at launch less than 15mT

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4.2.4.2 Technical Approach:

Offerors shall describe the approach and schedule for designing, analyzing, and testing the proposed Element(s) for the HLS. At a minimum, the following items should be addressed:

- Overview of enveloping engineering approach
- Overview of end-to-end Element development schedule(s)
- A plan for requirements flowdown
- A brief summary of past relevant activities/tests

- After selection and no later than one week after ATP, NASA intends to provide successful offerors with preliminary versions of the HLS Concept of Operations, HLS requirements, and Element requirement documents for review and comment. Offerors are to include milestone(s) for providing comments to NASA.

- Describe plan for supporting NASA-led common interface working groups and a review of design concepts against relevant standards (more detail in Section 4.3.4). Include identification of necessary interface standards required prior to DDT&E of proposed Elements.
- A plan for NASA-contributed expertise and test facilities to augment the proposed technology development activities during the 6-month Phase A effort. NASA may provide facilities, functions, equipment, subject matter expertise, and technologies as requested by and negotiated with, the Offeror. Supporting details may be included as an Attachment to the proposal (please see Sections 4.2.7 and 4.3.3 for additional details).
- A plan for design maturation including current TRLs, and any associated intellectual property-patents and/or data rights associated therewith, of key systems and subsystems, technology development and evaluation. This may include Phase A risk reduction prototype development and testing. Prototypes to reduce Element external interface risks are a focus area. A limited number of the awarded prototype development units may be requested for Government testing to validate or capture lessons learned in form, fit, and functionality of the prototypes and interfaces. All offerors proposing prototypes should include the option for this additional NASA on-site testing (see Section 4.3.2 Government Testing for additional detail).
- Identification of any long-lead procurement items, as well as provide a plan for how proposers would acquire those items, including potential procurement during the 6-month period of performance of this Phase A effort.

4.2.5 Business Proposal:

4.2.5.1 Partnership Model

The Offeror shall describe how the proposed activity advances the intent of the public-private Partnership concept and meets NASA's strategy to stimulate the U.S. space industry while leveraging those same commercial capabilities through this Partnership and future contracts to deliver mission capabilities by:

- Providing a business overview
- Defining customer/Partnership model
- Describing business case(s) and potential future marketability that may be leveraged by the hardware development

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- Identifying any overlaps between commercial lunar lander system capabilities/technologies and NASA HLS requirements
- Explaining business risks (for example, the development of affordable and commercial cis-lunar and surface capabilities, the establishment of economical and sustainable lunar infrastructure services and the creation of new space markets)

4.2.5.2 Capabilities:

The Offeror shall provide evidence of existing capabilities for designing and developing space-qualified systems applicable to the Elements described in this appendix.

4.2.5.3 Intellectual Property:

The Offeror shall describe the approach for data rights and inventions, and how they meet the objectives outlined under Section 2.7, “Intellectual Property Developed under an Award,” of the omnibus BAA. Attachment E provides as a reference the standard FAR patent and data rights clauses used by NASA in contract awards. Offerors are advised to carefully review these clauses and provide any exceptions, with justification thereto, at the time of proposal submittal.

4.2.6 Price Proposal:

The price proposal shall include the overall firm fixed price for Phase A. The Offeror shall provide total direct labor hours by skill mix, travel, and subcontracts in accordance with the sample format set forth in omnibus Attachment A.

- Offerors are required to provide certified cost or pricing data for proposals exceeding \$2M. The threshold for certified cost or pricing data does not include the amounts Offerors propose for corporate contributions, nor the amounts to be provided as Government furnished equipment/property (GFE/GFP) (i.e., NASA resources). See Section 3 and 4.2.3 (Eligibility).
- Pricing shall be structured by CLINs and sub-CLINs to give the Government the flexibility to select specific CLINs based on programmatic requirements and availability of resources. Refer to section 4.1 Instructions for Proposals for additional details on CLINs.
- Offerors shall provide a list of Government-contributed resources, including GFE/GFP, with the estimated value as required under the proposal instructions in the omnibus BAA, Section 4.1.2.10. Supporting details may be included as an Attachment to the proposal (please see Sections 4.2.7 and 4.3.3 for additional details).
- Offerors shall provide existing rate agreements, if any.
- Offerors shall include the proposal adequacy checklist in accordance with NASA FAR Supplement 1852.215-85.

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4.2.7 Attachments to Proposals:

Proposals shall include the following Offeror-provided attachments:

- **Draft Statement-of-Work:** The Offeror shall provide a draft statement-of-work that addresses those activities to be performed in the 6-month Phase A period of performance. It shall include a work breakdown structure and a description of the major tasks, activities and resources necessary to complete those tasks, and products linked to the milestone achievements. The draft SOW shall also contain proposed technical and payment milestones, including deliverables (please refer to Section 4.3.1 for additional details on expected deliverables). The payment milestones shall include a title, associated objective success criteria/deliverables, payment amount, and planned dates for completion of the milestone.
- **Quad chart:** The proposal shall contain a quad chart in MS PowerPoint format summarizing the proposed objectives, team, and major milestones. A PowerPoint template of the chart is provided as Attachment C of this appendix.
- **Resumes:** Resumes shall be included for key personnel. Resumes should be limited to no more than 2 pages each.
- **Corporate Resources documentation:** This attachment should include documents containing verifiable evidence of the corporate contributions that are being proposed, as well as the completed Corporate Contribution Worksheet (Attachment D).
- **Key Facilities and Equipment:** Facilities critical to proposed risk reduction prototype efforts should be identified and described here.
- **Requested GFP/GFE:** Please see section 4.3.3 for additional details.

4.3 Additional Proposal Guidance

4.3.1 Deliverables

Offerors shall propose the items they will deliver as milestone events. Table 5, below, contains the minimum required deliverables:

Table 5. Deliverables

Deliverable:	Notes:
Updated long-lead items plan	Identify post-Phase-A long lead items remaining, acquisition cost, acquisition plan.
Draft Phase B SOW (only for Descent Element)	Draft Statement of Work for partner from post-Phase-A Element DDT&E ATP through first flight demo. SOW should include milestones and deliverables.
Operational concept and requirements document comments	After selection and no later than one week after Phase A ATP, NASA will provide successful offerors with preliminary versions of the HLS Concept of Operations, HLS requirements, and Element requirement documents for review and comment

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Element development schedule	Refined preliminary development schedule for partner from post-Phase-A Element ATP through first flight demo of each applicable Element
Estimated Element cost	Estimated cost for partner from post-Phase-A Element ATP through first flight demo of each applicable Element
Summary Reports	Report(s) summarizing assessments of designs against applicable standards, feedback on interface and any other Working Groups. See section 4.3.4.
Updated GFP/GFE/NASA Subject Matter Expertise Plan (only for Descent Element)	Updated Plan for NASA-contributed expertise and facilities post-Phase-A Element ATP through first flight demo (only for Descent Element). See sections 4.3.2 and 4.3.3.
Risk reduction prototype as-built and test documentation	If one or more risk reduction prototypes are proposed, provide details to inform requirements.
Updated Element technology maturation plan	Identify remaining key technology maturation areas and create updated technology maturation plan
Element Design Package	An updated Element Design, optionally presented at a Design Review with NASA. Include relevant updates to overall technical approach if applicable.

In addition to the fixed-price performance-based milestones and major deliverables above, offerors shall propose routine deliverables as well as the technical data and engineering briefings, minutes and reports on the development, as follows:

- Conduct a Kickoff Meeting at the start of the contract to discuss the study and risk reduction topics and the proposed plans for conducting the study and risk reduction. The location of the briefing shall occur at the contractor’s facility (with WebEx) unless otherwise agreed to by the Government.
- Quarterly project status/technical briefings in contractor format (past quarters activities, upcoming activities, risks retired, financials, other)
- Quarterly technical reports (NASA will provide a format)
- Monthly progress/status reports (NASA will provide an abbreviated format)
- Bi-weekly coordination telecons with NASA
- Conduct a pre-final Phase A briefing approximately 30 days prior to the end of the period of performance to present results. The location of the briefing shall occur at the Contractor’s facility (with WebEx) unless otherwise agreed to by the Government. For Descent Element awardees, data will be assessed to inform NASA’s decision whether or not to proceed to Phase B and how NASA will do so.

For proposals that include hardware delivered to and/or tested at NASA centers, offerors shall include appropriate Safety and Health plans to address hazardous materials/activities, environmental and

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facilities considerations commensurate with their hardware and in accordance with NASA policy and regulations. Required documentation is dependent upon the hardware, identified hazards, and nature of the tests and facilities being exercised.

4.3.2 Government Testing

NASA may designate a limited number of the proposed prototypes being developed for independent Government testing. This designation does not constitute a downselect decision. The nature of the testing has not been fully decided, but testing is anticipated to occur at the end of or after completion of the contractor's testing in Phase A. The contractor shall include an option for a priced sub-CLIN to provide potential support for shipping of selected modules to a NASA center. Note: For purpose of pricing this option, the Government intends to pay for shipping as part of the resulting awards under this solicitation and the contractor will be responsible for providing a shipping concept, developing associated shipping hardware (special fittings), and preparing and packaging the article for shipping. Alternatively or in addition, NASA may participate in or observe contractor testing of prototypes.

4.3.3 GFP/GFE/NASA Subject Matter Expertise:

Offerors may request access to Government facilities or Government services in their proposals. Such resources will be made available to all requesting offerors on a non-exclusive basis, subject to the availability of those resources. It is the responsibility of Offerors to determine the availability of any Government facilities or Government services. For any tasks that include Government-funded participants, Government facilities, or GFP/GFE, include a SOW or description of tasks and a related cost estimate for those Government resources and any associated letters of commitment and associated points of contact. Attachment B contains a list of the Center points-of-contact for each NASA Center should an offeror choose to inquire about relevant facilities or expertise. Requested Government-contributed resources should involve only those NASA facilities, services, or other in-kind contributions that are unique or not reasonably available commercially.

4.3.4 Standards Review and Interface Working Group:

The Phase A awardees shall support interface working groups led by NASA. These working groups will also discuss prototype ground testing. The working groups will be made up of Government and industry team members working together. The working group activity, along with the other activities of the awarded contractors, will inform the requirements and architecture refinements for meeting NASA's requirements for the HLS.

Awardees shall provide feedback on how their design concepts align with international space standards as part of this effort. Current standards can be found at www.internationaldeepspacestandards.com and include standards on Avionics, Communication, Environmental Control and Life Support Systems, Power, Rendezvous, Robotics, and Thermal..

Assume HLS-specific interface working groups are two hours long and occur once per week.

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4.3.5 Access to Research Results/Data Management Plan.

Offerors are not required to provide a Data Management Plan with proposals for this appendix.

4.3.6 Summary of Phase A Proposal and Deliverables Expectations

Table 6 provides a high-level summary of key expected proposal content and Phase A deliverables separated by objectives. Note that the table is not comprehensive but is intended to provide summary context.

Table 6. Summary of expected Phase A proposal and deliverables

BAA Phase A Objective	Expected in Proposal	Expected Phase A Deliverable(s)
Inform requirements, concept of operations, architecture	SOW Milestone(s) to provide comments	Comments
Inform interfaces	Approach to standards review, support of interface working groups	Report(s)
Mature designs	Capability concept	Updated design package
Technology maturation	Technology maturation plan, including proposed prototypes	1) Prototype documentation 2) Updated technology maturation plan for post-Study phase
Element Development Schedule thru flight	Rough schedule with assumptions	Refined preliminary schedule
Study SOW (includes schedule)	Phase A SOW w/milestones	N/A (deliverables per SOW)
Element SOW thru flight	N/A	Draft SOW (expected only for Descent Element)
Element cost thru flight	N/A	Estimated Element cost with assumptions
Mature program technical approach	Element technical approach	Updated design package
Long-lead items	Long-lead plan, including proposed Phase A procurements	Updated long-lead items plan
NASA GFP/GFE/Subject Matter Expertise Plan	Phase A NASA GFP/GFE/Subject Matter Expertise Plan	Updated GFE plan (expected only for Descent Element)

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5. Proposal Review Information

Consistent with the public-private partnership objectives set forth in this BAA, and in accordance with the criteria set forth below, NASA will evaluate offerors' proposals to develop and demonstrate their Element concepts in a manner resulting in the most advantageous alignment of both industry's commercial and NASA's programmatic needs. NASA seeks proposals that provide the best and most synergistic partnership approach for fulfilling both partners' desired objectives and performance requirements.

NASA will execute proposal review as defined in the omnibus BAA section of this solicitation. NASA will evaluate proposals using the following evaluation factors.

Factor 1 – Relevance: The Government will evaluate the relevance of the proposal to meet the overall objectives of the HLS.

Factor 2 – Technical Merit: The Government will evaluate the quality, depth, and thoroughness of the proposed technical approach as well of the Quality of the Team, including the organization's capabilities and the qualifications of key personnel.

Factor 3 – Price: The total price of the sum of all proposed CLINs shall not exceed \$9M. The Government will evaluate the overall price reasonableness of the total firm fixed-price estimate and corporate contributions including the extent to which the Offeror complied with the specified dollar limits in this appendix. The Government will evaluate the total direct labor hours by skill mix, travel, and subcontracts. Also an analysis will be done on the corporate contribution to ensure that it properly aligns with the proposed effort.

The Technical Merit, Relevance, and Price factors are equally important. Within the Technical Merit factor, Technical Approach is more important than Quality of Team.

Factor 1-Relevance and Factor 2 –Scientific/Technical Merit will be evaluated against the following criteria:

5.1 Relevance

In evaluating relevance of offerors' proposals to meet the overall objectives of the HLS, proposals will be judged in the quality and detail of their responses addressing the relevance of the proposed effort to the requirements and objectives listed in this appendix. Specific areas of evaluation under relevance include:

- How well does the proposal align with NASA's strategy to stimulate the U.S. space industry while leveraging those same commercial capabilities through this Partnership and future contracts to deliver mission capabilities?
- How well does the proposed work address one of the specific HLS Elements?

5.2 Technical Merit

Proposals will be judged in the quality and detail of their responses addressing the Technical Approach and the Quality of Team.

Specific areas of evaluation under Technical Approach include:

- To what extent does the proposed element address the preliminary minimum and goal requirements for that element? Note that meeting goal requirements will be assessed more favorably than meeting only minimums.

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- To what extent does the proposed technical approach support robust design such that Elements used in earlier missions are expected to be robust enough to be used for later missions without significant design changes?
- To what extent does the proposed technical approach incorporate reusability, recyclability, or extensibility?
- To what extent does the proposed technology maturity plan support the schedule and objectives of three anticipated missions described in Attachment A?
- To what extent are individual risk-reduction prototype activities proposed to be accomplished during Phase A (refer to Prototype CLIN in section 4.1 Instructions for Proposals) critical in supporting the schedule and objectives of the proposed Element?
- To what extent does the proposed long-lead item plan support the schedule and objectives of three anticipated missions described in Attachment A?
- To what extent are individual long-lead items proposed to be procured during Phase A (refer to Long-Lead CLIN in section 4.1 Instructions for Proposals) critical in supporting the schedule and objectives of the proposed Element?
- To what extent is the SOW – including key technical milestones and deliverables – specific, measurable, appropriate, realistic, and timely?
- To what extent does the proposed use of NASA GFE, GFP, and subject matter experts align with the objectives?
- To what extent does the proposal include an adequate plan to assess proposed design concept against applicable standards, as well as provide feedback on interfaces, requirements, concept of operations?
- To what extent are sufficient SOW milestones and deliverables offered such that the progress can be tracked?
- To what extent does the proposal recognize significant potential risks and consider reasonable mitigation strategies?

Specific areas of evaluation under Quality of Team include:

- To what extent does the proposed team possess sufficient technical knowledge and capabilities to complete the proposed study and risk reduction effort?
- To what extent is there evidence of successful past performance for designing and developing space-qualified systems applicable to the objectives of this appendix?
- To what extent are proposed staffing levels for the Phase A period of performance adequate?
- To what extent are roles and an appropriate management structure clearly defined?
- To what extent do the Offeror's proposed infrastructure and facilities support the Phase A effort and potential follow-on development and manufacture of space-qualified systems?

Refer to Section 5 of the omnibus BAA for additional details on the evaluation process.

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6. Award Information

6.1. Funding Availability

NASA reserves the right to select for award multiple, one, or none of the proposals received in response to this appendix. NASA reserves the right to negotiate, with selected Offerors, cost/price terms and any other terms, as appropriate. The overall number of awards will be dependent upon funding availability and evaluation results.

6.2. Period of Performance:

The period of performance for Phase A will be 6 months and will start as of the ATP effective date. For Phase B, period of performance is expected to be between 3 – 6 years.

6.3. Award Date:

Award is anticipated in approximately July 2019. The price proposal should be based on this anticipated award date. Any reduced appropriations or continuing resolution may effect NASA's ability to award selected Offerors or exercise options.

6.4. Funding Allocation:

NASA anticipates initially allocating \$30-40M for the Phase A Studies in FY19 (in accordance with the President's Budget request). These are total amounts covering efforts selected from this Appendix E solicitation. Contracts shall be firm fixed-price with milestone payments structured in CLINs and sub-CLINs. The Government's obligation to make awards is contingent upon the availability of appropriated funds from which payments can be made and the receipt of proposals that NASA determines are acceptable.

7. Attachments

- A. Reference Architecture
- B. NASA Centers Points-of-Contact
- C. Quad Chart Template
- D. Corporate Contribution Worksheet
- E. Patent and Data Rights Clauses