

ANNEX NO. 1  
BETWEEN  
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
LANGLEY RESEARCH CENTER  
AND  
UNITED LAUNCH ALLIANCE, LLC  
UNDER  
SPACE ACT UMBRELLA AGREEMENT SAA1- 37876  
FOR  
HIAD DEVELOPMENT TO MISSION PDR LEVEL

ARTICLE 1. PURPOSE

This Annex shall be for the purpose of NASA Langley Research Center (LaRC) design and analysis of Hypersonic Inflatable Atmospheric Decelerator (HIAD) technology for use on the ULA Vulcan launch vehicle to enable BE-4 engine reentry and recovery (engine reuse). A segment located on the aft end of the Vulcan booster known as the Reuse Module (RM) is designed to separate from booster and return to Earth via ocean splashdown. The RM payload includes, but is not limited to, two BE-4 engines, the Vulcan Thrust Structure (VTS), an ascent heatshield, avionics, and propulsion systems. The recovery hardware required for reentry includes the inner and outer HIAD structural and heatshield elements, inflation system, instrumentation suite, data collection, spray shield, and parachutes. The RM plus HIAD systems constitute the reentry vehicle (RV).

This Annex covers development of HIAD elements (inflatable structure, thermal protection system (TPS), inflation system, instrumentation suite, and data collection) and a HIAD-to-RM structural attachment – through the mission Preliminary Design Review (PDR) level. Efforts beyond PDR level will be outlined in subsequent Annexes.

The legal authority for this Annex, consistent with the Umbrella Agreement, is in accordance with the Space Act, Other Transactions Authority (OTA), 51 U.S.C. § 20113(e).

ARTICLE 2. RESPONSIBILITIES

A. NASA LaRC will use reasonable efforts to:

1. Develop a preliminary design package for a HIAD system to protect and decelerate the Vulcan launch vehicle RM during atmosphere reentry based on launch vehicle ballistic trajectory that includes, but is not limited to:
  - a. Construction methods, interfaces, materials list, mass estimates, and cost and schedule estimates to fabricate and test a complete HIAD.
  - b. Definition of system and subsystem level design requirements and verification plans for the HIAD inflatable structure, TPS, and instrumentation suite for each HIAD.

- c. Definition of geometry (diameter, cone angle, etc.) for inner and outer HIAD articles, including tori geometry. Inherent to this is the design of braid, cords, webbing, and joints.
  - d. Definition of preliminary reentry environments (aerodynamic, aero-heating, and structural loads) for various HIAD designs, including magnitude and impact of payload impingement.
  - e. HIAD analyses including flight dynamics, aero/aero-heating, thermal, structural, and inflation system analyses to support the ULA RM preliminary design cycles.
  - f. Collaboration with Partner and suppliers to define preliminary reentry and landing timeline to accommodate inflation of HIAD systems, vehicle reentry, parachute deployment, and ocean splash down.
  - g. Study of concepts for generating lift for controllability and g-load mitigation. Concepts might include movable or fixed center of gravity (CG) offset, static or dynamic morphed HIAD, and mounting the HIAD to the RM at a fixed or articulating angle of attack, or some combination of these.
  - h. Preliminary definition of any tooling, Transportation & Handling (T&H) equipment, Mechanical Ground Support Equipment (MGSE), Electrical Ground Support Equipment (EGSE), or instrumentation required for the HIAD or any other hardware to be provided by LaRC.
  - i. Preliminary concept for HIAD packaging on the Vulcan launch vehicle.
  - j. Collaboration with Partner for definition of interfaces and development of an Interface Control Document (ICD).
  - k. Preliminary concept of operations (ConOps) for manufacturing, certification, transportation, and installation of new HIAD hardware.
  - l. Preliminary assessment of feasibility to reuse HIAD elements in the future.
  - m. Descriptions and mitigation plans for all system and subsystem level risks.
2. Develop and deliver Manufacturing Demonstration Units (MDUs). For the inflatable structures this includes manufacture of MGSE, fabrication of torus elements, stacking of torus elements. For the TPS, this will include manufacture of MGSE, and fabrication demonstrations for HIAD baseline shape.
  3. Support partner and supplier meetings and reviews as required including, but not limited to:
    - a. ULA Monthly Technical Interchange Meetings (TIMs)
    - b. ULA Bi-weekly telecons
    - c. ULA Mission PDR Dry run
    - d. ULA Supplier TIMs

e. ULA Mission PDR

B. Partner will use reasonable efforts to:

1. Provide all necessary design parameters, requirements, and constraints including, but not limited to, reentry trajectory, RM mass properties, hardware qualification limits, and hardware size/volume constraints.
2. Develop, with input from NASA LaRC, an ICD between all NASA LaRC-provided hardware and Partner hardware.
3. Facilitate meetings between NASA LaRC and Partner suppliers, as necessary.
4. Conduct mission PDR and track all associated action items.

ARTICLE 3. SCHEDULE AND MILESTONES

The planned major milestones for the activities for this Annex defined in the "Responsibilities" Article are as follows:

- |   |   |
|---|---|
| 1. Authority to Proceed   | Effective Date of Annex +<br>Receipt of Partner<br>Payment at NASA LaRC |
| 2. ULA to provide all necessary design parameters, requirements, and constraints to NASA LaRC | Within one (1) week<br>following Milestone 1                            |
| 3. ULA to conduct mission PDR   | By August 31, 2023  |
| 4. NASA LaRC to provide MDUs to ULA   | NLT Milestone 4   |
| 5. NASA LaRC to provide preliminary design package for HIAD system                            | Within two (2) months<br>following Milestone 4                          |

ARTICLE 4. FINANCIAL OBLIGATIONS

A. Partner agrees to reimburse NASA an estimated cost of \$6,022,326 for NASA to carry out its responsibilities under this Annex in accordance with the following payment schedule:

- \$1,000,000 upon full execution of Space Act Umbrella Agreement SAA1-37876, Annex 1
- \$5,022,326 on January 27, 2023, provided that the parties revise the terms and conditions of Article 10 Intellectual Property Rights – Data Rights and Article 11 Intellectual Property Rights - Invention and Patent Rights under Space Act Umbrella Agreement SAA1- 37876 to mutually agreeable terms by such date.

Each payment shall be marked with Langley Research Center, SAA1-37876, Annex 1.

B. NASA will not provide services or incur costs beyond the current funding. Although NASA has made a good faith effort to accurately estimate its costs, it is understood that NASA provides no assurance that the proposed effort under this Annex will be accomplished for the estimated amount. Should the effort cost more than the estimate, Partner will be advised by NASA as soon as possible. Partner shall pay all costs incurred and have the option of canceling the remaining effort, or providing additional funding in order to continue the proposed effort under the revised estimate. Should this Annex be terminated, or the effort completed at a cost less than the agreed-to estimated cost, NASA shall account for any unspent funds within 90 days after completion of all effort under this Annex, and promptly thereafter, at Partner's option return any unspent funds to Partner or apply any such unspent funds to other activities under the Umbrella Agreement. Return of unspent funds will be processed via Electronic Funds Transfer (EFT) in accordance with 31 C.F.R. Part 208 and, upon request by NASA, Partner agrees to complete the Automated Clearing House (ACH) Vendor/Miscellaneous Payment Enrollment Form (SF 3881).

#### ARTICLE 5. INTELLECTUAL PROPERTY RIGHTS - DATA RIGHTS

A. Data produced under this Annex which is subject to paragraph C. of the Intellectual Property Rights - Data Rights Article of the Umbrella Agreement will be protected for the period of one year.

B. Under paragraph H. of the Intellectual Property Rights - Data Rights Article of the Umbrella Agreement, Disclosing Party provides the following Data to Receiving Party. The lists below may not be comprehensive, are subject to change, and do not supersede any restrictive notice on the Data provided.

1. Background Data:

The Disclosing Party's Background Data, if any, will be identified in a separate technical document.

2. Third Party Proprietary Data:

The Disclosing Party's Third Party Proprietary Data, if any, will be identified in a separate technical document.

3. Controlled Government Data:

The Disclosing Party's Controlled Government Data, if any, will be identified in a separate technical document.

4. The following software and related Data will be provided to Partner under a separate Software Usage Agreement:

None

ARTICLE 6. TERM OF ANNEX

This Annex becomes effective upon the date of the last signature below ("Effective Date") and shall remain in effect until the completion of all obligations of both Parties hereto, or one (1) year from the Effective Date, whichever comes first, unless such term exceeds the duration of the Umbrella Agreement. The term of this Annex shall not exceed the term of the Umbrella Agreement. The Annex automatically expires upon the expiration of the Umbrella Agreement.

ARTICLE 7. RIGHT TO TERMINATE

Either Party may unilaterally terminate this Annex by providing thirty (30) calendar days written notice to the other Party.

ARTICLE 8. POINTS OF CONTACT

The following personnel are designated as the Points of Contact between the Parties in the performance of this Annex.

Management Points of Contact

NASA Langley Research Center

Laurie Roberts  
Agreements Lead, Space Technology and  
Exploration Directorate  
Mail Stop: 104  
Hampton, VA 23681  
Phone: 757.864.5803  
laurie.d.roberts@nasa.gov

UNITED LAUNCH ALLIANCE, LLC

Caleb Weiss  
Program Manager  
Mail Suite: 9501 E. Panorama Circle  
Centennial, CO 80112  
9100 East Mineral Circle  
Centennial, CO 80112-3401  
Phone: 303.391.4630  
caleb.c.weiss@ulalaunch.com

ARTICLE 9. MODIFICATIONS

Any modification to this Annex shall be executed, in writing, and signed by an authorized representative of NASA and the Partner. Modification of an Annex does not modify the terms of the Umbrella Agreement.

ARTICLE 10. SIGNATORY AUTHORITY

The signatories to this Annex covenant and warrant that they have authority to execute this Annex. By signing below, the undersigned agrees to the above terms and conditions.

NATIONAL AERONAUTICS AND  
SPACE ADMINISTRATION  
LANGLEY RESEARCH CENTER

UNITED LAUNCH ALLIANCE, LLC

BY: \_\_\_\_\_  
David A. Dress  
Director, Space Technology and  
Exploration Directorate

BY: \_\_\_\_\_  
Don Tidwell  
Contract Administrator

DATE: \_\_\_\_\_

DATE: \_\_\_\_\_