

ANNEX  
BETWEEN  
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
LYNDON B. JOHNSON SPACE CENTER  
AND FIREFLY AEROSPACE INC.  
UNDER SPACE ACT UMBRELLA AGREEMENT  
NO. 37611, DATED 2/7/2023 (ANNEX NUMBER 5).

ARTICLE 1. PURPOSE

This Annex between JSC and Firefly is for the purpose of assessing micrometeoroid and orbital debris (MMOD) risk to satellite components (including composite overwrapped pressure vessels) shielded by multi-layer insulation (MLI) blankets, etc.. NASA JSC will provide Firefly with training for the Bumper-code risk assessment software and ongoing support to help determine the risk posture for the Firefly Elytra spacecraft associated subsystems and provide consultation for mitigating MMOD risk. Supporting Firefly to ensure adequate MMOD protection for their satellites will help reduce orbital debris risk to all other operational spacecraft (i.e., ISS, CCP crew transport vehicles, NASA/US Government, and spacecraft from various commercial operators), which promotes a safer environment in low-Earth orbit for science, exploration, and economic vitality that aligns with the agency's goal of debris mitigation.

The Johnson Space Center (JSC) Hypervelocity Impact Technology (HVIT) group, part of the JSC Astromaterials Research and Exploration Science (ARES) Division, is the lead NASA organization for MMOD risk assessments and evaluating risk reduction options. The combination of JSC-HVIT capabilities in MMOD impact risk assessments, MMOD shielding design expertise, hypervelocity impact test evaluation, and shielding performance equation development (i.e., Firefly ballistic limit equations), is not available in the commercial world. HVIT uses the Bumper Code to assess MMOD risk, which contains Firefly ballistic limit equations relevant to a wide variety of spacecraft structures based on many (thousands) of hypervelocity impact tests. HVIT is recognized worldwide for its initiative in addressing orbital debris and shielding issues.

Using its unique skill sets in hypervelocity impact and MMOD risk assessments, the ARES HVIT group will advise, assess, and perform analysis on Firefly spacecraft designs to determine risk from MMOD to current and future Firefly missions. ARES personnel also will advise Firefly, as needed, on risk assessments based on ARES personnel's extensive knowledge on the orbital debris population and risk that may affect Firefly spacecraft design and operations.

The work under this agreement will include conducting an initial training on the Bumper-code software. Ongoing work will involve continued consultation on incorporating Firefly's design into a Bumper-code risk assessment. This will involve providing advice on current and proposed MMOD shielding, and how to integrate various shielding applications into the Bumper assessment. Hypervelocity testing is always suggested for novel designs of MMOD shielding, and HVIT will assist with the development of a test plan, conduct testing activities, and provide full documentation of the test results to

Firefly, and incorporate any newly developed/modified ballistic limit equations into the Firefly version of the Bumper-code.

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 JSC will use reasonable efforts to:

1. Risk Assessment – provide MMOD probability-of-no penetration (PnP) risk assessments of Firefly’s satellites using loss of spacecraft failure modes for the Firefly provided orbital parameters.
2. Provide Bumper software training to Firefly personnel. (Bumper software will be released via NASA-JSC technology transfer office process.)
3. Provide operational guidance to Firefly personnel using Bumper software.
4. Provide updates to the MMOD risk analysis Bumper software based on testing and analysis of satellite systems and/or developed ballistic limit equations.
5. Provide status updates on Annex activities via web conferences with Firefly personnel.
6. Testing activities
7. Impact testing – NASA-JSC to perform 5 hypervelocity impact tests (.17 cal launcher) for the purpose of understanding MMOD risk associated with MMOD shielding to be implemented on Firefly’s spacecraft. NASA will supply target fixtures, projectiles, witness plates and other materials required for the tests.
8. Reporting – A delivered report shall be delivered two weeks after completion of testing.

B. Partner will use reasonable efforts to:

1. Support regular status meetings with NASA-JSC.
2. Provide any spacecraft design (CAD) required to complete Bumper risk analysis.
3. Provide NASA JSC with all relevant information needed to construct targets for hypervelocity tests.
4. Supply Firefly specific materials needed for hypervelocity testing.

## ARTICLE 3. SCHEDULE AND MILESTONES

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

Both NASA and Partner attend Project Kick-off & Status meetings via web conference at intervals requested by Partner	ED + Two (2) Weeks; scheduled on request by Partner thereafter
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NASA will provide support and updates for use of Bumper Software Training to Partner, up to and including conducting risk assessments once CAD information provided by Firefly	Scheduled within 90 days of agreement execution or within two weeks from partner request.
Partner will provide Spacecraft Design (CAD) for NASA to perform MMOD Risk Assessment	ED + Three (3) Months or within Two (2) Weeks of Partner request
NASA will provide MMOD Risk Assessment & Bumper Support	As needed and as supplied for Risk Analysis as needed and ongoing post kick-off
Partner will provide NASA its Test Article configurations and materials for NASA to begin Hypervelocity Test Campaign	ED + Two (2) weeks before hypervelocity testing
NASA will perform Hypervelocity Impact Testing upon receipt of all required configurations and materials from Partner	Test campaign to begin within Six (6) weeks of Partner request
NASA will deliver Post-Test Report to Partner	Within Two (2) weeks of test campaign completion
NASA will provide Bumper Software updates to Partner	Within Three (3) weeks of test campaign completion

**ARTICLE 4. FINANCIAL OBLIGATIONS**

A. Partner agrees to reimburse NASA an estimated cost of \$148,710.95 for NASA to carry out its responsibilities under this Annex. The Partner agrees to pay NASA JSC \$27,570 prior to initiation of work under this Agreement. Subsequent advance payments will be determined based on the testing and analysis requested and scheduled to ensure that funds are resident with NASA before Federal Obligations are incurred in support of this Annex. Each payment shall be marked with JSC Annex 5.

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 one year 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 two years 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. TERMINATION

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 Lyndon B. Johnson Space Center  
Heather Cowardin, Ph.D.  
Branch Chief, Hypervelocity Impact and  
Orbital Debris Office  
Mail Stop: XI5-B9E  
2101 NASA Parkway  
Houston, Texas 77058  
Phone: 281-542-7568  
heather.cowardin@nasa.gov

FIREFLY AEROSPACE INC.  
Shea Ferring  
Sr. Vice President, Engineering  
1320 Arrow Point Drive  
Cedar Park, TX 78613-2169  
Phone: 512-277-6959  
shea.ferring@fireflyspace.com

Technical Points of Contact

NASA Lyndon B. Johnson Space Center  
Christopher Cline, Ph.D.  
Hypervelocity Impact Portfolio Scientist  
Mail Stop: XI5-B9E  
2101 NASA Parkway  
Houston, Texas 77058  
Phone: 281-792-2844  
christopher.j.cline@nasa.gov

FIREFLY AEROSPACE INC.  
Eric Lund  
Systems Engineer  
1320 Arrow Point Drive  
Cedar Park, TX 78613-2169  
Phone: 206-595-8035  
eric.lund@fireflyspace.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

FIREFLY AEROSPACE INC.

LYNDON B. JOHNSON SPACE  
CENTER

BY: \_\_\_\_\_  
Burt Laws  
Director, Exploration Architecture,  
Integration, and Science

BY: \_\_\_\_\_  
Chris Clark  
Vice President, Spacecraft

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

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