

Attachment 2

Statement of Work

Integrated Design and Analysis Support

List of Acronyms

ADAC	Ares Design Analysis Cycle
CFD	Computational Fluid Dynamics
CITSPP	Contract Information Technology Security Program Plan
CLV	Crew Launch Vehicle
Cx	Constellation
CxP	Constellation Program
DAC	Design and Analysis Cycle
DCR	Design Certification Review
DOD	Department of Defense
DOF	Degree of Freedom
DPD	Data Procurement Document
DRD	Data Requirement Descriptions
ED	Engineering Directorate
ELO	Exploration Launch Office
IDA	Integrated Design and Analysis
IDAC	Integrated Design Analysis Cycle
IRD	Interface Requirements Document
IT	Information Technology
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
PDR	Preliminary Design Review
SE&I	Systems Engineering & Integration
SHE	Safety, Health, and Environmental
SIGs	System Integration group
SRD	System Requirement Document
VI	Vehicle Integration

1.0 Objective

The Contractor shall provide technical discipline specialist support to the System Design and Analysis Division of the Engineering Directorate, Spacecraft & Vehicle Systems Department. This shall include, but not limited to, the Design Integration Branch of that Division. The Contractor shall provide support for, but not limited to, the development of/support to the Constellation Program (CxP), Ares Program Elements and other launch vehicle, spacecraft and technology development programs/projects products, tasks, and activities for the National Aeronautics and Space Administration (NASA).

2.0 Task Description

2.1 Integrated Design and Analysis (IDA) Integration Support (Element 1)

ED requires senior vehicle design and analyses discipline planning, integration and control support during the design, development, and test phases of the Ares I. The ED is responsible to the Ares I Vehicle Integration Office for this responsibility.

The contractor shall provide daily on-site support to the government customer. The contractor shall evaluate, select, and apply standard engineering techniques, procedures, and criteria. The contractor shall be responsible for making minor adaptations and modifications. The contractor shall lead and facilitate complex tasks and trade studies as well as independently manage subtasks with minimum government oversight.

The contractor shall provide program management specialists in the integration of integrated vehicle design and analyses, including, but not limited to, vehicle requirements analysis, modeling and simulation, design and analysis cycle (DAC) planning and execution, and verification methods. The contractor shall support and/or lead, as needed, IDA work package discipline integration, DAC planning, implementation, and re-integration tasks. The contractor shall work with the Level 3 design and analyses working group as well as other working groups and integration groups as needed.

The contractor shall directly support the IDA work package manager for fulfilling IDA work package responsibilities including integration, technical implementation, and the on-time delivery of quality products to the VI project office and other customers. Integration responsibilities shall include planning, evaluations, status of technical disciplines, establishing, tracking, coordinating, and addressing technical actions from Project and Engineering. Responsibilities shall also include supporting and/or providing, as needed, status reviews, project monthly reviews, associated metrics and risk identification, mitigation, and tracking responsibilities for IDA. The contractor shall support the coordination and technical resolution, as needed, for the following documents: System Requirement Document (SRD), Interface Requirements Document (IRD), and technical Data Requirement Description (DRD). The contractor shall conduct and support trade study planning, Level 2, Level 3, and Level 4 coordination as needed.

The contractor shall perform and/or lead trade study and decision analysis efforts, including technical disciplines, and facilitate decision making for a wide range of Ares I technical issues.

The contractor shall evaluate technical quality and status; provide integration of analyses; and design products and documentation in support of vehicle design, development, operational flight tests and flight operations for the Ares program.

The contractor shall provide subject matter expert support to verification and validation activities for models and simulations used for IDA work package. The contractor shall review technical reports, requirements documents, and engineering memorandums for technical adequacy and content.

The contractor shall provide technical subject matter expertise for integration of the following IDA disciplines for human rated space launch vehicle or similar vehicle:

- Guidance and navigation algorithm development, implementation, and assessment
- Flight control system performance determination through linear stability analyses; 3-degree of freedom (DOF) and 6-DOF simulation implementation, development, and analyses.
- Static and dynamic structural loads determination through estimation, analyses, and test, including finite element analyses
- Aeroelastic analyses
- Trajectory and performance analyses
- Determination of valid ranges for Vehicle/discipline specific Monte Carlo dispersions
- Aerodynamics, aerothermal, flight acoustics analyses
- Thermal analyses
- Propulsion and lift-off acoustics
- Solid and cryogenic liquid systems
- Mass properties estimation techniques and CAD integration

The contractor shall have past experience and/or working knowledge (specifically strengths, weaknesses, and areas of applicability) of the tools and tests used to perform analyses typical to human rated space launch vehicles or similar vehicles specifically in the areas mentioned above.

The contractor shall support development of all key vehicle integrated design and analysis products for key project milestones. The contractor shall prepare and deliver technical and programmatic briefings as requested by the government customer.

To accomplish its goals, the Exploration Launch Office (ELO) Ares Vehicle Integration Office shall work closely with the Ares elements, the Orion Project Office, multiple Constellation Level II organizations, as well as advanced project groups developing the concepts for lunar exploration and beyond. This will be necessary to not only ensure smooth integration of the Ares vehicle(s) development, but to ensure Ares compatibility and smooth integration as part of the larger Constellation Program. This will require senior Systems Engineering specialists with expertise in assisting with integration of the Ares I elements and the Orion as well as integrating the Ares I as part of the larger Constellation Program. The contractor shall provide Ares I support to Constellation (Cx) Systems Engineering and Integration activities including, but not limited to Cx Analysis Working Group and Cx systems integration groups' (SIGs) efforts as needed.

The contractor shall support Cx/VI project with architecture integration activities including architecture development and feasibility analyses, physical configuration definition, architecture reference documentation, mission modeling and simulation.

The contractor shall support analytical integration activities between Ares I, Level II and the Ares I Level IV elements including Ares Design Analysis Cycle (ADAC)/Cx Integrated Design Analysis Cycle (IDAC) coordination as needed.

The contractor shall support identification, preparation and implementation of analyses and trade studies efforts, documentation and presentation of related work to the various

working groups and control boards, as well as issues tracking and resolution. The contractor shall support development of the ADAC/IDAC plans, integrated analysis schedules, as well as requirements coverage and design feasibility assessments. The contractor shall have experience with NASA or DOD requirements development and verification processes. The contractor shall provide requirements development and verification support.

The contractor shall provide resources and support in the implementation of systems engineering processes as defined by MPR 7123.1, and shall provide support and participation in preparing for and executing technical reviews.

2.2 Guidance, Navigation, and Mission Analysis Support for the Spacecraft & Vehicle Systems Department (Element 2)

The contractor shall perform GN&C integration and requirements tasks in support of NASA MSFC Vehicle Integration Project as required to support NASA MSFC Guidance, Navigation & Mission Analysis Branch. The contractor shall support GN&C tasks including Abort Scenarios Modeling, Analysis and Algorithm Development, but not limited to, development, modeling, implementation and testing in Ares I MAVERIC II high fidelity simulation various Ares failure and abort scenarios, and abort algorithm; and performing failure and abort analysis and algorithm development for the baseline and any alternate vehicle configurations.

The contractor shall provide resources and support in the implementation of systems engineering processes as defined by MPR 7123.1, and shall provide support and participation in preparing for and executing technical reviews.

2.3 Systems Analytical Integration Support for the Spacecraft & Vehicle Systems Department (Element 3) *(Authorization to proceed with this subtask will be provided by the Contracting Officer in written direction.)*

The contractor shall provide senior vehicle, technology, design and analyses discipline planning, integration and control support during design, development, and test phases.

The contractor shall evaluate, select, and apply standard engineering techniques, procedures, and criteria. The contractor shall lead and facilitate complex tasks and trade studies as well as independently manage subtasks with minimum government oversight.

The contractor shall provide program management specialists in the integration of integrated vehicle design and analyses, including, but not limited to, vehicle requirements analysis, modeling and simulation, technical implementation, design and analysis cycle (DAC) planning and execution, and verification methods. The contractor shall support and/or lead, as needed, work package discipline integration, DAC planning, implementation, and re-integration tasks. The contractor shall work with the design and analyses working group as well as other working groups and integration groups as needed.

The contractor shall perform and/or lead trade study and decision analysis efforts, including technical disciplines, and facilitate decision making for a wide range of technical issues.

The contractor shall evaluate technical quality and status; provide integration of analyses; and design products and documentation in support of design, development, operational tests and operations.

The contractor shall provide technical subject matter expertise for integration including, but not limited to, the following disciplines for launch vehicle, similar vehicle, spacecraft, or technology development:

- Guidance and navigation algorithm development, implementation, and assessment
- Flight control system performance determination through linear stability analyses; 3-degree of freedom (DOF) and 6-DOF simulation implementation, development, and analyses.
- Static and dynamic structural loads determination through estimation, analyses, and test, including finite element analyses
- Aeroelastic analyses
- Trajectory and performance analyses
- Determination of valid ranges for Vehicle/discipline specific Monte Carlo dispersions
- Aerodynamics, aerothermal, flight acoustics analyses
- Thermal analyses
- Propulsion and lift-off acoustics
- Solid and cryogenic liquid systems
- Mass properties estimation techniques and CAD integration

The contractor shall have past experience and/or working knowledge (specifically strengths, weaknesses, and areas of applicability) of the tools and tests used to perform analyses typical to human rated space launch vehicles or similar vehicles specifically in the areas mentioned above.

The contractor shall support development of integrated design and analysis products for key milestones. The contractor shall prepare and deliver technical and programmatic briefings as requested by the government customer.

The contractor shall provide resources and support in the implementation of systems engineering processes as defined by MPR 7123.1, and shall provide support and participation in preparing for and executing technical reviews.

2.4 Guidance, Navigation and Mission Analysis Support (Element 4) (Authorization to proceed with this subtask will be provided by the Contracting Officer in written direction.)

Contractor shall provide engineering support in the design, development and definition of the guidance, navigation, and control systems including system and subsystem requirements or specifications to support, but not limited to, launch vehicles, spacecraft or technology development. Provide engineering support for mission analysis to include

trajectory and performance analysis, dispersion analysis, and ascent and reentry flight dynamics analysis. Support shall include but will not be limited to mathematical modeling, computer simulation and code development, guidance, navigation, and control architecture and performance design, analysis, and integration. Participation in requirement reviews, technical meetings and working groups is required along with supporting development of presentations and documentation.

The contractor shall provide resources and support in the implementation of systems engineering processes as defined by MPR 7123.1, and shall provide support and participation in preparing for and executing technical reviews.

2.5 Spacecraft and Vehicle Project and Management Support (Element 5)
(Authorization to proceed with this subtask will be provided by the Contracting Officer in written direction.)

Provide support to include, but not limited to, program planning, integration and control support during the design, development, and test phases of the launch vehicle, spacecraft or technology development program. The contractor shall provide subject matter specialists in requirements analysis, models and simulation, analysis cycle planning and execution, and verification methods. The contractor shall use state-of-the-art trade study and decision analysis techniques (including Kepner-Tregoe and Probabilistic methods) to facilitate decision making for a wide range of technical issues. The contractor shall assist in developing analysis products and documentation in support of vehicle, spacecraft, technology development and other projects as needed. The contractor shall provide subject matter specialist support to verification and validation activities for models and simulations. The contractor shall review technical reports, requirements documents, engineering memorandums for technical adequacy and content. The contractor shall provide expertise in the areas of scheduling and earned value management as needed. The contractor shall prepare and deliver technical and programmatic briefings as requested by the government.

The contractor shall provide resources and support in the implementation of systems engineering processes as defined by MPR 7123.1, and shall provide support and participation in preparing for and executing technical reviews.

2.6 Aerosciences Support (Element 6) *(Authorization to proceed with this subtask will be provided by the Contracting Officer in written direction.)*

The contractor shall provide subject matter specialists to guide and mentor in state-of-the-art tools, methods, and processes related to modeling including, but not limited to, launch vehicle flight events, spacecraft events and technology development efforts. The contractor shall provide CFD analysis support to wind tunnel test planning and aerodynamic database development. The contractor shall model vehicle aerodynamics and aerodynamic structural loads for candidate outer mold lines. The contractor shall run production CFD solutions as the basis of preliminary aerodynamic databases for 3 Degrees-of-Freedom (DOF) and 6-DOF simulations and for structural analyses. The contractor shall model time accurate, viscous launch vehicle flight events with 6-DOF motion when necessary (including liftoff, maximum dynamic pressure, and stage

separation events). The contractor shall provide expertise in methodologies and approaches for verification and validation of CFD tools with wind tunnel test data and flight test data. The contractor shall evaluate CFD analyses performed by other technical teams (both Euler and full viscous Navier-Stokes solvers using structured and unstructured grids). The contractor shall prepare technical briefings and engineering memorandums documenting analyses. The contractor shall review requirements documents, support aerodynamics related trade studies and problem resolution teams, and provide input to risk assessments, schedule planning and cost estimates for CFD / aerodynamics products. The contractor shall competently run the following CFD related tools / solvers: USM3D, FlowCart, GRIDGEN, GASP, U²NCLE, and Overflow.

The contractor shall generate aerodynamic databases and related analyses of configurations using wind tunnel measurements, flight test measurements, computational fluid dynamics analyses, and empirical / engineering code analyses. The contractor shall generate ascent and descent aerodynamic databases used in structural loads analyses, trajectory simulations, and 6 Degree-of-Freedom simulations in support of trade studies and baseline configurations. The contractor shall document the sources of data used and the methodology used in generating aerodynamic databases in Engineering Memorandums.

The contractor shall provide resources and support in the implementation of systems engineering processes as defined by MPR 7123.1, and shall provide support and participation in preparing for and executing technical reviews.

3.0 Skills, Experience, Education and Other Qualifications

For elements 1 through 4 described in Section 2.1 through 2.4 of this SOW, the Government requires Senior Systems Engineers with a desired 15 years experience in performing the following:

- Extensive experience with vehicle integration for human rated space launch vehicle or similar vehicles
- Extensive experience planning and executing vehicle design and analyses cycles
- Extensive experience in three and six degree of freedom (3-DOF and 6-DOF) simulations to determine system level performance and margins. Past MAVERIC experience is desired.
- Extensive experience with Monte Carlo dispersion analyses techniques
- Extensive experience integrating the following disciplines for design, analyses, and flight operation of human rated space launch vehicle or similar vehicle. Also, direct experience with the following disciplines is desired:
 - Guidance, navigation and control architecture and algorithm design and analyses, 3-DOF and 6-DOF flight dynamics analyses
 - Vehicle Loads, dynamics, and strength for all phases of ground and flight operations, including 3-D finite element, transient, buffet, wind gust, slosh, flex, vibro-acoustics and aeroelastics analyses
 - Trajectory design and analyses and Monte Carlo dispersion analyses techniques
 - Range safety analyses and requirements

- Aerodynamics and Computational Fluid Dynamics (CFD) analyses for ascent flight
- Aerothermal analyses including ascent, separation, re-entry aerodynamic heating
- Acoustics analyses for lift-off, ascent flight, and propulsion systems
- Thermal and venting analyses between vehicle elements
- Mass properties predictions for flight configurations
- Requirements for natural environments, weather, and winds etc.
- Aero, aerothermal, acoustics, loads and vibration testing
- Experience and knowledge in systems requirements analysis, risk identification and mitigation, modeling and simulation, and verification approaches for complex, multi-element aerospace systems
- Experience with NASA or DOD requirements development and verification process
- Experience with Space Shuttle vehicle or other similar space vehicles and programs.
- Experience in leading and facilitating trade studies on complex aerospace problems involving evaluation of technical, cost, and schedule issues with associated risk
- Experience in project planning and management
- Extensive experience in coordinating meetings/reviews, preparing review presentations, and consolidating review comments and action items

For elements 1 through 4 described in Section 2.1 through 2.4 of this SOW, the Government requires the following education:

- Bachelor and/or Master Degree in Aerospace, Mechanical or equivalent Engineering.

4.0 Deliverables

The contractor shall report and document this work and fulfill the requirements of associated Data Requirement Descriptions (DRD's) as outlined in Data Procurement Document (DPD) 1154 (Attachment 3). The contractor shall determine the data restriction that applies to each data deliverable and mark or transmit the data restriction in accordance with section 2.3.3 of the Data Procurement Document.

The contractor shall prepare and maintain a report identifying and listing all equipment, tools, etc., provided by the Government for use by the contractor in the performance of contracted effort, and for which the contractor has been given physical custody. This report shall be prepared and maintained in accordance with DRD 1154LS-001.

The contractor shall provide a monthly status report in contractor format that consists of relevant activities performed and problems encountered during that period as well as expected work to be performed during the next reporting period. The contractor shall prepare and deliver a Monthly Status Report in accordance with DRD 1154MA-001.

The contractor shall report mishaps and safety statistics to the MSFC Industrial Safety Branch in accordance with DRD 1154SA-002. The contractor shall submit direct to the

NASA Incident Reporting Information System (IRIS) or shall use the forms listed in section 15.4 of DRD 1154SA-002 or electronic equivalent to report mishaps and related information required to produce the safety metrics.

The contractor shall prepare and deliver Badged Employee and Remote IT User Listings in accordance with DRD 1154MA-002.

The contractor shall prepare and deliver Contractor Employee Clearance Documents in accordance with DRD 1154MA-003.

The contractor shall prepare and deliver Position Risk Designation for Non-NASA Employee in accordance with DRD 1154MA-004.

The contractor shall establish and implement an industrial safety, occupational health, and environmental program and provide a signed Safety, Health, and Environmental (SHE) Work Agreement in accordance with DRD 1154SA-001.

5.0 Travel Estimate

The contractor shall travel as requested to accomplish each technical requirement. Travel projections are provided below. The number of trips, travel locations, number of people and length of stay can change based on the customer's requirements. Travel must be authorized by the Contracting Officer's Technical Representative prior to the beginning of the trip.

Element 1 (Section 2.1)

- 4 one week trips to NASA Johnson Space Center in Houston, TX
- 1 one week trip to NASA Langley Research Center in Hampton, VA
- 1 one week trip to NASA Ames Research Center in Mountain View, CA
- 1 one week trip to NASA Kennedy Space Center in Cocoa Beach, FL

Element 3 (Section 2.3)

- 4 one week trips to NASA Johnson Space Center in Houston, TX
- 1 one week trip to NASA Langley Research Center in Hampton, VA
- 1 one week trip to NASA Ames Research Center in Mountain View, CA
- 1 one week trip to NASA Kennedy Space Center in Cocoa Beach, FL

Element 5 (Section 2.5)

- Five (5) one week trips to Johnson Space Center in Houston, TX per year.
- Four (4) one week trips to Kennedy Space Center in Coco Beach, FL per year.
- Three (3) one week trips to Ames Research Center in Mountain View, Ca per year.
- Two (2) one week trips to ATK in Ogden, Utah per year.
- Five (5) one week trips to Langley Research Center in Langley, Va per year.

Element 6 (Section 2.6)

- Five (5) one week trips to NASA Ames Research Center in Mountain View, CA per year.
- Seven (7) one week trips to NASA Langley Research Center in Hampton, VA per year.
- Two (2) one week trip to NASA Johnson Space Center in Houston, TX per year.
- Two (2) three day trips to Kennedy Space Center in Coco Beach, FL, per year.
- One (1) one week trips to the Boeing Facility in St. Louis, MO per year.
- Four (1) one week trips to ATK – Ogden, Utah per year.

6.0 RESERVED