Task Order Total Cost (Total Estimated Cost + Total Maximum Fee): $97,212,952.22

IV&V PROJECTS
FY20 STATEMENT OF WORK (SOW)

Task Order No. 2 \ Mod No. 13, Version 1
Task Monitor (TM): Sadie Downs

Contract SOW References:

Section 1.6 – Contract Management
Section 3. – Requirements
Section 3.1 – IV&V for NASA Projects

1. SCOPE

The contractor shall perform IV&V on IV&V Projects identified in Section 3 below, and complete uncanceled work specified in previous modifications to this task order, as modified if modified, consistent with the Contract SOW and IV&V requirements specified below. Requirements in this task order modification supersede and replace any conflicting requirements in previous task order modifications.

2. PERIOD OF PERFORMANCE

The period during which the work for this task shall be performed is from May 11, 2017 thru September 30, 2021.

3. TASK DESCRIPTION

3.1 **Support to IV&V Projects:** For each IV&V Project, the contractor shall comply with all applicable requirements specified in the Contract SOW. The specifics of each IV&V Project are documented in the respective IV&V Project Execution Plans (IPEPs) or Memorandums of Agreement (MOAs) and schedules identified in the tables below. The contractor shall refer to these documents and schedules to ascertain the support needed, including specific deliverable requirements.

Further requirements for the support needed are specified following each table.

Human Exploration and Operations Mission Directorate (HEO MD) Projects

Project	IPEP\MOA	Schedule
Exploration Ground Systems (EGS)	[redacted] (Enterprise/IV&V PROJECTS/HEOMD-ESD/EGS/FA & Project P../FA/FY21/)	[redacted] (Enterprise/IV&V PROJECTS/HEOMD-ESD/EGS/Schedules/Working-IVV/FY21/)
HEO ESD Integration (HEO\I)	N/A	N/A. HEO\I IV&V tasking has been transferred to the other Artemis IV&V projects, and the HEO\I project has been discontinued as a separate IV&V project.

Project	IPEP\MOA	Schedule
International Space Station (ISS)	[redacted]	[redacted]
Orion Multi Purpose Crew Vehicle (MPCV)	[redacted]	[redacted]
Space Network Ground Segment Sustainment (SGSS)	N/A	N/A. IV&V support to SGSS has been terminated.
Space Launch System (SLS)	[redacted]	[redacted]
Mission Control Center (MCC)	[redacted]	[redacted]
Gateway	[redacted]	[redacted]
Human Landing System (HLS)	To be developed in FY21	[redacted]

Staff Allocation, Expertise, and Skill Mix

- Gateway – Contractor support to the Gateway tasks defined herein should include staff who can support ad hoc meetings at the NASA Johnson Space Center (JSC), Glenn Research Center (GRC), and Kennedy Space Center (KSC).
- HLS – The contractor should staff the HLS IV&V Planning and Scoping activity with personnel who are knowledgeable of NASA's Human Rating Requirements for Space Systems and experienced in the certification of space systems for human spaceflight.
- HLS – The contractor should staff the HLS IV&V Planning and Scoping activity with personnel who are knowledgeable and experienced in the development or V&V of the types of software systems that may be necessary to realize the Concept of Operations for the HLS.
- HLS – The contractor should staff the HLS IV&V Planning and Scoping activity with personnel who are knowledgeable with and experienced in the execution of the latest version (Version E) of the IV&V PBRA process (S3106) and the IV&V Program's objective to develop and maintain a complete network (i.e., related set) of risk-prioritized assurance objectives (AOs) for the Artemis IV&V Program and its projects (i.e. HLS) to assure the safety and success of critical software supporting the NASA Artemis missions.

Security Requirements

- HEO MD – No further requirements are specified.

Additional Project Requirements

- ISS – The contractor shall purchase the yearly renewal maintenance of OpenText which is being utilized for the ISS IV&V MADE Lab.
- ISS – The contractor shall perform backups of the ISS IV&V MADE Lab data as appropriate. The contractor shall store the backup data on at least two separate devices and one of these devices shall be stored in a secure area outside of the MADE Lab. The contractor shall review the frequency of backups and overall backup strategy with the IV&V Project Manager during semi-annual IV&V planning cycles.
- Gateway –The contractor shall initiate development of Gateway Assurance Network to model Gateway subsystem behaviors to support IV&V assurance of integration activities.
- Gateway – The contractor shall initiate assurance activities for the Power and Propulsion Element (PPE), the Habitation and Logistics Outpost (HALO), and the Vehicle System Manager as these activities are defined in the Gateway IPEP, TS&R, and Schedule.
- Artemis – The contractor shall work collaboratively across projects and with the Government to ensure that the Artemis IV&V projects (Orion, SLS, EGS, Gateway, HLS, and MCC) work together efficiently and effectively to assure the safety and success of critical software supporting NASA Artemis missions. The contractor's primary performance objectives in support of the Artemis IV&V Program follow:
- Integrate the previously planned and executing work of the HEO Integration IV&V project into each program/system project (Orion, SLS, EGS, Gateway, HLS, and MCC), adjust and execute the work as appropriate, e.g., to best leverage each project's resources in consideration of Artemis IV&V Program priorities, and adjust each project as necessary to take ownership of planning, execution, management, and reporting of Cross-Program integration assurance associated with that project going forward.
- Develop and maintain a complete network (i.e., related set) of risk-prioritized assurance objectives (AOs) for the Artemis IV&V Program and its projects to assure the safety and success of critical software supporting the NASA Artemis I, II, III, and IV missions. The assurance network is required to relate actionable IV&V AOs to Artemis mission-level objectives and scenarios.
- Develop and maintain a backlog of AOs and associated analysis activities sufficient for timely coordination and planning of the work of each project, collaborative work among the projects, and most effective and efficient use of Artemis IV&V Program resources.
- Identify, develop, and adopt a common set of best practices, guiding principles, assurance approaches, processes, and tools, consistent with IVVO direction, that facilitates and promotes efficient, effective, and collaborative work across the Artemis IV&V projects, including integration assurance, and results in clear, consistent, and cohesive reporting of project and Artemis IV&V program assurance activities, findings, results, and recommendations.

- Ensure progress on all Artemis IV&V objectives consistent with the need to present a clear, consistent, and cohesive assurance message at Artemis I SMSR and provide timely IV&V assurance for Artemis missions.
- HLS - The contractor shall work collaboratively with the Government to establish and execute an approach for the assurance of the safety and success of HLS software. Below are the contractor's primary HLS IV&V performance objectives in support of the Artemis IV&V Program:
- Support fact finding to establish IV&V understanding of the HLS Program's approach to procuring and assuring software systems and services in support of its role in achieving the Agency's goals for Artemis Missions.
- Support determination / tailoring of appropriate planning, scoping, and assurance approaches for HLS IV&V, consistent with Artemis IV&V Program direction.
- Support HLS IV&V planning, scoping, and assurance design activities and start executing plans upon approval by the Government.
- Support the integrated system modeling and testing efforts across the Artemis missions. Support includes working with the Artemis Modeling and Test lead to perform the tasking needed to effectively model and test behaviors and functionality at various levels of abstraction across the Artemis missions.

SMD-APL Projects

Project	IPEP\MOA	Schedule
Dragonfly	ECM/Enterprise/IV&V PROJECTS/Dragonfly/Workspace/Planning/IPEP/FY 21/Dragonfly IPEP FY21_v1.0_DRAFT.doc [redacted]	ECM/Enterprise/IV&V PROJECTS/Dragonfly\Schedules/DRAGONFLY_IVV_FY21-26_Working mpp [redacted]

SMD-GSFC Projects

Project	IPEP\MOA	Schedule
James Webb Space Telescope (JWST)	[redacted]	[redacted]
JPSS Ground	N/A	N/A. IV&V support to JPSS Ground has been terminated.
JPSS-2	[redacted]	[redacted]
LandSat 9 (L9)	Enterprise/IV&V PROJECTS/Landsat 9/02-FA & Project Plans/FY21 Project Plans/IPEP/Landsat9 IPEP FY21 [redacted]	Enterprise/IV&V PROJECTS/Landsat 9/02-FA & Project Plans/FY21 Project Plans/Schedule/Landsat 9 FY21 Schedule [redacted]

Project	IPEP\MOA	Schedule
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Lucy	ECM/Enterprise/IV&V PROJECTS/LUCY/Workspace/Planning/IPEP/FY21/Lucy IPEP FY21_v4.0_DRAFT.doc [redacted]	ECM/Enterprise/IV&V PROJECTS/LUCY/Schedules/ LUCY_IVV_FY18-21_Working.mpp [redacted]
Parker Solar Probe (PSP)	N/A	N/A. IV&V support to PSP is complete.
RST	[redacted]	[redacted]

Staff Allocation, Expertise, and Skill Mix

- RST – The contractor should staff RST with personnel proficient in embedded software development, software testing, software-hardware integration, and flight dynamics.
- RST – The contractor should staff RST with personnel with prior experience on GSFC in-house missions and relevant experience with Core Flight System software, ASIST ground system software, System Test Operational Language (STOL), build verification testing, 42 dynamics, and software-based simulation and testing.
- L9 assurance activities involve:
  - IV&V analysis of C code. Tracing of execution paths through the code and call hierarchy. Identification of common errors and design mistakes associated with the language. Technical discussions directly with the developer, demonstrating fluency in the language "speak" at a level greater than the tool's provided output.
  - Software modeling and ability to perform model-based IV&V analysis using Simulink models
  - IV&V analysis of attitude control systems, fault management, spacecraft bus interfaces, and flight software systems and architectures
  - Analysis of FPGA code\software
  - Running tools and reviewing results of static code analyzer (SCA) tools (e.g. KW, CPPCheck, etc.) This includes knowledge of the configuration of the tools since many times configuration needs adjusted or a tool may need re-installed during an unintended anomaly on a remote effort.
  - Using text editors, IDEs and other software\code job aids to efficiently navigate through code and\or derive metrics
  - Familiarity with flight\instrument software - including following common flight patterns\structures, assessing code for anomalies, and knowledge of known anomalies to identify (if discovered during normal task execution)
  - Proficient use of ATS and A-Scan
  - Analysis of FPGAs, proprietary design models, and analysis of any proprietary code will involve travel to Arizona to conduct analysis at the development site. There are currently no remaining planned activities to be completed in these areas. However, unplanned risk resolution or project requests for this type analysis would

depend on engineers with these skillsets to be able to travel. Some equipment, such as needed for remote login, would be needed for each analyst that travels. Again, all travel for performing remote analysis for L9 would be unplanned activities.

- Lucy – The contractor should staff Lucy with skills necessary to perform analysis on a Lockheed Martin Product Line Discovery class mission, with a skill mix to include experience in Fault Protection and Guidance, Navigation and Control functionality. Assurance activities will include but are not limited to:
  - Conducting reuse analysis to establish the veracity of heritage reuse claims from previous LM Product Line missions
  - Creating scenarios which will be used to establish an independent testing regimen
  - Refining existing assurance objectives and developing new ones using the Follow the Risk process
  - Participation in Requirements, Design, Code, and Unit Test reviews in phase with the development effort
  - Participation in Software Item Qualification Test reviews in phase with the development effort
  - Participation in System Verification Test reviews in phase with the development effort
  - Analysis of expected fault, failure, and hazard documentation
  - Creating and executing an Independent Test Plan utilizing a local or remote installation of SoftSim
  - Conducting Build analysis to include Change Impact Analysis from Heritage to Build, RDCU to Build, Build to Build artifacts
  - Other work consistent with the IV&V Technical Reference appropriate to where the Lucy project is in the lifecycle

Security Requirements

- SMD-GSFC – No further requirements are specified.

Additional Project Requirements

- JWST - The contractor shall support analyst reach back, since JWST is not anticipated to be staffed on a continuous basis
- JWST - The contractor shall support JWST project closeout in accordance with SLP 09-4.
- RST – The contractor shall work with the Government to identify, track, and manage a RST IV&V Assurance Register.
- RST - The contractor shall contribute to the RST IV&V Assurance Register quarterly report that includes the following:
  - Assurance Objectives worked during the previous quarter\increment
  - What went well during the previous quarter\increment
  - What could be improved during the next quarter\increment
  - Planned Assurance Objectives for next quarter\increment
  - (Note: RST increments will start January 2, April 2, July 2, and October 1 and each increment will be three months in duration)

- RST - The contractor shall work with the Government in the execution of the RST IPEP to reduce risks associated with entries in the Assurance Register as well as support the generation of the RST IV&V Products.

SMD-JPL Projects

Project	IPEP\MOA	Schedule
MARS 2020	N/A	N/A. IV&V support to MARS 2020 has been terminated.
Europa	[redacted]	[redacted]
Psyche	[redacted]	[redacted]

Staff Allocation, Expertise, and Skill Mix

- Europa – Planned activities require expertise and experience on how to perform IV&V analysis of the following spacecraft domains: GN&C, fault management/protection, embedded systems, systems engineering, test development, test execution, and test results analysis, attitude control systems, flight software systems and architectures, FPGAs, software-hardware integration
- Europa – Planned activities require expertise and experience in the following activities: understanding and tracing developed C code and its implementation, running static code analysis tools and reviewing their results, risk management and mitigation, software build analysis and change impact analysis, mission lifecycle gate review preparation, and other work consistent with the IV&V Technical Reference as applicable to in-focus work for the Europa Clipper lifecycle
- Psyche – Experience is desirable in the following areas: embedded systems, systems engineering, GN&C, fault protection, C code, ARINC-653, scenario development, independent testing

Security Requirements

- None

Additional Project Requirements

- Psyche – The contractor shall maintain the PBRA, RBA, and technical reference and assist with the development and refinement of the assurance strategy
- Europa - The contractor shall work with the Government in the development, maintenance, and execution of the Europa Clipper PBRA/RBA, Schedule, Technical Scope and Rigor, IPEP and assurance network in support of semi-annual IV&V planning cycles

3.2 Additional Requirements Applicable to All IV&V Projects

- The contractor shall implement all NASA IV&V Program IV&V Management System (IMS) procedures and guidelines relevant to assigned tasks.
- The contractor shall document, track, and manage all IV&V Project internal and external risks, with Priority Score greater than 7, using the IV&V Risk Manager application. Internal risks should be documented as risks to planned assurance rather than risks to the plan itself.
- The contractor shall develop and provide, for each IV&V Project, IV&V assurance, supported by objective evidence, that results in developer actions that reduce risk and/or increased IV&V confidence in IV&V risk assessments.
- The contractor shall document and maintain cumulative assurance conclusions. Each analysis activity should conclude with update of planning risk assessments and documentation of assurance conclusions that consider all relevant assurance evidence developed to date.
- The contractor shall ensure timely, complete contractor inputs to project management records are maintained per Project Manager and Project Lead direction in the appropriate JIRA or other PM\PL designated repositories.
- The contractor shall draft TIMs in Resolve for any Severity 3 or higher severity issue as soon as possible after issue identification and no later than two weeks after delivery of the issue to an external stakeholder.
- The contractor should implement a formal analyst training program that includes a variety of training venues (e.g., guided self-study, on-the-job training, tailored IV&V classroom training, external training) that target development of analyst knowledge and skills (esp., for technical domains, e.g., GN&C) to reduce staffing plan risks.
    - The contractor should assess and work to ensure Contractor staff are skilled in development and communication of assurance value statements and conclusions.
    - The contractor should assess and work to ensure Contractor staff are skilled in assessment of the risk associated with identified defects.
    - The contractor should increase emphasis on assessment and understanding of system and software architecture to improve IV&V risk and impact assessments.
    - The contractor should increase emphasis on assessment and understanding of system and software internal and external interfaces and integration, including interfaces and integration with hardware, to improve IV&V risk and impact assessments.
- The contractor should work to promote and advance IV&V Project use of relational data and assurance management systems like ATS, SysML\UML models, and relational databases.
- The contractor shall identify opportunities to advance application of dynamic analysis capability, formal methods, and model-based system and software assurance on each IV&V Project.
- The contractor shall work to normalize technical and managerial approaches and use of applications (e.g., JIRA) to implement best practices across all IV&V Projects.
- The contractor shall ensure that Contractor staff maintain IV&V Core Values and support the IV&V Project Manager in his\her role of leading, guiding, and directing the IV&V work.

- The contractor shall provide timely, in-phase IV&V assurance where possible, consistent with IV&V project plans and schedules. The contractor should apply assurance approaches that deliver best effort IV&V assurance when it is most actionable by developers and IV&V assurance at needed rigor levels, commensurate with IV&V assessment of software risk, as timely as possible, consistent with IV&V project plans and schedules.
- The contractor's task order response for this task order modification shall describe the contractor's planned approach to complete requirements specified in section 3.1, above. The task order response should include the following content and any other relevant content typical to SAS task order responses.
  - Overall
    - Staffing Profile Roll-Up
    - Assumptions
    - Risks
    - Recommendations, e.g., areas where the contractor believes modification of the requirements would result in greater value for the Government
  - For each Project
    - Controlling Documents
    - Potential OCI
    - FTE profile with Rationale
    - Technical skill profile with Rationale, demonstrating appropriateness of number, skill level, and timing of skilled staff availability for key/specialized tasks
    - Specialized knowledge and experience to be provided
    - Staffing approach and location
    - Security clearances
    - Travel
    - Assumptions
    - Risks
    - Recommendations

4. DELIVERABLES\SCHEDULES\MILESTONES

The contractor shall electronically submit all contract deliverables directly to the designated ECM folder. All formal deliverables shall be in a format approved by the CO and COR. In addition to those deliverables required by the contract, all informal deliverables, such as, Requirements Verification Reports, Test Design Validation Reports, Verification Issue Reports, Project Milestone Review Reports or Trip Reports for an IV&V Project\Activity will be identified and submitted in accordance with the IPEP for each project.

5. PLACE OF PERFORMANCE

All IV&V personnel should be located at the IV&V Facility in Fairmont, WV, unless a project specific need or other pre-approved circumstance warrants location at another NASA center, developer location, or other off-site location.

6. GLOSSARY

Should – denotes a guideline or recommendation where compliance with the specification is highly encouraged and appropriate rationale for deviations should be available but compliance is not mandatory.

Planning and Scoping Activities - Per IV&V IMS (esp., IVV 09-1, IVV 09-4, and S3106), these activities include development of system understanding, risk / priority assessment, and assurance design. Examples of products produced by these activities include: heritage analysis reports, IV&V Technical Reference (TR), PBRA/RBA, IV&V goals and objectives, Technical Scope and Rigor (TS&R) document, Assurance Network(s), documentation of planned assurance activities (e.g., JIRA Backlog), IPEP, schedule, and resource requirements. These activities are executed following current IVVO best practices ([redacted]

7. MODIFICATION NOTES

7.1 Mod 1 – JPSS-2 OMPS, MADE Lab Refresh, and L9 Remaining FY17 Work
7.2 Mod 2 – FY18 re-baseline
7.3 Mod 3 – Added planning and scoping tasks for Lucy and Psyche, section 3.1
7.4 Mod 4 – Added requirements for Lucy and Psyche execution, section 3.1
7.5 Mod 5 – L9 Static Code Analysis (SCA), Canceled
7.6 Mod 5 – FY19 re-baseline
7.7 Mod 6 – FY19 mid-year update. Added planning and scoping tasks for Gateway. Changed all references to MPCV to Orion (except for text embedded in links). Combined the HEO ESD and HEO Non-ESD sections.
7.8 Mod 7 – Revised Gateway requirements and added planning and scoping tasks for HEO Mission Control Center (MCC).
7.9 Mod 8 – FY20 re-baseline.
7.10 Mod 8, v2 – Revised to required initiation of MCC assurance activities in parallel with completion of planning and scoping
7.11 Mod 9 – FY20 mid-year re-baseline, adding Dragonfly and HLS and updating to reflect stand up of Artemis IV&V Program with HEO/I being absorbed into core program projects
7.12 Mod 10 – FY21 update.
7.13 Mod 11 – HLS and Dragonfly schedules have been updated to reflect current analysis needs to accommodate changes in developer schedules as well as changes in required assurance and approaches. Additional requirements cited for the needed support for Artemis Modeling and Test.
7.14 Mod 12 – administrative – changed TM and Branch Head to Sadie Downs.
7.15 Mod 13– HLS and Dragonfly are both experiencing delays in the development schedule. Given this new information, changes in the IV&V staff for HLS should not occur before May 2021. Dragonfly IV&V staffing changes are not expected before June 2021. Contractor will submit an updated cost plan indicating these adjustments.