SASS II DRAFT STATEMENT OF WORK Rev A

1.0 INTRODUCTION

This statement of work describes the effort necessary to provide simulation services in the areas of robotics; biomechanics; graphics; vehicle guidance, navigation, and control (GN&C); and flight software; as well as advanced software services in the areas of advanced software development technology; advanced human-computer interaction; avionics flight software; and advanced collaborative engineering and process automation to support the NASA Lyndon B. Johnson Space Center (JSC), Engineering Directorate's Software, Robotics, and Simulation Division (SRSD), other NASA users, and external customers for both ground and space flight applications. This effort includes providing engineering and training simulation support for the International Space Station Program, Orion Multi-Purpose Crew Vehicle (MPCV) Program, Commercial Crew Program, and Artemis programs such as Human Landing System (HLS), Gateway and Extravehicular Activity & Human Surface Mobility Program (EHP). The contractor is not required to be Capability Maturity Model Integrated (CMMI) certified. However, the contractor shall follow the CMMI software development processes for projects as defined in task orders. As used throughout this section, the term "software" is inclusive of software, firmware, and complex electronics computer programs.

2.0 MANAGEMENT

2.1 CONTRACT MANAGEMENT

The contractor shall implement management functions as defined in DRD, Contract Management Plan, to ensure that all work activities are accomplished in accordance with contract provisions. The contractor shall provide management functions and processes to ensure that all engineering design, development, and test activities defined in task orders are accomplished in accordance with the highest engineering standards, in accordance with DRD, Contract Management Plan. The contractor shall provide monthly status reports as defined in DRD, Monthly Status Reports, to status the contractor's financial and technical activities under this contract. The contractor shall manage organizational conflicts of interest in accordance with DRD, Organizational Conflicts of Interest (OCI) Plan.

2.2 INFORMATION MANAGEMENT

The contractor shall provide information technology security in accordance with DRD, Information Technology (IT) Security Program Plan and Reports. The contractor shall support Information Technology Capital Planning and Investment Control in accordance with DRD, Information Technology (IT) Capital Planning and Investment Control (CPIC). The contractor shall manage government property used in support of this contract in accordance with DRD, Government Property Management Plan. All contract deliverables shall be defined in task orders and provided as described in DRD, Data and Records Management Plan.

2.3 SAFETY AND HEALTH MANAGEMENT

The contractor shall perform tasks to ensure the protection of personnel, property, equipment, and the environment in contractor products and activities generated in support of institutional and spaceflight program objectives. To ensure compliance with pertinent NASA policies, requirements, federal, state, and local regulations for safety, health, environmental protection, and fire protection, the contractor shall develop and implement a safety and health plan in accordance with DRD, Administrative Safety and Health Plan. JPR 1700.1, JSC Safety and Health Requirements, provides detailed requirements and instructions regarding safety and health procedures and policies at JSC and is incorporated by reference into all JSC contracts when performance is on site at a JSC facility. It can be viewed at http://jschandbook.jsc.nasa.gov.

3.0 SCOPE

3.1 SIMULATION SERVICES

The contractor shall provide simulation model development, integration, verification, validation, analysis, documentation, maintenance, and troubleshooting support of Trick-based non-real-time (NRT) and real-time (RT) human-in-the-loop (HITL) simulations including, but not limited to:

- Space-based robotic manipulator systems
- Space-based vehicle models
- Advanced future robotic systems
- Human biomechanical representations for analysis and development of countermeasures devices
- GN&C of space-based vehicles for all flight phases including Rendezvous, Proximity Operations, Docking, and Undocking (RPODU); Descent, De-orbit, and Landing (DDL), and ascent/abort
- Space-based vehicle On-Board Computer Systems simulations and emulation of Flight Software (FSW) systems, as well as development and support services for avionics and embedded FSW systems
- Astronomical object surface interaction of space-based vehicles
- Graphics support for simulation visualization & engineering analysis
- Ground based and onboard training systems to support HITL training

The primary purpose of these simulations is to address engineering analysis, operations, and training requirements. The Contractor shall utilize the Trick Simulation Environment, space-based robotics, OpenSim biomechanics with countermeasure devices, vehicle GN&C and flight software emulation, and astronomical object surface interaction of space-based vehicles.

The contractor shall use the following software including but not limited to: Engineering Dynamic Onboard Ubiquitous Graphics (DOUG) Graphics for Exploration (EDGE), Digital Lunar Exploration Sites (DLES) Unreal Simulation Tool (DUST), and NASA

Virtual Exploration Rendered Simulation Environment (NVERSE) and associated graphics technologies to support NASA's RT HITL simulations.

3.2 ADVANCED SOFTWARE SERVICES

The contractor shall provide avionics flight and mission support software engineering tasks, including the development, integration, verification, validation, analysis, documentation, maintenance, and troubleshooting of flight software systems. The contractor shall provide advanced knowledge and machine-learning based AI systems engineering tasks to support the development, integration, verification, validation, analysis, documentation, maintenance, and troubleshooting of real-time and non-real-time automation, intelligent assistants, decision support systems tailored for human-spaceflight design and operations. The contractor shall perform the following, including but not limited to:

- Development of Avionics Flight and Mission Support software for the development and deployment of human-rated flight software.
- Development of Intelligent model-based engineering and machine learning tools and processes to support the design and development of intelligent systems.
- Development of Advanced Human-Computer Interaction (AHCI) hardware and software tools and processes to deliver intelligent systems data with multimodal interfaces, to capture human psychophysiological performance and to adjust the user interface based on user mental conditions.

The primary purpose to develop these intelligent systems is to address engineering analysis, operations, and training requirements. The Contractor shall have in-depth knowledge, including but not limited to the following suite of software tools and technologies, such as Core Flight Software (CFS), Model Based System Engineering (MBSE), Model Based Mission Assurance (MBMA), Artificial Intelligent / Machine Learning, Explainable AI (XAI), Generative AI, Machine Vision, Natural Language Processing (NLP) Large Language Models (LLMs), Extended Reality (XR) and biometric sensing and data analytics, and cloud and on-premise Kubernetes containerization, to implement intelligent systems applications to support human spaceflight operations.

4.0 PRODUCT DESCRIPTIONS

4.1 ROBOTICS AND BIOMECHANICS SIMULATION SERVICES

The contractor shall provide simulation development, integration, verification, validation, analysis, documentation, maintenance, and troubleshooting support for the space-based robotic systems and biomechanical simulation model efforts which include but are not limited to:

- Computationally efficient articulated rigid multibody dynamics (include rigid and flexible bodies as well as interbody joint friction)

- Seamless integrated multibody/orbital dynamics for robotics operations in the orbital setting
- Hard-surface contact dynamics modeling for mechanical interactions such as payload berthing mechanism interfaces or end-effector to grapple fixture interfaces needed for payload/vehicle capture and release
- Dynamic state transition management to account for operations such as payload capture/releases, payload or vehicle berthing/unberthing, and handoff (manipulator to manipulator or manipulator to fixed structure)
- High fidelity human musculoskeletal and electromechanical systems modeling for integrated human-system assessments both in ground facility and reduced gravity settings, including support for data collection

The contractor shall provide maintenance and upgrade of simulations to meet engineering analysis, operations, and training customer requirements, as well as the capability to resolve verification and validation issues related to supporting related to supporting space-based robotic systems in support of ISS and Gateway operations, as well as other Artemis programs and projects. The contractor shall enhance and maintain the Digital Astronaut Simulation (DAS) architecture to support related engineering analysis for existing and future countermeasures concepts or prototype devices. The contractor shall incorporate miscellaneous models (e.g., contact dynamics, mechanical systems, or vehicle flight control) from organizations external to SRSD into robotics and biomechanical simulations as required in task orders.

4.2 SPACE-BASED VEHICLE MODELING SIMULATION SERVICES

The contractor shall provide simulation development, integration, verification, validation, analysis, documentation, maintenance, and troubleshooting support for space-based vehicle, including space-based surface vehicle, modeling simulation efforts. These tasks include but are not limited to:

- High fidelity orbital dynamics and natural environment modeling (e.g., JSC Engineering Orbital Dynamics (JEOD))
- Combined orbital body/multibody dynamics modeling for integrated vehicle with articulated body operational scenarios (e.g., rotating solar arrays, surface vehicle suspension)
- Vehicle GN&C modeling, including appropriate level of detail for flight controls/flight software, hardware sensors, and effectors for RPODU, DDL, and ascent/abort
- Docking mechanism and contact dynamics modeling for programmatic systems including but not limited to the NASA Docking System

The contractor shall provide maintenance and upgrade of simulations to meet engineering analysis, operations, and training customer requirements, as well as the capability to resolve verification and validation issues related to supporting space-based vehicle simulation models. The Contractor shall incorporate miscellaneous models (e.g.,

contact dynamics, mechanical systems, or vehicle flight control) from organizations external to SRSD into space-based vehicle simulations as required in task orders.

The contractor shall develop and maintain simulation mockup interfaces to computer-based simulations, including development of customized hand controllers to replicate the functionality of hand controllers on current and proposed NASA vehicles; control panels, both physical and virtual, that provide simulation users with the ability to interact with a simulation; and user interfaces to start, stop, and control the simulation.

The contractor shall develop and maintain data visualization tools for comparing simulation runs, analyzing data spikes, and creating reports. These tools must handle very large data sets (thousands of runs) and run during sim execution and post processing.

4.3 ASTRONOMICAL OBJECT SURFACE SIMULATION SERVICES

The contractor shall provide simulation development, integration, verification, validation, analysis, documentation, maintenance, and troubleshooting support for space-based surface vehicle interactions, which is a subset of space-based vehicle, with astronomical object simulation efforts, including but not limited to soil/regolith/rock contact interaction modeling with lander or rover vehicles, robotics systems, and other anchoring type mechanisms. Contact and surface interaction modeling considerations include but are not limited to:

- Space-based surface vehicle mobility system (e.g., wheel, track, tires) or lander footpad modeling with traction and/or slippage with various astronomical object surface characteristics
- Change in the astronomical object surface elements (i.e., soil/regolith/rock) characteristics through the interactions with space-based surface vehicle mobility system or lander footpad
- Robotic systems attachment or excavating interaction with various astronomical object surface materials
- Other anchoring type mechanisms stabilizing on various astronomical surface characteristics with appropriate space-based vehicle imparted loads and slippage

Analysis using the surface vehicle simulation shall include but are not limited to:

- Predicting the dynamics response, mobility traction, and resistance from the surface elements for both powered and unpowered space-based surface vehicles as they traverse from one point to another through various surface conditions on an astronomical object surface.
- Predicting lander dynamic response and stability when landing on astronomical body sites assuming various combinations of slope, soil, and rockiness characteristics.

The contractor shall provide maintenance and upgrade of simulations to meet engineering analysis, operations, and training customer requirements; as well as analysis of verification and validation issues related to supporting surface interaction

simulation models. The contractor shall incorporate miscellaneous models (e.g., contact dynamics, mechanical systems, terramechanics, or vehicle control) from organizations external to SRSD into astronomical object surface interaction simulations will be addressed as required in task orders.

4.4 GRAPHICS SIMULATION SERVICES

The contractor shall provide development, integration, maintenance, and troubleshooting support services for 3D graphics capabilities needed for RT simulation visualization and NRT engineering analysis. The contractor shall provide Trick-based simulation to graphics communication library capabilities, various model format loaders, software plug-ins, and other user specific customization as required in task orders.

The contractor shall provide graphics support, including but not limited to, the development and maintenance of 3D graphics and eXtended Reality (XR) capabilities for simulation scene visualization requirements in support of the Orion MPCV Program and other advanced exploration and Flight Operations projects. The contractor shall provide software development services supporting simulation and graphics interfaces and applications including EDGE, DUST, NVERSE and commercial game engine development for XR technologies including virtual reality, augmented reality, and mixed reality.

4.5 AVIONICS FLIGHT AND MISSION SUPPORT SOFTWARE

Avionics FSW work involves developing and deploying human-rated flight software for embedded flight applications and Onboard Vehicle functions and the associated System Engineering and Integration (SE&I) effort, as well as development and support services for avionics and embedded flight software systems and software process engineering services.

The contractor shall provide but are not limited to:

- The development and deployment of embedded flight software for onboard vehicle functions, including vehicle level Fault, Detection, Isolation, and Recovery (FDIR), electronic procedures system, operating mode management, resource management, onboard test and checkout support and autonomous operations functions (for when the vehicle must operate unattended),
- Simulation and FSW development, integration and test in ground flight avionics facilities and functional equivalent environments
- Mission support software development, test and deployment of applications used to support onboard training, autonomous logistics management, machine learning, wireless sensing, and operation
- SE&I tasks involving the collaborative management of the flight software requirements analysis, architecture design trade studies, application integration and test, verification and validation analyses, and flight certification
- Software process engineering services to include development and maintenance of software engineering processes and artifacts required for compliance with

NASA software engineering standards (e.g., NPR 7150.2) and CMMI standards, including services to support CMMI certification appraisals and audits

- Integration of software to run on a Real Time Operating Systems (RTOS) as needed by projects. This could include driver development, kernel tuning, schedule/timing support as well as cross compiling for non-x86 computer architectures.

In particular, the contractor shall provide but is not be limited to vehicle-specific configuration of the Core Flight Software (CFS), development, integration and testing of VSM-specific applications/ functions using the CFS framework and Agile lifecycle model processes for human-rated (Class A safety critical) software deployments.

4.6 ADVANCED SOFTWARE TECHNOLOGY SYSTEMS DEVELOPMENT

Advanced Software Technology Systems (ASTS) work involves developing and deploying methods, tools and applications that will assist the developers and users of Artificial Intelligence (AI) systems (the flight and ground crew) to create and operate complex space and human systems both in space and on the ground.

These tasks provided by the contractor shall include but are not limited to:

- Develop AI systems to identify, isolate, plan execute nominal and off-nominal procedures to support all facets of human spaceflight systems
- Develop MBSE model to capture knowledge and extract artifacts from the model, to ensure interoperability of the enterprise systems and to enhance communication among all the stakeholders
- Develop MBSE methodology to capture Model Based Mission Assurance (MBMA) products and artifacts such as but not limited to Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis (FTA), Probability Risk Assessment (PRA) and Bayesian Network simulations.
- Develop Generative AI and Deep Machine Learning technologies to diagnose, predict and explain (e.g., Explainable AI – XAI) unforeseen anomalies of space and human systems
- Develop Generative AI and Deep Machine Learning technologies to support machine vision and augmented reality tasks such as and not limited to object recognition, tracking, and pose determination
- Develop Generative AI and Deep Machine Learning and Natural Language Processing (NLP) technologies (e.g., Large Language Models LLMs) to capture space and human systems knowledge to support human spaceflight design and operations
- Develop Generative AI and Deep Machine Learning technologies to assist in operational planning optimization tasks to generate and validate procedures
- Develop digital twins models to support Model-Based Engineering Design, Develop, Test and Evaluation (DDT&E) processes of space and human systems
- Develop digital twins models to plan, train and execute human spaceflight missions

- Utilize cloud and super computer platforms (e.g., Kubernetes) to host advanced software technology applications.

The contractor shall provide maintenance and upgrade of these AI and MBSE applications to meet engineering analysis, operations, and training customer requirements, as well as the capability to resolve verification and validation issues related to supporting the on-going MBSE models, real-time AI Machine Learning, Crew Assistance, Digital Twins applications.

4.7 ADVANCED HUMAN-COMPUTER INTERACTION

Advanced Human-Computer Interaction (AHCI) work involves developing and deploying methods and tools that will assist the designers and users of software systems in the user-centered design and analysis of next generation human interfaces with computing assets both in space and on the ground which includes but is not limited to the design and implementation of flight crew interfaces using adaptive multimodal user interface technologies to support authoring and execution of the systems procedures, medical and countermeasure procedures, inventory logistics management task list and collaborative human-robot interactions operations.

The tools and frameworks capabilities shall include but are not limited to graphical user interfaces, multiscreen displays, 2D and 3D spatial modeling, augmented reality and virtual environments, hybrid and mixed reality chromakey, eye tracking, brain computer interface, biometric data collection and processing, mental workload detection, gesture recognition, haptic feedback systems, intelligent procedure assistants, audio based interaction, speech synthesis and understanding, natural languages, direct manipulation, and multimodal interaction dialogues, data fusion, statistical pattern recognition, as well as human factors evaluation.

The contractor shall utilize these tools to enhance human capacities for situational awareness and effectiveness during operations in the context of specific mission objectives, predefined procedures and processes, collaborative decision-making with the ground, and resource availability constraints. The contractor shall also utilize these tools to access, organize, visualize and discover relationships in huge data sets during development, nominal and off-nominal real-time operations, or post-flight analysis.

The contractor shall provide development and utilization of these tools and frameworks to provide these capacity enhancements for:

- Research and development of AHCI applications and enhancements for these functions across engineering lifecycle phases
- Integration and deployment of AHCI applications for NASA software engineering organizations and associated programs and projects
- Ongoing operational support and maintenance of the deployed AHCI applications and environments

5.0 APPLICABLE DOCUMENTS

Documents applicable to this Statement of Work are listed in Attachment J, List of Applicable Documents, or in task orders. The contractor shall ensure that the official, latest version of the applicable documents is utilized in performance of this contract.

[END OF SECTION]