

Using Open Standards and NASA Open Source Simulation Tools to Model Artemis Base Camp Mission Timelines

The United States' National Aeronautics and Space Administration (NASA) has announced that the Artemis Program will return humans to the Moon, establishing a persistent presence with the Artemis Base Camp (ABC), and extend human exploration to Mars. The NASA Exploration Systems Simulations (NExSyS) team at NASA's Johnson Space Center is using internationally developed simulation interoperability standards and NASA open source simulation tools to support Artemis concept, analysis, designs, development, training, and ultimately operations. The NExSyS team has been tasked to support early ABC architecture and mission analysis using mission time lines developed by the crew operations mission planning team. The NExSyS team is developing a distributed simulation framework with initial Artemis element implementations to model the ABC mission timelines using the international simulation interoperability standard High Level Architecture (HLA), the Simulation Interoperability Standards Organization's Space Reference Federation Object Model (SpaceFOM), the NASA open source Trick Simulation Environment, and another NASA open source interface package called TrickHLA.

The ABC architecture is composed of a number of key surface elements and resources. Some examples of modeled elements (also known as entities) are landers, habitats, rovers, logistics carriers, and astronauts. Some examples of modeled transferable and consumable resources are power, water, oxygen, nitrogen, scientific samples, and food. These entities and resources are modeled in a collection of individual simulations called Federates. A coordinated collection of interoperable federates is called a Federation and when these federates are tied together in a coordinated simulation run, it is referred to as a Federation Execution. The federates communicate through HLA using data exchange formats defined by a collection of machine readable files called Federation Object Models (FOMs). These FOM files are based on extensions to the SpaceFOM. This enables the instantiation and sharing of objects and interactions between federates in the federation. These provide for entity and resource tracking, object transfer, and data collection. Federate interactions are used to trigger events and notify federates of entity or resource transfers.

For the initial implementation, the constituent federates are Trick-based simulations that use TrickHLA to provide the required HLA-base interoperability. These Trick-based simulations provide the required modeling for the individual Artemis elements along with the associated element resources. These federates provide a means to explore traverses between surface elements and exploration sites as scheduled in a mission timeline and explore the affects traverse times have on the overall mission timeline. The mission time lines are modeled using a Trick input file event handling capabilities. Each timeline operation is handled as individual simulation events, and triggered based on previous event status, time of operation, and simulated task completions. In addition, the ABC Federation can be used to perform Monte Carlo analysis. The Monte Carlo tool can vary the inputs, timings, and malfunctions to show how various contingencies in the mission can affect the mission timeline.