X2.01  Autonomous Rendezvous and Docking Sensors

Lead Center: JSC

Participating Center(s): ARC, GSFC, JPL, MSFC

The Exploration Systems Architecture defines missions that require rendezvous, proximity operations, and docking (RPOD) of two spacecraft both in Low Earth Orbit (LEO) and in Low Lunar Orbit (LLO). Uncrewed spacecraft must perform automated and/or autonomous rendezvous, proximity operations and docking operations (commonly known as Automated Rendezvous and Docking, AR&D). The crewed versions may also perform AR&D, possibly with a different level of automation and/or autonomy, and must also provide the crew with reliable, fault tolerant relative navigation information for manual piloting. The capabilities of the RPOD sensors are critical to the success of the Exploration Program. The relatively low technology readiness of existing relative navigation sensors for AR&D has been carried as one of the Crew Exploration Vehicle (CEV) Project's top risks.

This subtopic seeks innovative technologies that can provide relative navigation capabilities for rendezvous, proximity operations and docking of two spacecraft. Long-range rendezvous sensors should provide bearing from beyond 200 km to 5 km distance between spacecraft, but range and range-rate are also desirable. Proximity operations sensors should provide range, range-rate, and bearing from approximately 5 km to 100 m. Docking sensors should provide relative position and relative attitude from approximately 100 m to docking; relative attitude may only be needed from 30 m in to docking but longer ranges are desirable. Ideal solutions would combine multiple relative navigation sensing capabilities into a single system in order to reduce mass, volume, and power. Solutions should be designed to operate in Low Earth Orbit, Low Lunar Orbit, or both. Solutions can include a relative navigation sensor "suite" that consists of multiple sensor types but covers the full range; the sensor suite should allow RPOD under any lighting conditions. Solutions should also include a robust and fault tolerant capability that is suitable for a human-rated space vehicle. In addition, the relative navigation technologies should be designed so that existing infrastructure on the International Space Station (reflectors, communications systems, etc.) does not interfere with the relative navigation capability of the maneuvering vehicle.

Some specific technology focus areas of interest include: (1) use of relative navigation sensors that do not require special retro-reflectors or targets on the target spacecraft but can make use of natural features or existing infrastructure; this focus area may make use of Light-Imaging Detection and Ranging (LIDAR) components in order to get range and range-rate to the objects in the field of view, or may use video-based technology; (2) fault tolerant sensor systems; and (3) other technology areas for long-range rendezvous sensors that may include star trackers, infrared sensors, and radio frequency-based sensors; these types of sensors may have an extended range well beyond 200 km.