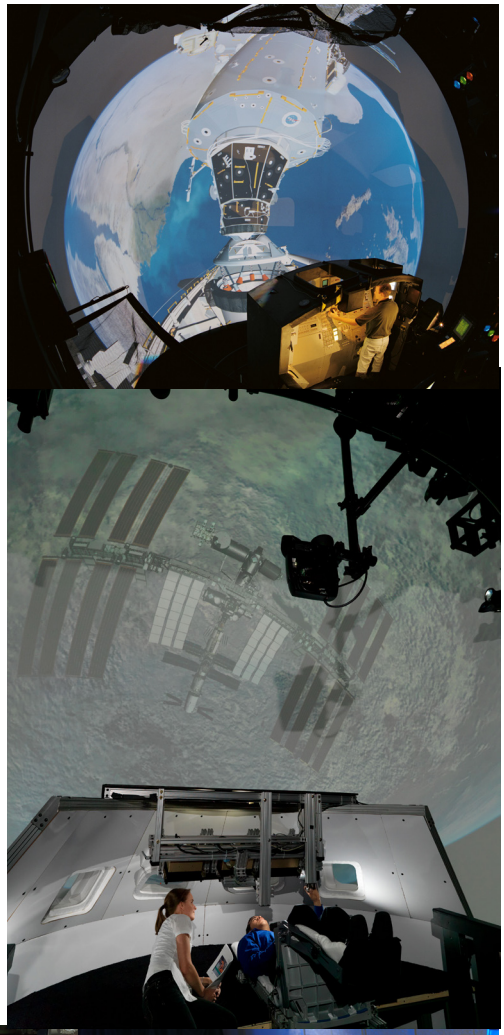
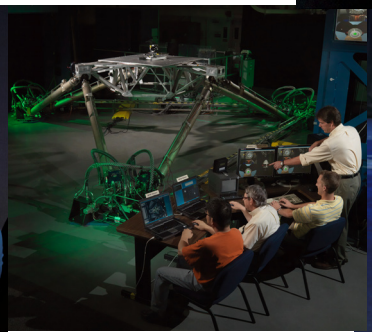
Rendezvous, Proximity, and Docking

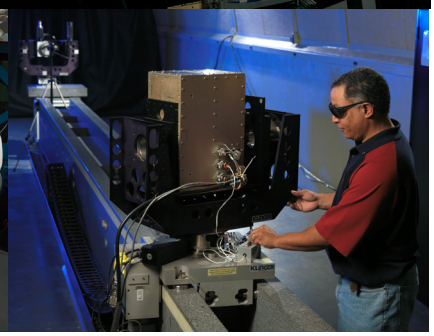
Orbital dynamics make rendezvous and proximity operations a complex task. Johnson Space Center (JSC) performs systems requirement definition, analyses, design, and testing necessary to support the development of rendezvous, proximity, and docking system designs and to verify the compatibility of the designs with functional and performance requirements. JSC provides ground facilities, including real-time simulators for development, testing, and training for manned and unmanned spacecraft rendezvous, proximity, and docking operations. Facilities offer high-fidelity, real-time, human-in-the-loop engineering simulations utilizing math models, scene generation, and realistic control station mockups.

Services Provided

- Simulation of multiple free-flying vehicles with accurate six-degree-of-freedom equations of motion
  - Docking contact dynamics
  - Thruster plume impingement
  - Vehicle control systems
  - Robotic manipulator dynamics
- Automated rendezvous, proximity operations, docking, and undocking (RPODU) design, analysis, and operations – guidance and targeting algorithm design and analysis for RPODU
- Real-time, six-degree-of-freedom, short range motion base simulation
- Open and closed-loop testing of automated rendezvous and docking systems
  - Envelope limit testing of hardware in system level test environment
  - Fault injection scenarios in true off nominal conditions
- Automated power quality testing
  - Closed-loop testing of mating interfaces, including contact forces
  - Physical emulation of spacecraft motion with motion platforms
  - Human-in-the-loop control







Johnson Space Center

Rendezvous, Proximity, and Docking Laboratory Capabilities

Systems Engineering Simulator (SES)

The SES is a real-time, crew-in-the-loop engineering simulator for Space Station and advanced programs. The facility is composed of three main elements:

- Host computer complex supporting ascent/entry and on-orbit simulations (high-fidelity math models of spacecraft and their subsystems)
- Functional flight cockpits with displays and controls interfaced to the host computer complex
- High-fidelity, out-the-window, and closed-circuit television visuals created by electronic image generators

The SES on-orbit simulation can accommodate up to six independent vehicles within a single simulation. These models can be selected at run time to simulate a desired scenario. The dynamics of all vehicles are modeled as six-degree-of-freedom rigid bodies.

Flight Mechanics Laboratory

The laboratory utilizes a high-performance Linux computing cluster along with many specially designed software tools in order to solve various flight mechanical disciplines, including flight phase development and performance analysis for rendezvous and proximity operations, design of flight envelopes and trajectories for targeting and profiles for on-orbit rendezvous, launch windows, rendezvous timelines, and vehicle performance capability evaluations.

Six-Degree-of-Freedom Dynamic Test System (SDTS)

The SDTS is a real-time, six-degree-of-freedom, short range motion base simulator designed to simulate the relative dynamics of two bodies in space mating together (i.e., docking or berthing). The SDTS has the capability to test full scale docking and berthing systems.

- Repositionable, stationary upper platform
- Motion base is a hydraulic powered Stewart platform, capable of supporting a 3,500 lb payload.

Simulation is controlled by interconnected computers running real-time simulation software. The motion base can also be used for non-mating applications (e.g., docking sensors, instruments).

Robotic Motion Platform (RMP)

The RMP is a very large model-following motion-base simulator that is hydraulically actuated, computer-controlled, and designed to maneuver payloads of up to 500 lb at the end of its 60-foot-long robotic arm. A model following, closed loop control system allows the RMP to emulate any simulated system as long as the desired motions are within its rate and travel limits.

Air Bearing Floor (ABF)

The ABF or "flat floor" is a 70' x 98' epoxy surface designed to support rendezvous and contact testing that requires low friction movement of test articles along a flat surface. Test articles are mounted on perforated pads that distribute a cushion of compressed air between the pads and the floor. The test articles "ride" on the air cushion and do not contact the floor.

SDTS Specifications	
Parameter	**Value**
Payload capacity	3,500 lbm
Lateral motion range (average)	±40 inches
Lateral motion range (peak)	±62 inches
Vertical motion range (maximum)	124 inches
Angular motion range	±20°
Data channels available (analog)	96

RMP Specifications	
Parameter	**Value**
End effector translational velocity	14 in/s
End effector rotational velocity	10 d/s
Degrees of freedom	8
Number of joints	7
Joint velocity	0.08 – 5 d/s
Joint reach limits	± 270 degrees
Arm reach limits	100 ft Dia hemisphere
Payload capacity	500 lb

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For the benefit of all

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