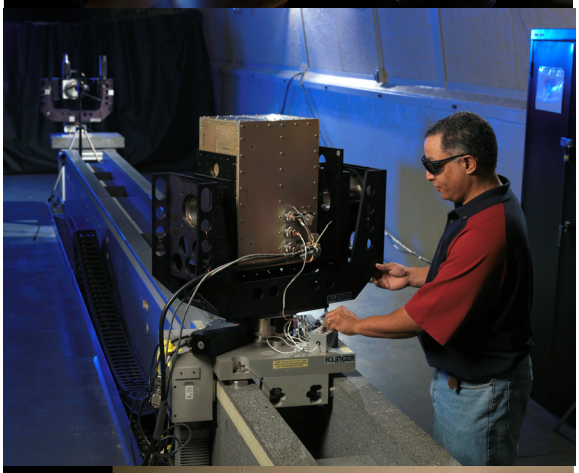
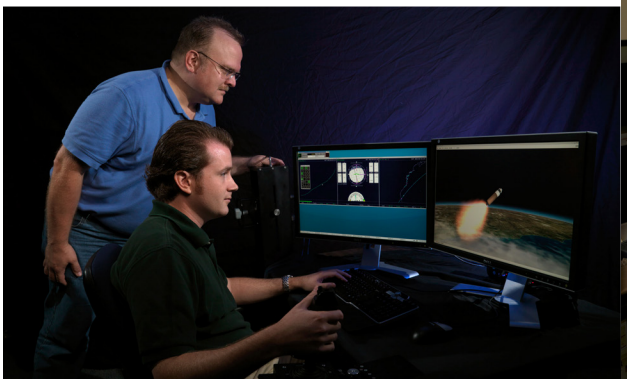
Guidance, Navigation, and Control

Johnson Space Center (JSC) provides leadership in architecture and algorithm design, development, and evaluation for navigation systems and autonomous and intelligent guidance, navigation, and control (GN&C) systems. JSC personnel perform systems requirement definition, analysis, design, and testing necessary to support the development of GN&C system designs and to verify the compatibility of the designs with functional and performance requirements. JSC also provides the technical expertise and facilities to support GN&C hardware and software development, testing, and verification. This includes real-time, hardware-in-the-loop and pilot-in-the-loop simulations; end-to-end GN&C system test and verification; and navigation systems definition, design, development, and test.

Services Provided

- GN&C flight hardware and software development, test, and verification – hardware and software interaction testing
- Spacecraft GN&C simulation design and development – real-time, hardware-in-the-loop and pilot-in-the-loop testing
- GN&C analysis – system requirements, functional architectures, system algorithms, system software requirements, dynamics, and control interaction
- Navigation architecture and algorithm design, analysis, and development and integration with navigation hardware design and testing
- Automated Rendezvous, Proximity Operations, Docking, and Undocking (RPODU) design, analysis, and operations; guidance and targeting algorithm design and analysis for RPODU
- Low Earth Orbit (LEO), trajectory optimization, design, and performance analysis
- Flight phase development and performance characteristics for ascent, orbit, interplanetary, deorbit, entry, skip-entry, aerocapture, and landing mission phases





Johnson Space Center

GN&C Laboratory Capabilities

Advanced GN&C Development Laboratory (AGDL)

The AGDL serves as a center of excellence for the development and evaluation of advanced GN&C systems. The laboratory provides the computational resources required to build high-fidelity, six-degree-of-freedom simulations of single and multiple-vehicle missions for various flight phases. It also provides excellent visualization capabilities and real-time (human-in-the-loop) simulation capabilities. The AGDL features Linux-powered blade servers with over 300 cores used to run Monte Carlo analysis, scheduling the blade resources through the open source scheduling software. This software allows engineers to submit their 2,000- or 3,000- run Monte Carlo analysis simulations to the laboratory and have those jobs automatically distributed across all the blades along with the jobs of all the other engineers in the laboratory. The AGDL makes extensive use of the Trick simulation environment and maintains a comprehensive suite of Trick-compliant simulation models for modeling rendezvous, proximity operations, and capture.

The AGDL also provides rapid hardware and software development, real-time hardware-in-the-loop simulation, and end-to-end GN&C system verification as well as development and evaluation of space-based navigation systems, including the design and development of space capable GPS receivers. Additional investigations include

- Absolute and relative on-orbit GPS navigation analysis
- Refined navigation filtering and sensor measurement combining
- Sensor analysis, particularly optical, RF, and inertial sensors

The AGDL also is home to specialized GPS and inertial test capability as referenced in the following tables:

	Model	Output	Channels	Frequency	GPS Attitude Capable?	Notes
GPS Signal Generators	Spirent 7700	4 RF	12	L1 only	Yes	Rack mounted/portable
	Spirent 4760	4 RF	16	L1 only	Yes	Rack mounted/portable
	Spirent 6560	4 RF	12	L1 only	Yes	Rack mounted/portable

	Table	Rotation Rates	Position Accuracy	Rotational Accuracy
3-Axis Rate Table	Acutronic Model 357L	500 deg/sec – Outer gimbal 1000 deg/sec – Middle gimba 1500 deg/sec – Inner gimbal	5 arc sec (All gimbals)	0.1% at 1 deg/s 0.01% at 10 deg/s 0.001% at 10 deg/s

Flight Mechanics Laboratory

The laboratory uses a high-performance Linux computing cluster, along with many specially-designed software tools, in order to solve various flight mechanical disciplines, including definition of GN&C concepts for orbital maneuvers, ascent, interplanetary, and entry/landing,

Kedalion Laboratory

The Kedalion laboratory supports software development, integration, testing, and analysis with an emphasis on flight software. It contains flight-like computer processors, high-fidelity, six-degree-of-freedom closed-loop simulations; human-in-the-loop hand controllers and display units; high-definition graphics simulation displays; full software development tool suites; and several guidance, navigation, and control sensor hardware stimulators. The hardware stimulators include a rate table (used to impart angular rates to a mounted inertial measurement unit) and a GPS signal generator (used to simulate flight by generating GPS radio frequency signals that are fed into GPS receiver hardware). The laboratory uses time-triggered gigabit Ethernet and Mil-Std 1553, among other bus topologies for flight bus emulations.

We have developed customer-friendly agreements to streamline business relationships and are eager to share our unique facilities and expertise with new customers. We invite your inquiries regarding application or adaptation of our capabilities to satisfy your special requirements. Briefings on general or specific subjects of mutual interest can be arranged at JSC or at your business site.

For the benefit of all

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