AUTONOMOUS NAVIGATION, GUIDANCE, AND CONTROL

National Aeronautics and Space Administration

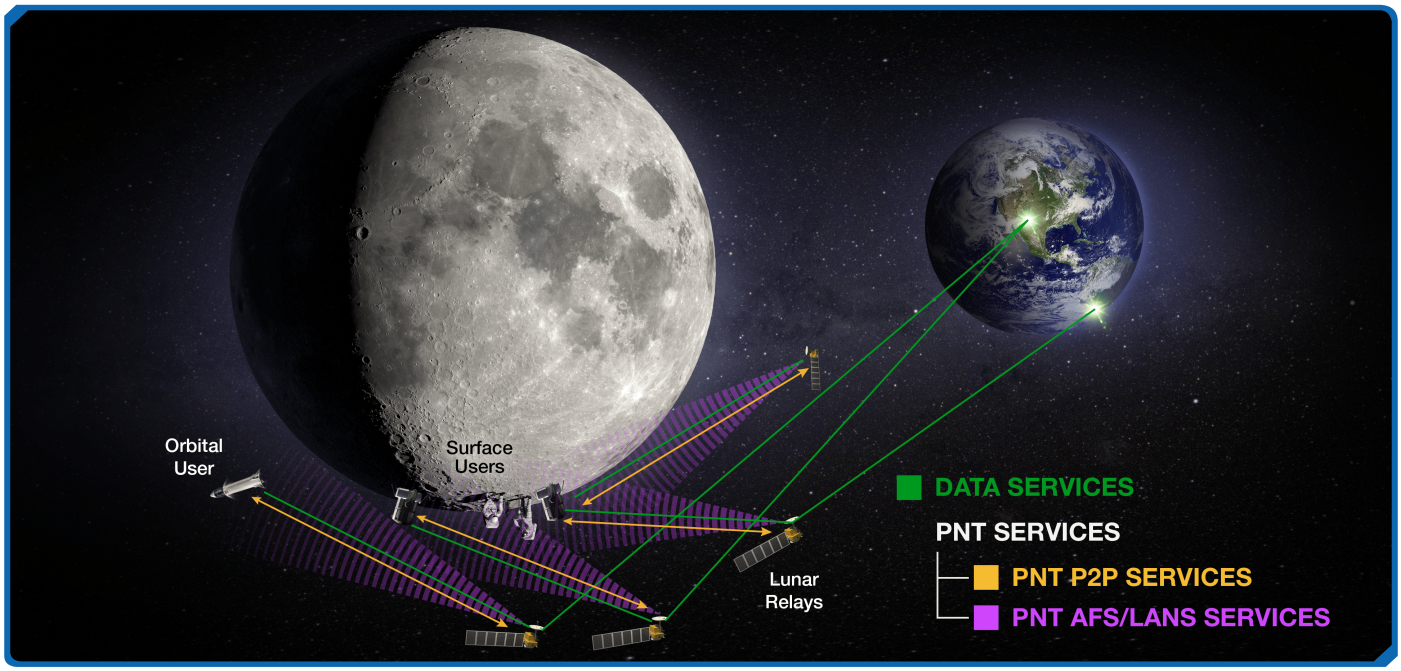
The farther NASA travels toward the Moon, Mars, and beyond, the more missions will need to function autonomously. NASA's Goddard Space Flight Center is developing an onboard core Flight System (cFS) application suite and flight hardware solution that performs autonomous spacecraft navigation, guidance, and control – or autoNGC – for a wide variety of missions. autoNGC will provide missions with onboard navigation support and executive decision / control for maneuvers, thereby enabling new mission capabilities including distributed space missions, in-space assembly, low-latency operations, lower reliance on ground assets, and reduced operations costs. autoNGC could significantly benefit space exploration by reducing mission cost, schedule, and risk and increasing scientific return.

AUTONGC, GEONS, AND CGIANT

The Goddard Enhanced Onboard Navigation System (GEONS) is an onboard navigation flight software library, and it is a key component of autoNGC. Developed as a multi-mission capability, GEONS can process many measurement types including Global Navigation Satellite Systems (GNSS), ground station and crosslink radiometric, optical data to estimate the orbital states, onboard clock errors, and additional parameters for one or more spacecraft in a variety of orbital regimes, including cislunar/lunar space. GEONS has over 20 years of flight heritage and is flying on the Magnetospheric Multiscale (MMS) mission.

The cFS Goddard Image Analysis and Navigation Tool (cGIANT) is a high-fidelity software suite used to perform autonomous, precision optical navigation (OpNav) based on the GIANT ground software successfully used on OSIRIS-REx. cGIANT, implemented in C++, integrates into the autoNGC tool suite, and has been demonstrated in both software and processor in-the-loop test environments.

Both GEONS and cGIANT are available for the Lunar Communications Relay and Navigation Systems (LCRNS) satellites at the Moon. LCRNS' position, navigation, and timing instrument would ingest a variety of measurement types and estimate the relay's position, velocity, and time with sufficient accuracy for the delivery of navigation services to user missions in cislunar space.



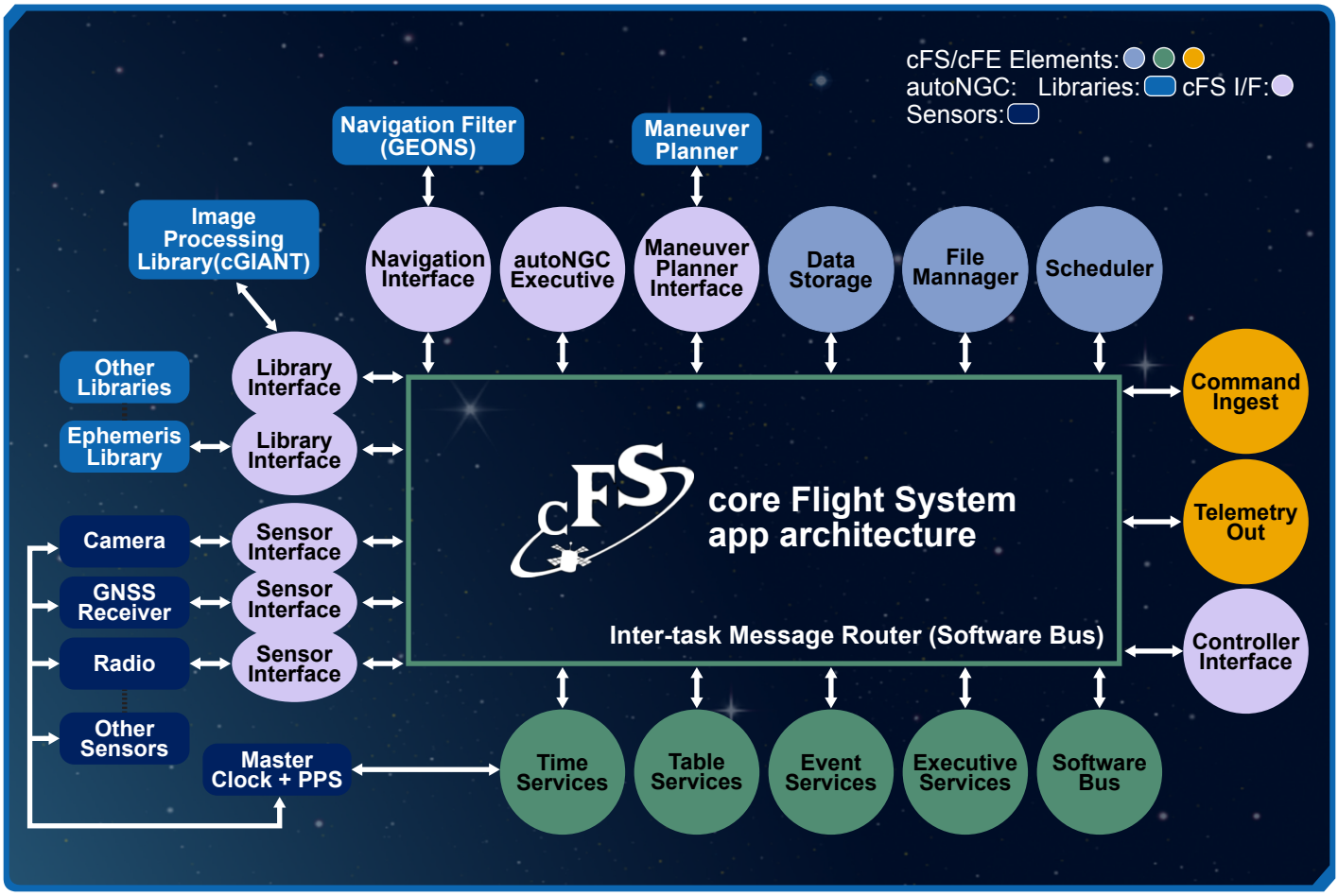
The Peer-to-Peer (P2P) Position, Navigation, and Timing service is where navigation data is directly shared with the user. The Lunar Augmented Navigation Service (LANS) is achieved by providing Augmented Forward Signals (AFS) to users, similar to GPS.

HARDWARE AND TECHOLOGY

The autoNGC system incorporates a wide variety of cFS-compatible navigation hardware and technology, from measuring velocity through Doppler shifts in communications signals or onboard inertial sensors to radar, lidar, or optical navigation using data from a variety of cameras. It could even use X-ray pulsar navigation – a concept developed out of the Station Explorer for X-ray Timing and Navigation Technology (SEXTANT) system – to navigate space by tracking millisecond pulsars.

Other ongoing adaptations being developed within the same cFS and autoNGC system architecture include: improving lidar 3D imaging for steering, navigation, and hazard avoidance; developing an active wavelength scanning lidar; improving optical navigation techniques for future small-body sampling missions; improving combined optical and lidar navigation solutions for lunar landers; developing and testing a Space Qualified Rover Lidar (SQRLi) for use on planetary missions, and investigating how autoNGC could benefit future distributed space missions. Advanced processing and memory cards for space use are also being developed to enable fast reliable computational capabilities needed by autoNGC.

Scalability, adaptability, and a universal operating system for spacecraft make the combination of cFS, autoNGC, and optical navigation a powerful constellation to guide future deep space and planetary missions.



autoNGC Flight Software on the Core Flight System Plug-N-Play Architecture

LEARN MORE

To learn more about autoNGC, visit

https://go.nasa.gov/40KruOt