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Autonomous Navigation, Guidance, and Control Software in a Low SWaP Box

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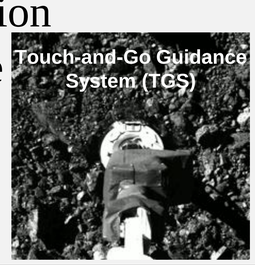
What is autoNGC?

*An **onboard** software application suite built on the core Flight System (cFS) and flight hardware solution that performs real-time **autonomous** spacecraft navigation, guidance, and control (NGC)*

Why autoNGC?

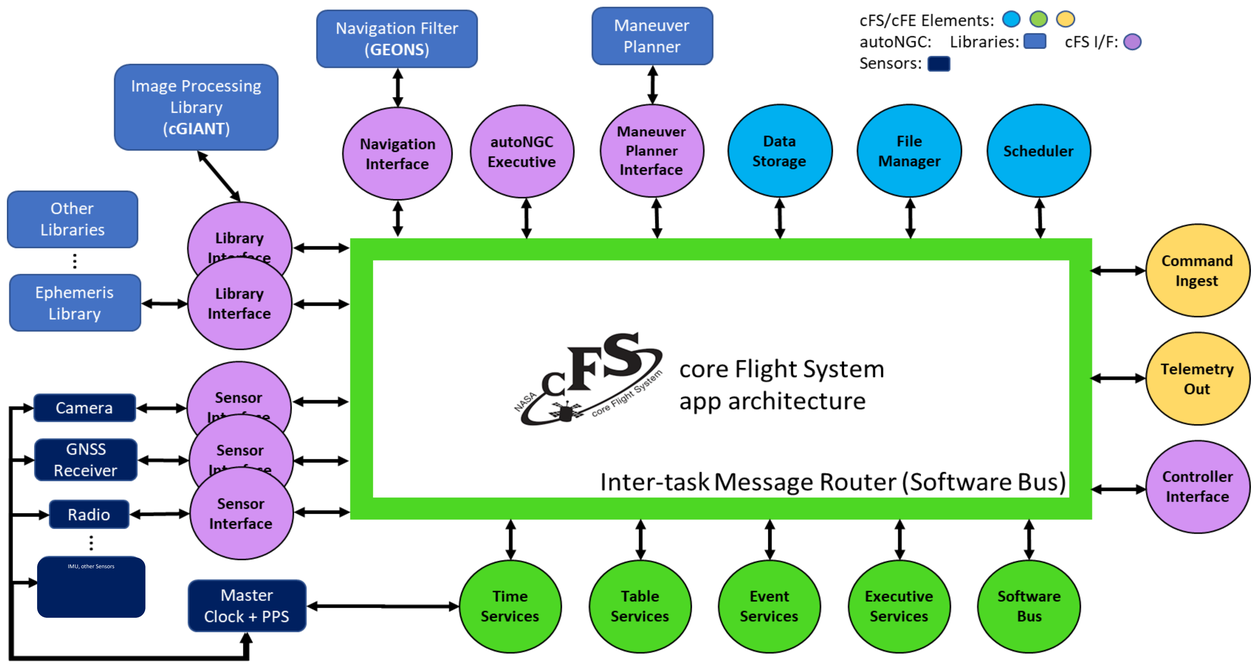
- Reduces reliance on over-subscribed ground assets and costly ground operations
- Enables new mission capabilities
  - Low latency mission operations, e.g. in-situ planning and execution
  - Complex missions at far distances, e.g., Touch-and-Go Guidance
  - Distributed Systems Missions (DSMs)
  - Dynamic replanning and reallocation of orbital assets
- Readily adaptable to reduce mission cost, schedule, and risk



autoNGC Attributes:

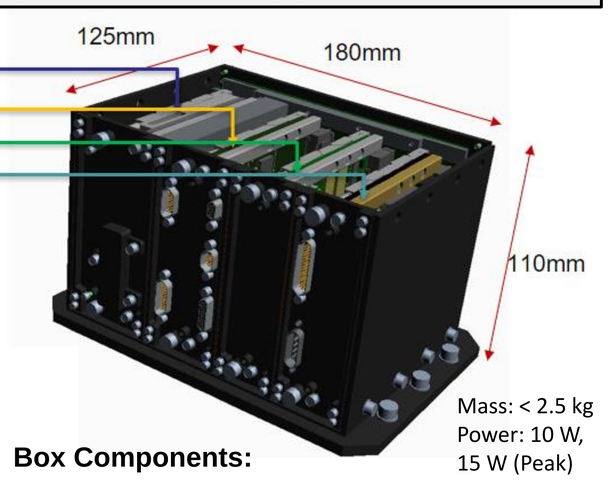
- Resilient across multiple orbit regimes
- Heritage design elements
- Plug-n-play customizable architecture
- Fault tolerant autonomy
- Low SWaP hardware & modular implementations – suitable for a wide range of mission types

Plug-n-play cFS architecture allows customization and insertion of new capabilities, even in flight



Key autoNGC Flight Software Libraries

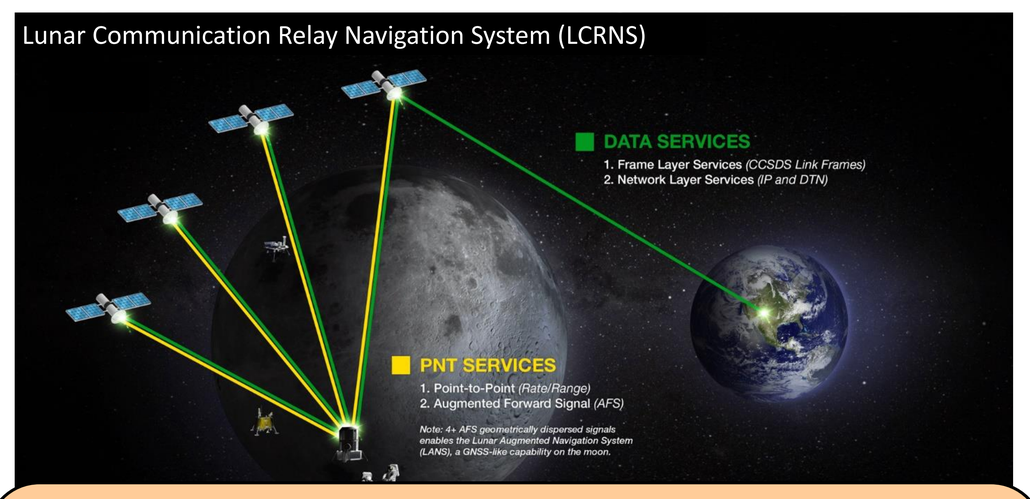
- Goddard Enhanced Onboard Navigation System (**GEONS**) – extended Kalman filter
  - Nominal and weak signal GNSS
  - Terrain Relative Navigation (TRN)
  - Limb/centroiding optical navigation
  - 1-way & 2-way range & Doppler: ground & relay
  - Accelerometer
  - Celestial object bearing
  - LiDAR
- cFS Goddard Image Analysis and Navigation Tool (**cGIANT**) – advanced image processing



Mass: < 2.5 kg
Power: 10 W, 15 W (Peak)

Box Components:

- **Two Processor Card Implementation**
  - **Primary Processor Card**
    - Xilinx Kintex UltraScale with RISC-V Software Processor
    - 2GB DDR3 SDRAM (x72 wide for ECC) / 2x 16GB NAND Flash
  - **Secondary Processor Card**
    - Xilinx Zynq with Dual ARM Cortex-A9
    - 1GB DDR / 4GB NAND Flash
- **Low Voltage Power Card (LVPC)**
  - 28V Input, 6x internal switched services of 3.3V, 5.0V or 12V power rails
- **Configurable IO Card**
  - 12 Buffered Differential Transmitters (LVDS or RS422)
  - 12 Buffered Differential Receivers (LVDS or RS422)
  - 16 Buffered Single Ended Lines
  - 32 Un-Buffered Signals – Routed as Differential Pairs
- **Backplane**
  - Power Distribution, 8-Channel Temperature Monitoring, and Point-to-point topology for high-speed data interfaces



Upcoming Milestones

- LCRNS PNT Instrument TRL 5 ~ early 2025
- TRN/LiDAR Touch-and-Go Guidance Field Test 2025
- Flight Test on CAPSTONE spacecraft (already in Lunar Gateway orbit) 2025

Sample Lunar Navigation Flight Software-in-the-Loop Simulation

12-hour elliptical frozen orbit with Terrain Relative Navigation and Weak Signal GPS (shown below ~9 hours into sim)