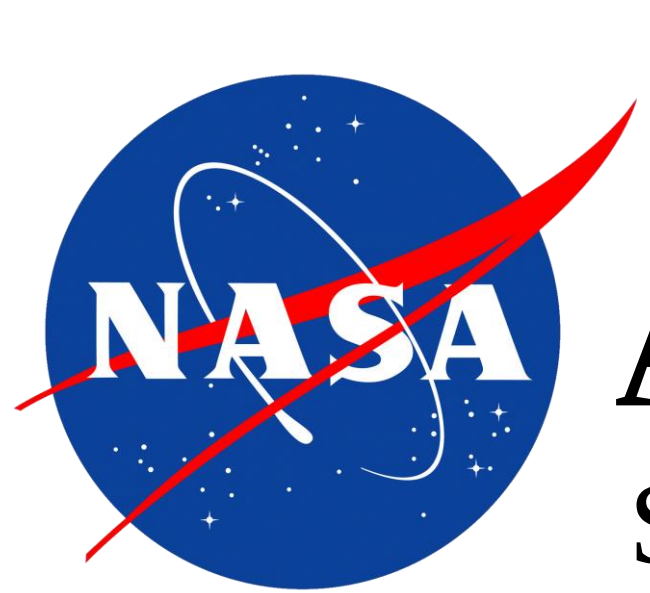




Autonomous Navigation, Guidance, and Control Software in a Low SWaP Box

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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?

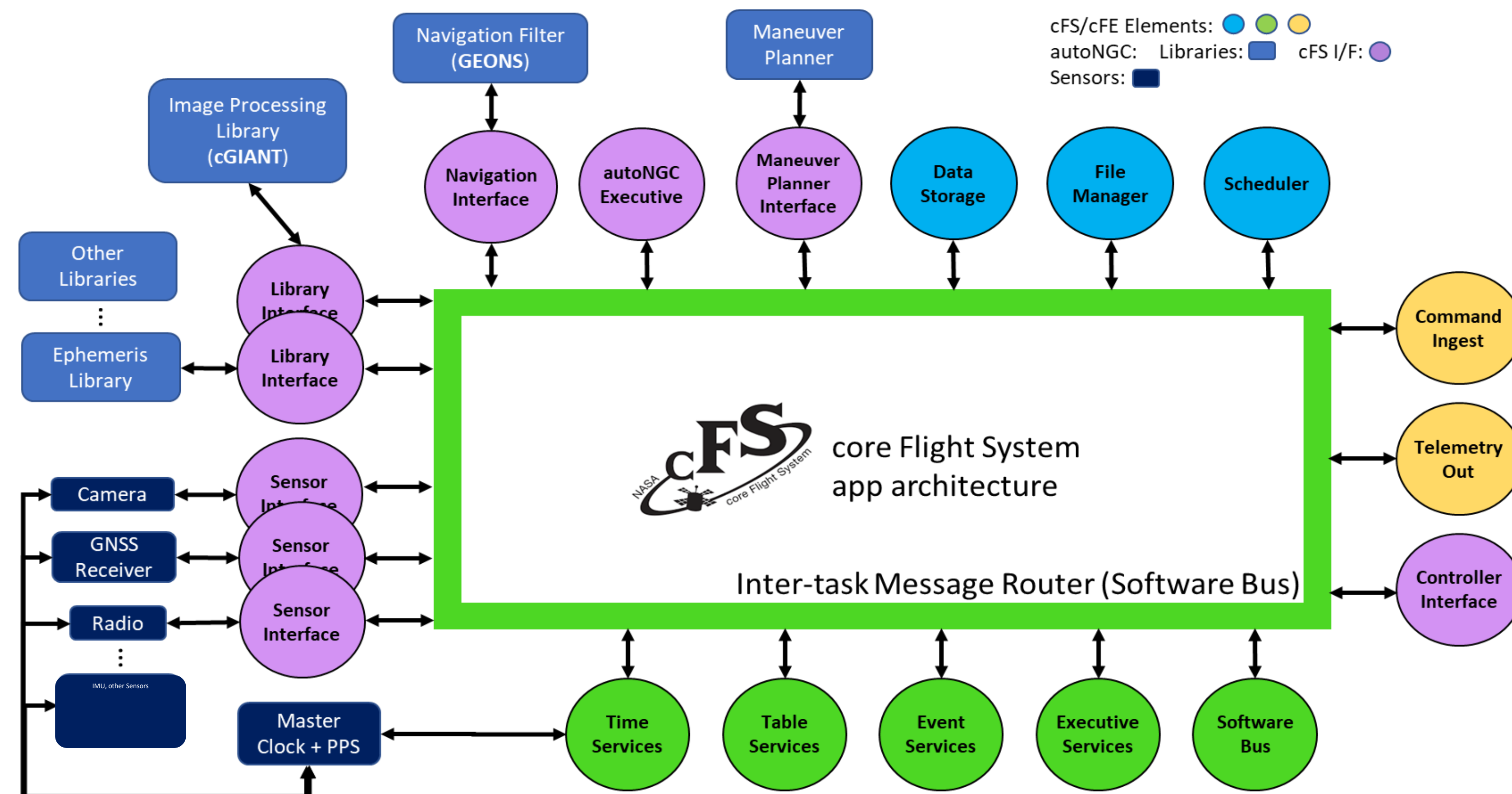
- Reduces reliance on over-subscribed ground assets and costly ground operations
- Enables new mission capabilities
 - Low latency mission operations, e.g. in-situ planning and execution
 - Complex missions at far distances, e.g., Touch-and-Go Guidance
 - Distributed Systems Missions (DSMs)
 - Dynamic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



autoNGC Attributes:

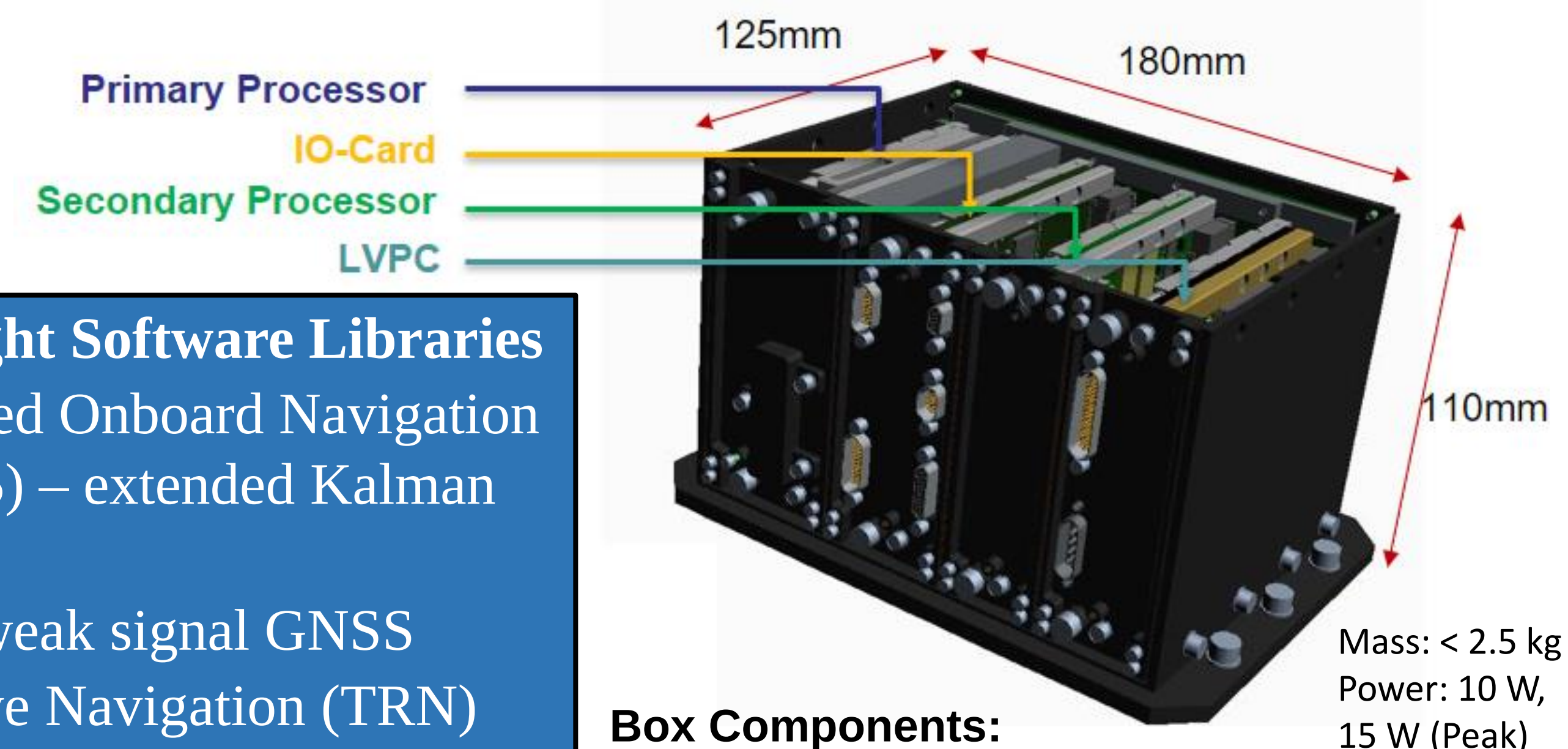
- Resilient across multiple orbit regimes
- Heritage design elements
- Plug-n-play customizable architecture
- Fault tolerant autonomy
- Low SWaP hardware & modular implementations – suitable for a wide range of mission types

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



Key autoNGC Flight Software Libraries

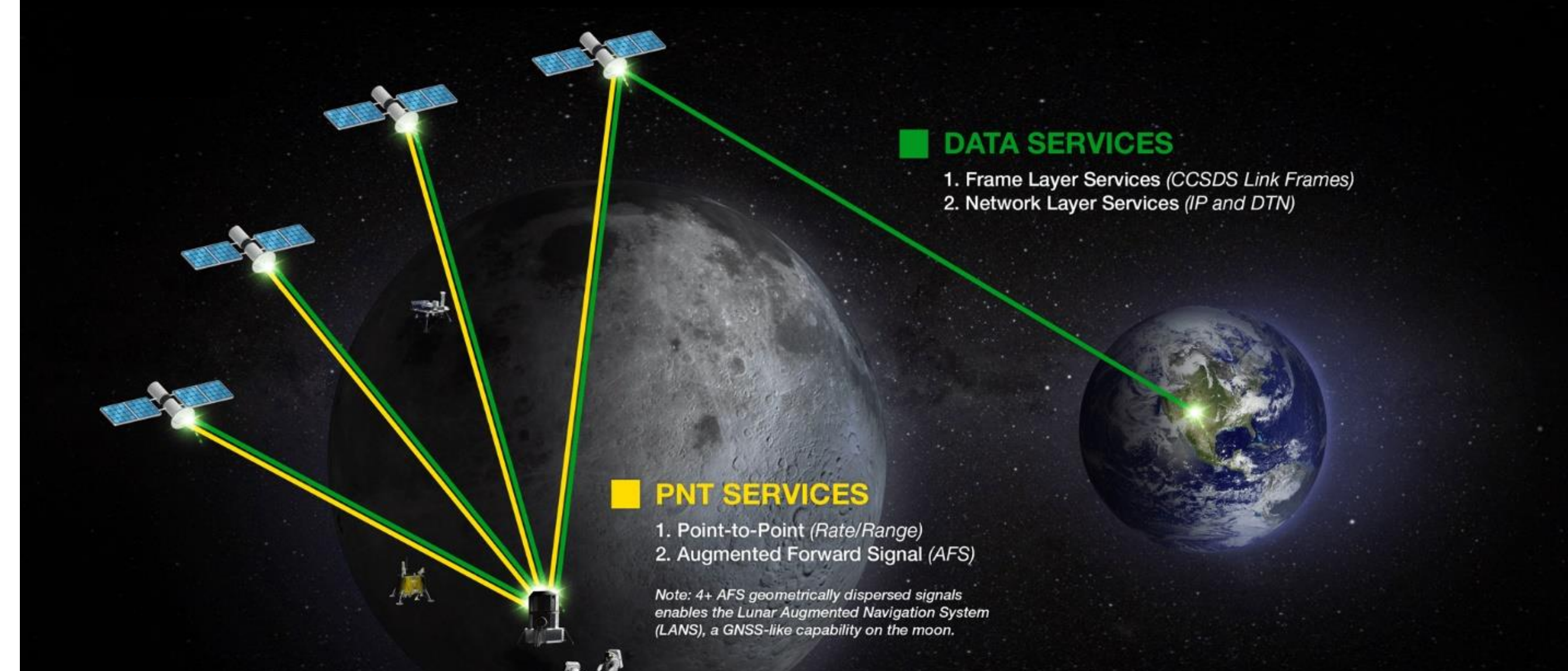
- Goddard Enhanced Onboard Navigation System (GEONS) – extended Kalman filter
 - Nominal and weak signal GNSS
 - Terrain Relative Navigation (TRN)
 - Limb/centroiding optical navigation
 - 1-way & 2-way range & Doppler: ground & relay
 - Accelerometer
 - Celestial object bearing
 - LiDAR
- cFS Goddard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



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

Lunar Communication Relay Navigation System (LCRNS)



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)

