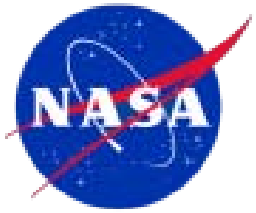

Avionics System Architecture for NASA Orion Vehicle

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TTA Group Open Forum

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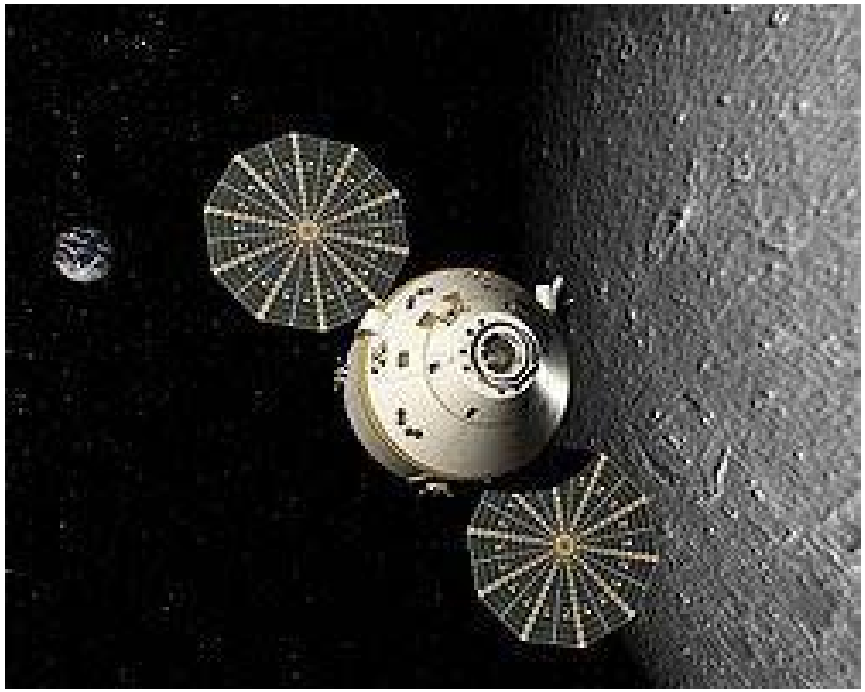
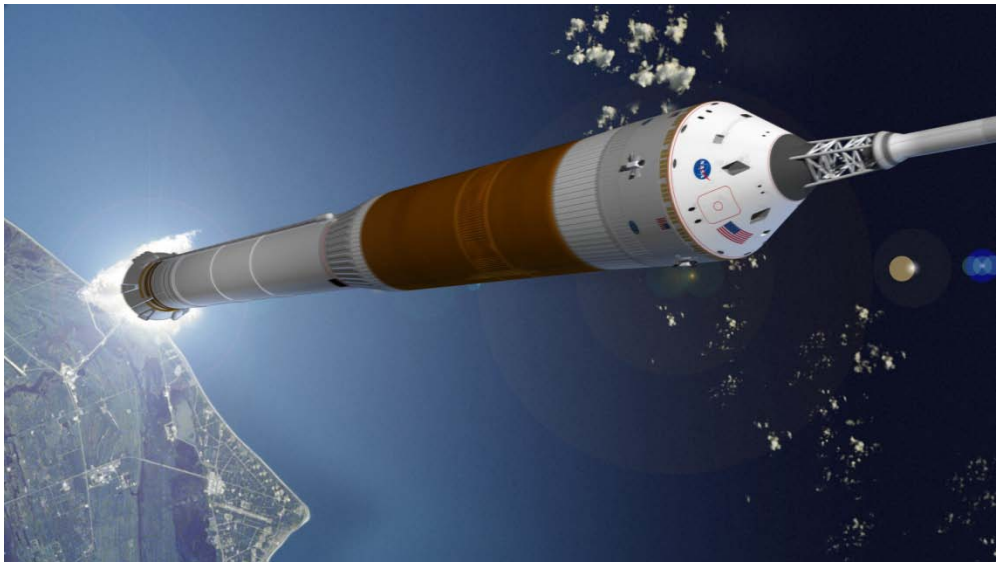
What is Orion?

- The Orion Crew Exploration Vehicle will provide a capability to deliver humans to space reliably and return them safely
- Orion is currently under development by NASA, Lockheed Martin, and other industry partner
- The first Orion spaceflight will be an uncrewed flight test



Orion Concept of Operations

- Potential Orion mission objectives include delivering a crew to the International Space Station, transporting a crew to a near-Earth objects, and providing emergency return capability from the International Space Station



- Crew of 4
- Crew launch from Kennedy Space Center
- Ocean landing off California coast
- Ability to abort during launch

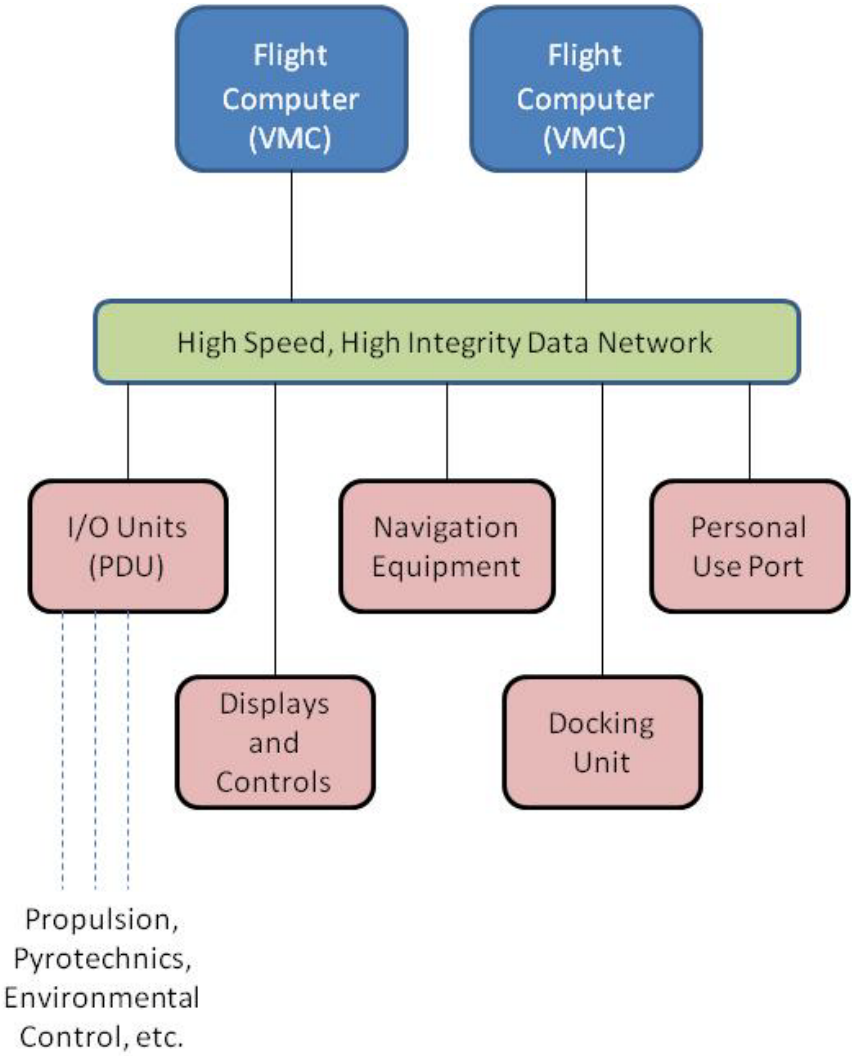
Orion Subsystems

- Orion contains the following vehicle subsystems:
  - Propulsion
  - Vehicle power
  - Life support
  - Communications
  - Docking adapter
  - Structures
  - Pyrotechnics
  - Displays and Controls
  - Parachutes
  - Guidance & Navigation
  - Mechanisms
  - Crew Systems
  - Thermal Control
  - Thermal Protection
- *The Orion Avionics subsystem must provide an infrastructure to command, control, and monitor all of these subsystems*

Orion Avionics Architecture

- Orion uses an IMA-based high integrity architecture with the following elements:
  - Vehicle Management Computers (VMCs)
    - Provides a central computing platform to host software applications for a variety of vehicle subsystems
  - Time-Triggered Ethernet (TTEthernet) Onboard Data Network
    - Provides priority-based network communications via time triggered, rate constrained, and best effort traffic classes
  - Power and Data Units (PDUs)
    - Provides sensor data gathering, actuator control, and power distribution for critical vehicle subsystems

Orion Avionics Architecture

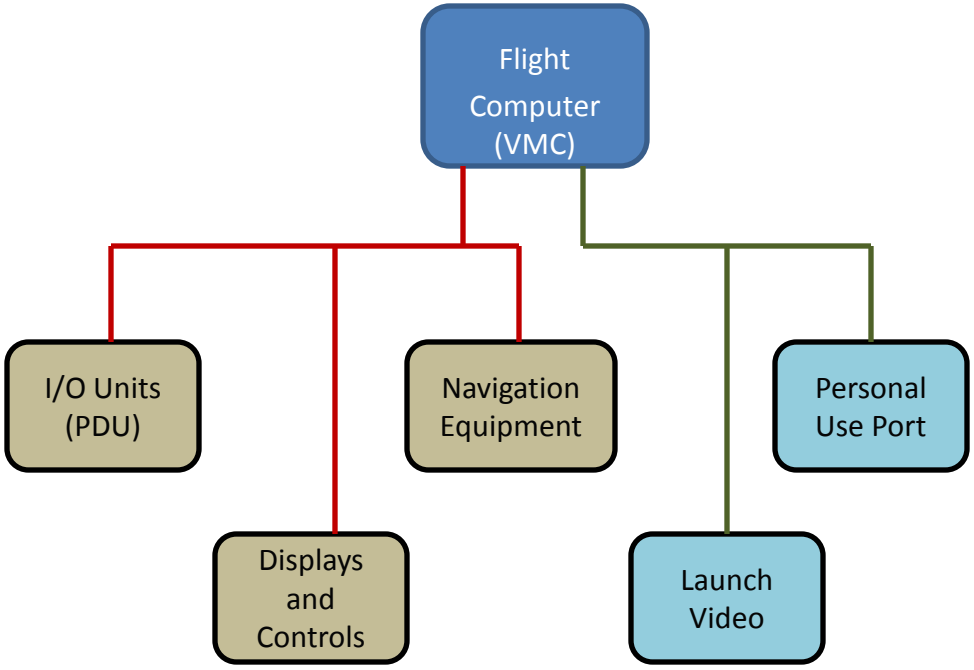


Orion Avionics- *Network*

- Orion uses Time Triggered Ethernet (TTEthernet) to provide high-integrity, deterministic data network communications across the vehicle
  - The data network is deterministic to guarantee latency and response time for critical sensors and effectors
  - Traffic classes (time triggered, rate constrained, and best effort) allow prioritization of network data
  - Cross-comparison of data provides fault containment at the network switches and safety critical interfaces

Orion Network Unification

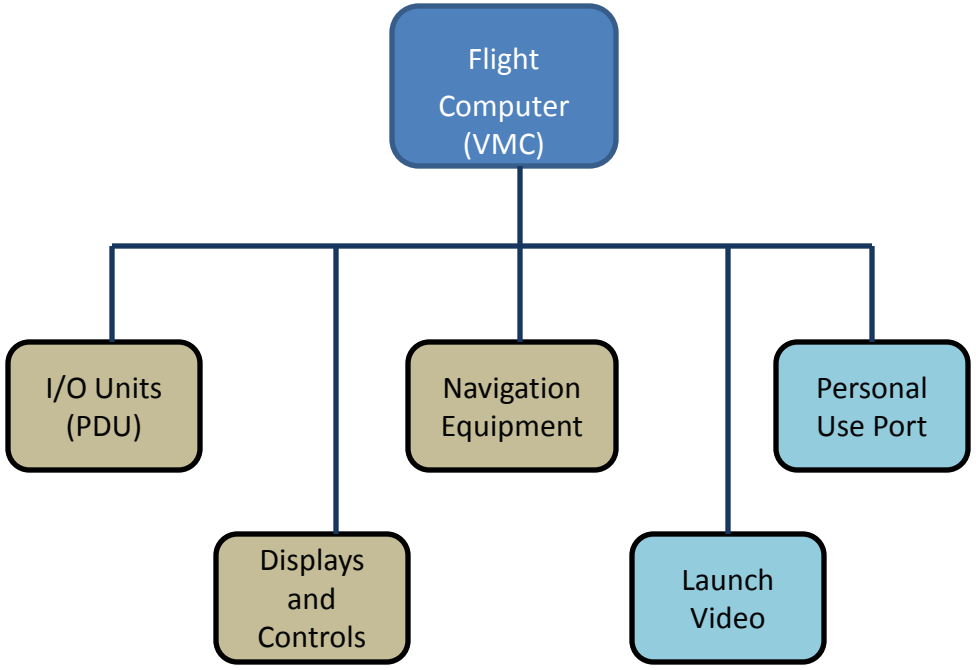
- The original Orion architecture contained two Ethernet-based data networks:



- A flight-critical control bus that handled time-sensitive and/or safety critical commands
- A general-purpose data bus that handled non-critical traffic such as video and personal crew equipment

Orion Network Unification

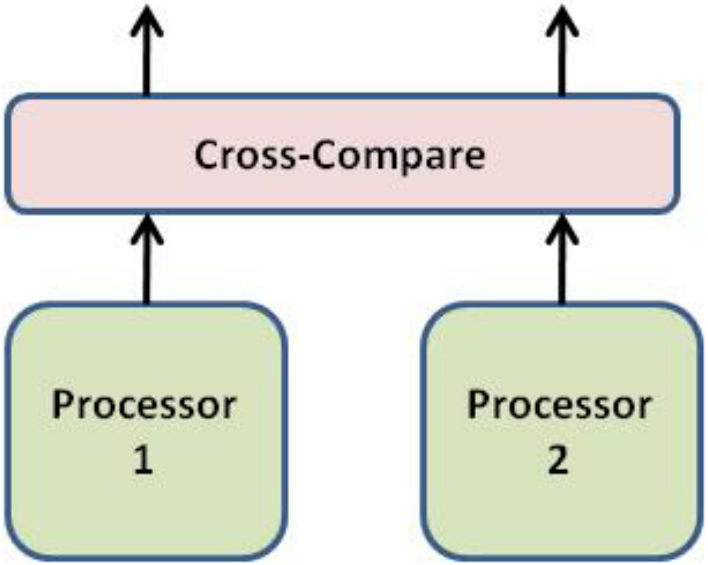
- However, to reduce vehicle size, weight, and power while maintaining acceptable reliability, Orion collapsed both networks into one, TTEthernet-based infrastructure



- Critical or time-sensitive data utilized time-triggered or rate-constrained TTEthernet traffic classes
- Video and personal crew data utilized the best effort TTEthernet traffic class

Orion Avionics- *Integrity*

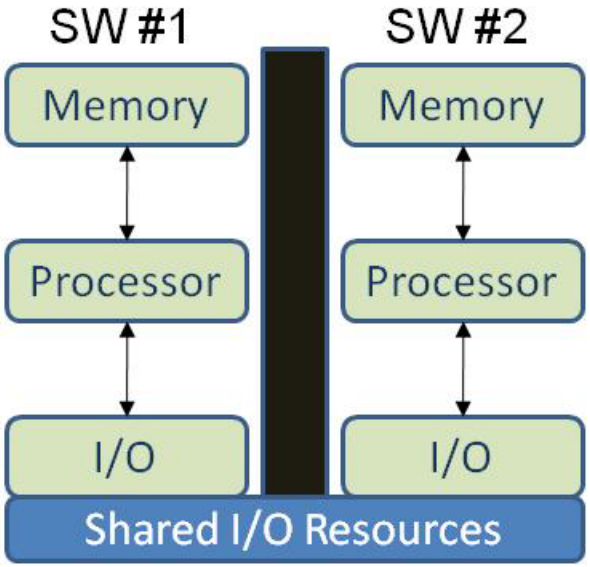
- Orion VMCs utilize a self-checking pair of processors to ensure the integrity of commands issued to vehicle subsystems



- Each VMC contains two processors
- Each processor independently runs the same applications
- The processor outputs are bit-by-bit compared to one another
- If any miscompares are detected between the outputs, that command is truncated

Orion Avionics- *Partitioning*

- Orion VMCs utilize time and space partitioning of software and memory to ensure faults do not propagate between systems
  - VMCs execute code for a variety of software applications supporting various vehicle systems
  - Code for each software application is located in a unique, specific memory space
  - Each software application runs during a specific, periodic slice of time
  - As a result, faults from one system will not threaten the execution of other systems' code



Orion Avionics- *Redundancy*

- Orion avionics uses simple redundancy (minimum one fault tolerance) to ensure that commands are successfully received
  - A command follows the following sequence:
    - A command is generated on each VMC
    - It is then sent simultaneously over two plane of the Data Network
    - The valid command is received from both VMCs at each of two PDUs
    - The PDUs send control signals initiated by the commands to redundant effectors