CubeSat Flight Software Workshop

Flight Software System Engineering And Architecture

Timothy Canham
Flight Software Engineer
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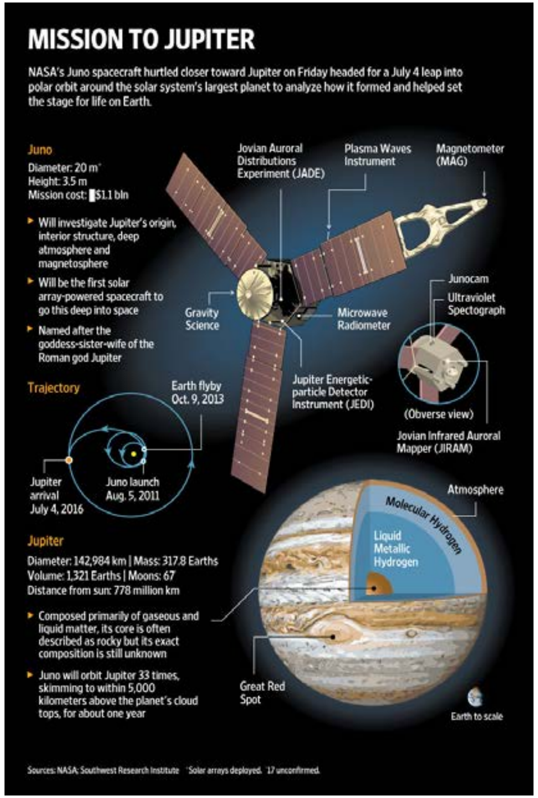
Jet Propulsion Laboratory
California Institute of Technology

Flight Software System Engineering and Architecture

- **Definition** – Designing the various functions of the flight software and their interactions with the spacecraft and each other
- Understanding the mission objectives
  - What does the mission want to accomplish?
- Understanding the spacecraft system
  - How is the spacecraft design going to enable accomplishing the objectives?
- Concept of Operations
  - How are you going to operate the spacecraft to achieve the objectives?



MISSION TO JUPITER

NASA's Juno spacecraft hurtled closer toward Jupiter on Friday headed for a July 4 leap into polar orbit around the solar system's largest planet to analyze how it formed and helped set the stage for life on Earth.

Juno

Diameter: 20 m*
Height: 3.5 m
Mission cost: $1.1 bln

- Will investigate Jupiter's origin, interior structure, deep atmosphere and magnetosphere
- Will be the first solar array-powered spacecraft to go this deep into space
- Named after the goddess-sister-wife of the Roman god Jupiter

Jupiter

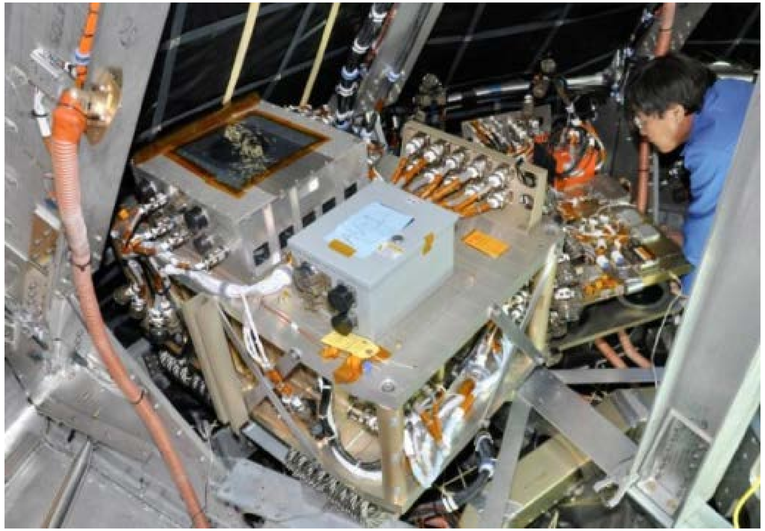
Diameter: 142,984 km | Mass: 317.8 Earths
Volume: 1,321 Earths | Moons: 67
Distance from sun: 778 million km

- Composed primarily of gaseous and liquid matter, its core is often described as rocky but its exact composition is still unknown
- Juno will orbit Jupiter 33 times, skimming to within 5,000 kilometers above the planet's cloud tops, for about one year

Sources: NASA; Southwest Research Institute *Solar arrays deployed. 17 unconfirmed.

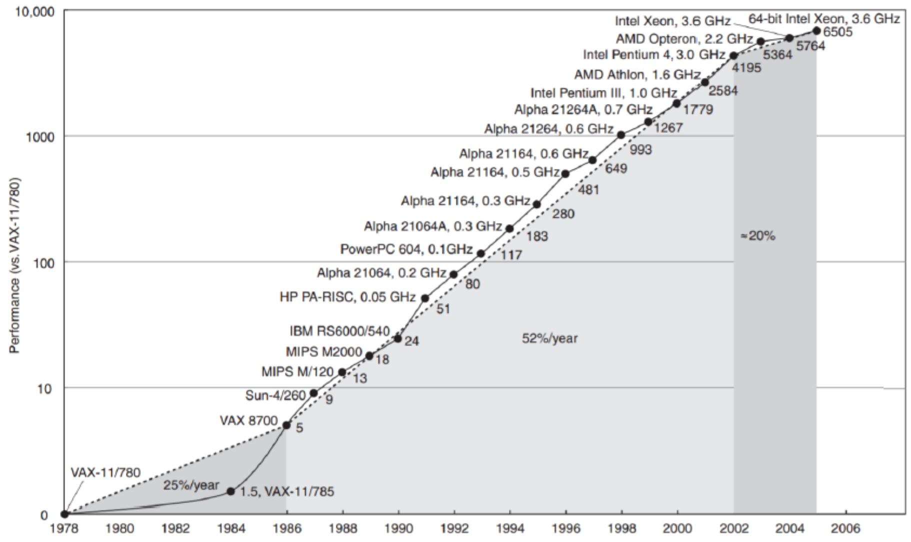
Flight Software System Engineering and Architecture

- Understanding the interfaces to the system
  - How does it interact with the environment?
  - How does it interact with payloads?
  - What is the avionics platform?
  - What is the execution environment?
    - RTOS, Non-RTOS, bare metal


Orion

Flight Software System Engineering and Architecture

- Understanding the requirements
  - Performance
    - Deadlines
    - Computing load
    - Data throughput
  - Resources
    - Energy
    - Memory
    - Storage
  - Activities
    - Behaviors to complete mission
  - Testability



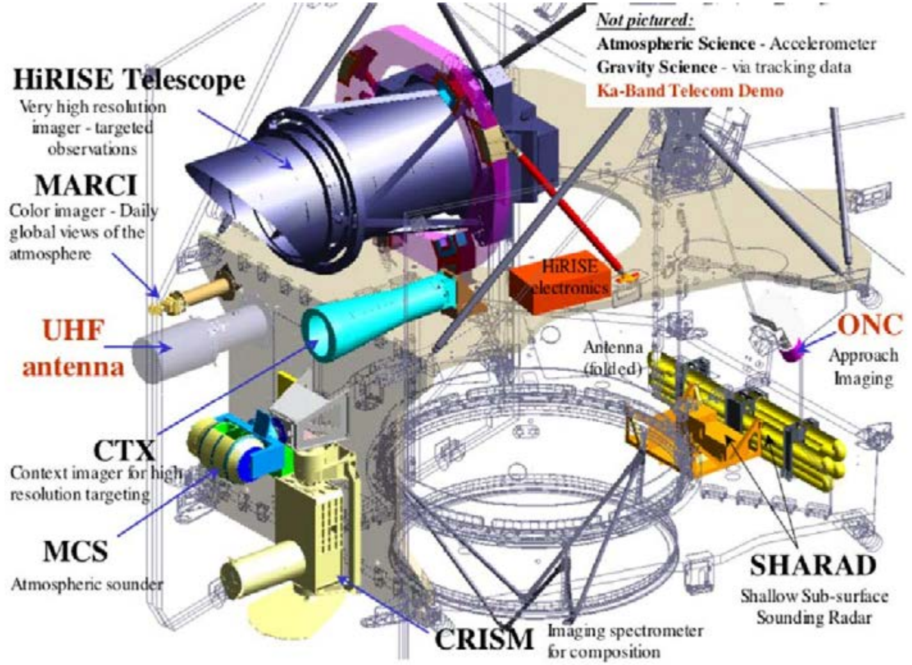
Moore’s Law

Spacecraft Subsystems – Hardware Layering

Peripheral
(Payload, Power,
Telecom, etc)

I/O
Device

Processor



Not pictured:
Atmospheric Science - Accelerometer
Gravity Science - via tracking data
Ka-Band Telecom Demo
HiRISE Telescope
Very high resolution imager - targeted observations
MARCI
Color imager - Daily global views of the atmosphere
UHF antenna
CTX
Context imager for high resolution targeting
MCS
Atmospheric sounder
HiRISE electronics
Antenna (folded)
ONC
Approach Imaging
SHARAD
Shallow Sub-surface Sounding Radar
CRISM
Imaging spectrometer for composition

MRO Spacecraft

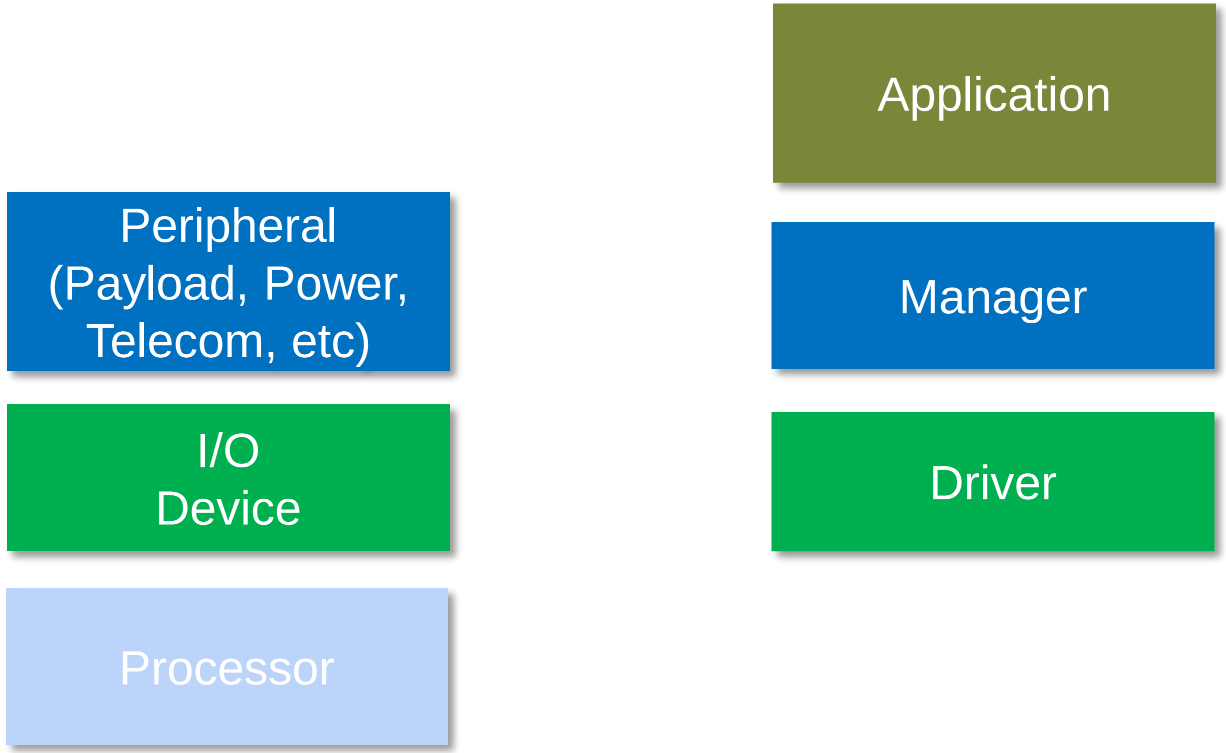
Flight Software System Engineering and Architecture

- Hardware layers are designed (for the most part) to be modular and reusable
  - Peripherals can be reused
  - I/O can be reused
  - Processors can be reused
  - Layers can be tested independently
  - Clear interfaces
- Software
  - Software should be layered for the same purpose
  - Modularity
  - Reusability
  - Testability

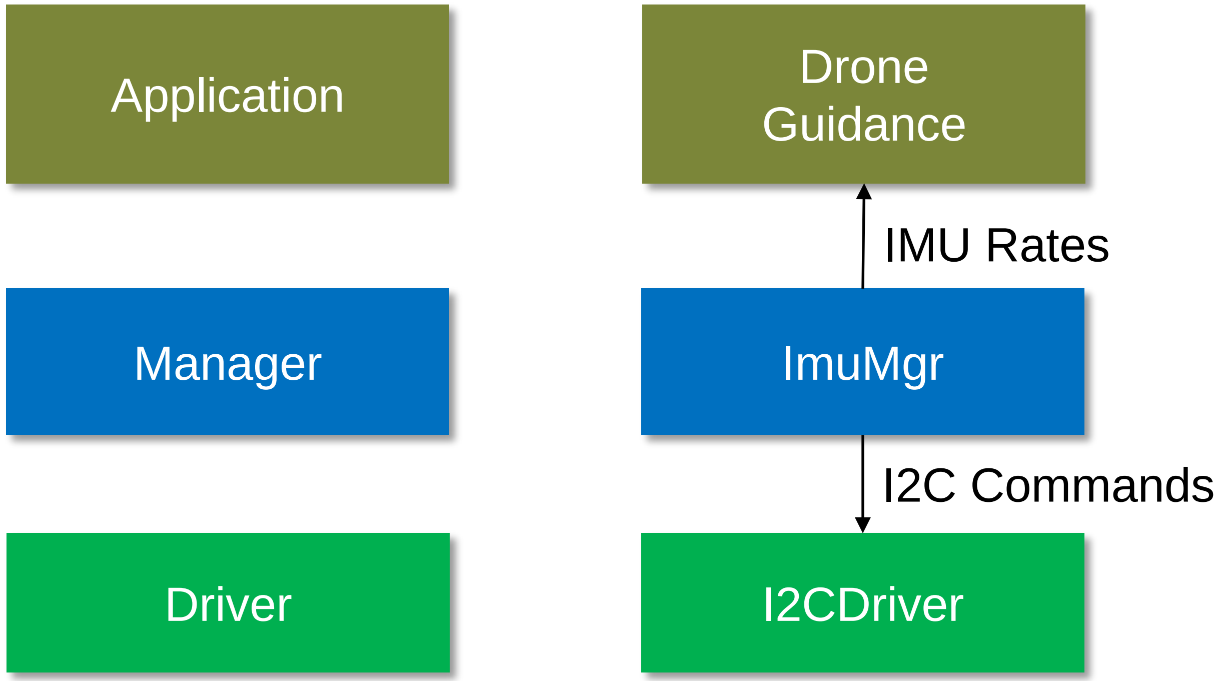
Software System Architecture

- Decompose software into modules
  - Separation of function
  - Definition of interfaces
  - Behavioral characteristics
    - Rate groups
    - Concurrency
    - Data flow
  - Test at the unit level
  - Ownership

Spacecraft Subsystems – Software Layering



Example - IMU



Adafruit I2C IMU

Software Layers

- Driver
  - Dedicated to a particular hardware interface
  - Written to interact with that device only
    - Interrupt driven, polling
  - Should not need to know use of hardware
  - Provide abstracted interface
- Manager
  - Manages a particular peripheral
  - Uses the interface driver at abstract level
  - Should not know the use of the peripheral
  - Also provide abstracted interface
- Application
  - Implements mission specific use of the peripheral (and others)
  - Should not know about the driver to get to the peripheral
- Calls should be down the layers; no upcalls

Software Layers

- Layering allows:
  - Separation of concerns
    - Only implement logic for that layer
  - Reusability
    - Reuse software modules on other projects
  - Replacement
    - Abstraction allows layers to be replaced with other implementations with same interface
    - New driver or manager
    - Simulation
  - Testing
    - Layers can be tested at their level with stubs for lower levels
  - Fault protection
    - Faults can be handled at the appropriate layers

References (shortened via bitly.com)

- Juno - https://yhoo.it/2QmFedE
- Orion - https://bit.ly/2YVga0B
- Moore’s Law - https://bit.ly/2K4nZgc
- MRO - https://bit.ly/2VUQH5D
- IMU - https://bit.ly/2jF4rlo

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