Payload Accommodation

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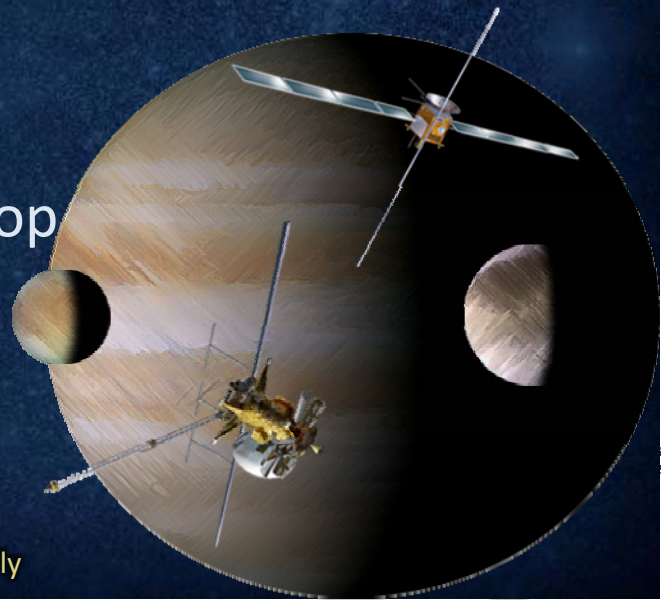

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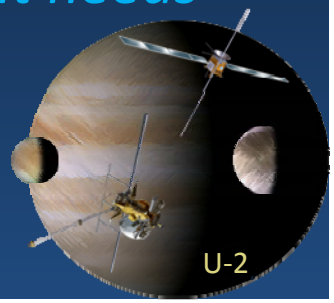
Pre-Decisional - For Planning & Discussion Only

Payload Accommodation

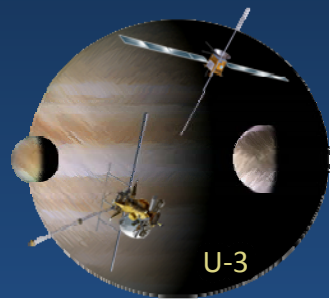
- The project will be performing trade studies that impact payload accommodation *in parallel* with the instrument selection process
  - Input from the instrument community can help shape the outcome of these early trade studies
  - This presentation provides instrument teams with the latest project thinking on:
    - Spacecraft to instrument mechanical, thermal and electrical interfaces
    - Instrument use of a shared Science Electronics Chassis
    - Possible services provided to instruments by the spacecraft
    - Possible project supplied hardware for instrument use
- *Feedback from the instrument community is requested to help ensure that early decisions are consistent with instrument needs*



Mechanical Accommodation (1)

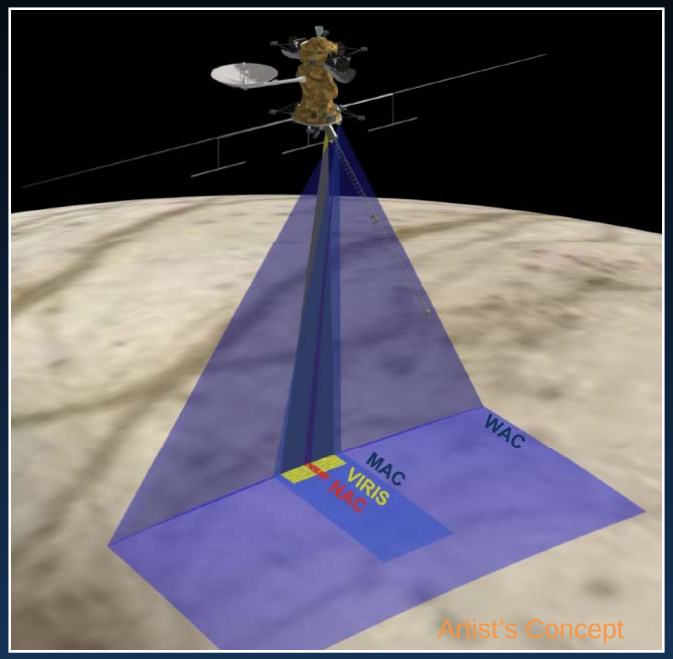
- JEO Approach : All instruments would be located on spacecraft nadir deck
  - Co-location facilitates possible implementation of a separable payload module
    - Separable payload module would allow parallel integration and test with the spacecraft
  - Co-location facilitates the use of a shared electronics chassis
    - Shared chassis reduces the required radiation shielding mass
  - Current baseline = ~3 meter circular nadir deck
    - Some increase in deck dimension OR change of shape would be possible within the current fairing envelope
  - Current baseline = All instrument electronics also on the nadir deck
    - Intra-instrument cable length can be minimized

Nadir Deck

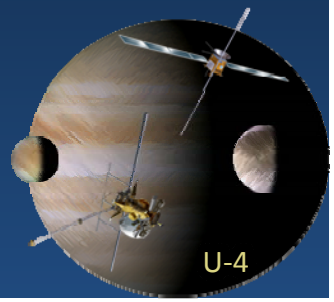


Mechanical Accommodation (2)

- JEO Approach: Remote sensing instruments would be co-boresighted
  - Co-boresighting would simplify fly-by operations during the Jupiter tour
    - All eyes would be on the same target at the same time during fly-bys
  - Co-boresighting would enable mapping operations at Europa
    - Fixed nadir pointing would provide global map coverage in the shortest possible time
  - Co-boresighting would simplify targeted observations at Europa
    - All eyes would be on the same target at the same time during off-nadir targeted observations during Campaign 4
  - Exceptions such as limb viewing instruments are possible provided they are compatible with spacecraft nadir pointing during Europa mapping campaigns

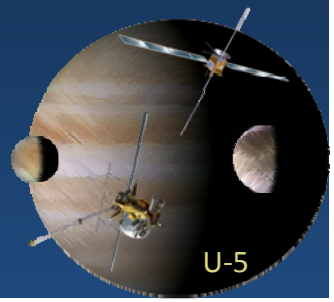


JEO in targeted observation mode



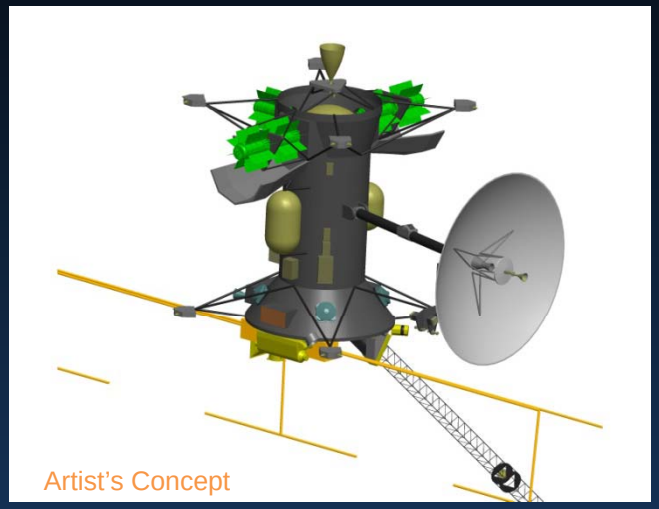
Mechanical Accommodation (3)

- JEO Approach : Instruments requiring articulation must provide that capability as part of the instrument
  - No spacecraft scan platforms will be provided
  - Examples of possible instrument articulation include:
    - Stellar occultations
    - Limb sounding
    - Target motion compensation
    - Deep space calibration (frequent)
  - Two instruments in the JEO Planning Payload are assumed to require articulation within the instrument
    - Vis-IR Spectrometer (target motion compensation)
    - UV Spectrometer (stellar occultations)
  - Periodic (infrequent) spacecraft maneuvers for payload-wide calibration events while in Europa orbit are under consideration

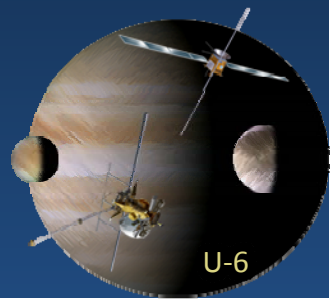


Mechanical Accommodation (4)

- JEO Approach : Instruments requiring deployments must provide that capability within the instrument – except the Magnetometer
  - Magnetometer boom would be supplied as part of the spacecraft
    - Boom design is considered generic and not part of the competed science investigation
    - Current baseline = 10 meter boom allowing probes at the tip and the half-way point
  - Ice Penetrating Radar antenna must be supplied as part of the instrument
    - Antenna design is considered specific to any given science investigation
    - Antenna shown is notional only
  - Booms and antennas for other instrument types must be supplied as part of the instrument

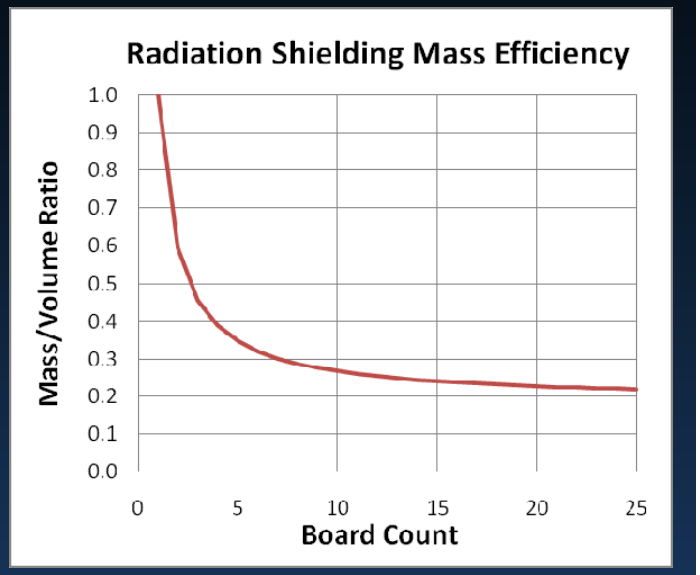


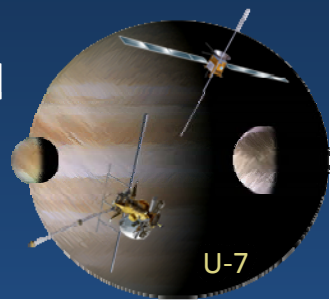
JEO with deployed MAG boom and IPR antenna



Mechanical Accommodation (5)

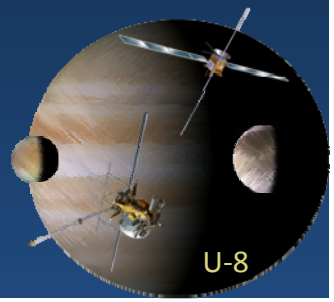
- JEO Approach : Instrument electronics, to the extent possible, would be co-located in a Science Electronics Chassis
  - Improved shielding mass efficiency is the driving reason for this approach
    - A larger chassis provides the same shielded volume with lower mass than multiple smaller chassis
    - Example shown does not include additional efficiency improvement from shielding provided by adjacent electronics
  - Current baseline = 6U compact PCI format
    - 233 mm x 160 mm board size
  - Current baseline = 22 boards
    - Based on assumptions made for the 2008 study
  - Current baseline = 0.4 cm Ta shielding, allowing 300 krad parts
  - Splitting the Science Electronics Chassis into two chassis would not significantly impact radiation shielding mass efficiency





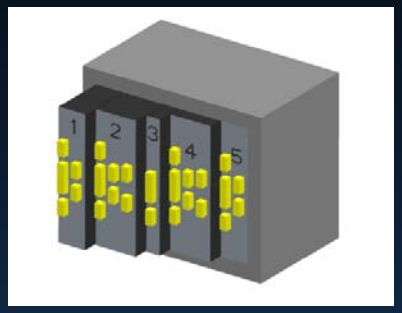
Mechanical Accommodation (5 cont.)

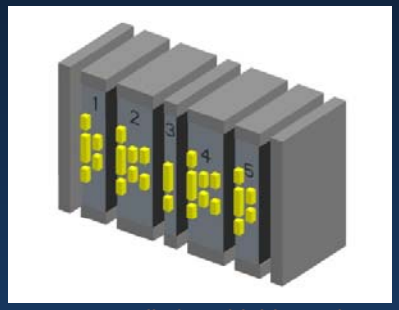
- JEO Approach : Instrument electronics, to the extent possible, would be co-located in a Science Electronics Chassis
  - Science Electronics Chassis mass will be apportioned to instruments on a ***per-board*** basis
  - ***This is a change from the 2008 EJSM Study Report***
    - A direct relationship between board count and instrument mass is required to reinforce the principle that for two instruments of the same capability ***fewer boards is better***
  - Notional scheme for apportioning mass:
    - Project will carry the portion of the Science Electronics Chassis mass not effected by instrument board count
      - Chassis endplates and other overhead
    - Instruments will carry the portion of the Science Electronics Chassis mass required by adding their boards
      - Chassis "slice" around each board
      - Current estimate = 1 to 1.5 kg/board plus actual board mass



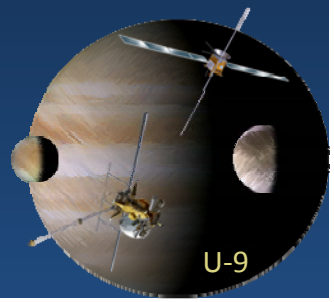
Mechanical Accommodation (5 cont.)

- JEO Approach : Instrument electronics, to the extent possible, would be co-located in a Science Electronics Chassis
  - Science Electronics Chassis implementation is under study
    - Desired attributes for the design
      - Mitigation of EMI/EMC from adjacent electronics
      - Provision for staggered instrument integration/reintegration
      - Cleanability for planetary protection
  - Concept#1 = mechanical bay structure
    - Outer structure provides radiation shielding
    - Inner modules house instrument electronics
      - Sealed for EMI/EMC
      - HEPA filtered for planetary protection
  - Concept#2 = abutted modules
    - Outer structure consists of only endplates for shielding
    - Inner modules provide top/bottom/rear radiation shielding
  - Current baseline = project provides reference design
    - *Final design will be developed with instrument team input*



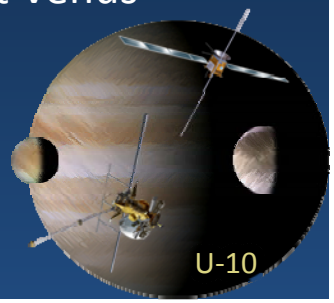


Note: Front radiation shield not shown



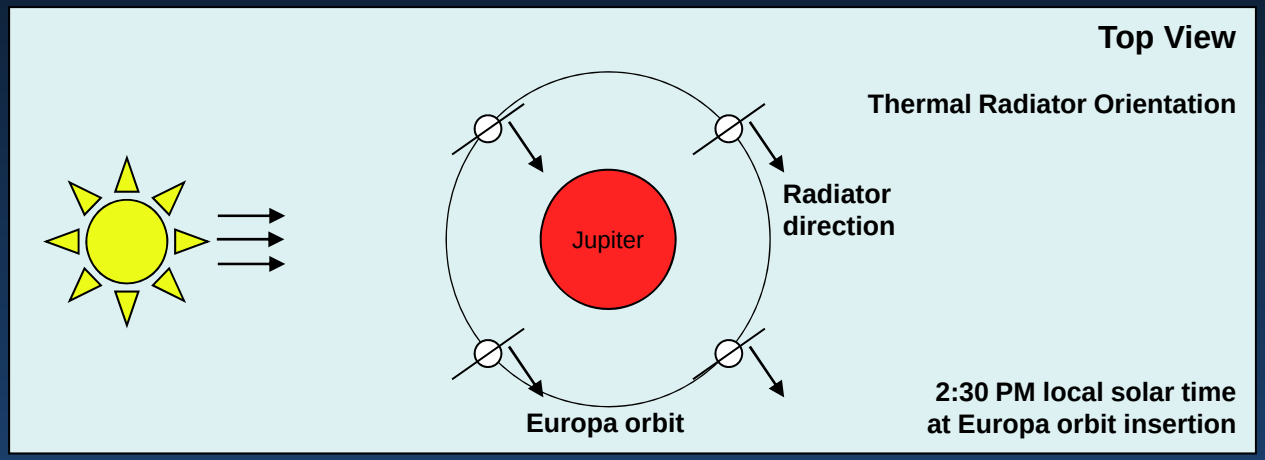
Thermal Accommodation (1)

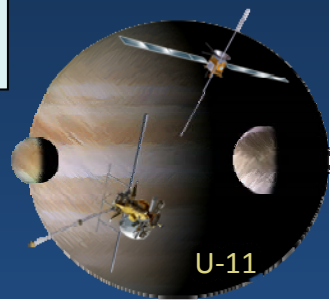
- JEO Approach : Instruments would provide all thermal control hardware required for instrument operation
  - Radiators, heat pipes, thermal blankets, heaters, thermo-electric coolers, cryo coolers, etc are the responsibility of the instrument provider
  - Spacecraft thermal engineers and instrument thermal engineers will work interactively during instrument development to establish thermal interface requirements
  - While the Venus fly-bys have not yet been analyzed, it is assumed that any additional covers required to survive the environment are the responsibility of the instrument provider
    - It is anticipated that instrument compatibility with dry-heat microbial reduction will mitigate susceptibility to temperature excursions at Venus



Thermal Accommodation (2)

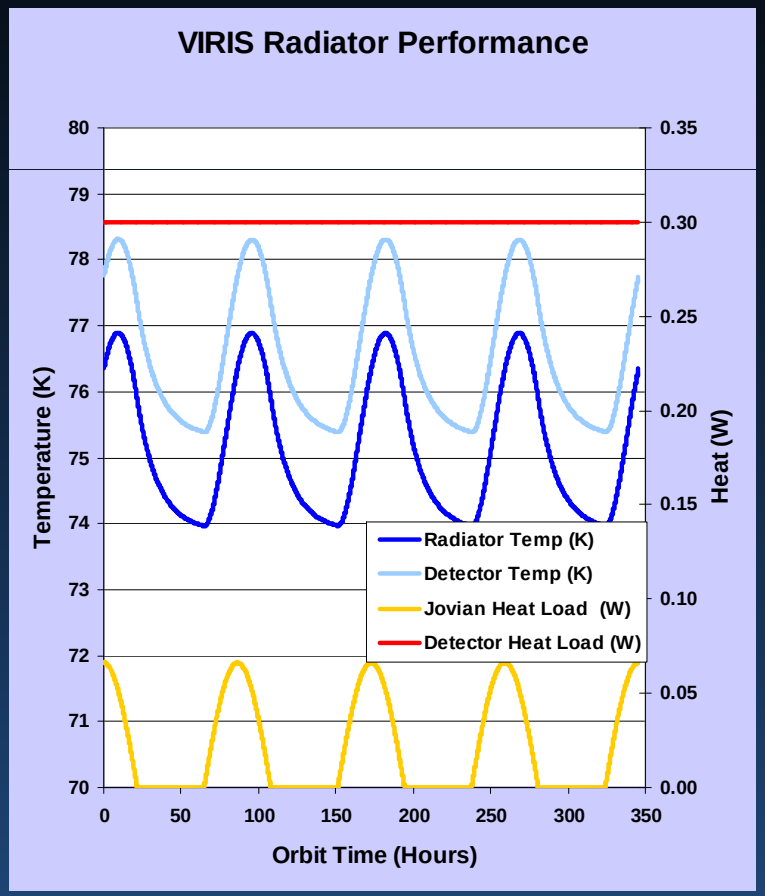
- JEO Approach : The high-inclination orbit at Europa would provide a solar-protected side of the spacecraft for thermal radiators
  - Current baseline: Orbital insertion at 2:30 PM local solar time with a regression rate of 0.11 to 0.33 degrees/day (subject to change)
  - Worst-case regression rate provides >430 days before sunlight would be incident on radiators, necessitating a spacecraft roll maneuver



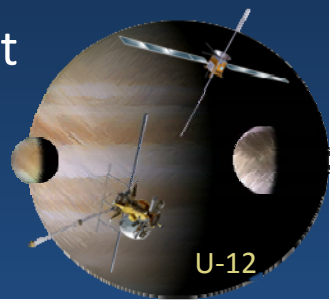


Thermal Accommodation (2 cont.)

- JEO Approach : The high-inclination orbit at Europa would provide a solar-protected side of the spacecraft for radiators

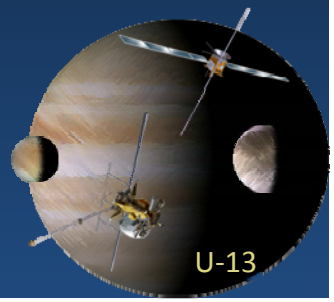


- While the orbit is solar-protected, it is not Jupiter-protected
  - Jupiter will move across the radiator field of view every ~3.5 days
- The transient heat load from Jupiter, if unmitigated, will perturb detector temperatures as shown in the VIRIS radiator analysis
- Mitigation of thermal effects from Jupiter, or analysis to demonstrate no mitigation is required, is the responsibility of the instrument provider



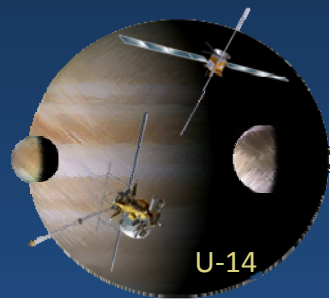
Thermal Accommodation (3)

- JEO Approach : Minimize the instrument power dissipation outside of the Science Electronics Chassis
  - For elements outside of the Science Electronics Chassis, heaters would be used to maintain safe temperatures when instruments are powered off
    - These “make-up heaters” are part of the instrument power budget
    - JEO science instruments are duty-cycled day/night and orbit-to-orbit to meet a limited orbit-average power budget
    - Make-up heater power impacts the JEO payload power budget and must be minimized in order to maximize instrument operational duty cycles
  - The Science Electronics Chassis will be thermally controlled by louvers which largely eliminates the need for make-up heaters for the portion of instrument power dissipated there
    - This is a **MAJOR ADVANTAGE** of using the Science Electronics Chassis

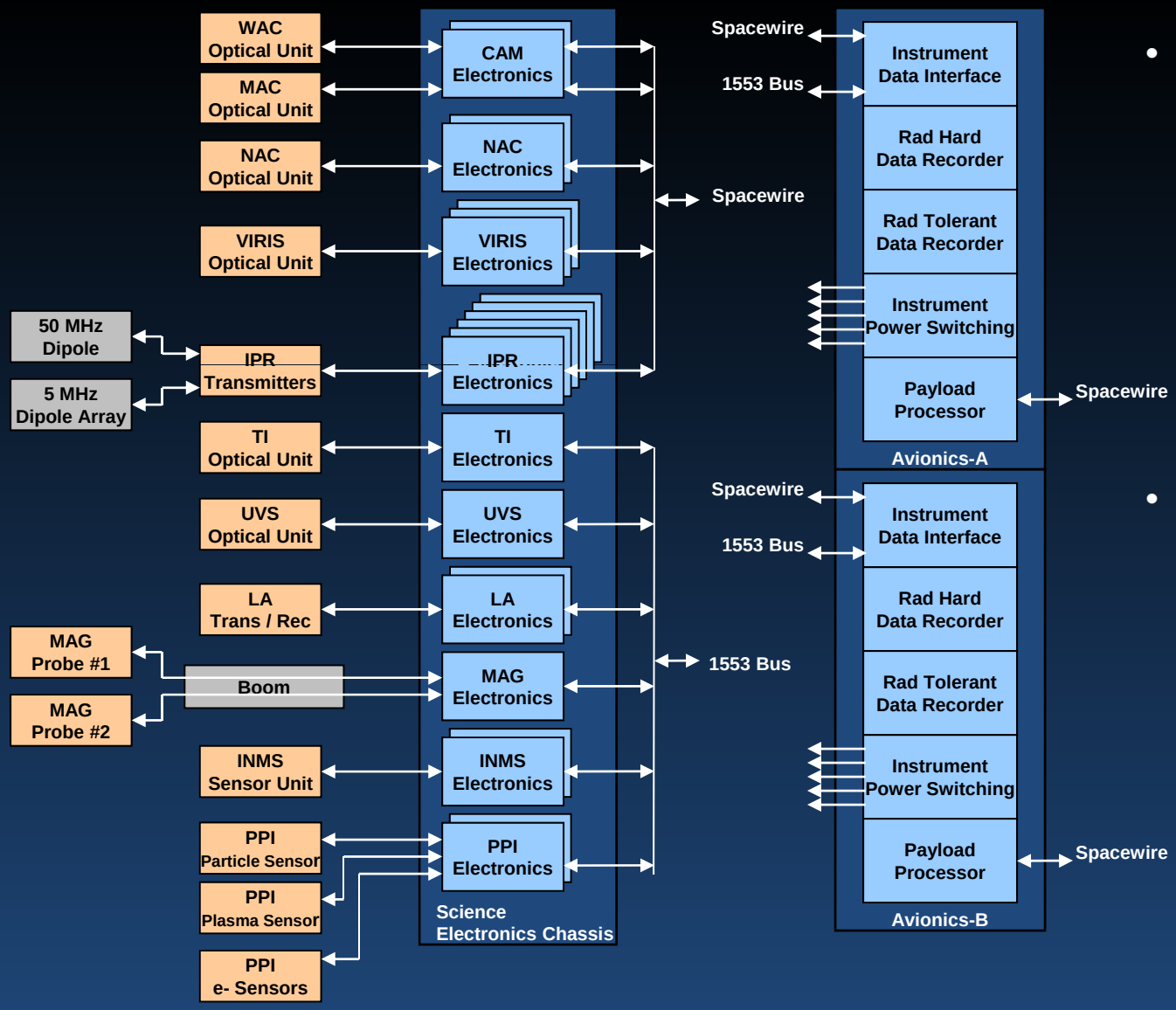


Electrical Accommodation (1)

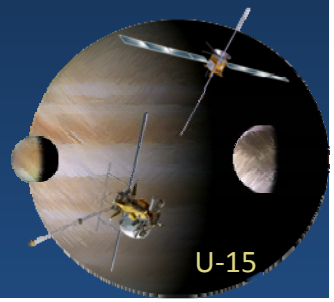
- JEO Approach : Use industry standard interfaces for power, command, and telemetry
  - Use of appropriate standards simplifies development and lowers risk
    - Especially important when baselining development of new radiation hardened ASICs
    - Especially important on large projects involving many institutions
    - Especially important when integration and test is complicated by planetary protection
  - Instrument power interface
    - Current baseline = +28V nominal unregulated primary power (22V to 36V)
  - Instrument command and telemetry interface
    - Current baseline = Mil-Std-1553 for low-bandwidth instruments
      - Requires further project review
        - » Pros: robust, fault-tolerant
        - » Cons: high power dissipation, electrical noise generation
    - Current baseline = SpaceWire for high-bandwidth instruments
  - Instrument time distribution
    - Undetermined at this time



Electrical Accommodation (2)

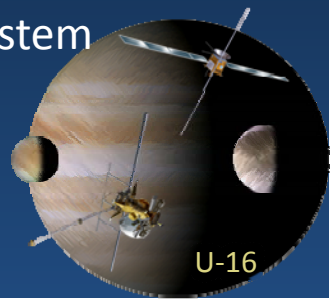


- Possible payload avionics would provide services previously baselined as spacecraft services
  - 1 Gbit radiation hardened solid-state data recorder
  - 16 Gbit radiation tolerant solid-state data recorder
  - Payload primary power switching
- Possible payload avionics may provide additional services
  - Science data compression
  - Enhanced instrument sequencing and fault management



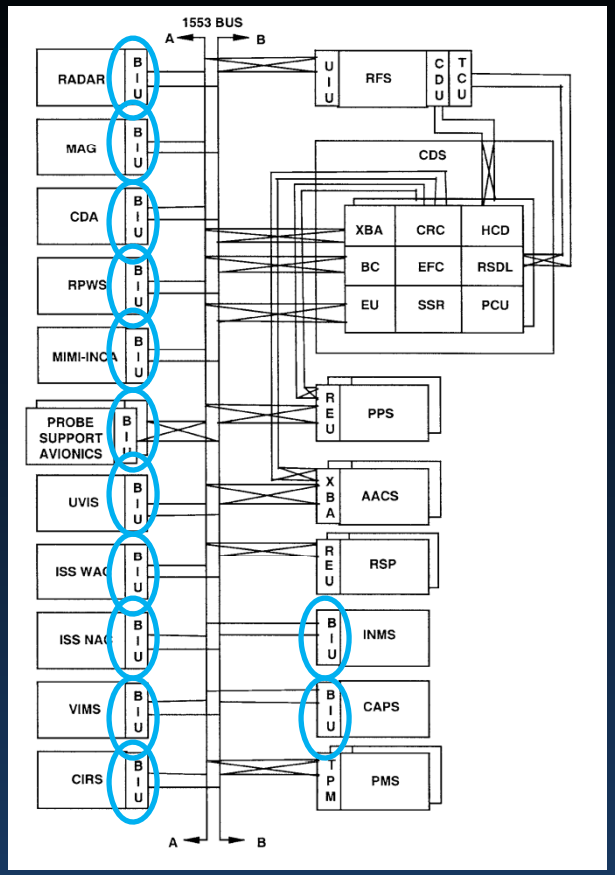
Project Supplied Hardware

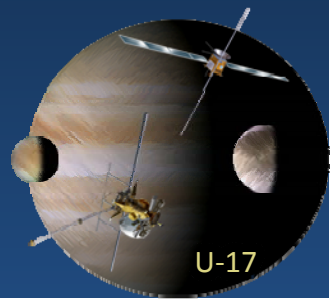
- A range of options for project supplied hardware are under study
  - From board-level reference designs to fully tested flight boards
  - From intellectual property (IP) for ASICs to fully tested flight ASICs
- Project supplied hardware can provide significant advantages to the project and to the instrument teams
  - Reduced cost
    - Fewer board designs
    - Fewer radiation hardened ASIC designs
  - Reduced risk
    - Designs can be reviewed and tested more thoroughly
    - More attention can be paid to other areas of the instrument design
  - Improved system operability
    - Common hardware can result in common and *well understood* system behavior



Project Supplied Hardware

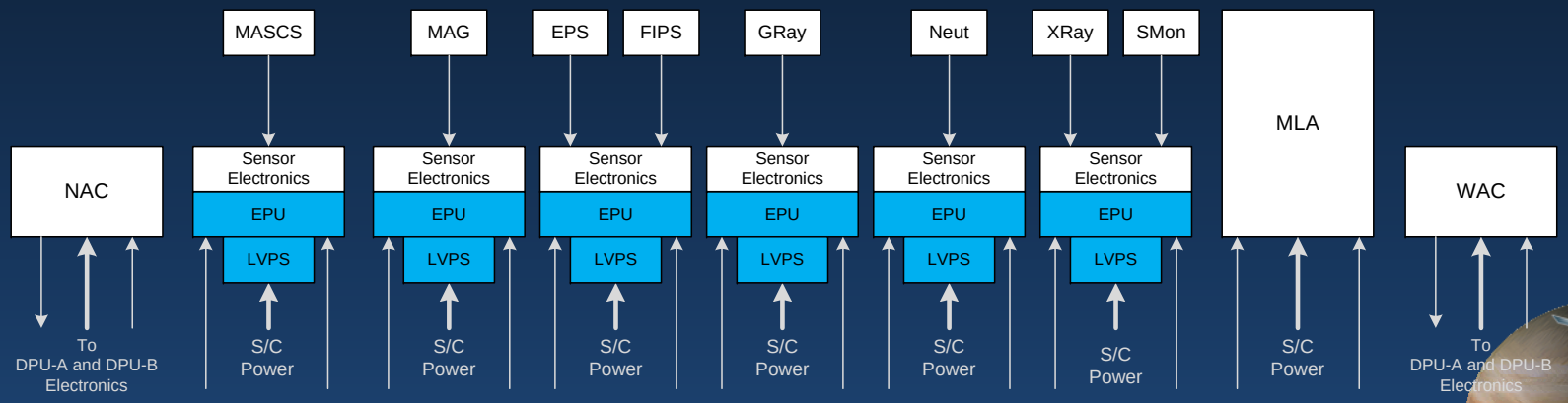
- Prior example: Cassini
  - Bus Interface Unit (BIU)
    - Flight board used by all instruments
    - Based on Mil-Std-1553
    - Memory-mapped interface to instrument controller
    - Discrete outputs for instrument reset, safing, selection of redundant units, etc
  - Low voltage power supply board
    - Reference design shared among JPL spacecraft subsystems and JPL instruments
  - Attributes provided
    - Standardization of instrument communications including command and data packet structure
    - Standardization of the first layer of instrument behavior
    - Reduced cost due to fewer required designs

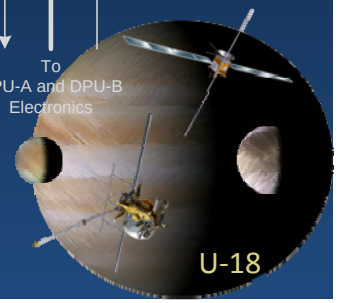


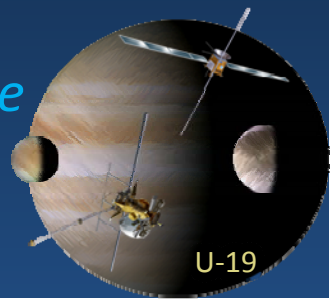


Project Supplied Hardware

- Prior example: MESSENGER
  - Microcontroller board including command/telemetry interface
  - Low voltage power supply
  - Flight software core
  - Electronics packaging
  - Common elements used by instruments ***and*** the redundant payload processors
  - Attributes provided
    - Standardization of instrument communications including packet structures
    - Standardization of much of instrument behavior
    - Greatly reduced cost due to fewer hardware and software designs





Project Supplied Hardware

- Possibilities for consideration on JEO
  - Low voltage power supply
    - Option: Reference design to be implemented by the instrument teams
      - Cassini approach
    - Option: Flight boards delivered to the instrument teams
      - MESSENGER approach
  - Command and telemetry interface
    - Option: IP to be implemented in ASICs developed by the instrument teams
      - Interface may be a small portion of a larger ASIC design
    - Option: Flight ASICs delivered to the instrument teams
      - May not be viable if Interface can be a small portion of a larger ASIC design
    - Option: Board level product
      - Cassini approach
      - Would likely be a small mezzanine board
  - System-on-a-Chip ASIC with microcontroller
    - "Swiss army knife" including A/D converters, D/A converters, etc
    - Would include boot software and flight software core
- *Your feedback can help to shape project decisions like this one*