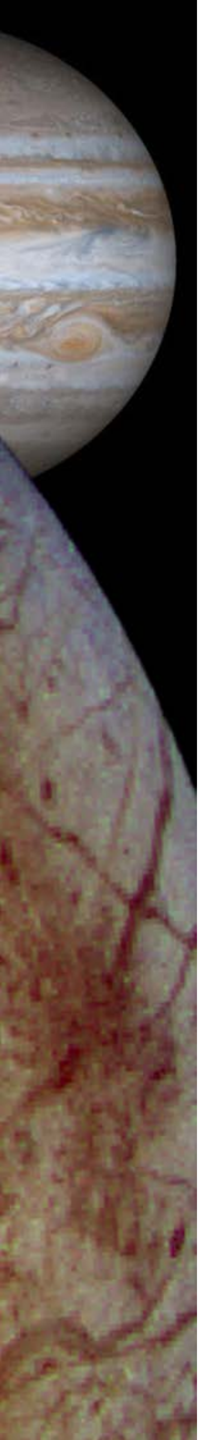

Use of Model Payload for Europa Mission Development

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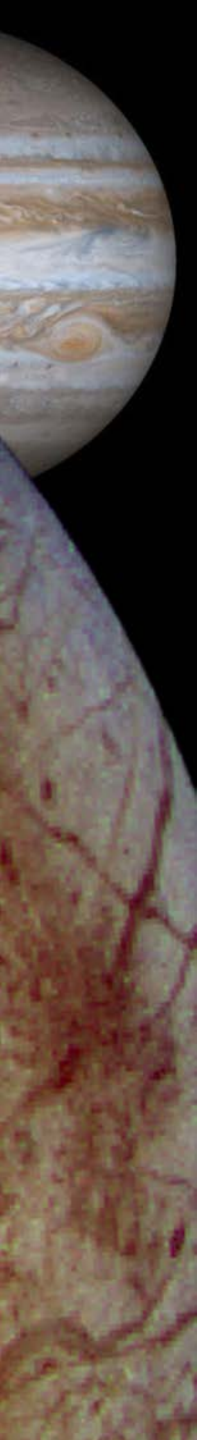
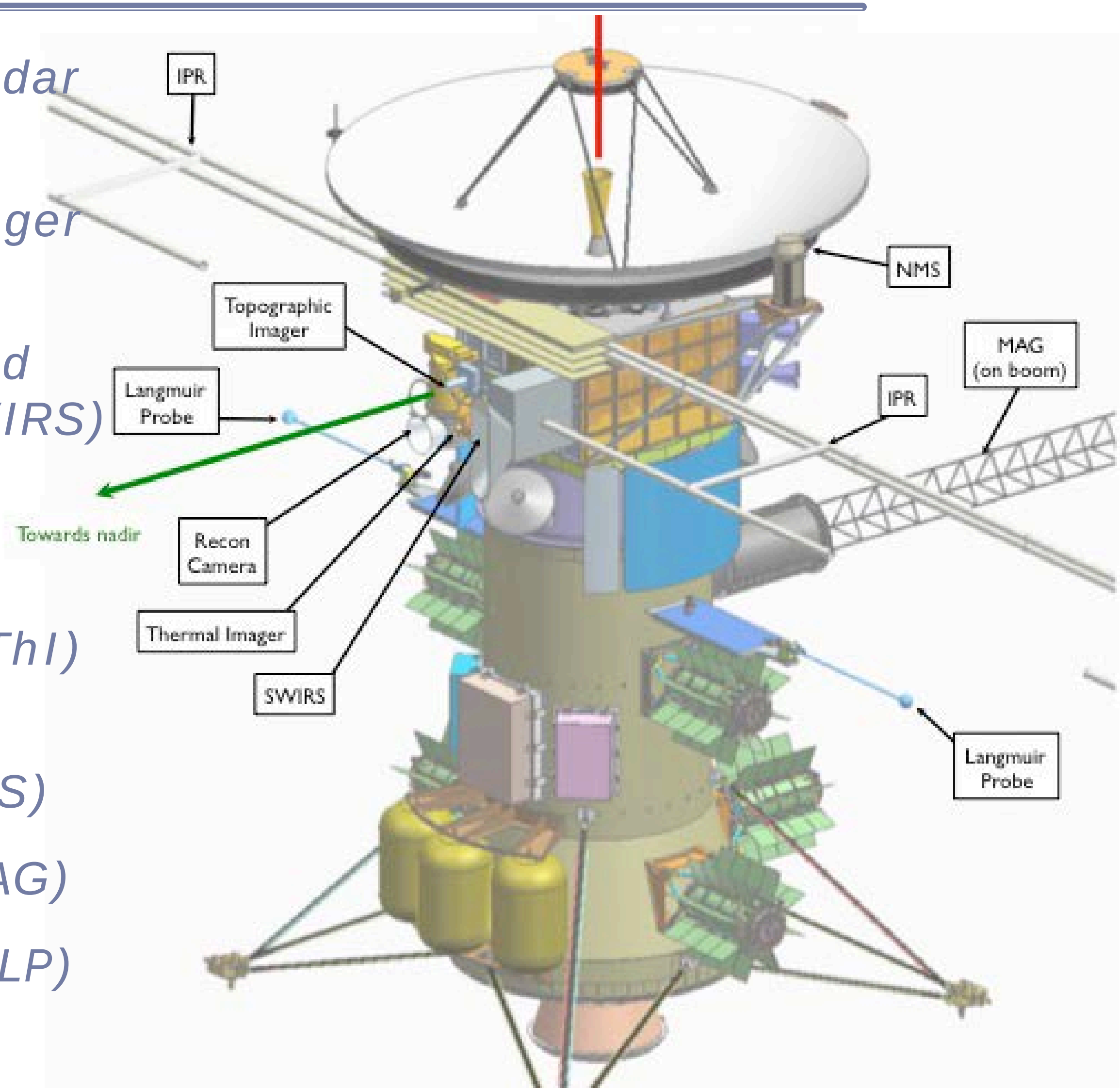


Introduction

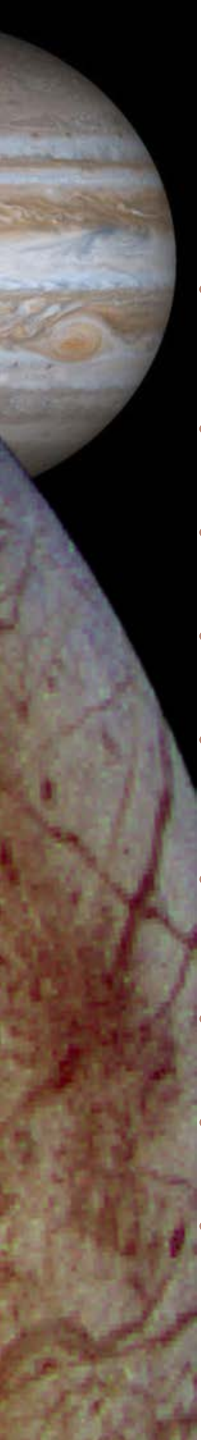
- JPL/NASA has been developing missions to Europa since the late 1990s
- The latest incarnation of the mission concept utilizes a multiple-flyby trajectory with closest approaches as close as 25 km to the surface of Europa
- Responsive to the National Research Council planetary science decadal survey in 2011
- The project needed to scope out the mission during pre-phase A, so a model payload was developed to meet science objectives and also the engineering requirements of a mission to Europa
- Announcement of Opportunity (AO) for science investigations released in fall of 2014, selection was in spring of 2015
- **How well did we do in sizing the mission to handle the selected payload?**

Model Payload

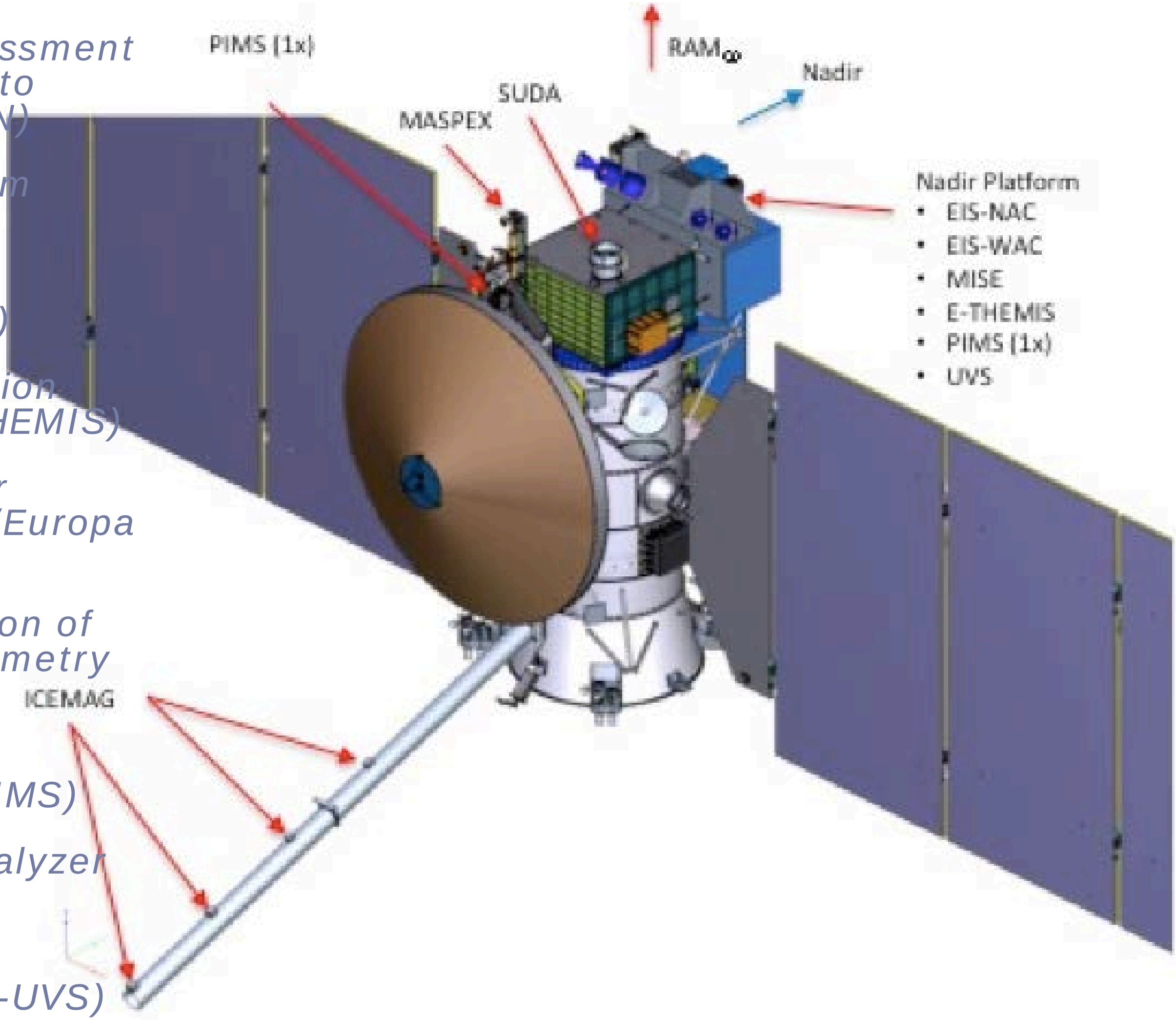
- *Ice Penetrating Radar (IPR)*
- *Topographical Imager (TI)*
- *ShortWave Infrared Spectrometer (SWIRS)*
- *Reconnaissance Camera (RC)*
- *Thermal Imager (ThI)*
- *Neutral Mass Spectrometer (NMS)*
- *Magnetometer (MAG)*
- *Langmuir Probes (LP)*

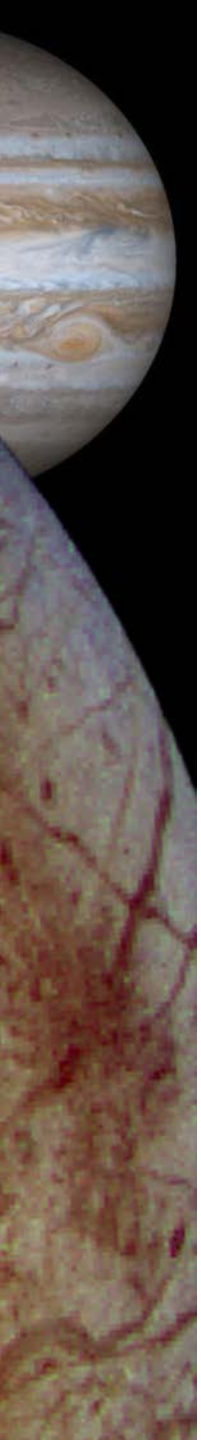


Selected Payload



- Radar for Europa Assessment and Sounding: Ocean to Near-Surface (REASON)
- Europa Imaging System (EIS)
- ShortWave Infrared Spectrometer (SWIRS)
- Europa Thermal Emission Imaging System (E-THEMIS)
- MAss Spectrometer for Planetary EXploration/Europa (MASPEX)
- Interior Characterization of Europa using Magnetometry (ICEMAG)
- Plasma Instrument for Magnetic Sounding (PIMS)
- SUrface Dust Mass Analyzer (SUDA)
- Europa Ultraviolet Spectrograph (Europa-UVS)

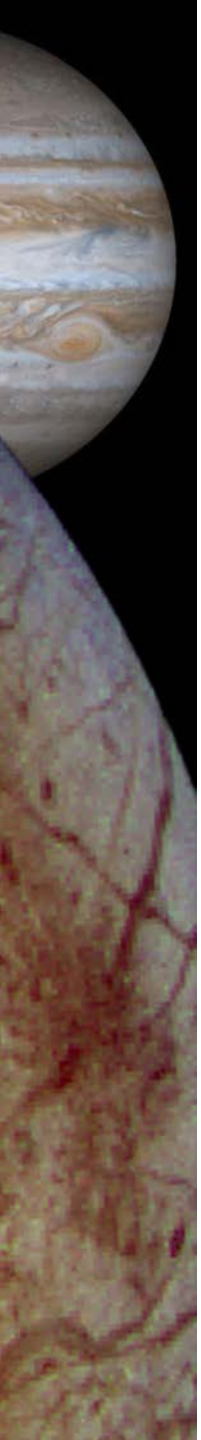




Comparison between Model and Selected Payload

Model Payload	Selected Payload
IPR	REASON
TI	EIS
SWIRS	MISE
RC	EIS
ThI	E-THEMIS
NMS	MASPEX
MAG	ICEMAG
LP	PIMS
	SUDA
	Europa-UVS

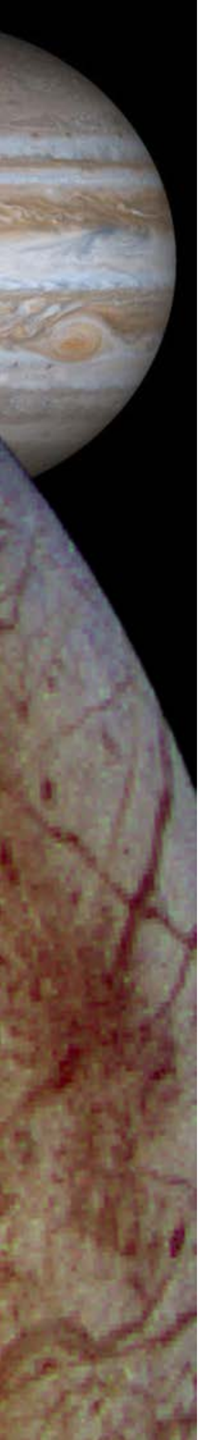
- Besides the eight types of instruments in the model m payload, NASA also selected two additional instruments
- Across the board, the instruments selected were more capable than those developed for the model payload
- NASA also added a new science investigation, the search for plumes, which was not part of the decadal survey recommendations
- Independently, the spacecraft baseline design changed from multi-mission radioisotope thermoelectric generators (MMRTGs) to solar arrays and moved the HGA in the time between the AO and selection



Resource Comparison between Model and Selected Payload

	Model Payload	Selected Payload	Delta
Mass	101.4 kg	156.85 kg	+55.45 kg
Power	153.3 W	176.25 W	+22.95
Data Volume /Orbit	36.47 Gb	39.63 Gb	+3.16

All values are Current Best Estimates (no margin)



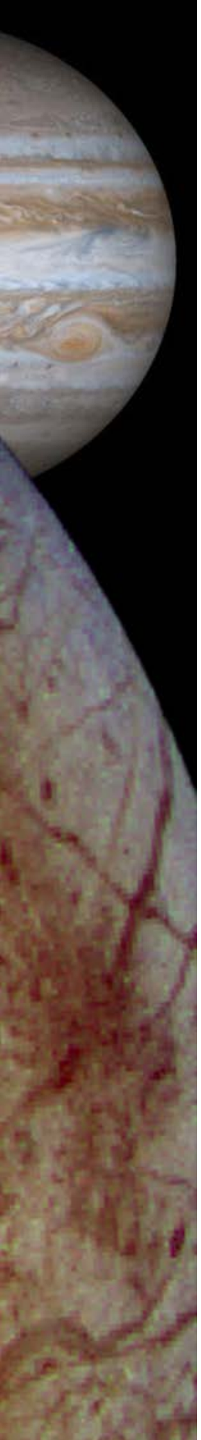
Affect on Mission Concept

Areas of Significant Change

- Observing Scenarios
  - Addition of new investigation calls for more observations further from the moon
  - More capability corresponds to more science observations
- Spacecraft Configuration
  - Two additional instruments, plus larger Field of Views of instruments grew the instrument deck
  - Selected magnetometer requires a dedicated boom rather than original solar array mounted concept
  - Radar coupling with solar array put additional constraints on configuration
- Mass
  - Not only instrument mass, but secondary support mass increased as well
  - Project is still within acceptable margins

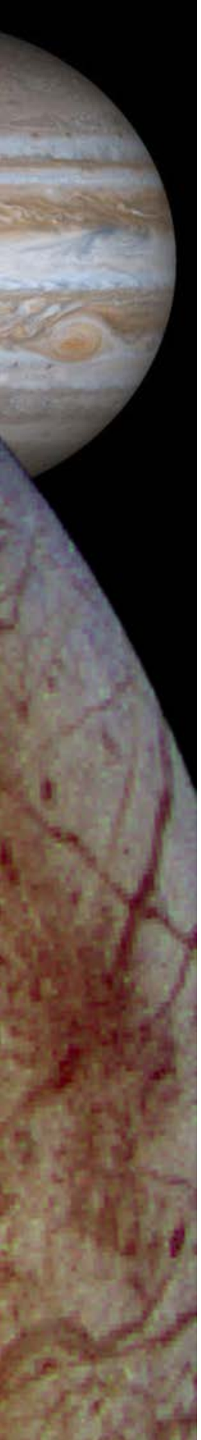
Areas without Significant Change

- Data Return Strategy
  - No change was required
- Guidance, Navigation, and Control
  - Existing spacecraft capability is sufficient for selected instruments
- Thermal
  - Heater sizes will need to be revised, but overall strategy is still valid
- Power Strategy
  - Solar arrays had to grow, but overall architecture remains the same



Lessons Learned

- Early requirements development using the model payload saved considerable time and effort post-selection
  - Complete set of Level-3 requirements, including interface requirements, were developed for the model payload
  - The requirements had to be updated for selected payload, but having the structure and text already developed greatly accelerated the creation of the new documents
  - Allowed for early concurrence on critical interface issues
- Impacts of switch from MMRTGs to Solar Arrays was not fully captured with the model payload
  - Simplifying assumptions and lack of depth of knowledge of instrument design meant impacts of switch were underestimated
- Stress analyses using the model payload were useful, but not complete
  - The team did sizing exercises for mass, power, and data, which helped the spacecraft absorb the growth due to the selected payload
  - The team did not stress the configuration and this area has struggled to accommodate the selected payload.



Conclusion

- Using the model payload allowed the project to form a coherent mission design prior to the AO
- The model payload did a good job of developing a baseline that was able to absorb, with some additional effort, the payload selected by NASA
- The use of model payload in early requirements development was extremely useful
- The model payload was insufficient in developing configuration “margin”; future users should consider additional volumetric margins as part of stress analysis
- The model payload design did not provide enough depth to fully flush out impacts due to major design trades