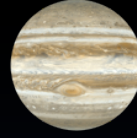
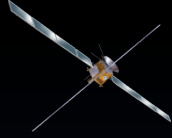


# Science Scenario Modeling

Rob Lock, Erick Sturm, Tracy Van Houten

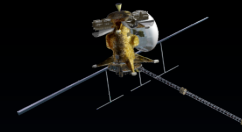
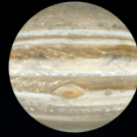
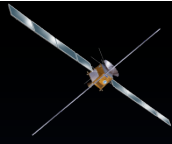
Presented to OPAG Satellite Break-out Group  
February 2010



# Introduction

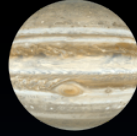
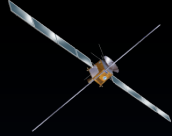
- Scenario Strategy

- For Europa Explorer and Jupiter Europa Orbiter studies, the study teams met with the Science Definition Teams to create scenarios
  - To use science goals to develop and size the system concepts with realistic science implementation schemes and positive margins
  - To validate the feasibility of the science implementation options
- These earlier studies focused mainly on Europa science goals and mission development
  - Some effort was spent on examining satellite flyby opportunities
- Currently, there is additional focus on Jupiter science and Jupiter system science objectives in addition to flybys



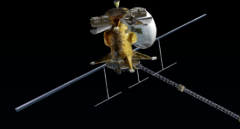
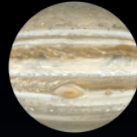
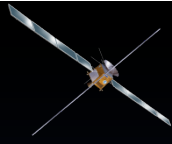
## Scenario Development Approach

- Scenarios are identified and developed only for aspects of the mission that are most challenging, drive the concept design constraints, or where validation of science objectives is needed
  - Due to limited resources, just enough modeling and simulation are developed to explore a few scenarios and find feasible solutions
- Science objectives and constraints are balanced with feasible system design concepts and constraints
  - Dynamic process - ideas are discussed, opportunities exploited, and strategies examined with qualitative and quantitative analysis
- Some of the parameters captured include:
  - observation extent, coverage, resolution
    - Strategic and tactical grouping and timing to meet higher order priorities (e.g., campaigns, multi-orbit observing schemes)
    - System performance measures such as data rate, DSN support, power consumption, pointing and articulation constraints, configuration



## Where are we?

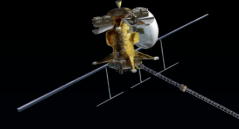
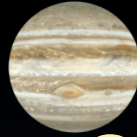
- Europa scenarios are well understood
  - Expected to be the driving scenarios for the flight system
- Tour scenarios have been sparse and priorities are not yet defined
  - Previously examined Flyby strategies and coverage for each Galilean satellite
  - A few Jupiter observation types were analyzed (e.g., feature tracking example)
- A more complete Tour scenario is needed
  - Establish science objectives and priorities and assess whether they can be met (or not) and with what margin
  - Estimate spacecraft resources, check feasibility and margins
  - Find additional driving constraints on the system



# Sample Tour Orbit Scenarios

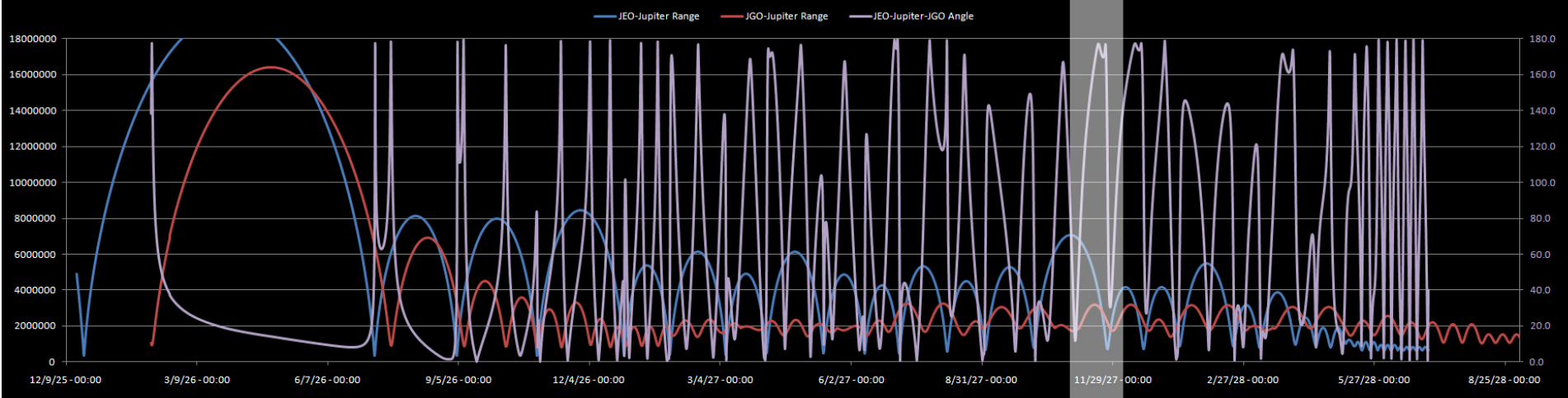
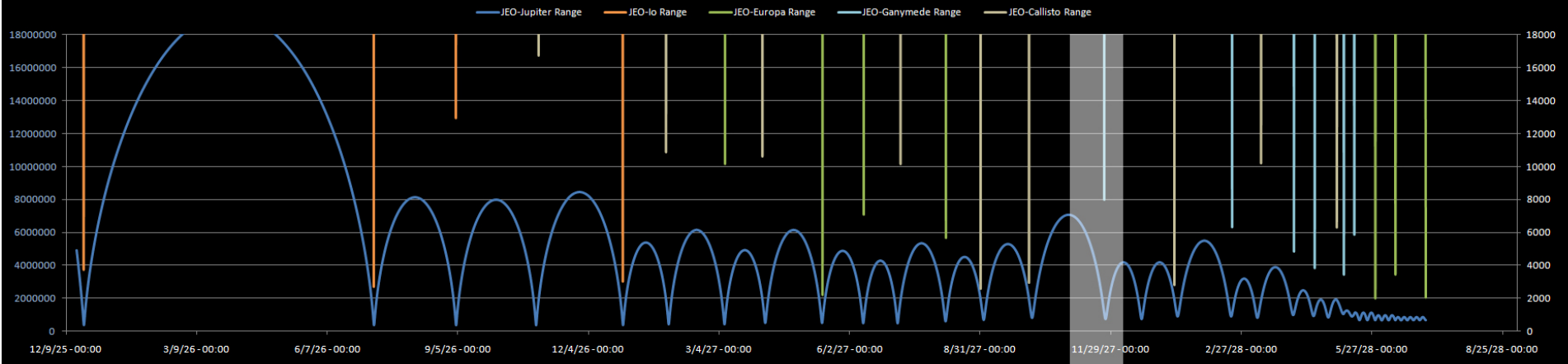
- This table is scenario teams' first cut at scenario categories and observations of interest during one sample orbit in the baseline JEO tour (08-008) plus an example JGO tour

Scenario	Category	Observations of Interest	Cadence	Instruments / Mode	S/C Attitude	Ops Concept	Constraints
1 Sample Orbit during Tour	F&P / Mag Observing	From spinning s/c	1/ 2 days	MAG PPI	Earth Point	Do during 8hr DSN passes. Spin the s/c 2-3 times in 2 orthogonal directions and re-orient.	Do on wheels, maintain Earth-point. Turn off all other instruments and utilize X & Ka.
	Jupiter Monitoring	Atmospheric	1/wk (4-5/orbit)	VIRIS (long wavelength) TI UVS NAC MAC	Jupiter Point	Want 20 hrs of monitoring --> every 10 deg longitude. For each observation, make movie (72 images).	Some instruments will need to mosaic to get desired resolution b/c so far away in some cases. Don't plan to observe at perijove at this cadence. (Perijove would be its own observation category).
		Feature Monitoring (e.g. brown band)					
	Io Monitoring	Io in Jupiter shadow	1/wk	NAC VIRIS UVS	Io Point	Take image every ~5deg longitude (72 images) & look at limb.	
		Io's dark side	1/wk				
		Io longitudinal grid	1-2/wk				
	JEO-JGO Synergy	S/C occultation	1-2/orbit	USO	JGO Point	Monitor for 1-2 hours before an event and 30 minutes after plus time to get back to Earth-pointed orientation.	Tracking angle limited to ~0.1 deg/s (conservative) because issue for s/c.
Fly-By (Ganymede)	Areas not previously mapped by Galileo	~1/orbit	NAC WAC&MAC	Ganymede Point			
Other Observations	Galilean Moons		NAC, WAC&MAC				
	Small Moons		NAC, WAC&MAC		Jovian disc crossings desired?		
	Rings						
	UV Stars		UVS				
	UV Aurora		UVS				

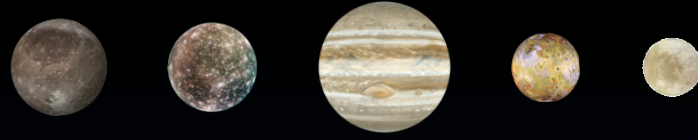
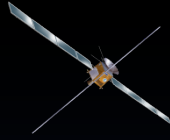


# Selecting the Sample Orbit

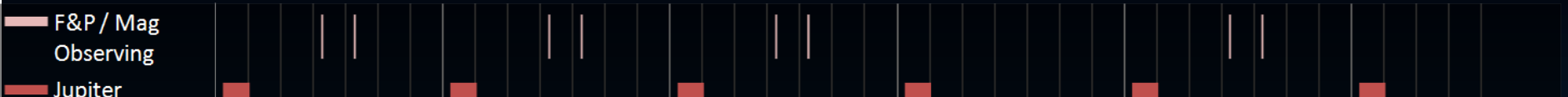
- Desired orbit characteristics:
  - Ganymede Fly-by
  - JGO occulted by Jupiter
- Selected orbit:
  - Orbit #14
  - October 31, 2027 to December 8, 2027



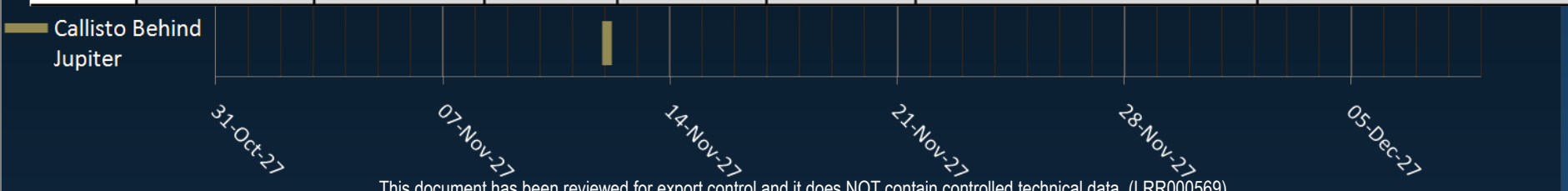


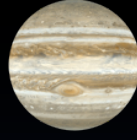
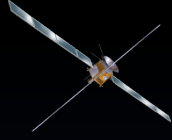


# Event Timeline

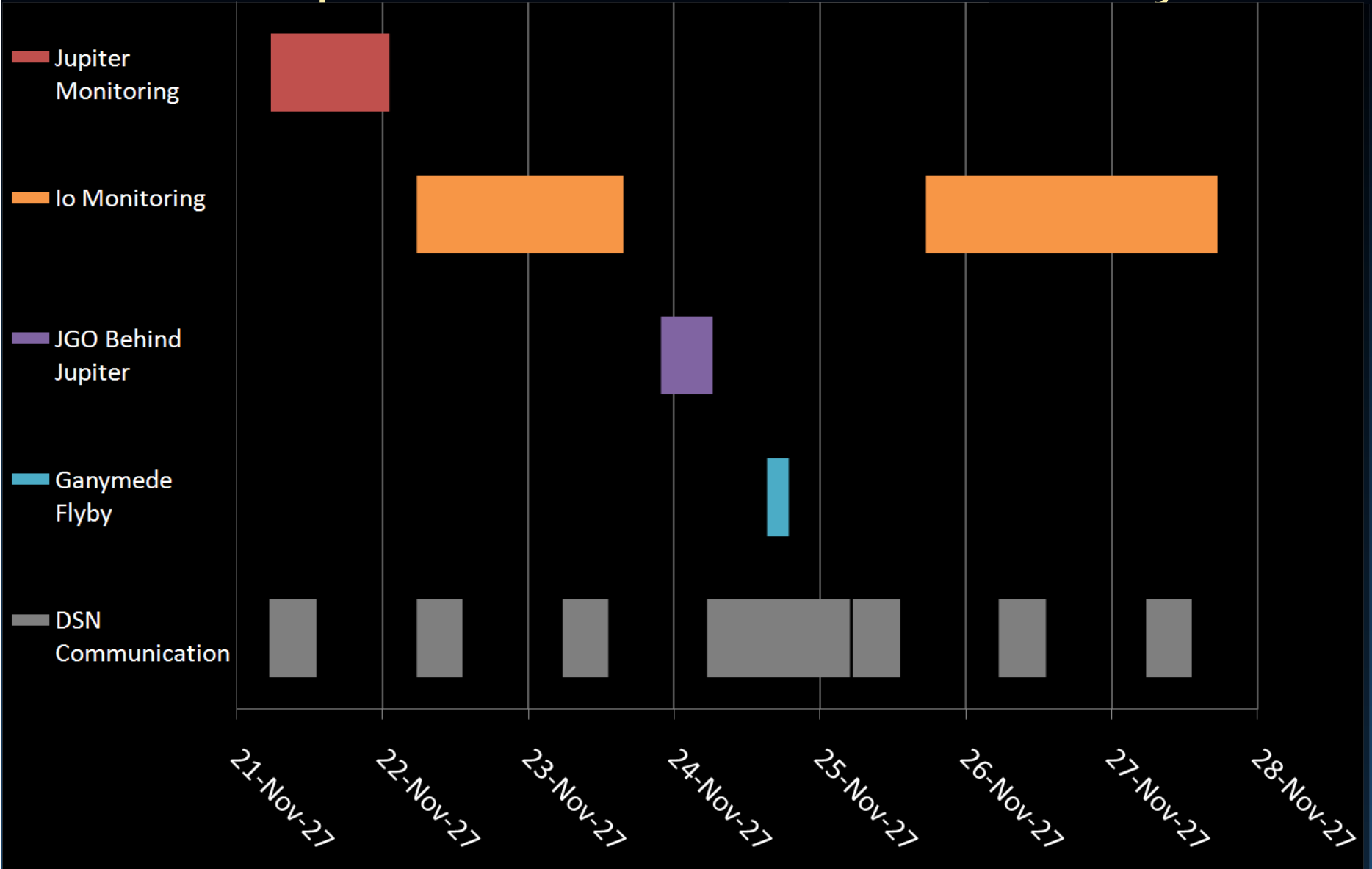


Scenario	Category	Observations of Interest	Cadence	Instruments / Mode	S/C Attitude	Ops Concept	Constraints
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		Feature Monitoring (e.g. brown band)					
	Io Monitoring	Io in Jupiter shadow	1/wk	NAC VIRIS UVS	Io Point	Take image every ~5deg longitude (72 images) & look at limb.	
		Io's dark side	1/wk				
		Io longitudinal grid	1-2/wk				
	JEO-JGO Synergy	S/C occultation	1-2/orbit	USO	JGO Point	Monitor for 1-2 hours before an event and 30 minutes after plus time to get back to Earth-pointed orientation.	Tracking angle limited to ~0.1 deg/s (conservative) because issue for s/c.
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Other Observations	Galilean Moons		NAC, WAC&MAC				
	Small Moons		NAC, WAC&MAC		Jovian disc crossings desired?		
	Rings						
	UV Stars		UVS				
	UV Aurora		UVS				





# Example Products & Resource Analysis

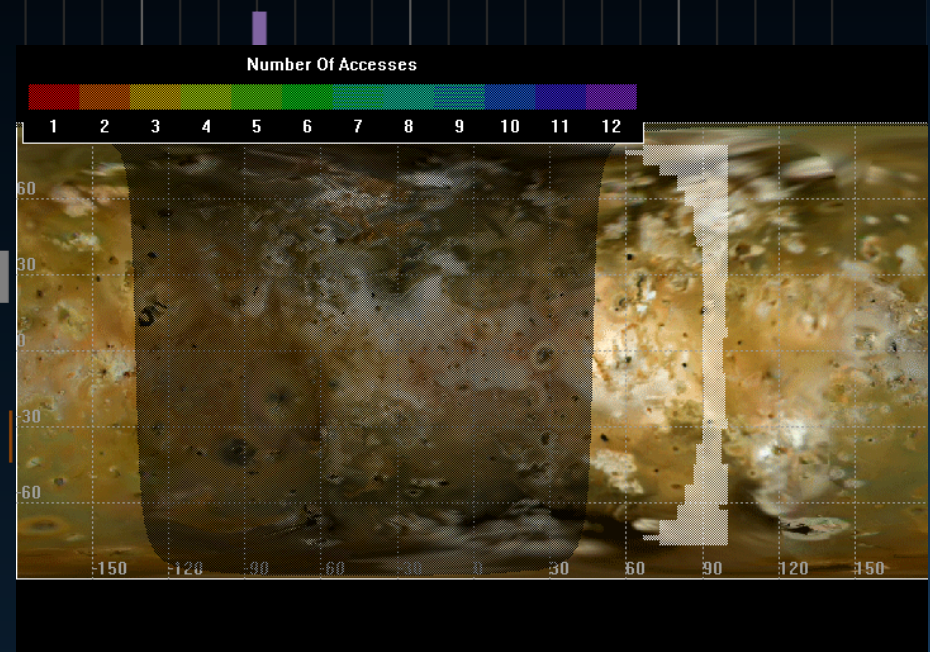
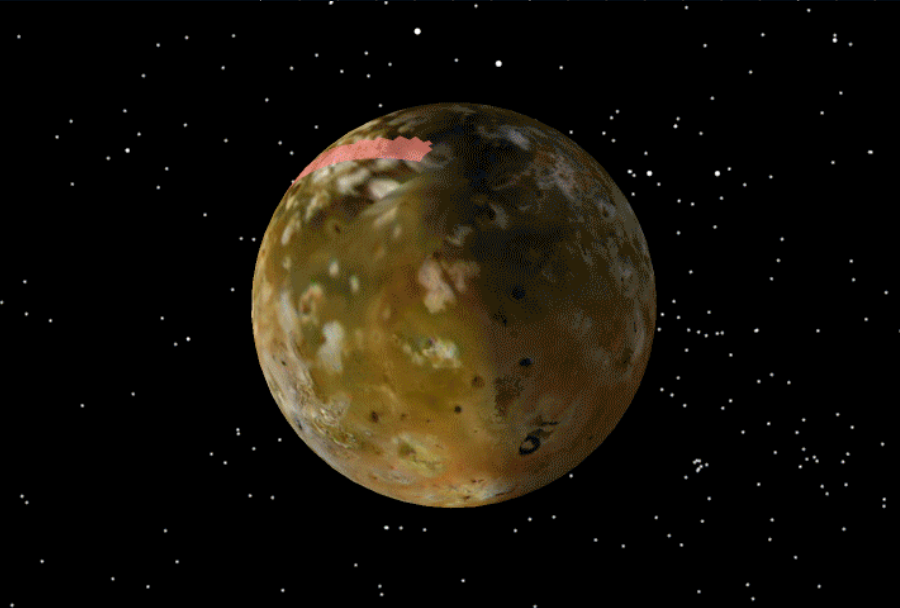




# Io Monitoring

Category	Observations of Interest	Cadence	Instruments / Mode	S/C Attitude	Ops Concept	Constraints
Io Monitoring	Io in Jupiter shadow	1/wk	NAC VIRIS UVS	Io Point	Take image every ~5deg longitude (72 images) & look at limb.	
	Io's dark side	1/wk				
	Io longitudinal grid	1-2/wk				

JGO Behind



Ganymede Behind Jupiter

Callisto Behind Jupiter

31-Oct-27

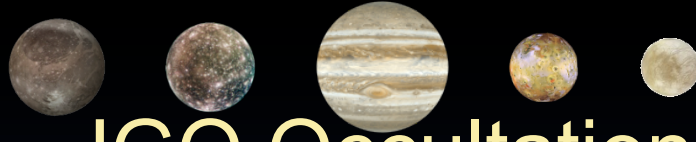
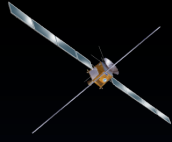
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14-Nov-27

21-Nov-27

28-Nov-27

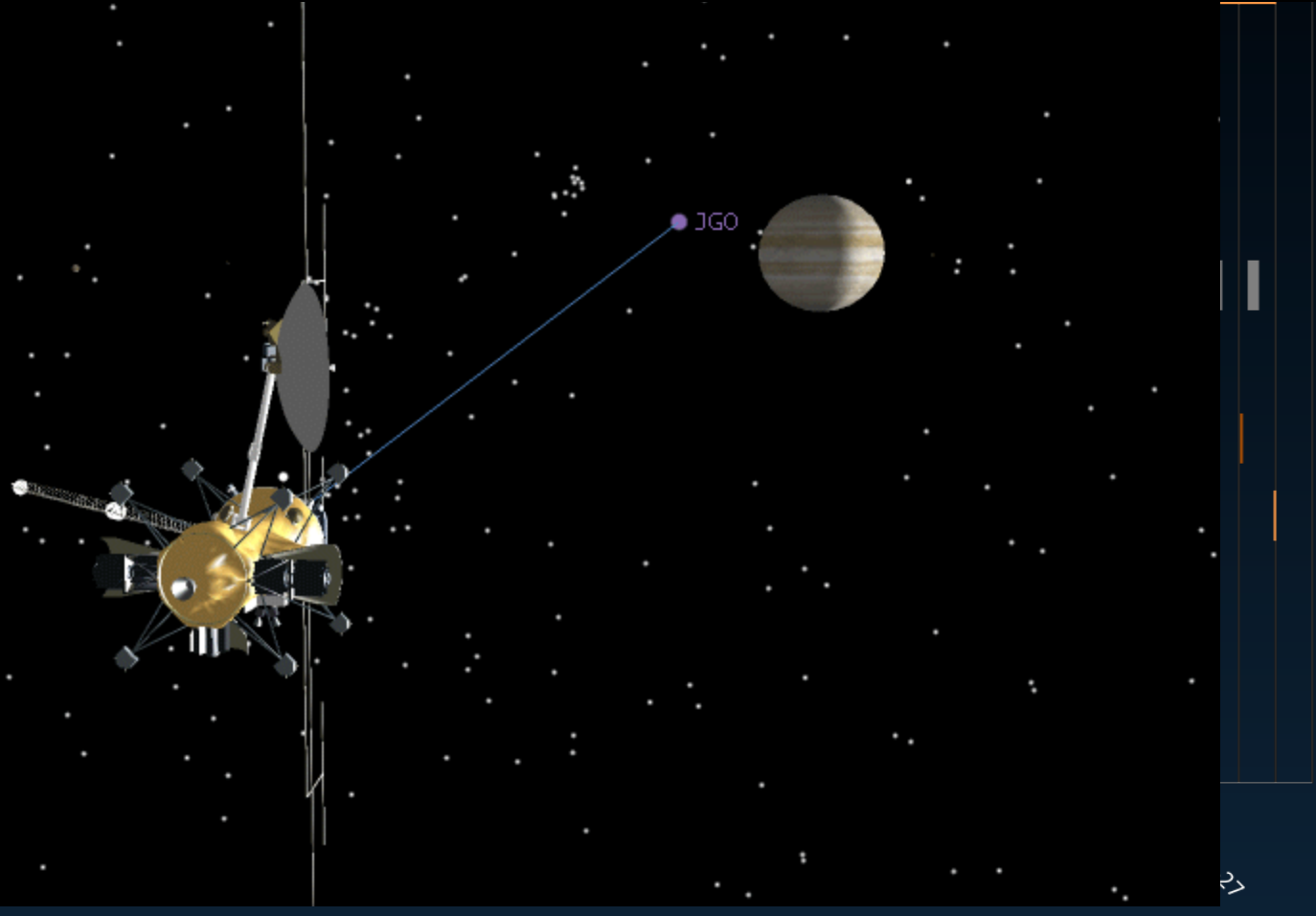
05-Dec-27

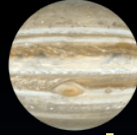
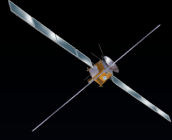


# JGO Occultation

Category	Observations of Interest	Cadence	Instruments / Mode	S/C Attitude	Ops Concept	Constraints
JEO-JGO Synergy	S/C occultation	1-2/orbit	USO	JGO Point	Monitor for 1-2 hours before an event and 30 minutes after plus time to get back to Earth-pointed orientation.	Tracking angle limited to ~0.1 deg/s (conservative) because issue for s/c.

- JGO Behind Jupiter
- Ganymede Flyby
- UV Star Behind Jupiter
- DSN Communicat
- JEO in Jupiter Shadow
- Io in Jupiter Shadow
- Io Behind Jupiter
- Europa Behind Jupiter
- Ganymede Behind Jupiter
- Callisto Behind Jupiter





# Ganymede Flyby

Category	Observations of Interest	Cadence	Instruments / Mode	S/C Attitude	Ops Concept	Constraints
Fly-By (Ganymede)	Areas not previously mapped by Galileo	~1/orbit	NAC WAC&MAC	Ganymede Point		

Galileo + Voyager



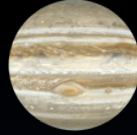
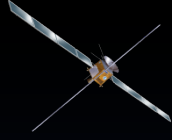
Resolution (m/pixel)



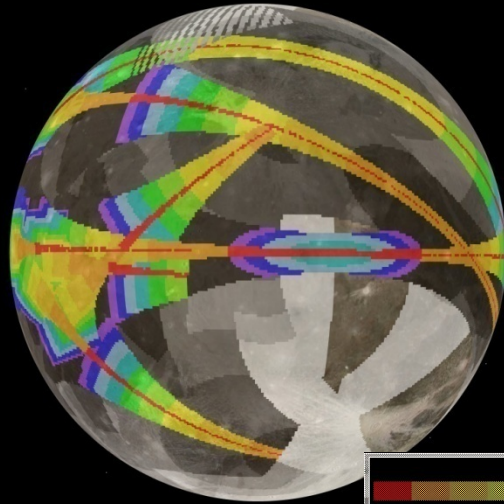
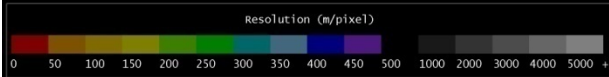
31-Oct-27

05-Dec-27



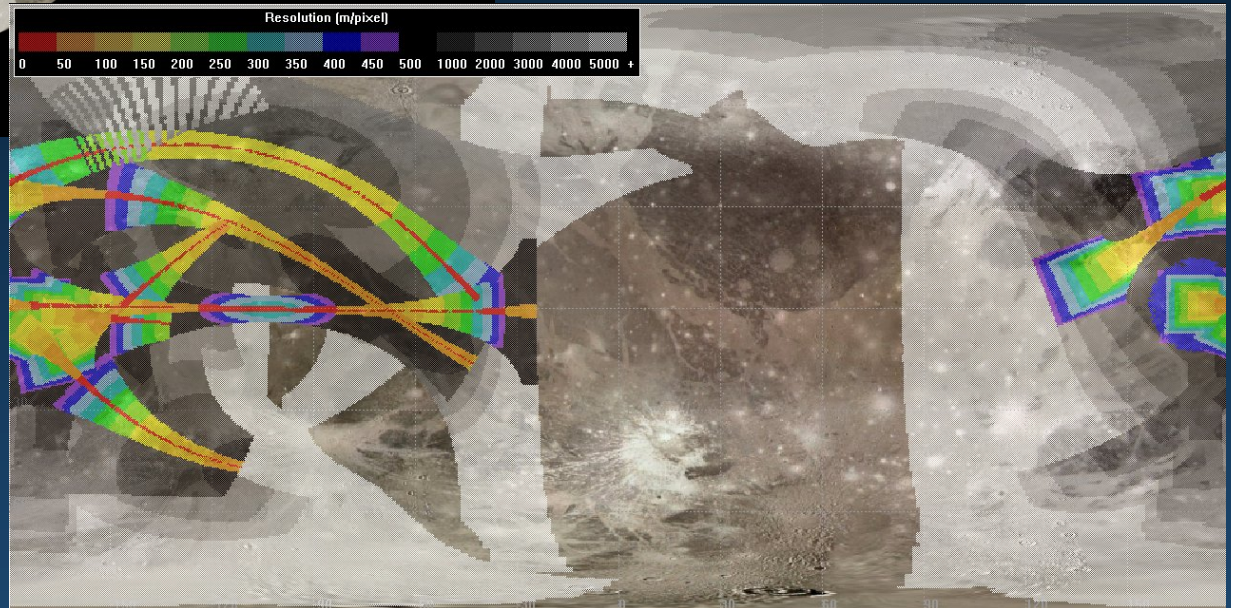


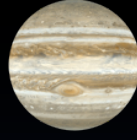
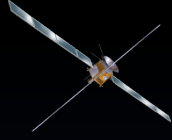
# Resolution for All Ganymede Flybys



- Notes:

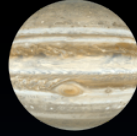
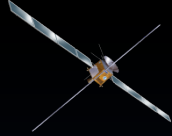
- Currently shows resolution coverage based on NAC, MAC&WAC from model payload
- Spacecraft resources (power, data) are not accounted for, this is simply available coverage
- No night-time or off-nadir imaging





# Feedback from the SDT (1)

- SDT was asked to provide feedback on the tour and example scenario: What's missing from the example scenario? What trace matrix objectives are met well/poorly with this tour? Are there conflicts between instruments in the model payloads/the objectives? What additional products are needed to evaluate the tour? *Items in yellow have been addressed since SDT meeting*
- Missing from example scenario:
  - Europa monitoring
  - Occultations of UV stars by Europa
  - A more realistic mix of observations
- Additions desired to the tour:
  - *What are the impacts of modifying the tour to include apoapses on the Jupiter day side?*
  - Increase inclinations to (1) View Jupiter poles (atmospheres, aurora), (2) Get 2-4+ degrees above the ring plane (rings), (3) Spread occultation latitudes, (4) Maximize local time coverage (magnetospheres)



# Feedback from the SDT (2)

- Potential Conflicts:
  - Radio science – don't do Cassini!
  - Encourage JGO to have steerable antenna
- Additional products needed for tour evaluation:
  - Ranges and phase angle for the various tour apoapses and periapses
  - When are Jupiter's poles visible?
  - Examples of the complementary JEO/JGO coverage & JEO/JGO stereo viewing of the same target and opportunities
  - Occultation opportunities – Radio (Earth, SC 2 SC), Solar, Stellar
  - Desire the Jovian environment (Radiation, Mag Field for Jupiter and Ganymede, Rings, Plasma-Aurora, Io Torus, Dust/Rocks/Micrometeoroids, Satellite Atmospheres) – This is already being worked
  - Different coordinate systems (e.g., local time, magnetic lats, moon coordinate systems, co-rotation direction, etc.)
  - Non targeted encounters (less than 500,000 km)