The Europa Jupiter System Mission

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A Joint NASA-ESA Outer Planet Mission Study
**EJSM Theme:** The emergence of habitable worlds around gas giants

- NASA & ESA: shared mission leadership
- Two independently launched and operated flight systems with complementary payloads
  - Jupiter Europa Orbiter (JEO): NASA-led mission element
  - Jupiter Ganymede Orbiter (JGO): ESA-led mission element
- Mission Timeline
  - Nominal Launch: 2020
  - Jovian system tour phase: 2–3 years
  - Moon orbital phase: 6–12 months
  - End of Prime Missions: 2029
- ~10–11 Instruments on each flight system, including Radio Science
**JEO Goal:** Explore Europa to Investigate Its Habitability

**Objectives:**
- Ocean and Interior
- Ice Shell
- Chemistry and Composition
- Geology and Landing Sites
- Jupiter System
  - Satellite surfaces and interiors
  - Satellite atmospheres
  - Plasma and magnetospheres
  - Jupiter atmosphere
  - Rings

**JEO would characterize the archetype of icy world habitability**
## JEO Model Payload

<table>
<thead>
<tr>
<th><strong>JEO Instrument</strong></th>
<th><strong>Similar Instruments</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio Science</td>
<td>New Horizons USO, Cassini KaT</td>
</tr>
<tr>
<td>Laser Altimeter</td>
<td>MESSENGER MLA, NEAR NLR</td>
</tr>
<tr>
<td>Ice Penetrating Radar</td>
<td>MRO SHARAD, Mars Express MARSIS</td>
</tr>
<tr>
<td>VIS-IR Spectrometer</td>
<td>MRO CRISM, Chandrayaan MMM</td>
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<tr>
<td>UV Spectrometer</td>
<td>Cassini UVIS, New Horizons Alice</td>
</tr>
<tr>
<td>Ion &amp; Neutral Mass Spectrometer</td>
<td>Rosetta ROSINA RTOF</td>
</tr>
<tr>
<td>Thermal Instrument</td>
<td>MRO MCS, LRO Diviner</td>
</tr>
<tr>
<td>Narrow-Angle Camera</td>
<td>New Horizons LORRI, LRO LROC</td>
</tr>
<tr>
<td>Camera Package</td>
<td>MRO MARCI, MESSENGER MDIS</td>
</tr>
<tr>
<td>Magnetometer</td>
<td>MESSENGER MAG, Galileo MAG</td>
</tr>
<tr>
<td>Particle and Plasma Instrument</td>
<td>New Horizons PEPSSI, Deep Space 1 PEPE</td>
</tr>
</tbody>
</table>

Capable model payload with a conservative approach
JEO Baseline Mission Overview

- NASA-led portion of EJSM, extensively studied in 2007–2008
- Objectives: Jupiter System, Europa
- Launch vehicle: Atlas V 551
- Power source: 5 MMRTG
- Mission timeline:
  - Launch: 2018 to 2022, nominally 2020
    - 6-year Venus-Earth-Earth gravity assist trajectory
  - Jovian system tour phase: 30 months
    - Multiple satellite flybys: 4 Io, 6 Ganymede, 6 Europa, and 9 Callisto
  - Europa orbital phase: 9 months
  - End of prime mission: 2029
  - Spacecraft final disposition: Europa impact
- 11 Instruments, including radio science
- Radiation dose: 2.9 Mrad (behind 100 mils of Al)
  - Handled using a combination of rad-hard parts and tailored component shielding
  - Key rad-hard parts are available, with the required heritage
  - Team is developing and providing design information and approved parts list for prospective suppliers of components, including instruments
JEO Jupiter System Science

- Jupiter and Io monitoring, atmospheres, magnetospheres, rings, and small bodies
  - Io: 3 flybys
    - Opportunities for imaging, IR spectroscopy, altimetry
    - In situ analysis of extended atmosphere with INMS at ~75 km
- Europa: 6 flybys
  - Radar and optical remote sensing characterization and calibration
  - Imaging up to 10–50 m resolution, NIR 250–1250 m
- Ganymede: 6 flybys
  - Radar and optical remote sensing of grooved and dark terrains
  - Range of lats, lons for in situ magnetosphere sampling
- Callisto: 9 flybys
  - High-latitude flyby for gravity field determination
  - Ocean characterization with magnetometer

<table>
<thead>
<tr>
<th>Satellite</th>
<th>≤1000m</th>
<th>≤200m</th>
<th>≤50m</th>
<th>≤10m</th>
<th>Length IPR (km)</th>
<th>Length LA (km)</th>
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<tbody>
<tr>
<td>Io</td>
<td>30%</td>
<td>20%</td>
<td>5%</td>
<td>-</td>
<td>1000</td>
<td>7400</td>
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<tr>
<td>Europa</td>
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<td>60%</td>
<td>15%</td>
<td>0.01%</td>
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<td>19000</td>
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<tr>
<td>Ganymede</td>
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<td>50%</td>
<td>10%</td>
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<td>Callisto</td>
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<td>75%</td>
<td>5%</td>
<td>0.01%</td>
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<td>30000</td>
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JGO Science

• Key Science Objectives
  – In-depth post-Galileo exploration of the Jupiter system, synergistically with JEO
    • En route to Callisto and Ganymede
  – In-depth study and full mapping of Callisto
    • Multiple flybys using a resonant orbit
  – Detailed orbital study of Ganymede
    • Elliptical orbit first, then circular orbit

• A major step forward in our understanding of the two iciest Galilean satellites, Ganymede and Callisto:
  – Ocean detection and characterisation
  – State of internal differentiation
  – Global surface mapping: geology and chemistry
  – Comprehensive study of Ganymede’s magnetism
  – Relations between thermal history, geology, oceans and the Laplace resonance
JGO Baseline Mission

- ESA-led portion of EJSM
- Objectives: Jupiter System, Callisto, Ganymede
- Launch vehicle: Arianne 5
- Power source: Solar Arrays
- Mission timeline:
  - Launch: 2020
    - 6-year Venus-Earth-Earth gravity assist trajectory
  - Jovian system tour phase: ~28 months
    - 9 Ganymede flybys
    - 21 Callisto (19 close flybys)
  - Ganymede orbital phase: ~9 months
  - End of prime mission: 2029
  - Spacecraft final disposition: Ganymede impact
- **Radiation**: ~85 krad behind 320 mils of Al (requirement to keep below 100 krad)
EJSM Synergistic Science

Illustrative timeline

Calendar Year

<table>
<thead>
<tr>
<th>2020</th>
<th>~</th>
<th>2025</th>
<th>2026</th>
<th>2027</th>
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<tbody>
<tr>
<td>JEO</td>
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<td>Dec</td>
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<td>JGO</td>
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<td>Feb</td>
<td>GOI</td>
<td></td>
<td>EOM</td>
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<tr>
<td>Mar</td>
<td></td>
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<td></td>
<td>May</td>
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Jupiter Magnetosphere Studies

Io Volcanism & Io Torus Dynamics

Satellite/Jupiter Monitoring

Ganymede Magnetosphere Studies
Europa Jupiter System Mission
NASA Jupiter Europa Orbiter + ESA Jupiter Ganymede Orbiter

- **EJSM Study**
  - International team
  - Built on previous studies
  - Community involvement
- **Technology and mission design are mature**
- **Well-defined hypotheses**
- **Exploration opportunities**
- **Scientifically rich mission to compelling planetary system**

*EJSM would revolutionize our understanding of the emergence of habitable worlds around gas giants*