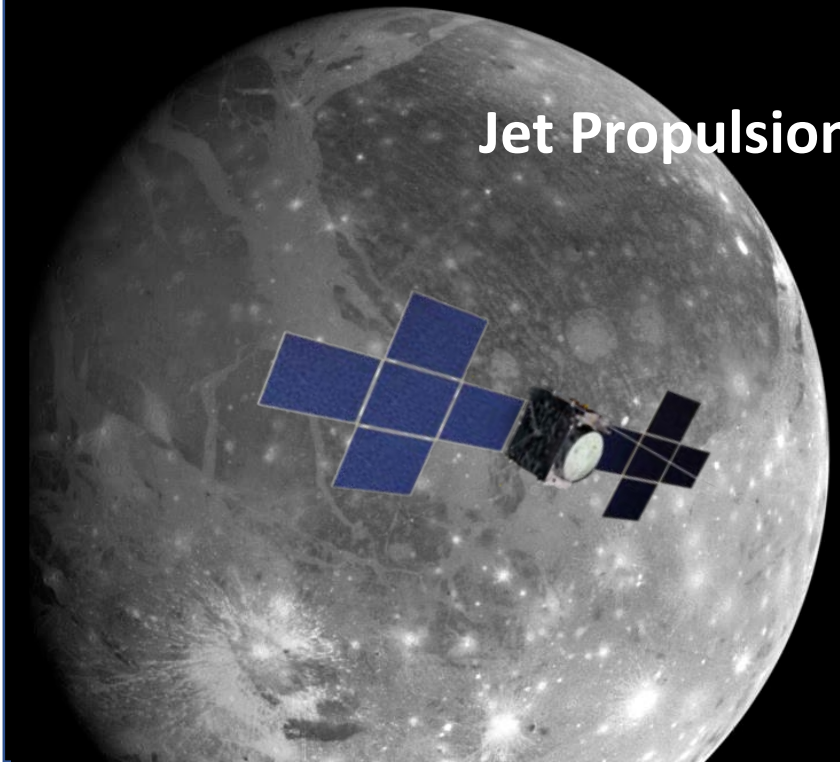
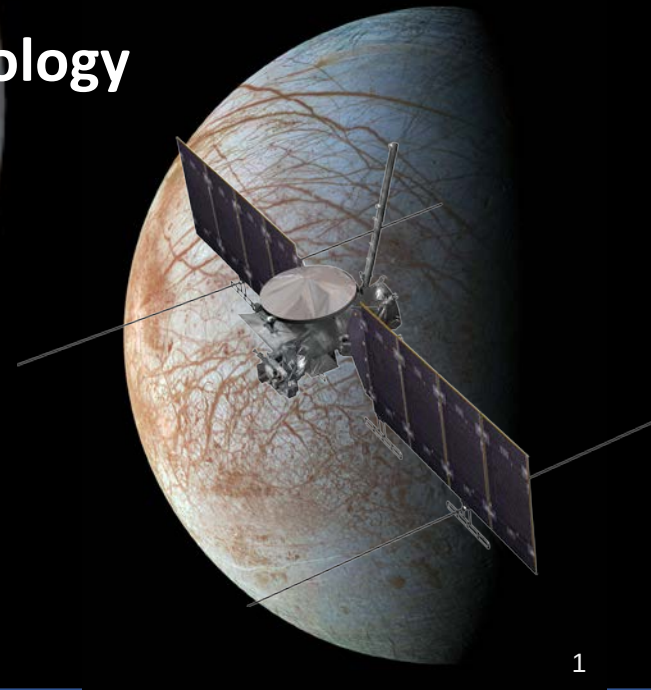
Summary of the
JUICE – Europa Clipper Collaborative Science Workshop





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JUICE – Europa Clipper Collaborative Science Workshop

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Members of the JUICE and Europa Clipper science teams met to discuss potential synergistic and complementary science between the Europa Clipper and JUICE missions

- **Investigations if both missions *are* in the Jupiter system at the same time:**
  - Multi-point measurements of the characteristics of the Jovian magnetodisc, with each spacecraft providing far-field context for the other
- **Investigations if both spacecraft *are not* in the Jupiter system at the same time:**
  - Opportunities for observations that are spatially or otherwise complementary, e.g.
    - Complementary coverage in spatial, spectral, energy, and geometric domains
  - Observations providing long temporal baselines, e.g.
    - Time-variability of the Jovian magnetodisc
    - Europa's atmosphere and potential plume activity
- **Combined data sets would offer a more complete view of the Europa, Ganymede, and the Jupiter system, while enabling in-depth comparative studies of the ocean worlds Ganymede and Europa.**

Opportunities for Satellite Science (1/2)

- The payloads of the two spacecraft are not identical (except for UVS), providing the opportunity to bring a greater set of instruments to address satellite science
- The remote sensing instruments onboard the Europa Clipper will obtain extensive coverage of Europa that could be augmentented by JUICE observations
- The Europa Clipper is a Europa focused mission, however calibration opportunities at Ganymede and Callisto could augment the JUICE data set
  - In principle, combined flybys from JUICE and Europa Clipper could be used to increase the overall coverage at Callisto (the JUICE coverage alone is non-optimal and constrained by dynamical needs).
- Assessment of Active Processes (if in the system at the same time):
  - If the Europa Clipper were to discover outbursts in activity at Europa or Io, JUICE could provide backup support with additional observational coverage.
  - Stereo imaging of plumes using imagers on both spacecraft could provide a valuable constraint on plume dynamics.

Opportunities for Satellite Science (2/2)

- **Geophysical investigations:**
  - If JUICE and Europa Clipper were to be in the Jovian system simultaneously, then Same Beam Interferometry (single-dish and standard) could significantly improve the Europa Clipper's positional accuracy, facilitating better measurement of the physical tides of Europa (h_2 Love number);
  - Comparative characterization of the surface properties and ionospheres of Ganymede and Europa could be obtained through radio tracking and bistatic radar observations;
  - Multiple spacecraft could improve gravity field coverage at Callisto by distributing closest approach positions more widely over the satellite
- **Potential Investigations of Io*:**
  - Simultaneous imaging of Io in eclipse from the two spacecraft could provide unique information on the three-dimensional plasma interaction;
  - One spacecraft could image volcanoes while the other images the torus to connect mass loading rates to plasma state;
  - Io volcano monitoring

*The Europa Clipper mission has direction to investigate only Europa

Opportunities for Magnetosphere Investigations (1/2)

- The best science opportunities would take place if both spacecraft were in the Jupiter system at the same time
- Multipoint measurements:
  - Inside vs outside (magnetosphere vs solar wind);
  - Inside vs inside magnetosphere (Jovian environment);
  - Inside vs inside magnetosphere (Ganymede environment);
  - High latitude vs equatorial
- Remote/in-situ JUICE observations in support of Clipper Europa measurements during flybys.
- Characterization of distant wake crossings of Ganymede, Europa and Callisto.
- Identify distant Alfvén wing crossings of moons, if any.
- Callisto synergistic science from combined data sets could allow an induction experiment at multiple frequencies.
- Unique trajectories (JUICE can reach the upstream regions where plumes have been detected).

Opportunities for Magnetosphere Investigations (2/2)

- **Two point observations (requires simultaneity)**
  - Could provide upstream information for the other spacecraft observing the interaction (especially useful for JUICE once it is in orbit around Ganymede).
  - Remote and local observations (visible, UV or ENA emissions from JUICE and local measurements from Clipper).
  - Local measurements through Alfvén wing and remote sensing of ionospheric footprints.

- **Future Europa Clipper-JUICE interactions:**
  - Continue to refine potential synergistic and complementary science opportunities for further joint discussion
  - Plan for a follow-on project-to-project workshop in conjunction with the Sept, 2019 EPSC-DPS meeting in Geneva