# Discussion during the Europlanet meeting, June 2, 2011, Helsinki, Finland

## Participants:

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Presentations given in Helsinki will be available soon on the Europlanet NA2 website: https://europlanet-scinet.fi/index.php?id=91

## Executive summary:

During the Europlanet workshop on the Jupiter magnetosphere on May 31 – June 2, Helsinki, Finland, many of the leading European and US scientists in the field of magnetospheres of the outer planets discussed the reformulation of the EJSM – Laplace mission and considered the options for a new European led Jupiter mission. The options under discussions are:

*Option 1:* The present baseline Laplace/JGO mission

*Option 2:* An optimized mission profile, incorporating some Europa (flyby) science, at the expense of some previously planned science (1-4, 10s Europa fly-by's)

*Option 3:* A mission focused on ocean research at Ganymede and Europa, with a reduced instrument payload.

Additional given constraints for all three options include no significant changes to spacecraft mass and power from the current JGO spacecraft concept. In order to evaluate the overall science value of each option one has to determine how added Europa flybys

- impact the science of the original baseline mission,
- impact on the science payload to be able to make measurements close to Europa,
- impact on other mission phases (eg. Ganymede science, Jupiter system science (magnetosphere, atmosphere), Callisto science).

## The findings of the group are:

**Option 3:**
Option 3 is so different from the nominal plan that this option would constitute an entirely different mission parameter space in terms of mission requirements, science scope and payload, and would have to be studied as a new mission.

**Option 2:**
(1) Option 2 cannot fulfill the prime Europa objective to "characterize and determine the extent of sub-surface oceans" using the magnetic signature due to unrealistically high amount of the required fly-bys (> 50)
(2) Option 2 would provide the first detailed information about the surface and near space environment of Europa, an important objective of the original JEO program, and could potentially provide unprecedented interior composition information from plume outgassings. Therefore the science priorities in Option 2 should be given to:
   a. composition measurements from surface to external environment to understanding the origin of and the habitability of Europa and, through comparative studies, other Galilean moons
   b. search for plumes/active regions on Europa
(3) New potential science must be weighed against extreme requirements to be imposed on instrumentation not only to cope with substantial total ionizing dose increase, but to operate in the extreme Europa environment under much higher backgrounds. Also the new potential science must be weighed against the loss of Ganymede science.
(4) The radiation environment of option 2 is very different compared to that of the initial JGO design. This will put an extra risk for a mission selection. On page 10 of Laplace technical report it is stated that "pure european contribution to JEO [were] considered as medium/high risk", because of radiation and planetary protection

**Option 1:**
(1) Option 1 is a strong and mature mission concept that already addresses several high priorities in the Cosmic Vision.
(2) Remote observations of Europa and its environment from Ganymede orbit and beyond can characterize some aspects of the Europa space environment and determine its impact on the surface and atmosphere.
(3) Option 1 still has a high potential to make a winning mission that will provide ESA and the science community with ground-breaking discoveries for a long time ahead.

## Recommendations:

(1) Form an interdisciplinary "remote-sensing" task force to identify and optimize cross-instrument investigations that would maximize the science return from Europa under option 1. This task force should be formed immediately and their findings should provide measurement requirements for potential instruments;
(2) Study in more detail the impact of possible Europa flybys on the current model payload (necessary design changes etc.)

## Detailed Summary of the Europlanet workshop from the particles and fields science perspective:

1. This group only considers options 1 and 2 to be realistic within the time frame. Within option 3 we lose too much of our particles and fields science in a not fully studied completely new Ocean science mission
2. Ganymede magnetosphere science remains top priority for the particles and fields group → unique case in our solar system of a small magnetosphere within a huge magnetosphere at sub-Alfvenic flow parameters
3. If option 2 would be selected:
   - Keep Callisto phase as is (corotation breakdown region and comparative moon-in-situ studies)
   - Change Jupiter mission phase orbits to get better local time coverage in the tail AND in the dusk/dayside region of the magnetosphere
   - Include cruise science in mission concept months before arrival at Jupiter for solar wind monitoring, partial recovery of synergistic science
   - we support some (few) Europa flybys at the expenses of a reduced Ganymede science orbital phase, as far as it does not impact significantly the fields and particle payload, which we find fully satisfying for the science objectives of the mission.
   - keep Ganymede elliptical phase to fully characterize Ganymede's magnetosphere
   - Ganymede 500 km phase has less interest from the magnetospheric point of view (how many orbits are needed to the high resolution imaging?), would prefer 200 km instead
   - Keep the Ganymede 200 km phase (minimum duration has to be studied) for plasma/neutral measurements
   - Europa science priorities (ocean detection not possible with only a few flybys):
     1: Composition measurements from surface to external environment are key to understanding the origin of and the habitability of the Galilean moons
     2: Search for plumes/active regions on Europa
   - two flybys instead of one are preferred (one in the wake one in the magn. ram-limb flyby preferred, solar illuminated side, as low altitude as possible)
4. Remote sensing of Europa from a Ganymede orbit should be an explicit part of the new Jupiter mission scenario independent if option 1 or 2 would be selected→ partial "recovery" of Europa science can be done from Ganymede orbit (is mentioned in the original Laplace proposal)

## Pros for a close Europa flyby or several flybys

- Will address more of Cosmic Vision habitability theme (One big difference between Europa and Ganymede according to interior and astrobiology experts is that at Europa it is believed that the lower limit of the ocean is in contact with silicate but at Ganymede it is with ice - and according to them this gives Europa a much better chance for habitability)
- Political impact: "Europe going to Europa"
- First high-resolution ion composition measurements
- First INMS measurements in the vicinity of Europa
- First detailed plasma measurements both Europa and Europa torus region (ion and electron distrib functions, plasma waves, composition of plasma, ion charge states, negative ions?, …)
- First low energy ENA measurements close to Europa
- First chance to measure and compare escape and surface erosion for three different Galilean moons (important to understand moon evolution)
- Possibility of directly sampling surface material/composition (with instruments like a Dust detector (can look at large molecules), INMS, Gamma X-ray Neutron Spectrometer GXNS, …
- Probe region between 9.4 and 15 RJ at the expense of longer phase farther out
- Compare three moons with same suite of instruments
- Europa magnetospheric sputtering enables astrobiology from flybys & orbit
- only H, He, C, O, Na, S, Cl, K measured so far– minor species are important as bio-markers
- MAG + RPWI (dc E + conductivity) can put constraints on the electrical current flowing in the ocean below one flyby, and give the conductivity of the ocean material.
- First measurements of dc electric fields, conductivity and currents.
- First determination of sub-surface conductivity.
- First in-situ measurements of the Europa's dense ionosphere.

## Cons of one to several Europa flybys:

- Which G phase would we want to give up? INMS would like lower altitude/time spent, e.g. Methane, cover atmosphere more completely. How much time at a minimum do you need at 200 km to do the required science? Unsophisticated models of Ganymede's magnetosphere complicate this discussion.
- Current plan: 60 days at 200 km, 120 days at 5000km/elliptical and 120 days at 120km/500km. What if you just cut these time periods in half – would this change the science, what is the minimum amount of time at 200 km for instance to do required science?

- Can sense Europa from Ganymede orbit with e.g. ENA, UV?, so is there a compelling reason to do in situ?? What can be achieved remotely? Can we recover some of the JEO science remotely – for instance, can we do any surface science with IR, UV remotely? Balance Europa in situ versus Europa remotely.
- Get Europa for "free" if we emphasize remote science
    - auroral observations
    - ocean remote science (HST proposal by Saur)
    - atmospheric observations with HAST
    - Jupiter system in UV (e.g. New Horizons results (32 RJ flyby distance from Io))
    - radio observations
    - ENA observations
    - Dust observations
    - Io torus weather in (UV), IR (Nozawa, 2005) amateur astronomers
    - energetic particle observations at Earth (Owens, 2010)
    - satellite aurora (Europa tail → plasma plume in the wake of Europa if the moon is in the center of the plasma sheet)
- with a limited number of flybys, the remote sensing instruments (IR, UV, Vis,...) will just get a sparse and very small coverage of Europa's surface at high spatial resolution. It will not be much better than Galileo.
- Coverage of Ganymede in different configurations (e.g. dawn/dusk) – the more complete the G phase, the more we will see G in different configurations.
- Do one more extensively and do some science of other moons versus try to do several moons at a lower level.
- assess what is enough time in orbital phase to make sure we are doing one moon "right." If you lose 60 days at G to have 2 E flybys, is this worth it??
- What critical science return could we get with a flyby of Europa? What critical instruments are needed? How would you need to augment payload to do this or what functions would you need on the current instruments to address these goals? For instance, UVS to imager? Need time to study
- Radiation dose and redesign of orbit to accommodate Europa – will drive requirements for instruments (such as **operations, design**, parts, …), are at 85 krads (behind 10 mm Al) – so adding 10-20 krads per Europa orbit/flyby would push parts over 100 krads (on the shelf for many parts)
- The radiation environment of option 2 is very different compared to that of the initial JGO design. On page 10 of attached document it is stated that "pure european contribution to JEO [were] considered as medium/high risk", because of radiation and planetary protection
- There will be changes in the mission orbits that will lead to:
    - Loss of Ganymede science
    - Loss of Callisto science (C phase will be shortened/cancelled)
    - Loss of Jupiter system science

- additional problems with increased backgrounds in particle instruments (TID is NOT the main issue).

## Further recommendations to the SST-Team of the new Jupiter mission:

- origin theme is hidden too much→better address habitability theme in the new mission description
- encourage community to organize similar workshops for other disciplines for planetology, atmosphere, etc. in order to mobilize the community to support our Jupiter mission.
- take the shielding of the moons into account for the radiation dose calculation and you get a Europa flyby for "free"
- form a working group on Europa remote sensing from Ganymede orbit
- Study in more detail the impact on the current model payload of possible Europa flybys (necessary design changes, risk change, etc.)