Meeting of the Jupiter/Europa International Working Group
December 15-16, 2005, UCLA
Notes and Summary

PRESENTATIONS AND DISCUSSION

Melissa McGrath presented a summary of problems in the NASA funding profile including lack of overguide (additional funding) for 2007. There may be budget reductions in '06. No specific money has been allocated for a Europa study. However, congress supported the idea of a Europa mission.

Marcello Coradini told us that there are now 17 members in the ESA family. Greece and Luxembourg are the new ones. The Council of Ministers meeting in Berlin last week was chaired by the Minister of Economy from the Netherlands. They granted ESA a 2.5% per year budget increase, which is higher than inflation and reduces their budgetary problems. Within this context, the first possible launch date for a Europa mission is 2017. This is a good launch opportunity as well. As far as he is concerned, this committee can take this date as a target. Marcello stated that in the next two years he can lean on ESA to take leadership in carrying out studies and he recommends continuation of this Working Group on a longer basis than was originally envisaged.

The ESA philosophy is to support missions designed to advance science and knowledge. To achieve this goal in the coming years, they are guided by *Cosmic Vision 2015-2025*, a document (on their website) generated by their Space Science Advisory Committee, which strongly endorses further exploration of Europa and the Jovian system.

Bob Pappalardo presented an overview of processes thought to be acting on the crust of Europa. He supported coordinated observations by an Orbiter and a Lander to provide key parameters of the system.

Angioletta Coradini reported on a community workshop in Paris earlier this week. More than 70 people attended and functioning subcommittees reported back. Figure 1 summarizes their thinking on the critical problems of the Jovian system and proposes an ambitious suite of spacecraft to address the fundamental issues. At this point in the meeting conflicting comments arose regarding the status of planetary protection issues. These matters need to be clarified in advance of the next Working Group meeting.

Bill Moore of UCLA summarized five years of efforts in Astrobiology. He pointed out that remote sensing probes only the top layer of the surface. Ideally one would want to go down at least 1 meter (which is roughly the depth affected by gardening). This is difficult to achieve, especially without damaging complex molecular forms. He introduced us to the Europa Focus Group for the NASA Astrobiology Institute and stated that it is being revitalized. He announced meetings (Feb 27-28 NASA Ames) March 26-30 Astrobiology Conference in Washington DC. He said that the astrobiology requirements would be very demanding for a Lander. He also indicated that the community would strongly support a simpler Lander with limited capability as a precursor. This fits within concepts of the Decadal Report.

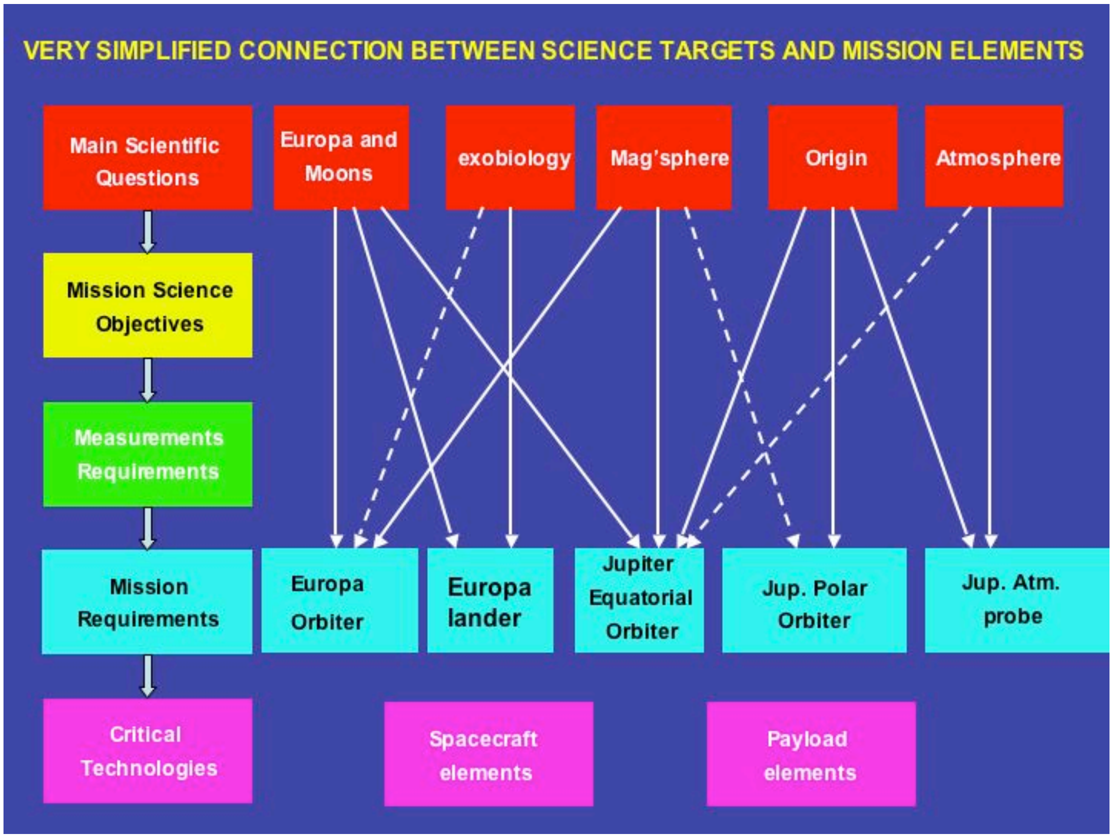

Figure 1.

NOTE: all arrows are lacking on this figure, and they must be reproduced if we want to convey the message. I have suggest (see above) a change in the comment of that figure in the text: the idea is certainly not to say that we want to fly all these spacecraft, but to examine all possible mission elements (e.g. spacecraft) that could a priori be used in a Jupiter system and Europa mission and to see how scientific objectives in a particular science area can be addressed by specific mission elements (e.g. spacecraft). That connection is shown by the arrows which are lacking here. The original figure is slide 19 of the attached document.

Jerry Schubert was asked to provide a critical analysis of the OPAG science objectives for Europa exploration. He agreed with OPAG priorities for the most part but recommend that a gravity field measurement be added. He reordered OPAG priorities. In particular, he emphasized that the first priority is to confirm the presence of a global ocean, an objective central to both geophysical and astrobiological interests. Bill Moore commented that some of the OPAG ordering is based on difficulty of measurement – this bias should not be lost when utilizing OPAC recommendations.

In order to characterize the internal structure, the quality of the radio science measurements is central. This aspect of the mission needs must be followed with care. Marcello Coradini confirmed that ESA has two operating 30 m dishes and plans to construct a third to give them their own Deep Space Net.

Nick Makris presented analysis of the use of seismic noise produced by surface cracks to probe the depth of Europa's ice shell with a single detector. His work assumed a large, localized event and illustrated limitations of the technique.

John Baross stated that an important and relevant question is "Can Europa support life as we know it on Earth?" Answering the question of whether life as we know it exists on Europa at the present time is much harder, so he chose to address only the first question. A key point is to seek environments where electron acceptors and donors are present. That is a minimal requirement for life. He emphasized that life can exist in the absence of oxidizing reactions. The question can be formulated as, "What do we measure to detect 'processes'?"

Krishan Khurana gave a tutorial on the measurements of inductive responses and what could be achieved with two point measurements (magnetometers on two Orbiters or an Orbiter and a Lander) that cannot be achieved with single point measurements. The two point measurements allow one to separate internal and external fields. He also emphasized that multiple frequencies of magnetic forcing, therefore single-point observations over a long time, can be used to constrain the thickness of Europa's oceans.

Daniel Prieur and **Angioletta Coradini** summarized the science objectives for the Lander that were formulated at the Paris meeting. The key points appear as Appendix A.

Michel Blanc and Marten Roos-Serote joined the meeting by telecon to summarize the science objectives for the Jupiter and its satellites that were formulated at the Paris meeting. The key points discussed in this telecon and presented by Angioletta Coradini and Daniel Prieur are summarized in Appendix B.

Tom Spilker discussed four independent JPL studies of Lander configurations. The constraints that were applied in the four cases differed. Spilker utilized the results to illustrate limitations on the level of science that can be accommodated within various mass ranges. Some of the key issues link to lack of information about surface properties. For example, he emphasized that the angle of attack of a penetrator cannot diverge by more than 5 degrees from the surface normal and is therefore not under consideration. Of the cases discussed in detail, one in the 60-70 kg range, similar to the "bowling ball" configuration, seemed to the group worthy of further consideration as a precursor for a sophisticated Lander on a later mission.

Peter Falkner gave us an extensive report of studies of Lander configurations carried out by ESA. We were struck by the degree to which the two independent groups converged in their conclusions, obtaining highly similar results for optimum configurations and mass and fuel estimates. We were heartened by evidence that gravity works.

Reta Beebe and Melissa McGrath clarified the roles of NRC reports and NASA Roadmaps and described how they are utilized to establish mission constraints. Reta reviewed the international collaboration that has been fundamental to the Cassini-Huygens mission and the success of this mission. She characterized the nature of the JUNO mission. The way in which Juno fits into the Cosmic Vision plan was discussed by the group.

The group discussion that followed produced a consensus recommendation that, based on the anticipated timelines for the development of a Europa mission, this consultative group continue to meet. A date for a follow-up meeting in April is being explored and telecons will be set up in the interim. The ESA group intends to support further technological studies. They requested guidance on desired studies. Some proposals included better definition of instruments that can pursue astrobiological goals from orbit. NASA is encouraged to support further technology studies to characterize a "precursor-type" Lander.

FOLLOW-UP ACTIONS

The Working Group needs a written statement on planetary protection issues that would constrain plans for a possible lander and orbiter mission scenarios, especially whether crashing into Europa is an acceptable end of mission. Melissa McGrath accepted this as an action item

From Pappalardo/Makris: The analysis of what can be learned from an isolated event that rises above the background seismic noise relies on having such an event occur during a limited time interval. This leaves unanswered the question: Can a single seismometer learn anything from recording of the background seismic noise over the lifetime of the Lander?

From Bob: [The preliminary answer is certainly "yes" as this provides opportunity to understand the background level of seismic activity, and how this activity correlates with the tidal cycle. Nick Makris and I can produce a more thorough answer.] This has been requested.

From ESA specialists: From experience with MARSIS on Mars Express, what can ice penetrating radar tell us about the existence of water beneath the surface under varying assumptions regarding the depth of the ice covering and the horizontal extent of the water layer?

APPENDIX A - Content of Paris Workshop
A Future Mission to Europa and the Jovian System
Dec 12-13,2005

Presentations will be available at
http://astro.oal.ul.pt/~eurojove/JS/index.html

Objectives of the meeting

- Inform the european science community on the on-going joint ESA/NASA activity and associate it to the work

- Provide community inputs to the 2nd meeting of the ESA/NASA working group: Dec. 15-16, UCLA by an assessment of Europa and Jupiter System science and priorities based on contributions by individuals or groups:

  – Moon Geophysics, Geology and Atmospheres (8 contributions)
  – Jovian Atmosphere: Composition and Dynamics (5 contributions)
  – Jovian and Jovian-moon Magnetospheres (8 contributions)
  – Origin of the Jovian System (5 contributions)
  – Europa and Jovian System Exobiolology (5 contributions)
  – Each session summarized/synthetised by a moderator –text and part of the contributions will be on line at

- Start definition of mission elements (Jupiter and Europa orbiters, Europa lander(s), Jupiter probe(s)) based on unconstrained community inputs

  – Contribute to the definition of the mission and lay the foundations for the preparation of the response of the future ESA AO

General comments

- Meeting very well attended (over 70 participants)
- Discussion was open, more or less all areas of Jupiter system science addressed, provided good and fruitful exchange between scientists and ESA and an improved mutual understanding of science expectations and technology/cost/mission design issues

- Through maintenance of the workshop site, will be a tool for the study group for further design of the mission:
  – Science inputs
  – Overall balance between themes and mission elements (see next slide)

- Provides an initial input to start developing the science and technology requirements matrix of the mission (see following slide)
- Complementarity with JUNO is a key element – suggests a closer link with JUNO should be established in our study work, for a better understanding of what JUNO will and will not cover
- Workshop summaries (by session) and general summary to come on http://astro.oal.ul.pt/~eurojove/JS/index.html
- start definition of mission elements (Jupiter and Europa orbiters, Europa lander(s), Jupiter probe(s)) based on unconstrained community inputs.
- Contribute to the definition of the mission and lay the foundations for the preparation of the response of the future ESA AO.

Summary of Paris meeting presentations -Searching for Life on Europa - Daniel Prieur

Key questions

Main difficulties correlated to the identification of sign of life on Europa are due to the insufficient knowledge of physical/chemical conditions and the abundance of organic compounds present on and under the surface. Here following some key questions are reported.

Is it present liquid water ocean under the surface and what are its properties?

How the surface and the ocean of Europe interact?

How thick is the surface ice crust and which is the chemically modified fraction?

Can hydrothermal motions present under the oceans maintain a chemical disequilibrium?

Is the mixing process of the crust active to such deepness to be able to carry the radiolysis products (such as H_2O_2) in the oceans below the surface?

Does the synthesis of nucleic acids precursor occur?

Is it possible to determine the parameters that probably have carried the oligomerization and/or polymerization of the prebiotic precursors?

Which are the parameters that drive the reactions of synthesis of nucleic acids and how they correlate to the local environmental conditions?

Suggested key measurements are grouped according to different kind of biomarkers.

Molecular: to determine the presence and the concentration of organic macro molecules
(> 1000 amu) for the identification of chemical pattern and biological activity.

Biomolecular: to determine the presence of biological macro molecules (nucleici acids, proteins, polisaccarids and lipids).

Biogeochemical: to measure the geochemical transformations of organic and inorganic compounds. To detect and measure the abundance of minerals.

Metabolic: to measure the concentration of compounds: H_2O, CO_2, CH_4, NH_3.

Isotopic: to measure the relative abundances of isotopes in organic compounds.

Environmental: to determine energetic sources and to measure the oxygen and hydrogen peroxide concentration. To measure the intensity and the space distribution of the particles irradiation.

Geological: to comprise the formation of the surface morphology and to characterize the undersurface interfaces ice-water. To determine the presence of the liquid ocean.

Conclusions

- Landing on Europa with a multi-instrument payload is mandatory to address the exobiological target of the mission
- If landing mission results unfeasible after evaluation of different mission scenarios (and different budget assumptions), only a well defined stepped program could guarantee the expected scientific return on the exobiology side
- Critical technologies (or at least to be developed) also on payload side (resources, environment, new applications)

Appendix B -The Paris Meeting: Planetology
Dec 12-13,2005 –Michel Blanc & Maarten Roos-Serote

NOTE : this is not from the ppt document by MB and MRS, but from the ppt summary of the same meeting by Angioletta. There are some significant differences due to the fact that we had to work separately and in a very short time. If you want to quote MB and MRS here, please add their presentation (attached) as appendix C and keep appendix B as it is but quoting Angioletta. Otherwise I suggest the best in the end will be to replace these two documents by the approved summaries of the Paris meeting, which will be produced, edited and validated by the whole ESA group early in January and posted on the meeting web site. This will provide a single approved document as the reference summary of the Paris meeting, and will be less confusing in the end.
Another possibility could be, just to produce an exact account of all the material presented at the UCLA meeting, to post on a web site all the documents produced and discussed, and to just refer to this site in your meeting summary (e.g., keeping the main text only and replacing the appendices by a reference to the web site). In fact it would be very useful and interesting for our group to have a restricted access to all documents, including those produced by the U.S. participants to the meeting. Reta, why not use the web site you started developing this summer for that ? I am sure Maarten could mirror it on his own web site and in return help you to mirror the Paris meeting web site if you think it is useful. We could then use that tool to post and archive all documents from all our working group and associated meetings, as you had suggested initially.

Subjects of the meetings

- Moon Geophysics, Geology and Atmospheres (8 contributions)
- Jovian Atmosphere: Composition and Dynamics (5 contributions)
- Jovian and Jovian-moon Magnetospheres (8 contributions)
- Origin of the Jovian System (5 contributions)
- Europa and Jovian System Exobiolology (5 contributions)
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Moons geophysics

- The focus was – as requested and expected – on Europa
- All the presentations however showed that the case of Europa should be seen in the right context of evolution and differentiation of satellites
- Geological, geophysical aspects were discussed

Europa Science

- What is the energy source of the Europa/Ganymede Activity?
- What is the size of the core and it composition?
- Does an ocean exists? And if so is it made of liquid water?
- How depth of the ocean?

- Are volcanism and outgassing present and are they sufficient to brink at the surface subsurface material?
- What is the geological history of these satellites→ how old are the surfaces?
- Does liquid water and vapor exists on Europa and is it associated with hydrothermal activity ?
- Are salts present in the Ocean and on the surface?
- What are organics present on the surface?
- Variability of the surface composition and its correlation with surface

Europa Science Surface and Interactions

- Interaction surface – ambient
  - Particles bombardment
    - Sputtering
    - Surface aging
  - UV irradiation, magnetospheric radiolysis
  - Dust production ?

- Craterization
  - Micro- Craterization → Sputtering
  - Style of cratering→ Craters as probes of the subsurface characteristics
  - Dust production

- Life

Surface composition and physical state

- Infer the complex composition of Europa surface and its spatial variability correlation with geology
- Understand the chemistry (internal, irradiation) by modeling and confrontation with the observation
- Determine the relative importance of exogenic and endogenic sources of material to Europa's surface
- Estimation of the brine composition (s) coming from the internal ocean

Space environment

- which energies and species are detected and which collide with the surface or sputter the atmosphere ?
  - preferred sputtering locations
  - focusing and shielding effects on the particle elds
- influence on the previous 2 points of the ionosphere properties

- Day-night asymmetry
- Localization of sources of volatiles
- Variations of atmospheric composition

- Influence of the space environment temporal variability
- Influence of the induced magnetic field
- Importance of the molecular ions
- Cosmic radiation

Dust measurements

- Are they fundamental?
  - Can the source be localized?
  - Can the particles size and composition be identified and put in correlation with their source?
  - Can they contribute to a kind of “in-situ”?

Particle measurements in the Jovian system, a tool to investigate:

- the global configuration of the Jovian magnetosphere beyond Galileo
  - determination of the charged particle population (ion composition and charge states as well as electrons) in the magnetosphere
  - determination of the neutral particle population
  - determination of the global flow patterns of plasma and energetic particles in the system, especially in the vicinity of the Galilean moons

- the dynamics of the Jovian system beyond Galileo
  - interchange motion/radial transport of plasma and energetic particles
  - mechanisms of particle injections and its consequences – correlation with auroral emissions
  - tail dynamics (reconnection, flow bursts, ...)
  - up/downstream particles (Jupiter as particle source)

- the interaction of the magnetospheric plasma with the moons and rings
  - investigate the local environment of the moons and rings
  - investigate existing particle beams along the flux tubes connecting the moons with the aurora/ionosphere of Jupiter
  - determine in detail the structure and composition of the plasma tori of Europa and Io
  - determine the surface composition of the moons by analysing the sputtered material

Jupiter System Formation

- How does an investigation of Jupiter explain solar system formation and evolution? Why study Jupiter?
- What is the role of giant planets in forming Earth-like planets?
- Do giant planets migrate after formation?
- What was the source of water in our solar system? Was there more than one source?
- What were the basic characteristics of the solar nebula and planetesimal (composition, temperature vs radial distance, evolution) that led to the differences we see in the planets today?
- When, how, where did Jupiter form?
- What did Jupiter form from?
- How did the giant planets form?
- What are the orbital evolutionary paths of giant planets
- Does Jupiter have a rock-ice core?
- What are the elemental compositions of the giant planets?
- What are the internal structures and dynamics of giant planets?
- How can we use the giant planets in our own solar system to understand extrasolar giant planets?
- What was the composition of the satellite nebula and how is reflected in the present satellite composition?

Red –links to JUNO
Yellow -Missing

Jupiter Atmosphere

- Three-dimensional view of the atmosphere
  - P,T, Spectroscopy
  - Hot spots should be avoided
  - 2 probes 40 bars→ better then 1 100 bars
  - From point of view of dynamics 40 bars is OK, from point of view of origin not.
  - Study at high latitudes, composition and photochemistry possibly with a probe
  - Separate mission→ Atmospheric/ magnetospheric orbiter
  - New measurements of Io atmosphere (Galileo didn't have the right instruments

Magnetic field

- Exploration in depth of interactions surface-magnetosphere
- Change the orbit from equatorial to polar (Ganymede → Callisto)

- Plasma package→ plasma measurements
- Dust measurements of Jovian ring
- Importance of the first part of the mission→ two measurements in different positions
- Alfven wings → could we target the Io tube and measure there twice? → secondary tour
- Characterization in 3 D of the magneto-disk→ inclination of the orbit

Possible Model payload- Orbiter

- Gravimetry and Radio science
- Altimetry (laser, radar)
- Cameras→ Stereo
- Imaging spectroscopy, high resolution spectroscopy, Thermal IR spectroscopy (particularly where some activity can be identified)
- Spectral analyses of surface → multi-spectral stereo imaging (IR preferred)
  - surface minerals, ices and organics – missing C&N: → IR spectroscopy (IFU?; 3.4μm feature)
- Millimetric and sub millimetric measurements MIRO type experiment can be used
- High resolution magnetometer and plasma spectrometer→ Magnetospheric package (LUAM)
- "Libration experiments"→ Beacons

Lander/ non life requirements

- Imaging at different scale → geology
- Thermal flux → Geophysics Interior
- Isotopic composition D/H ice composition→ Origin
- Composition of surface material
  - Seismometric measurements
  - Mineralogy→ Raman Libs
  - IR spectroscopy
  - GPR + Rover + Drill
  - Rheological Properties of materials
  - Viscosity measurements
- Small beacon→ Internal structure