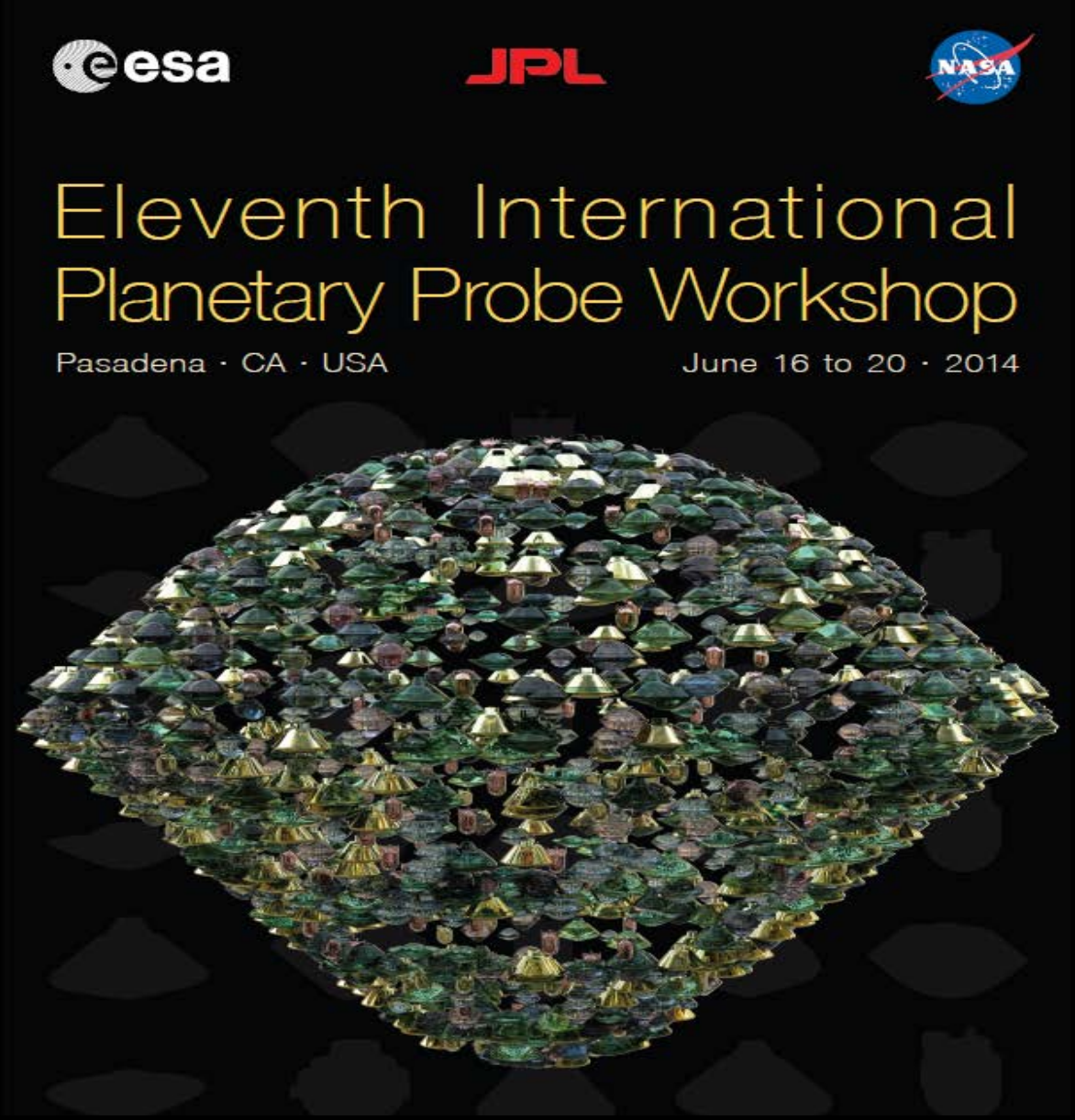

CLOSING SESSION: Highlights and Key Issues from IPPW11

Topics

- Missions
- Radio Science and Science Instrumentation
- EDL Technologies
- Inflatable and Deployable Technology
- Sustained Flight
- Modeling, Simulation and Testing
- Cross-Cutting Technologies

Highlights and Key Issues

Mission Session Highlights

- Mars Sample Return
  - Heritage Mars 2020 landing capability enables wide range of sample return sites resilient to the choice of mission date
  - ESA continues studies of missions leading towards Mars SR including PHOOTPRINT (Phobos) and INSIGHT (network science)
- Uranus
  - Investigation of direct ballistic entry and aerocapture
  - MUSE mission study reported (Student paper
- Competitive Missions
  - No presentations on current Discovery or M4 candidates
  - ***Twilight on Kraken*** (Lorenz) described lost opportunity to explore Titan seas
  - Animated discussions of whether science and technology should be the driver for new missions
- GN&C Technologies
  - Compensation for the roll motions of a spacecraft with a single ion or Hall thruster
  - Trajectory control for ADEPT deployable entry system
- Advanced Concepts
  - Venus VAMP hybrid airship concept accompanied by several poster papers

Key Issue: How to get new technology infused into missions?

Highlights and Key Issues

Mission Session – Key Issues

What mission enabling design and science attributes or features create the most implementable or selectable probe or small lander missions?

- There is a difference between the level of risk and science that is acceptable for in competed missions and sustainable for flagships and larger missions.
  - High TRL, very low risk are the desired attributes may be an unsustainable path, not acceptable for good science return.
  - Better approach was described as being the maximum science return possible while keeping the risk at acceptable levels.

- On probe and lander missions, in order to target certain areas, risks must be taken and needs to be an acceptable attribute of a mission rather than a very undesirable feature. Some changes in paradigm or technical breakthrough (such as the MSL Skycrane) can sometime be a important asset to a mission as they enable science that was before not possible.

- Technical, science and other attributes can be turned or trumped by politics and other outside influences. An example of that being the share of selected missions between various communities A good example was depicted in ESA's presentation, with 2 solar system and 2 astronomy missions .

- Certain topics (e.g. Mars exploration) can be helped by communicating the desirability of the science and mission, creating public acceptance that the risk and money is worth it. Public outreach and publicity become more important.

Mission Session – Key Issues

Are 'technology development' focused or driven lander missions a good idea or should science be the main design driver for all landers?

- Several missions (e.g. Pathfinder or Clementine) were initially thought as technology demonstrations, but an early involvement of the science community helped to get valuable science results from it.

- An early involvement of the science communities in technology oriented missions seems desirable as sometime small/early changes can enable a significant increase in the science return.

- Technology development demonstrations are also valuable (and in some respect necessary) in the form of additions to science focused missions:
  - these demonstrations being thought as addition to the threshold or baseline mission.
  - Many areas relevant to probe and lander missions need strong flight demonstrations.
  - Should encourage risky new capabilities to be flown with chosen missions where failure does not impact mission success

Cross over science and technology missions can be very desirable if the right balance is worked early, either adding highly desirable science results to technology driven missions or adding technology infusion or demonstrations to science driven flight projects

Highlights and Key Issues

Radio Science and Science Instrumentation

- When engineering measurements generate science results, a valuable synergy occurs that benefits both communities
- Although heat shield ablation sensors have not be flown on every planetary entry probe, heat shields must be instrumented to
  - Provide valuable engineering data that validates design parameters
  - Generate in situ “test” data that validates the design that can be used to minimize conservatism in future heat shields
  - Results in a independent check of the atmospheric parameters from science instrumentation
- Although rarely flown, up-looking cameras are invaluable for verifying parachute performance
- Mass spectrometer technology, including miniaturization, is constantly evolving to allow flight of more sophisticated instruments that can detect more isotopes to provide a measurement of planetary formation and age
- Although not yet validated on a flight mission, Doppler measurements from optical communications will provide wind measurements from planetary probes

Highlights and Key Issues

EDL Technologies

Key Issues

- Need proper balance between risk and reward.
  - Risk avoidance is leading to less innovation and constrained missions.
  - Current paradigm of risk needs to be revisited.
- Need proper balance of investments across the TRL range.
  - Projects reluctant to adopt new technologies on their own initiative.
  - Need to independently push high TRL technologies to final infusion
- Utility of hazard avoidance algorithms questioned, particularly for Mars landings

Highlights and Key Issues

Inflatable and Deployable Technologies

- Deployable and inflatable decelerators remain a challenging area. Advancements in material technology have allowed tremendous progress over the past two decades.
- The development of deployable heat shields is proceeding at a good pace, the primary limitation to using one on missions being the tendency to avoid mission proposals requiring them. The reasons are primarily risk aversion and costing uncertainty.
- Therefore, unless either a mission AO requires use of IRD technology or IRD is critical to execute a mandated mission, flight implementation will continue to be hindered.
- Risks and TRL levels are continually cited as reasons for not scoping IRD's, however, the methodology behind this characterization often has no quantitative backing and is indeed empirical.
- Inflatable and otherwise deployable heatshields are key to landing heavy payloads on planets (such as heavy rovers or human expedition hardware) and reaching high altitudes for in-situ science (incl. higher terrain on Mars).
- Aerobreaking, particularly aerocapture, would likely benefit greatly from inflatable and deployable decelerators.
- **Primary recommendation: Reinforcement of IRD technology development and overcoming the perception of their unreliability and lack of TRL maturity.**

Sustained Flight - Highlights

- Venus
  - Constant altitude balloon payload capability approaches 100kg (Hall*)
  - Variable altitude concept (pumped helium) balloon defined (Voss)
  - Venus aerosonde for unique high resolution surface images (Matthies)
  - Detection of Venus quakes with infrasonic signals promises to revolutionize investigations of Venus Interior (Mimoun)
- Mars
  - Demonstration of rotorcraft under Mars conditions (Tokumaru)
  - Advances in GN&C enabling for small rotorcraft (Balaram, Matthies)
  - Rotorcraft fills critical operational and science niche for Mars surface exploration (Balaram)
- Titan
  - Four orders of magnitude reduction in helium leakage in Titan balloon creates possibility of a balloon mission with multi year life (Pauken)
  - Titan Rotorcraft docking with balloon enhances Titan surface operations

* Paper by Jeff Hall at IPPW 11

Highlights and Key Issues

Sustained Flight - Highlights

Is the time ripe for a return to Venus with aerial platforms and if so what type of vehicle should it be?

- Science is there and technology is there too (Hannes)
- Entry technology may be remaining issue (Raj)
- Europe was a leader but has stepped back. Prospects for geophysical investigations could reinvigorate interest (Kevin)

Mars has been the target for numerous attempts to develop a mission involving balloons and winged vehicles. Can rotorcraft succeed where others did not?

- Technology demonstrations is the way to go. Model on Sojourner
- Seems to fill both a scientific and operational need

Question 3: What are the prospects for aerial exploration of Titan?

- Superpressure balloon with long life is a key development
- Helium pumping could permit efficient altitude control
- Rotorcraft important complementary capability – for sampling
- Power remains an issue – are there alternatives to RPS?

Highlights and Key Issues

Modeling, Simulation and Testing (1 of 2_

- The session contributions ranged over a very wide spectrum:
  - quantum mechanics modelling (with almost no experimental data to compare)
  - Monte Carlo simulations with analysis and fitting of empirical data

- Analytical/numerical tools and experiments complement each other and several trends can be identified
  - Although they are in competition at some times, both possibilities are urgently needed and used.
  - “Environment is different. Test on Earth might not reflect reality of space. We might miss something. Simulation could perhaps cover this.”
  - “Difference functions between simulation roles and test roles. Start with simulation to **build** a model. Then perform test to **validate** the model.

Highlights and Key Issues

Modeling, Simulation and Testing (2of 2)

- Both methodologies help each other to be improved, deficiencies removed and the level of trust improved.
  - “Nature of test is changing. Need difficult ground experiment. Simulation improved in terms of calculations but if the model is wrong it won’t help you.”
  - “Depends how much trust you have in your model. “

- There is insufficient sustained investment in the further development of numerical methods. It seems easier for experimental facilities.

- There is a lack of long-term strategies for development is stated on both sides of the Atlantic.
  - How do we continue to develop our tools and facilities in a broad sense when specific projects are the only source of funding and are only looking to meet their own needs?
  - Passion and advocacy must be leveraged to secure funding.
  - Projects should be paying for development of features that only they are concerned about.
  - Can we use institutional funds for tools development to fill gaps left by project money otherwise we will fall behind in term?

Highlights and Key Issues

Cross-Cutting Technologies

- Session is all fresh in our minds so no need to revisit!