Planetary Decadal Steering Committee Meeting
February 22-24, 2010

Open Sessions

Note – the content of the presentations is available on the Space Studies Board website, therefore, these notes focus on questions and discussions during and after the presentations as an additional resource. A question mark at the beginning of the line indicates a question or comment from the committee or audience.

Monday, February 22

Availability of Launch Vehicles, Warren Frick, Orbital Sciences

- ? Hint of price of Taurus 2?
    - Baseline ~$70 million ballpark
- ? NASA has criteria of a certain number of successes – when will deep space version have met that?
    - 3 successes at least before can put some payloads on top
    - Depends on how many have flown
    - In 2013 will have 3 done with liquid 1st stage and solid 2nd

Aerocapture, Tom Spilker and Michelle Munk

- ? For Mars case, how close to the surface can you go?
    - Minimum altitude is 30-50 km
- ? For aerocapture at the giant planets, how is the final orbit constrained by rings?
    - Particle avoidance, etc.
    - ? Constrains orbits?
        - Constrains the initial orbits
    - ? Saturn?
        - Not different, can use it to go to Titan orbit and then use Titan to decrease
    - ? Uranus?
        - The rings are more of a problem
- ? We are now at Technology Readiness Level (TRL) 5-6 for titan aerocapture today!
    - (nodding from audience)
- Proposal in now to look at validating the flattened ellipse aeroshell
- ? What would you prove in an earth flight test?
    - Have not yet done an atmospheric exit to a controlled target. Dipping in and out of higher density
- Skip entries have previously been qualified, but Orion was going to test it again and is not happening now

- Been directed to only look at chemical missions, so may have to demonstrate aerocapture directly
- ? TRL for Venus?
    - TPS is the only gap in understanding
    - TRL 5, but would need to add margin, so may not be quite as beneficial as it could be
- The tech experts say that it's ready to go!
- ? Subscale flight?
    - Yes
- ? Is this technology enabling for Neptune?
    - There are missions can get into orbit without it, but they are slow and give limited science
    - ? Corresponding for Uranus?
        - Not as much trouble with time spent to get there, so not as much of an advantage, but still delivers a lot more mass to orbit (2-3x)
- ? Titan system mission – what would it have been?
    - Could not have responded to the level 1 requirements – Saturn system and Enceladus science
    - Look at 2007 study by APL – aerocapture version of Titan mission

Solar Electric Propulsion for Outer Solar System Missions, John Brophy and Eric Pencil

- ? Anyone working on higher power solar arrays?
    - Yes, that is a key issue
    - Power vs Mass
    - Max power for a spacecraft has been just about doubling every 4 years
    - Dawn has more power than Skylab did!
- Hayabusa has used the ion propulsion for a lot longer than intended, but is still working
- ? Cost of PPU? Power Processor Unit (converts the solar array power to the currents and voltages to operate the thruster)
    - ~$8 million for 2
    - The vendor did not want to rebuild these when asked again
- For the near-term, the PPUs are the next technology problem (next discovery)
    - After that, it becomes the thrusters again
- Total impulse – longer life, higher power, higher specific impulse -> Dawn was really nice for the first science mission but capabilities aren't enough to capture all the other missions
    - ? No other missions?
        - Yes, there are, but fix the PPU for the thruster that has the best capability
- Lots of thrusters, but all come with some baggage

    - Some of that investment is ongoing to eliminate the baggage
- ? Still stuck with boutique manufacturing? Building one at a time so costs are not controllable
    - Yes, that is a problem.
- ? To what extent is a PPU for hall thruster similar to ion?
    - Not very close
- ? What about making one that is less efficient but cheaper?
- Nothing done on that so far, working on making it modular
- ? SEP doesn't have a tech issue, it has a system issue
    - Thrusters aren't the problem, the systems are not mature

Planetary Balloons, Julian Nott

- ? What's the experience of packaging balloons into small packages and then being unpackaged w/o people
    - Successful battlefield flare balloons, radar jammers launched from aircraft
- ? On Mars, can you follow the prevailing winds and just take what you get? What's the science return? How intentional do you think you can be in terms of guidance and steering?
    - At Titan could get easily to appropriate latitudes
    - Could experiment with launching a bunch of small ones and testing them here
- ? What's been done with robotic balloons here?
    - Jeff Hall – blimp testbed in Alberta
        - Operated a motorized blimp from JPL
        - Harder at Mars because of mass constraints

Status of NASA's Solar System Exploration Program, James Green

- The new budget has a major increase in the total science budget
- "This is the year of Earth Science."
- ? Really is a strong statement of support?
    - Looking at the creation of new initiatives but not taking the money from other divisions
- Still lower than what had been planned several years ago
- ? New Frontiers bounces around?
    - Projection based on current mission set
    - Balance of executing the missions and bringing the next one online
- Hoping to have a $1.6 B program in FY13 when the report comes out
    - Anticipate making significant changes to accommodate the decadal results
- ? New start for Outer Planet Flagship? Is that dependent on the decadal?
    - Never said that – process is involved
- Approved Cassini extended-extended mission
    - Didn't have the funding for this last year

- Getting prepared for the decadal
- Accommodated MSL in current budget, no additional impacts to planetary projects
- Near Earth Objects (NEOs)
    - Anticipate beginning to use Pan-STARRS, modified WiSE to be able to pull out NEOs in 12 micron band, starting very well
    - For $16 M per year more, program will extend WISE data, collect Pan-STARRS, support continued operation of planetary radar – Arecibo and Goldstone
        - $2 M will go to NASA-supported radar
- Pu-238 restart
    - Russians have defaulted on deliveries
    - NASA & DOE will share the cost of restart and production
        - Plan has been completed
        - Cost sharing in NASA budget
        - Now back in Congress's hands
    - ? How much money are you asking for?
        - $30 million the initial investment
        - Have split that in half with DOE
    - ? What is the schedule?
        - Depending on when Congress considers the bill – DOE is starting to talk to Russia again
        - Want to still purchase 10 kg from them
        - If Congress passes the bill for DOE providing the $15 M, then will begin planning process
        - But still at least 5 years away until it will begin to be produced
    - ? How much better is this really?
        - Personal views – due diligence should be that if you are at all concerned about this, you need to make that known!
        - Congress still needs to hear that!
    - ? Responsible people on house appropriations do not understand the urgency of this at all. Be very pessimistic
    - Request for a plan is a test of how important this is to NASA, but not all the info that is needed for congress
    - ? Plan between NASA and DOE - is there a white paper or anything?
        - DOE has it, not sure if it's publicly available
    - ? ASRGs – question from panels – how much flight experience do you need for ASRGs before they can be put on a flagship mission?
        - Fair amount of work yet left to be demonstrated – because they have moving parts and electronics. Not a passive capability and going to a tough radiation environment
        - ? Assume that we can't use these?
            - New Frontiers is a different ballgame
        - ? Needs to be a tech maturation plan, develop a policy
    - ? Why do you want to take on ASRGs?
        - Lack of Pu!

- Technology investments
    - ? Why are there 4?
        - History, each are managed a little differently and cover certain TRLs
    - Mars technology money moved to MSL budget
    - Has taken several years to bring back the tech development budget
    - ? How would NASA react to a suggestion for fusing some of these programs together? Allow more flexibility?
        - That can be used to our advantage – don't see a downside to that
        - Lots of problems in this area
    - ? What's still in the Mars line?
        - Maybe not right? Only $2 million in it right now
    - ? Cautionary comment from the past – when astrobiology took a 50% hit, was given the reason that it had multiple programs all piled into a single pot
        - A nice big pot may be attractive
- ? In 13-15 year time period, how much of a wedge is in there?
    - Will have to calculate it
- ? Anything about robotic precursor missions?
    - Those are not well defined yet

Tuesday, February 23, 2010

Mars Exploration Program Status, Douglas McCuistion

- FY10 and FY11 budgets are almost the same for the first time in 5 years.
- Safe on Mars was a humans to Mars precursor that has now been completely deleted
- Mars Technology program
    - Program level reserve has been removed (~5% of budget)
    - As budget started going down, APA and technology program went to pay for existing commitments
    - But for now, the tech program is ~$2 million per year, just finishing out the current contracts
    - Will be only focused tech in the future for specific missions
- ? Is there still some in planetary protection?
    - Only one task left to look at microbial variety on spacecraft
- ? How do we go from a subsidy program to zero? Decided to put more money in projects?
    - $100 M removed from FY05 budget caused the cancelling of MTO
    - Then major rephrasing of program $3 of 6 B moved to other programs
    - A "squeezing of the topline" to less than half of where we were
- MSL – going well, making progress, but not yet done

    - RTG is mounted with a new titanium fixture
    - All but three instruments delivered – REMS, ChemCAM and SAM
    - SAM Wide Range Pump is a problem right now
        - Expecting a solution in another month, delivery by the end of the year
    - Power shortfalls on RTG – doesn't need a rebuild, but may cause reductions in cold operations and beginning of life operations
- NASA-ESA partnership
    - Both budgets had lessened, so looked like a good opportunity to work together
    - Started discussions in '04-'05
    - Programs were aligned
- Exploration program has been very successful
- Really are pushing into searching for signs of life – ExoMars Rover
- Focusing on improvements in technology and the final destination
- ? Mars as the final destination is not in the president's budget, but Bolden has said so publicly
    - The president has not said so specifically in terms of the budget
- ? What is the timetable for working out with ESA what their role will be in post-2018?
        - Memo of understanding in draft right now to define commitments
        - 2018 mission has to be worked first
- ? When will someone be able to give numbers to contributions from Europe for sample return?
        - Today – not nailed down yet, but will see some of that
- ? Science in EDL demonstration in 2016?
    - Maybe, no long-lived lander
    - Requirement is technology, so concept is camera, battery, take a picture and done
        - Maybe do meteorology – only 5kg or less payload

Mars Sample Return Science Overview, Phil Christensen

- Really do need samples back on Earth to explore in a wide range of sophisticated labs to answer astrobiology questions
- Follow the Water has matured to Search for Evidence of Life
- Mars science community is committed to this as what to do next
- ? If had $10 B to spend, is the best thing to do bring a sample back rather than to build a lab there?
    - Absolutely
- ? Essential step for human exploration?
    - ? Project people at JSC do not think so
- ? The definition of a carefully selected sample has changed as time has progressed. Has that definition stopped changing? Do we know where to go and what to do?

    - No, it has not stopped changing
    - We have plenty of good sites to go to, but do think we are at the knee in the curve
- ? With less money, would you wait and save money until could get the sample return?
    - Yes. This is a strong statement.
    - ? Document the logic behind this in the report
- Work is being done to define what we mean by sample return – number, quality, and what's done to the samples
- No requirement now to study the samples on Mars
    - Take the core and seal it to keep it pristine
- Mars community is ready to begin this with MAX-C rover

Mars Sample Return Architecture Overview, Fuk Li

- 4 functional steps required to return a scientifically selected sample to Earth
    - MAX-C – sample caching rover
    - Sample return lander
    - Sample return orbiter
    - Mars returned sample handling facility
        - Orbiter could be done first, waiting in orbit for lander to get there
        - Would be good for infrastructure, relay for telecom
- ? Number of single point failures is high?
    - Will talk about that
- Rover is separate from the return lander so that we don't have to worry about time running out for the return launcher
    - Spreads out technical issues
    - Mission concepts are sized similarly to previous experience
    - ? Caching rover – how is the orbital recon for landing sites done?
        - Uses existing assets, not a new orbiter
- ? MAX-C rover mass 360 kg, fetch rover mass is 160kg (MER size).
- ? Why not just clone MER?
    - Instrument package is heavier than MER
    - Arm is heavier than MER
- Mission implementation approach takes a lot from MSL design - - landing platform, aeroshell, descent stage architecture
- ? Managing the risk of MSL stands above everything – anything to add risk should be questioned enormously – i.e. international cooperation at the beginning
- ? What is the programmatic approach if Exomars rover is not ready to go in 2018?
    - Started discussion with Europeans
    - Could always fly ballast but would violate the partnership
    - Separating out the rover simplifies things for them
- ? Bigger concern is not really MSL heritage because you're changing it?

- ? The pallet design is new. Terminal descent structure is in family with the past, but is new.
- ? Distance that MER class rover has to go
    - Site has already been scouted by previous rover
- ESA-NASA is already exchanging information for planetary protection
- ? What about alternate architectures?
    - Launching fewer elements total, launch rover, launcher, orbiter in one approach, but would be a major undertaking to land a much larger system
    - Trying to take advantage of as much heritage as can
- ? On the pallet mechanism – are the two identical?
    - Probably not because mass is different
- ? Summarize the sample collection capabilities
    - If the rover fails to rendezvous with MAX-C , contingency housed on lander platform
    - Can only assess the volume right in front of you

Technology Capabilities for Mars Sample Return, Samad Hayati

- Tall pole technologies
    - Sample acquisition and encapsulation
    - Mars ascent vehicle
    - Back planetary protection
- ? Is it possible that you would select two system concepts for sample acquisition?
    - Yes
- ? What's the seal on the sample container?
    - Cap will be pushed on the core in the tube
    - Or possibly hermetically seal the top of the tube to keep volatiles in
- ? Round trip for the fetch rover is going to be a race against the clock – very high risk
    - ? Extending MAV lifetime and improved landing accuracy are really important
- ? Is a trade between pinpoint landing and how far the fetch rover has to go? There is another way, but have to invest in a technology that reduces the capability of the EDL system.
- ? Does MAV get a sample in the flat posture?
    - Yes
- Back Planetary Protection
    - If parts of the orbiter are contaminated by dust, have to eject the parts in Mars orbit before coming back to earth
    - ? If the decelerator system doesn't work at all, the sample still has to be okay?
        - Yes
    - ? Maybe need to change the name of this challenge? Round trip for fetch rover system – operational capability has to be robust

    - ? Traditional approach to technology development is the "widget." With something as ambitious as MSR, the systems technology concerns need to be identified as the new thing
        - ? Missions have evolved to be in this territory
- ? Thermal canopy over the MAV using radioisotope heaters? What are the requirements for that? Extra safety studies before launch?

Cost Assessment for Multielement Campaign, Fuk Li

- Most of these done in October with rules at that time
    - Didn't know how to account for DSN and EO costs at the time
- Bottom line $6-7 B to do all 4 steps
- ? Did you put a premium in for the fact that it's international? Aerospace does 24%
    - No
- ? Construction with Europeans doing the bulk of orbiter and US doing the bulk of the lander fits with constructs that have been considered recently
- ? The current challenge is to take the current architecture and make it robust
- ? This has the most new elements of something that's never been done before. If you can't get the masses into a certain size, has to split it into two pieces. Knock some of those risks down early, but conflicts with outer planets flagship and funding… if this occurs in a form close to what's here, it will be the NASA mission of the decade – THE whole thing
- ? Where do we draw the line between the planetary science decadal survey and writing the script for NASA?
    - Pushed to mars discussion this afternoon
- ? Mars panel wants to see this process started!
- ? Great that Mars panel came in with a clear priority statement

Status of Instrumentation Technologies, Chris Webster

- Don't underestimate planetary protection for EJSM instruments
    - Have to design the whole instrument around it
- ? Has there been no technology work with a radiation-hard instrument focus?
    - Some done on Juno but EJSM is a very different mission
- Problem to think about: what's the leak rate for "hermetic" sealing for sample containers – no such thing as an absolute seal
- ? How does a two-stage selection for 20 instruments work?
    - For EJSM – 9-10 instruments on payload, so would be mission specific
        - NASA selecting 1-2 instruments
- ? Found that have selected instruments, and by time we get to PDR, the cost is very much higher, and the people who lost the competition were more accurate in cost estimate!

- ? Need instrumentation development adapted to new key findings scientifically, e.g. molecular breakdown, isotopic capabilities
- ? Cassini mission payload was remarkably successful – worked superbly
    - Was managed well, whatever the lessons learned should be considered
    - 1st time ever had a 2-step instrument process

An Enabling Foundation For NASA's Earth and Space Science Missions, Lennard Fisk

- ? Why are the levels for the different divisions so different?
- Thoughts on the decadal
    - Ask the question of what should the mission enabling program do to help with the plan for the future
    - Anything you could say in terms of workforce
        - Need a competent workforce to enable the mission
            - Does your mission have that?
- ? Explain to us how mission-enabling activities relate to R&D?
    - It's a broader name – others are included in mission enabling
    - R&A is included – probably the bulk of it