

SBAG 2 MEETING NOTES

Day 1: Nov 18, 2009

Sykes (Overview):

Focus – develop a roadmap for small bodies

Most of activity this year in support of Decadal report

- 7 community white papers

 - 139 participants

 - 65 institutions

 - 20 non-US participants (16 non-US institutions)

- Reports to primitive body panel

 - Mark Buie – white papers useful; formed core of material considering

 - Digging into mission concepts, studies

- Decadal priorities poll

 - 159 respondents (15 from non-US institutions)

Reported on NASA research funding

Johnson (HQ Overview):

Things pretty much in steady state in small bodies in NASA programs

- Increase in interest; larger percentage of various programs on small bodies research

- Relatively flat overall funding in R&A since 2004

- Discovery program not going to launch as often as originally intended

 - Slowed to every 36 months launch

 - Grail 4 years after previous

 - Next launch after that likely to be 5 years later

- Discovery AO on hold for release

 - NASA needs 2010 budget

 - Not expected to mid-December at earliest

 - Getting pass-backs from 2011 budget same time period

 - MSL has had difficulties and there is a big checkpoint in December

- Earliest draft comes out is mid-December

 - Nominally 3 – 4 months for AO but will try to shorten

- Still planning on putting out draft AO

 - Will reconsider launch window when put out AO

- New Frontiers in proposal evaluation – 8 proposals

 - Expect selection for Phase A to be in January

- Intent to have ASRGs as an option in Discovery AO

 - Science must be enabled by ASRGs

 - Flight units should be available in 2014 timeframe (2 units)

 - Will be a technical document on ASRGs at time of AO

- Plutonium

 - Did not get through Congress

 - Will not affect the ASRGs

Sykes (Mission Overview):

Lots more small bodies (and types) than for any other AG

Raymond (Dawn):

Comparative planetology and mapping

Framing camera, VIR, GRaND

Resolve the topography of Vesta to 10m height at 100-m spatial resolution

Map the gravity field to 90-km half-wavelength

Vesta operations July 2011 – July 2012

Ceres Operation Feb 2015-July 2017

Thrusting allows earlier arrival at Vesta and longer operations

Plays havoc with figuring out flyby opportunities

Survey orbits; high altitude mapping; low altitude mapping

Dawn at Vesta Participating Scientist call is out – proposals due January

Scheeres (NExT):

Will flyby Tempel 1 at 200km on Feb 14, 2011

Camera (NAVCAM), Comet Interstellar Dust Analyzer, Dust flux monitor

Objectives:

1. document surface changes between 2 perihelion passages
2. extend geologic mapping to study nature of layering
3. extend study of smooth flows
4. image Deep Impact crater

Crater size tells us about material properties

Targeting to a 200km flyby distance at 10.9 km/sec

Burn at Feb 2010

Best resolution = 12m/pxl

40 images better than 80 m/pxl

Weissman (Rosetta):

Arrival at 67P/CG summer 2014 at ~4au from Sun

R=2.2km, p=12.46 hrs

Philae lander deployed November 2014

Expected to last a few days on surface

If things go well it could remain powered through perihelion

Lutetia flyby next July

M-class asteroid

4.9 g/cc

Flyby 3160 km @ 15 km/sec

Nominal EOM December 2015

Perihelion 3 months earlier

Wellnitz (EPOXI):

MRI, HRI, Near-IR spectrometer

EPOCH science just ending

Last observation (Mars) tomorrow

Biggest challenge – pointing instability
Can wander out of very small box used for data volume
Observed 6 different planet candidates
50 ppm with HRI
Some timing inconsistency – disagree with ground-based

DIXI

What causes diversity of comets?
H₂O released primarily in sub-solar region; CO₂ in south
Target 103P/Hartley 2
R=0.57 km
Log water production 28.6
Most of surface active
Dust ~2.5x greater than Tempel 1
Gas ~7-20x greater than Tempel 1
Encounter 4 November 2010; V=12.319 km/sec
0.156 AU from Earth
Prot = 16.6 hrs

Buratti (Cassini):

Hope to have extended mission through 2017
Lots of cool pictures of inner satellites
Do not know if captured or formed there
Have spectra of several (0.2 to 5.5 microns)
H₂O ice bands; no CO₂
Inner small satellites coated with ring particles
Got phase curves out to 100-150 degrees and over large range
of filters; similar to main icy satellites
Outer irregular satellites – many observations but not good for photometry
Good for astrometry
6 excellent flybys in the extended mission: Helene flyby at 1800 km
For extended, extended mission (XXM) may not get any of the small satellites
Several incredible observational opportunities but highly unlikely will get
Four that really want

Weaver (New Horizons):

Pluto July 14, 2015; KBOs 2016-2020
Halfway to Pluto
Most of time now in hibernation
About 3 months out start to get HST spatial resolution
Last day most important
KBO is in the extended mission

Mainzer (WISE):

20 days from launch
Sensitive all sky survey with 4 imaging channels 3-25 microns
40 cm telescope operating at < 17K

Operational life 7 months (10 possible)

FOV 47 arcmin; 8.8s exposure/ 11s duty cycle

Break the degeneracy between albedo and size with these data

3-5% with 12 & 22 microns; 10% with single-band detections

8-10 obs/object over ~30 hours so crude IR lightcurves

All images saved (12TB – 300million sources in catalogue)

NEOWISE an enhancement to WISE baseline

Create an archive of individual epoch images and tool for accessing them

Permits discovery of new asteroids

Tracklets transferred to MPC within 10 days – only valid for ~20 days

Need ground-based observers

Spacewatch (N) and Catalina (S) workhorse for this

Will be able to say something about size-frequency relation down to ~300m range

With extended mission (extra half pass) will be able to see things in the outer SS

Detect Neptune @1600AU, earth @80AU

Detect dust trails

Sykes (Intro to Roadmap):

Exploration not restricted to spacecraft – cover all modes of investigation

Purpose of roadmap is to provide short and longterm guidance to NASA

Roadmap is a dynamic document

Draft Outline:

- Science issues
- Population identification and characterization
- In-situ study
- Sample return
- Human exploration

Cochran (Science Issues):

Mark took additional notes

Don't cede Flagship or New Frontiers missions

Johnson (NEO Surveys):

Having problem continuing to get support for NEO searches – perhaps education problem on what an NEO is.

879 large objects found to date – no new ones in last few weeks

34 are near comets

Over 5700 smaller ones

TNO discoveries about zero – not optimized for them

Lots of main-belt objects – many multi-oppositions orbits (466,000+)

First retrograde NEO find (2009 HC82)

3km+ one found (2009 UV..)

Right now really only have 2 productive search teams – LINEAR, Catalina

Spacewatch mostly doing follow up

Potential targets for crewed mission:

Accessible with planned capability (Ares-V) = <7.5 km/sec Delta V

Mission less than 200 days round trip (90 days preferred)
Return entry velocity < 12 km/sec
Greater than 70 meter size
Object in simple axis, slow rotation
Accessible by robotic precursor mission at least 3 years prior to crew launch
Currently, of > 6000 known objects, only 6 targets might meet these criteria
Only 1 categorized
Increased interagency cooperation needed and starting
Things NASA can implement now
Second generation MPC
NEOSSAT (with Canada)
Pan-STARRS for NEO
Planetary Radar
WISE for NEOS
140m goal is probably not achievable in Congressional timescale (2020)
If we are to be serious about crewed NEO missions, must get serious about
comprehensive survey and characterization of the NEO population → \$\$

Mainzer (NEOCam):

Discovery-class 50cm cryogenic IR telescope
Could launch in 2016 for 5 year mission
Earth-Sun L1 Lagrange point
Large FOV: 11.56 square degrees
Passively cooled to 30K
3-5 micron and 6-10 micron channels
4500 sq deg/day
Assess the present-day risk of NEO impacts; understand origins and fate of asteroids
Discover and characterize 75% of asteroids lying interior to Earth's orbit
Discover most main-belt asteroids > 1km
Cover entire search region ~every 5 days
Will find 75% of all PHOs > 140km in 5 years; 90% in 10 years if at L1

Benner (Radar):

Arecibo radar in perilous shape – has funding to operate through 2010 right now
Right now Arecibo is reacting as if the radar will continue – raising funds to buy new
generators
Goldstone – major changes coming, possibly as soon as 2015, more like 2020
Depends on the 70m telescope
Array of smaller telescopes still not proven; would require more telescope time
Science coming out is getting better and better
Don't have enough time or manpower to handle current opportunities
Will have more opportunities with new surveys
Vast majority of science is coming from Arecibo

Bottke (NEO surveys):

How do you find the rest of the objects?

Showed movie to show why it gets harder to find objects
Need next generation surveys
What variables do you have to play with?
Cost
Length of survey
Mission risk (likelihood of completing survey by chosen deadline)
Side benefits (science return from other areas)
As costs go up length of survey goes down

Weissman (In-situ):

How do you choose a target?
Go to the largest in class?
But largest objects are likely not primitive
Is anything primitive?
Taxonomic type
Do we need to visit every taxonomic type?
Active vs inactive? Young vs old?
Orbital type
Long-period vs Halley type vs short-period comets
NEAs, main belt, Trojans, Centaurs, KBOs, SDs
What instrument payload do we carry?
Orbiter: Rosetta payload is a pretty complete list – some not so useful for asteroids
Lander: Similar but want to add sampling instruments, seismic
Langmuir probe? Dust for asteroids
What propulsion system should we use?
Chemical, solar electric, nuclear electric, something new?
What power systems?
Solar, nuclear (thermocouples), nuclear (power plants), new technologies
How do we anchor to small bodies?
Harpoons, anchor screws, active thrusting, ??
Are in situ investigations more cost effective than sample return?
Are impactors a cost effective means of explorations?
How do we staff missions with very long durations?
Should impactors be preceded by target characterization, e.g. Marco Polo?

Day 2: November 19, 2009

Dankanich (Electric Propulsion):

Primary available EP modules:

NEXT, NSTAR, BPT-4000, XIPS-25, HiVHAC

Gridded Ion engines have higher ISP but Hall thrusters have higher thrust

Hall thrusters are less expensive

HiVHAC still in development (thruster only) and thruster will not be available till 2012

NEXT really more realistic for New Frontiers Budget; HiVHAC will be more reasonable for Discovery

NEXT good for all types of missions

BPT good for constrained missions, GEO qualified

XIPS qualified for GEO, Moderate Isp

HiVHAC ideal for Discovery but not yet available

EP opens up a wide range of missions; a little expensive but often less expensive than comparable chemical missions

Zolensky (Sample Return):

How do we identify small body targets for sample return missions?

Expense is always a major issue and the target orbit is a big cost driver.

Easiest is a target in a prograde, low inclination orbit

Want to sample things not in our lab collection (no meteorites)

We have sampled so few that going to what we can get is not that bad

There is what you can get versus sexiest target

Cost cap important driver

How does the nature of our potential targets affect planning for sample return?

Comes down to perceived homogeneity of our targets

Do we need samples from more than 1 place on a target?

Are microscopic and macroscopic samples going to give same answer?

Clark – asteroids telescopically almost always homogeneously with Rotation; Paul Abel disagrees

Rock vs. regolith sample

Lesson of Itokawa is we have to be careful where we sample, more than one sample

Don't count on being able to get samples from more than one site since there may be only one place safe to land (Hayabusa)

How do we sample a surface?

What is the effect of the sampling on the material sampled?

To what extent can stratigraphy be preserved?

What are the different technologies for doing this, both untested, attempted or successful?

What are options and challenges for volatile-rich samples?

What are the relative values of a merely frozen sample (sub 0C) vs a truly cryogenic sample (much colder)

How do you anchor on a small body to take a sample?

Should we be recommending to NASA that they develop new technology?

Comet white paper did – need to start in advance of need

If there is no frozen storage, then when warmed chemistry will occur

Venting gaseous material will still result in alteration

Planetary protection concerns: Is it worth sampling a P or D asteroid, eg, if we have to cauterize it before Earth return?

Haven't they fallen on the Earth before?

Worry about contaminating the body

Have to prepare individual steps towards this so we understand the issues

Once we get a sample back to Earth (assume not a cryogenic sample) then what happens to it? How is it handled? How is it stored?

To what extent is information about curated samples accessible to the broader community?

When a sample is analyzed, is there some capture of information from that analysis that goes into a central database?

Currently varies from mission to mission.

Curation facility needs to transition to a searchable database (Stardust is)

Are there manpower issues regarding maintaining and expand curatorial capabilities? Do we have the facilities we need?

Are there community capability issues (i.e. skills that are being lost with retirement)?

Are there training programs? Should there be?

If we train new people, how do we sustain them in the grant system?

Does JSC maintain a group of scientists to run things?

Not so much any more – now it is through proposal

Full cost accounting has complicated this

Some of the skills not captured well in documentation

Abell (Human Exploration):

Can you send people to an NEO using the constellation rockets (Ares, Orion)?

Yes – feasible

Working on a plan (JPL, JSC, Ames, GSFC) to support flexible path

Building large telescopes in L1 or 2 with man aid

Going to an NEO

Going back to the moon

Solar power

Hopkins (Crewed mission to an NEO):

Next step up above a flagship mission

The targets are close → synodic period long

Opportunities to visit are spaced widely in time

These objects are very small (<70km); many are fast rotators

Envision park spacecraft 10s of m away and send in astronaut

Small size makes them hard to study telescopically

What amount of prior knowledge is needed before we sent humans?

Bias against detecting them well in advance – many of the targets we want to visit in 2020s are what we see now, however

Where do we need to look to find them now?

Probably does not make sense to develop a new human spacecraft for just asteroid missions

Need more deep-space propulsion, living space, food, water, oxygen

Use 2 Orions?

Six months appears to be the upper limit of feasible missions using dual Orions

Longer missions difficult due to radiation, limited habitable volume, life support consumables, etc.

Shorter missions are better

Good middle step between going to Moon and Mars

Habitable volume in two Orions just enough for 2 astronauts

Sykes (role of small bodies in long-term human space activity):

Human exploration for human purposes but science can benefit

Within realm of consideration that there are enough targets for H₂O use

Space resource utilization offers a strategic option for NEO missions.

Sykes (IPEWG/Next SBAG meeting):

Jim Green has asked up to organize the next meeting – last one January in Japan

SBAG spring and fall?

Hayabusa sample in June 2010

Roadmap – need drafts of sections prior to next meeting

Leads:

Science Issues – Cochran

Human – Abell

Population identification and characterization – Nuth

In situ – Weissman

Sample Return – Zolensky

Kelley (Reaction to last meeting findings):

1) SBAG Flagship missions – really up to the community – should be part of decadal report

2) Serendipitous targets of opportunity for all missions

For strategic missions, HQ decision

For PI missions, up to PI

Small bodies community should be contacting the PIs proactively

But we don't know the trajectories

HQ would have to come up with \$ to enable this

3) Planetary and astrophysics communities should collaborate to identify small body science opportunities that can be accomplished.

Opportunities are explored divisions at HQ and when staff or the community brings it to our attention at HQ

4) Technology development

It community thinks this is needed to be funded, get it into decadal survey

PIDDP funds to a level short of the needed TRL

5) International collaboration

- HQ asks SBAG to organize IPEWG
Mike has a schedule of dates to avoid
- 6) R&A programs are critical
Of course, but don't know what else can do
Protecting R&A as much as can
 - 7) Ground-based support
No move afoot to reduce ground-based support of missions
 - 8) PDS system support to archive data
Nodes competed and peer-reviewed, recently put through Senior review
Invested in MPC II
 - 9) DSN support
DSN has developed a roadmap
For next SBAG meeting invite SOMD to talk about improvements/plans

Sykes (Feedback from this meeting):

Discovery Science Issues

- 1) Generic Questions
 - a) should be range of physical properties
 - b) what does this tell us about planet formation, evolution of the solar system,
- 2) Small satellites of the solar system
 - a) Add forming satellites in-situ as part of the giant planet system. How can that be distinguished from a capture origin?
- 3) NEOs
- 4) Dwarf Planets
 - a) gross characteristics common to all classes
 - b) nature and nurture for all classes
- 5) IDPs
 - a) very cheap sample return
- 6) Comets
 - a) grab bags of whatever came together to form them.

What is a top-level question?

- 1) Science questions:
 - a) What were things like at the beginning?
 - b) What are things like now?
 - c) How did the solar system and its components evolve from then to now?
 - d) What will happen in the future?
- 2) Science Applications:
 - a) Resource identification and utilization
 - b) Hazard assessment and mitigation

Is there a limit to the scope of a Small Bodies Roadmap? What would be excluded?