NASA Small Bodies Assessment Group

- Started March 2008 - the newest of the ‘AG’s
- A community-based forum designed to provide science input for planning and prioritizing the exploration of small bodies throughout the Solar System for the next several decades.
- It also provides input on how small bodies can be utilized in support of human space activities.
- It is open to all interested scientists.

SBAG does not speak for NASA, it provides input to NASA

SBAG Steering Committee

Mark Sykes *(PSI), Chair*

Bill Bottke *(SWRI)*

Anita Cochran *(UT Austin)*

Keith Noll *(STScI)*

Faith Vilas *(MMTO)*

Hal Weaver *(APL)*

Paul Weissman *(JPL)*

Mike Zolensky *(JSC)*

SBAG followed the other AGs in organizing their communities to provide input to the Decadal Survey

- Divided primitive bodies into seven sub-areas (NEOs, Asteroids, Comets, Dwarf Planets, Centaurs/Small Irregular TNOs, Small Satellites, and Interplanetary Dust)
- Called for community participation and volunteer leads for white papers covering these areas (PEN, DPS Mailings - common template following decadal statement of task.
- Coordinated plan and schedule with PB Chair, Joe Veverka, to ensure input would be useful and timely

CALENDAR

04 SEP	Subdiscipline white papers due (please follow White Paper Template)
05 SEP	White papers submitted to Primitive Bodies Panel
09-11 SEP	Primitive Bodies Panel Meeting 1, Washington DC.
16 SEP	Online forum opens regarding prioritization across sub-areas (based on white paper inputs)
7 OCT	SBAG workshop at DPS on primitive bodies priorities (online discussion continues)
16 OCT	Online forum closes (content preserved)
17 OCT	Community poll on primitive bodies priorities (all entries public)
21 OCT	Poll closes
24 OCT	Report on community priorities posted for endorsements
27 OCT	Report, Forum record, Poll data submitted to Primitive Bodies Panel
28-30 OCT	Primitive Bodies Panel Meeting 2, Irvine CA.

Small Bodies Community Goals and Priorities by Sub-areas

Small Bodies Community White Papers

139 Participants
65 Institutions
(20 non-US Participants)
(16 non-US Institutions)

11 - Jet Propulsion Laboratory
10 - JHU/Applied Physics Laboratory
10 - Planetary Science Institute
9 - NASA Centers
9 - Southwest Research Institute
5 - University of Maryland
5 - University of Arizona

Small Bodies Community White Papers

Near-Earth Objects
- M. Nolan (Arecibo Obs.) + 57

Asteroids
- D. Britt (UCF) + 68

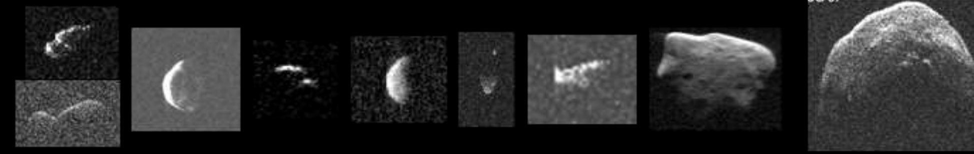
Comets
- H. Weaver (JHU/APL), K. Meech (U. Hawaii) + 59

Small Satellites
- B. Buratti (JPL) + 31

Dwarf Planets
- W. Grundy (Lowell), W. McKinnon (Wash. U) + 31

Centaurs/Small Irregular TNOs
- Y. Fernandez (UCF) + 35

Interplanetary Dust
- A. Espy (Flor. U), A. Graps (SWRI) + 35



Near-Earth Objects

Michael C. Nolan (Arecibo Obs.)
and 57 co-authors

NEOs sample the main-belt asteroids and comet reservoirs, while presenting resource opportunities and hazard concerns.

Top-Level Science Issues:

(1) What are the compositions of NEOs?

(2) What are the physical properties of NEOs (size, shape, texture, density) and how do they evolve (physically, chemically, collisionally, spectrally)?

(3) What are the specific NEO source regions and sinks?

(4) How can NEOs be used as resources?

Research and Technology Needs:

- Systematic population determination and characterization using ground-based and space-based facilities (including access to large-aperture facilities)
- Investment in ground-based instruments (e.g., 0.4-5 micron spectrometers)
- Deployable assets (e.g., penetrators, rovers) for microgravity environments
- Stable research funding

Mission Priorities:

- NF(1) - Sample Return from a volatile-rich object not represented in our meteorite collection
- NF (2) - Grand Tour (rendezvous) of several NEOs of diverse spectral type with “simple” surface probes (microlanders, penetrators)
- Discovery goals include in-situ characterization and population characterization remotely from space

Main Belt Asteroids and Trojans: A Reservoir of Knowledge of Solar System History and Processes

Daniel Britt (UCF) and 68 Co-Authors

Top-Level Science Issues:

(1) What was the compositional gradient of the asteroid belt during protoplanetary accretion?

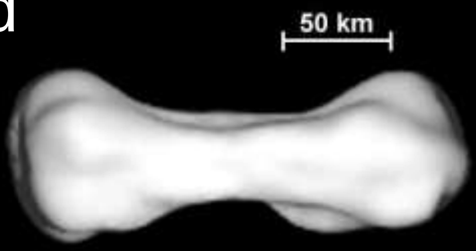
(2) What fragments originated from primordial parent bodies and what was the original distribution of those parent bodies?

(3) What do asteroids tell us about the early steps in planet formation and evolution?

(4) What are the characteristics of asteroids as individual worlds?

Research and Technology Needs:

- Support and Development of Ground-Based Telescopic Facilities
- Studies of Asteroid Families, Meteorites, Impact Processes,
- Support and Augmentation of PDS
- Technology: Propulsion, Telecom, Sensing and Landing Packages, Proximity Operations, Sampling Mechanisms



216 Kleopatra

Mission Priorities:

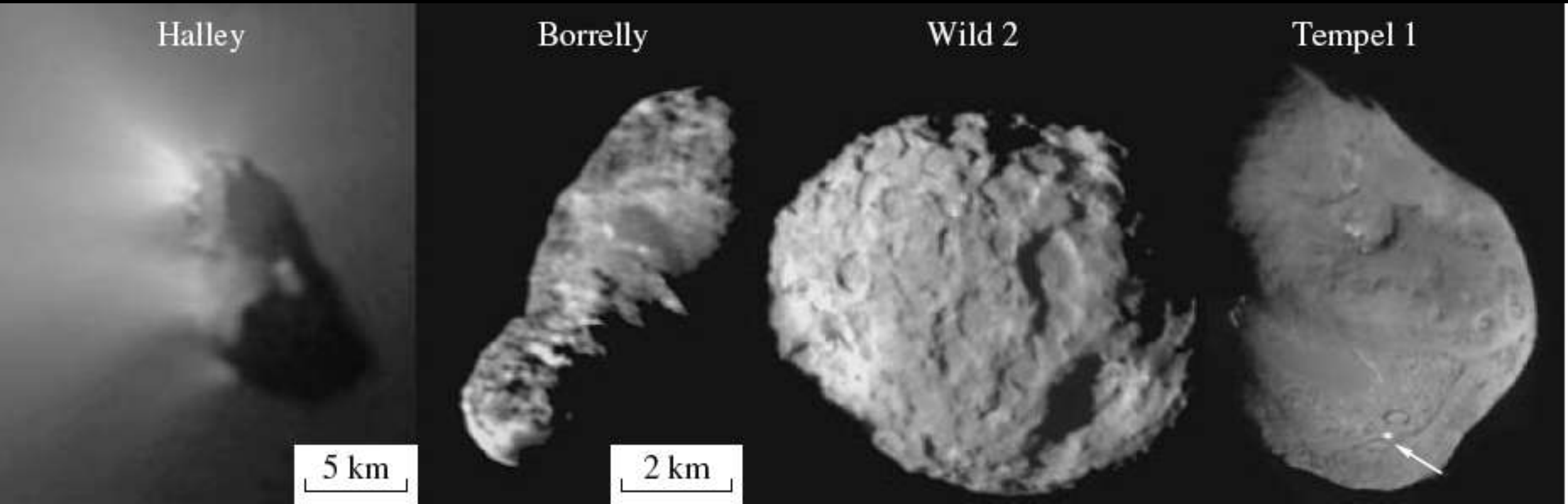
- New Frontiers: (1) Trojan Rendezvous, (2) Multiple Flybys of MBAs, (3) Multiple MB Rendezvous, (4) MB Sample Return
- Discovery Goals: In-situ characterization of principal asteroid taxonomic types, main-belt comets and interior processes revealed by families (e.g., Themis); continued reconnaissance of distant (e.g., Trojans) and diverse targets

Strategy for Comet Exploration (2011-2020)

H. Weaver (JHU/APL), K. Meech (U Hawaii) + 59 Co-Authors

Top-Level Science Issues:

(1) How did the Solar System form from the protoplanetary cloud?
(2) What is the history of volatile and organic compounds in the Solar System?
(3) What role did comets play in delivering water & volatiles to habitable zone?
(4) What does distribution of primordial icy volatiles in Solar System imply for evolution of habitable planets in extrasolar planetary systems?
(5) How is comet chemistry related to origin and processing history?
(6) What is the detailed physical structure of cometary nuclei?



Research and Technology Needs:

- NASA should maintain a stable, well-funded R&DA Program as the backbone for scientific advancement and as an enabler for future comet missions
- NASA & NSF should support a vigorous Earth-based observing program to characterize comets as a population and to support NASA missions
- NASA should maintain a strong technology development program that enables the sampling from depth in the nucleus, improved in situ analysis, and the return of nucleus material to Earth. Improvements should be developed in S/C power systems, propulsion technologies, and low power/lightweight instruments, including those that probe structure of nucleus.

Mission Priorities:

- New NASA Discovery missions should be selected every 18-24 months to provide innovative and paradigm-shifting investigations of comets
- A Comet Surface Sample Return mission is a high priority for NASA's New Frontiers program and is the best near-term means for investigating the nature of cometary organics
- During the next decade, NASA should perform a detailed feasibility study of a Cryogenic Nucleus Sample Return mission, which would return the most primitive material available in the Solar System for Earth lab study

The Small Satellites

B. J. Buratti and 31 coauthors

The small satellites offer windows into the physical conditions of the early Solar System, its formation, and its collisional history.

Phobos!

Top-Level Science Issues:

(1) What is the compositional and dynamical relationship between the small satellites and other objects such as KBOs, asteroids, and comets?
(2) What determines the densities of the satellites? Why do most have low densities? Are they reaccreted debris?
(3) What mechanism captured the outer irregular satellites, and how does this mechanism constrain processes of planet formation?
(4) What are the interior composition and structure of Phobos and Deimos? Do they create a Martian dust ring?

Research and Technology Needs:

- New technologies: Propulsion, sensing, guidance and control, sampling, and autonomy
- Observations on large telescopes to discover and characterize small satellites
- Laboratory measurements to create a complete library of possible surface materials
- Theoretical modeling on the dynamics of small satellites and collisional processes in the Solar System

Mission Priorities:

- A New Frontiers mission to return samples from Deimos and Phobos
- A targeted flyby of an outer irregular satellite of Jupiter as part of ESJM
- A targeted flyby of an outer irregular satellite as part of a New Frontiers or Flagship mission to the outer Solar System

Exploration Strategy for the Ice Dwarf Planets 2013-2022

W.M. Grundy, W.B. McKinnon
+ 31 Co-Authors

Ice Dwarf Planets represent a 3rd class of planets with rich potential for comparative planetology study.

Top-Level Science Issues:

(1) What is the solar system's inventory of ice dwarfs?
(2) What are their characteristics and taxonomy?
(3) What physical, geological, formation, evolutionary processes give rise to their observed characteristics?

Research and Technology Needs:

- Telescope access is critical to complete inventory and do gross characterization (with R&A funding support).
- Hasten development of mission-enabling technology:
  - + Electric power: ASRGs, ^{238}Pu production.
  - + Navigation: long distance ranging, autonomous GN&C.
  - + Low mass flight systems and instruments.
  - + Maintain very deep space communications capabilities.

Mission Priorities:

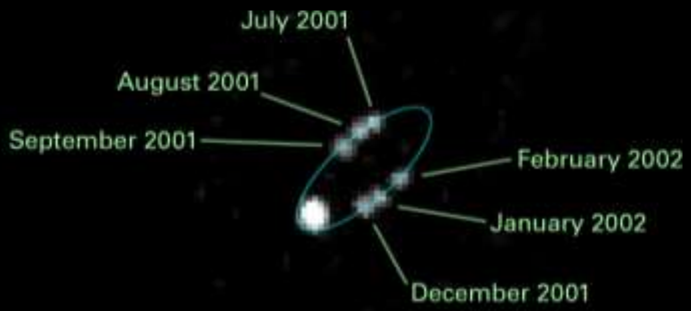
- Send a New Frontiers mission to an unexplored ice dwarf (e.g., Haumea).
- Ensure access to and necessary capabilities in relevant space-based observatories (JWST, SIM, etc.).

Balance competing priorities so none of these is neglected:

- Broadening the sample -vs- studying a few in detail
- Using existing technology -vs- developing new technology

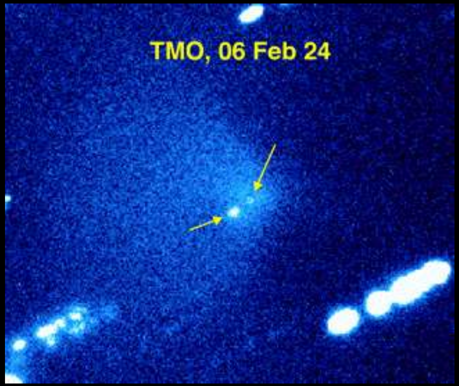
Centaurs and TNOs

Lead Y.R.Fernandez (UCF)
+ 35 Co-Authors



Binary TNO 1998 WW31, courtesy NASA & C. Veillet

Centaurs and small TNOs represent a remnant reservoir of icy building blocks that formed the outer planets and are the closest analogs to the objects underlying debris disks about other stars.



Centaur 174P/Echeclus, from Bauer et al. 2008

Top-Level Science Issues:

(1) What are their physical properties (color, albedo, spin, size, density, mass, porosity, conductivity)?
(2) What is their composition, especially ices and organics?
(3) What are the physical and chemical processes affecting their evolution?
(4) What is the dynamical structure of the trans-Neptunian region and how did it arise?

Research and Technology Needs:

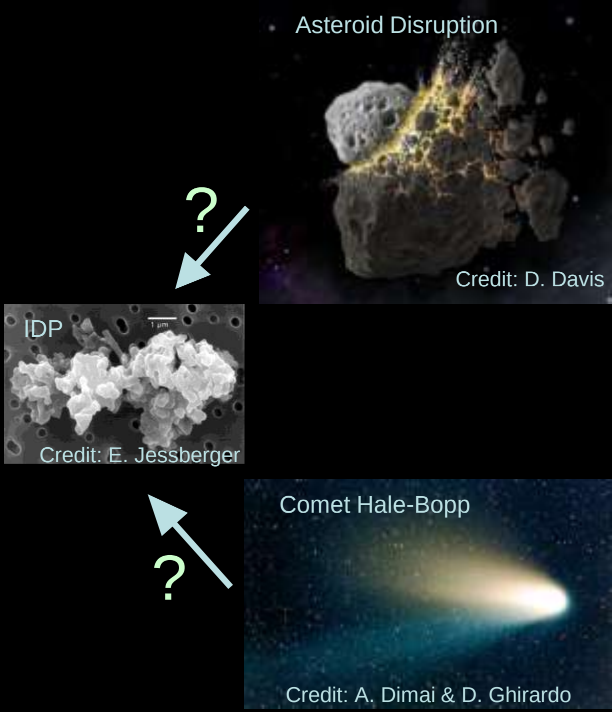
- Access to space-based & large ground-based telescopes.
  - -Need multi-wavelength and temporal characterization.
  - -Need sufficient time allocated understand the variety of Centaurs & TNOs.
- Support for laboratory work.
  - -Need to understand chemistry in TNO environments.
  - -Need to know spectral properties of ice and ice mixtures.
- Improved power systems for outer-SS trips.
  - -Nuclear would facilitate multi-object missions

Mission Priorities:

- Visits of serendipitously-located Centaurs and TNOs by other Flagship Missions.
- Multi-object NF missions that sample the variety in the population.
- Close-approaches of irregular satellites (proxies for TNOs) during missions to outer planets.

Interplanetary Dust

A. Espy (Flor. U), A. Graps (SWRI)
+35 Co-Authors



Dust released from asteroids, comets, KBOs and other sources make up the zodiacal cloud and the IDP's collected at Earth.

Top-Level Science Issues:

(1) What is the detailed composition of interplanetary dust?

(2) How are interplanetary dust particles generated, how do they evolve dynamically, and what are the dominant loss mechanisms?

(3) What are the relative contributions of dust particles from each source to the zodiacal cloud as a whole?

(4) What is the global structure of the cloud and how does it compare to exo-zodiacal clouds?

Research and Technology Needs:

- Continued collection and analysis of IDPs
- Support for ground- and space-based observing facilities and instruments
- Support for dynamical modeling to explain observations, link IDPs to sources, and produce a global cloud model
- Development of technologies for IDP collection and analysis

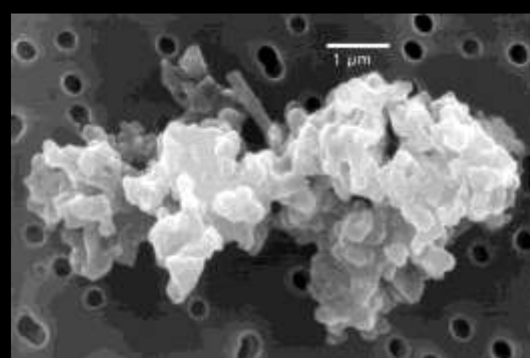
Mission Priorities:

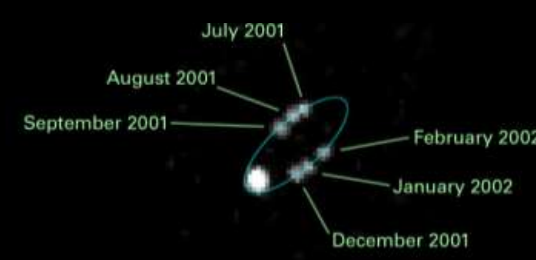
- Inclusion of instruments capable of studying the outer cloud on New Frontiers or Flagship-class missions to the outer solar system
- Discovery class facilities to study the full range of top-level science issues in near-Earth space

The study of collected IDPs tells us about the formation and evolution of their parent bodies, and the use of observations and dynamical modeling helps us link IDPs to their sources.



Primitive Bodies Themes

- Primitive Bodies populations are still being discovered, extended and characterized over size ranges and distance in the solar system.

- The breadth of top-level science and the numerosity and accessibility of targets today can drive many decades of Discovery and New Frontiers missions focusing on primitive bodies alone.

- Primitive bodies studies are unique by offering expanded science return from almost any non-PB mission (e.g., in-situ dust experiments, flyby opportunities of asteroids, comets, satellites, TNOs). This should be a standard part of all mission planning.

- Ongoing investment in ground-based observations over wide range of aperture sizes and laboratory studies are needed. Access to large observing facilities is needed. Support for theoretical work is needed.

- R&A funding stability is essential.

- [Sidebar] NASA planetary astronomy support dwarfs that of NSF. If NSF is going to fund ground-based observations of primitive bodies instead of NASA, NSF needs to be specifically charged to support the level of science required for the open-ended development of NASA planetary missions and to provide the context for the interpretation of NASA planetary mission data.