SBAG and the Planetary Science Decadal Surveys

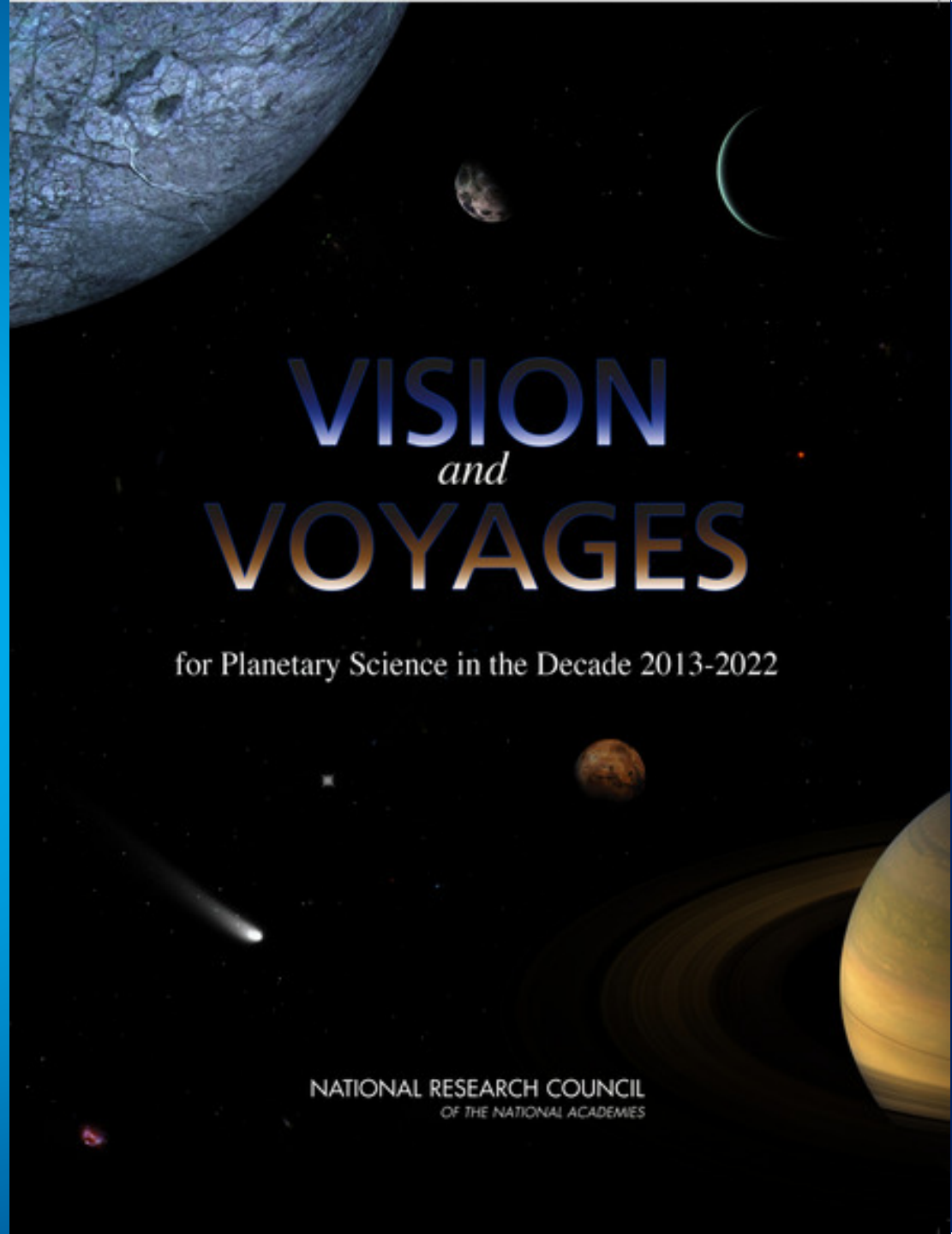
Tim Swindle
Chair, SBAG Steering Committee
SBAG 17, June 13, 2017

Part I

Small Bodies Perspective on the progress toward *Vision and Voyages*

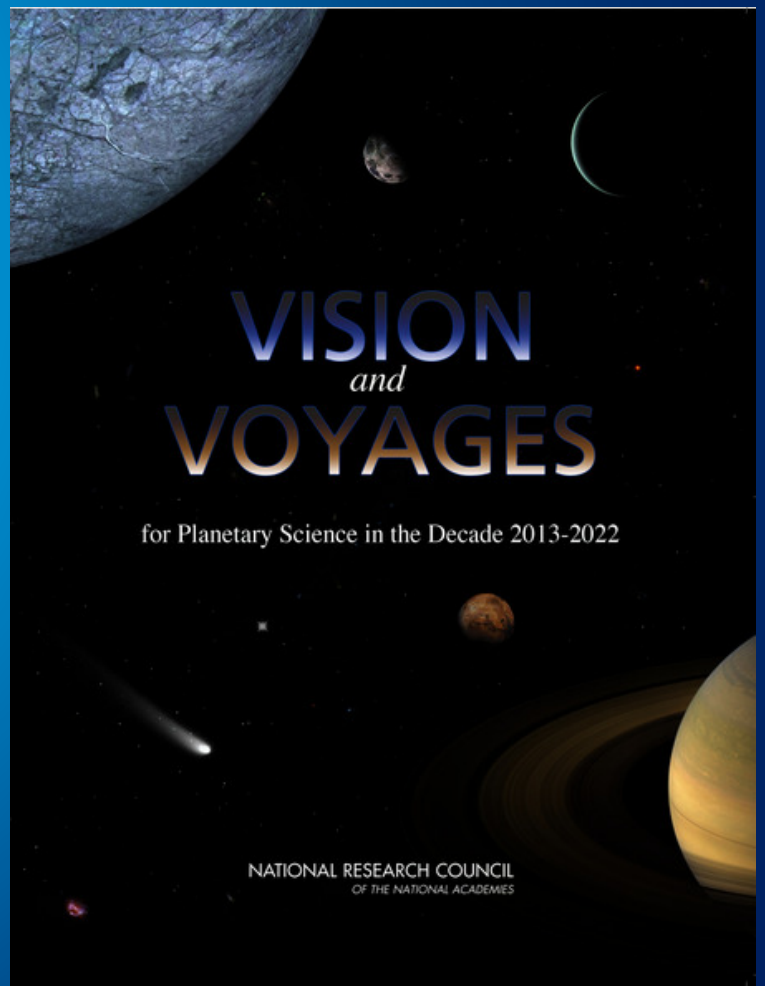
Based on presentation by SBAG Chair to the **Committee on the Review of Progress Toward Implementing the Decadal Survey *Vision and Voyages for Planetary Sciences* on** May 5, 2017

Full Presentation available on SBAG website under “SBAG Presentations”



What is the "Committee on the Review of Progress Toward Implementing the Decadal Survey *Vision and Voyages for Planetary Sciences*"

- Midterm evaluation of current Decadal Survey
- National Academies project
- Tasked August 2016
- First meeting May 2017
- Report expected December 2017
- Chairs: Louise Prockter, Joseph Rothenberg



National Academy of Sciences
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What does the SBAG Steering Committee have to say about the mid-term evaluation of progress toward Decadal Survey goals?

What does SBAG represent?

- "Other" bodies
  - Grouped into a single AG in part because they have the common property of being smaller than the bodies claimed by the other AGs
- Variety of types of bodies in a variety of locations
  - Main-belt asteroids, comets, KBOs, Jupiter Trojans, Martian moons, Near-Earth objects, meteorites, Solar System dust
  - Vast majority of cataloged objects in the Solar System
    - Even without meteorites, collected dust
  - Large diversity in processes experienced
    - Many, but not all, processed little since early Solar System

From presentation by SBAG Chair to the Committee on the Review of Progress Toward Implementing the Decadal Survey *Vision and Voyages for Planetary Sciences* on May 5, 2017

Why were small bodies ignored* for NASA's first 40 years?

- Not the planets, not the Sun, so not obvious first choices, and not understood well enough to understand why they are interesting
- Difficult
  - KBOs are the most distant objects we know of, so they're hard to get to with spacecraft or to study with telescopes
    - Not counting Pluto, the first was discovered 25 years ago
  - Difficult to target
    - Orbits often poorly known
      - Changing with Arecibo
    - Small, so can be hard for spacecraft to acquire
- Nearly 40 years after our first mission beyond low-Earth orbit before we had a mission dedicated to studying any small bodies

*Except for R&A funding of telescopic studies of many small bodies, laboratory studies of meteorites, and ISEE-3

From presentation by SBAG Chair to the Committee on the Review of Progress Toward Implementing the Decadal Survey *Vision and Voyages for Planetary Sciences* on May 5, 2017

Why have small bodies gotten more attention in the last two decades?

Scientific interest

- Many prized because they have been less processed than their larger kin, retain clues about the material and processes that went into the formation of the planets and large moons
  - Comets, many asteroids, most meteorites, probably Jupiter Trojans
- Others show the processes that occurred on larger bodies, but scaled to different sizes, different parts of the process exposed
  - Differentiation on Vesta, Pluto
  - Core formation and Psyche

Left, volatile-rich Orgueil meteorite (Encyclopedia of Meteorites). Below, artist's conception of asteroid 16 Psyche (Arizona State University)

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Why have small bodies gotten more attention in the last two decades? Scientific interest (continued)

- Tracers of the dynamical processes that formed the planets
  - How did the Martian moons form?
  - How did the Jupiter Trojans get there?
  - What does the distribution of Main Belt asteroids say about early Solar System dynamics?
  - Prevalence of volatile-rich double-lobed comets like 67P/Churyumov-Gerasimenko (right) suggests gentle accretion

ESA

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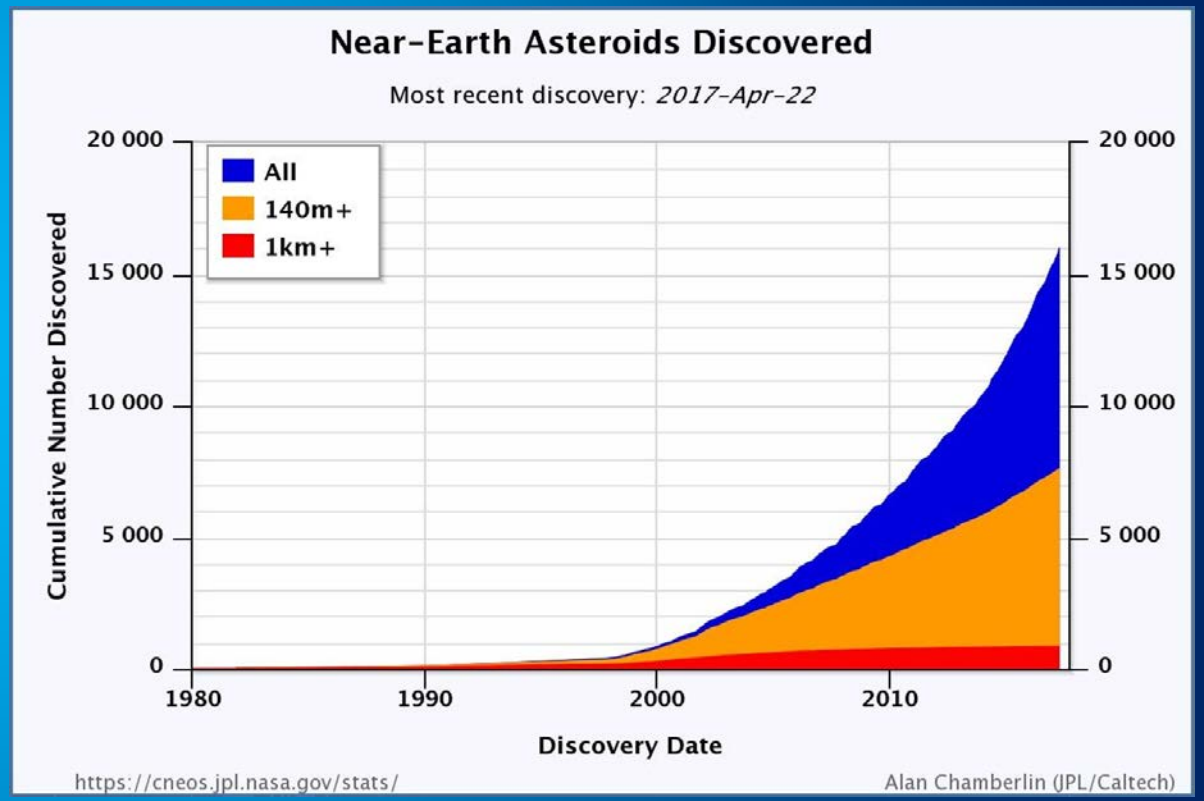
Why have small bodies gotten more attention in the last two decades? More targets

- New Horizons' second target wasn't discovered until shortly before Pluto encounter
- Numbers in most categories have increased significantly
  - First KBO other than Pluto discovered 1992, now more than 2000
  - Number of known Near-Earth Objects a few hundred in mid-1990s, now >15,000
    - NEO surveys have increased numbers in other categories as by-product



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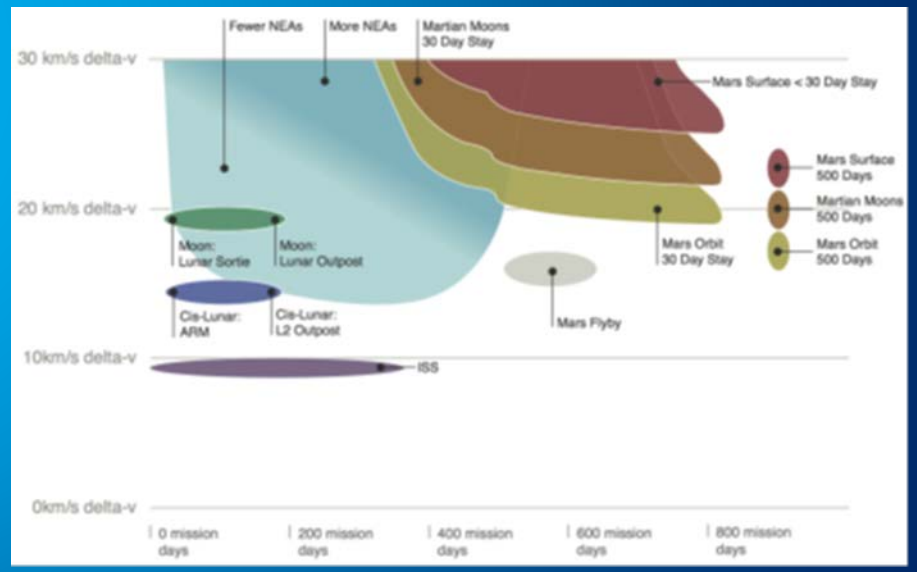
Why have small bodies gotten more attention in the last two decades? Ease of access

- Primarily possible because of increased number of targets
- Easiest objects to reach in terms of fuel are NEOs, so can try things for which cost of fuel or communications would currently be prohibitive
  - CubeSat missions
  - Sample return
  - Crewed missions (none currently planned)
  - Arguments apply for lunar missions as well
    - Time is shorter to the Moon
    - Fuel costs lower for many NEOs



Many NEOs (light green) require less fuel (vertical axis, in delta-V) than a trip to the surface of the Moon (dark green), although the trip time (horizontal axis) can be longer (from Near-Earth Object Human Space Flight Accessible Targets Study (NHATS)

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Why have small bodies gotten more attention in the last two decades? Resources, planetary defense

- It's NEOs that are being consider as resource utilization targets
  - Ease of access
  - Availability of resources
- NEOs are the only objects for which planetary defense is a concern
  - Possibly comets

Artist's conception of a major asteroid impact on Earth (University of California Observatories)

From presentation by SBAG Chair to the Committee on the Review of Progress Toward Implementing the Decadal Survey *Vision and Voyages for Planetary Sciences* on May 5, 2017

Goals from “Visions and Voyages”

- Represented by “Primitive Bodies Panel”
  - Chapter 4
- Science goals
  - Decipher the record in primitive bodies of epochs and processes not obtainable elsewhere, and
  - Understand the role of primitive bodies as building blocks for planets and life.

From presentation by SBAG Chair to the Committee on the Review of Progress Toward Implementing the Decadal Survey *Vision and Voyages for Planetary Sciences* on May 5, 2017

Six of 10 questions generated by “cross-cutting themes” (Table S.1) call out small bodies missions

Building new worlds

1. What were the initial stages, conditions, and processes of solar system formation and the nature of the interstellar matter that was incorporated?

2. How did the giant planets and their satellite systems accrete, and is there evidence that they migrated to new orbital positions?

3. What governed the accretion, supply of water, chemistry, and internal differentiation of the inner planets and the evolution of their atmospheres, and what roles did bombardment by large projectiles play?

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Six of 10 questions generated by “cross-cutting themes” (Table S.1) call out small bodies missions

Planetary habitats

4. What were the primordial sources of organic matter, and where does organic synthesis continue today?

Workings of solar systems

8. What solar system bodies endanger Earth’s biosphere, and what mechanisms shield it?

10. How have the myriad chemical and physical processes that shaped the solar system operated, interacted, and evolved over time?

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A seventh question didn't call out small bodies missions, but probably would if written today

Planetary habitats

6. Beyond Earth, are there contemporary habitats elsewhere in the solar system with necessary conditions, organic matter, water, energy, and nutrients to sustain life, and do organisms live there now?

Exploration of Ceres, Pluto suggest that the largest of the "minor planets" might also be ocean worlds

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Proposed small bodies missions

- No flagship missions considered
- New Frontiers
  - Comet surface sample return (part of current call)
  - Trojan tour and rendezvous
    - Lucy (Discovery class) is Trojan tour
- Stressed regular Discovery, New Frontiers cadence

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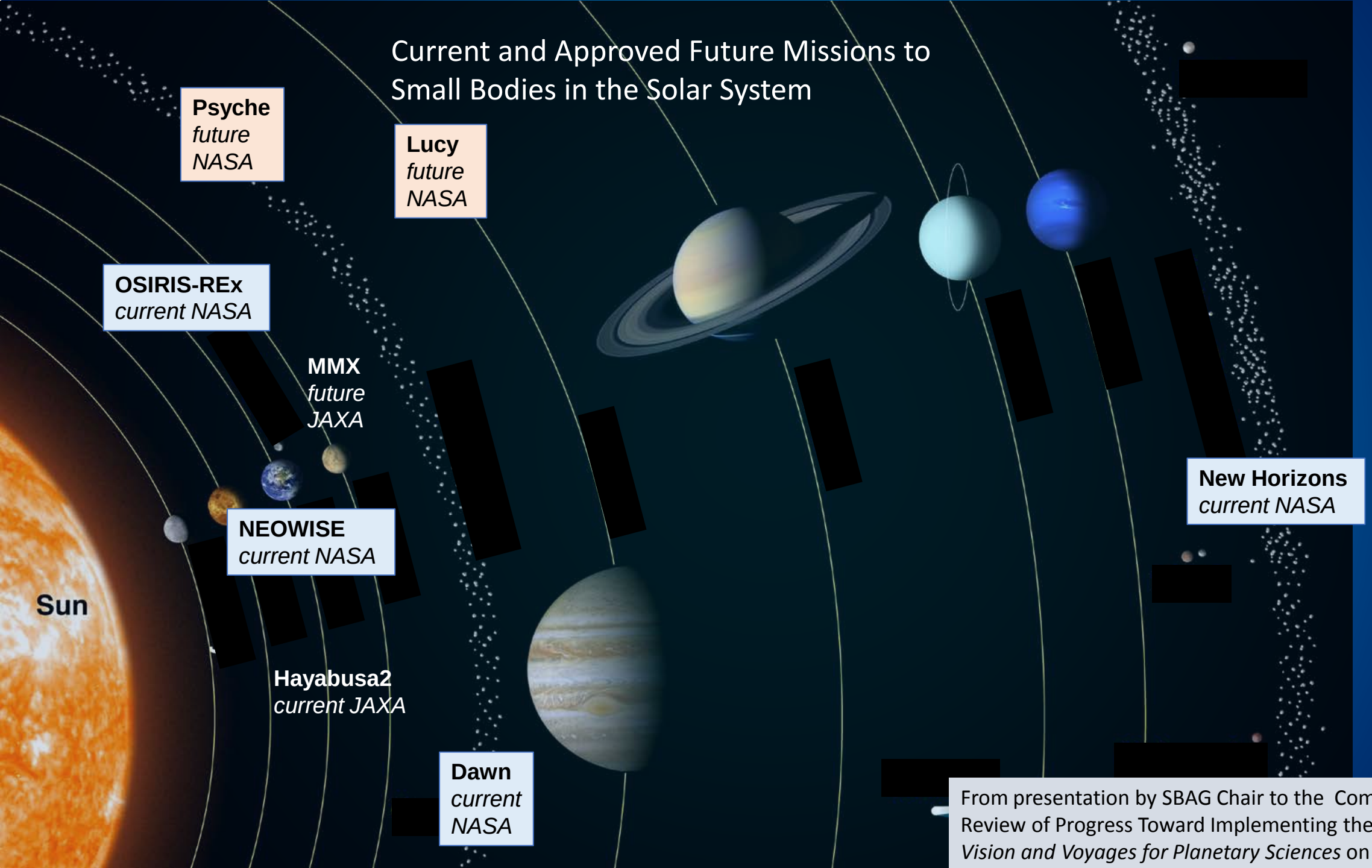
Current and Approved Future Missions to Small Bodies in the Solar System



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Current status

- Nine missions (including Rosetta) to 17 targets
  - NEOWISE doesn’t have specific targets, per se
- Only two of the nine (OSIRIS-REx and Hayabusa-2) are targeting similar bodies
- **This decade, we are beginning to study the available diversity**

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Supporting research and related activities

"The study of primitive bodies is also aided by ground-based telescopes and radar, which are highly useful in this field because the number of objects is so great that only a tiny fraction can be visited by spacecraft, and space missions are aided substantially by prior observation. Indeed, ground-based telescopes continue to discover unusual and puzzling objects in the Kuiper belt and elsewhere, and those objects might serve as the targets for future missions."*

One of several areas where small bodies science has more need of non-mission funding than other areas -- not counting comments on Research & Analysis and Technology, the Primitive Bodies chapter devoted more attention to this than any other

*Vision and Voyages, p. 87

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Supporting research and related activities

- Field collection of meteorites
- Ground-based telescopes (including Arecibo)
- Sample curation facilities
- Laboratory facilities
- Research and analysis funding
- Technology development
  - ASRG
  - High-power electric propulsion

Collecting meteorites in Antarctica (ANSMET/K. Joy)

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Concerns of the community

- Concerns about R&A
  - In particular, concerns about retaining the laboratory infrastructure needed to analyze returned samples
- Arecibo
- Concerns about how decisions are made to deviate from the Decadal Survey recommendations
  - Examples: extended cadence for Discovery and New Frontiers*, addition of Ocean Worlds to New Frontiers
  - Previous survey called for a formal decision-making process (p. 314)

***"If cuts to the program are necessary, the committee recommends that the first approach should be descoping or delaying flagship missions. Changes to the New Frontiers or Discovery programs should be considered only if adjustments to flagship missions cannot solve the problem." (Vision and Voyages, p. 275)**

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Planetary Defense

- Part of NASA Authorization Act
- Funded through SMD, but explicitly not considered by the Decadal Survey
  - Survey calls out 2010 NRC report on Planetary Defense*
  - While that report sets priorities for Planetary Defense, nothing equivalent to that or *Vision and Voyages* to establish relative priorities within SMD of Science and Planetary Defense goals

**Defending Planet Earth: Near-Earth-Object Surveys and Hazard Mitigation Strategies*

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Planetary Defense missions

- NEO surveys address hazard detection, but also have science merit
  - An SBAG Science Objective is to characterize the architecture of the small bodies in the Solar System
  - Several ground-based surveys
  - NEOWISE only survey mission flown, but is reactivation of prior mission, not optimized
  - NEOCam in Extended Phase A for Discovery
- Hazard mitigation missions also provide science value
  - DART (and ESA counterpart AIM), under discussion, results depend on internal structure of target
  - OSIRIS-REx has mitigation as part of its rationale, studying details of Yarkovsky effect

Artist's conception of ESA's AIM mission watching NASA's DART impact asteroid Didymos (ESA)

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Planetary resources

- Mentioned, but not explicitly prioritized
- Resource exploration has strong scientific component to it
- Resources to be used for human exploration of interest to HEOMD, commercial entities interested in those and other resources
  - Long discussed, but increased private interest since 2013
- Issue for lunar, Mars exploration as well

Artist's conception (by Denise Watts) of asteroid mining from 1977 NASA study on asteroid mining (NASA)

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Part II

Preparing for the next decadal survey

The past is the key to the future* SBAG activities in preparation for *Visions and Voyages*

- Community poll on priorities
- SBAG community white papers on types of objects (7)
- Individual white papers relating to small bodies submitted by individuals or groups (54)
- Information is all at http://www.lpi.usra.edu/decadal/sbag/
  - "SBAG Decadal Survey Materials" link on SBAG webpage

*With apologies to Charles Lyell

Community poll

- Highest priority for
  - Science issues (next slide)
  - Flagship missions
    - Only Cryogenic Comet Nucleus Sample Return listed
  - New Frontiers missions
  - Most important science goals that can be addressed by Discovery missions
    - Free response, not ranking of predetermined choices
  - Technology
  - Research facilities
  - Addressing budget shortfalls

SBAG Science Issues

- SBAG has a goals document
  - http://www.lpi.usra.edu/sbag/goals/
  - Goals include science, planetary defense, human exploration
  - Associated technology recommendations in support
  - Finalized March 2015; appropriate to reassess
- Goals are explicitly not prioritized
  - Decadal survey poll would be the chance to prioritize

SBAG Community white papers

- Typically 30-50 co-authors, one or two leads
- Topics:
  - Near-Earth Objects
  - Asteroids
  - Comets
  - Dwarf Planets
  - Centaurs and Small Irregular TNOs
  - Interplanetary Dust
  - Small Satellites

Next steps?