

Synergies for Human Exploration with Decadal Science Objectives

Richard P. Binzel

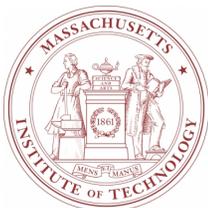
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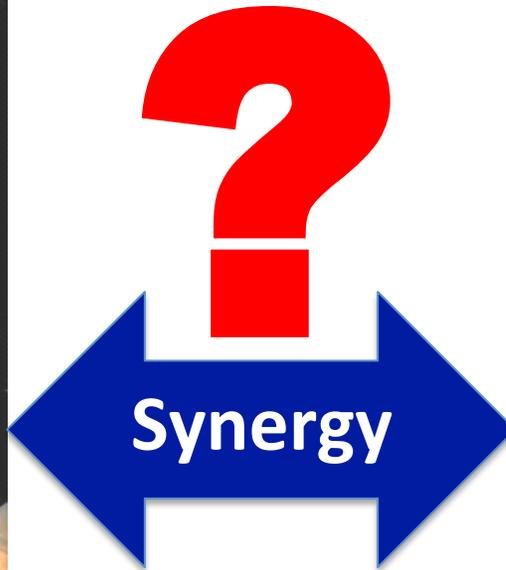
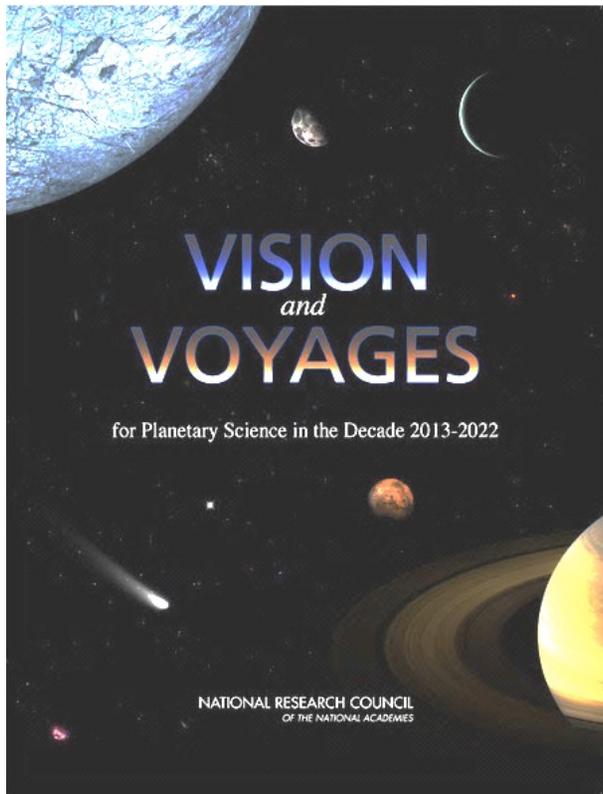
31 March – 2 April, 2015

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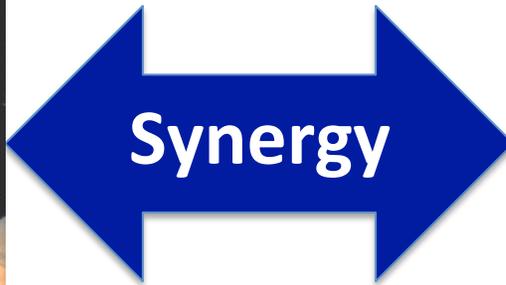
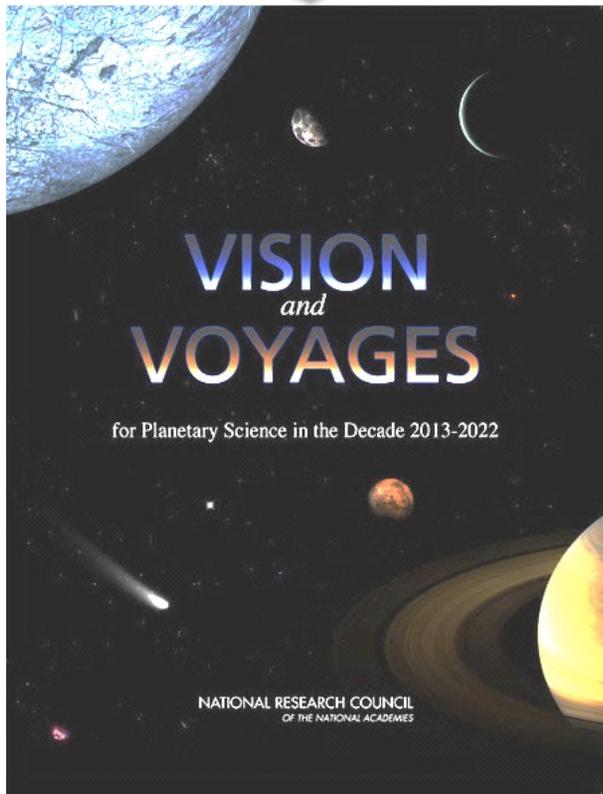


Why this presentation?

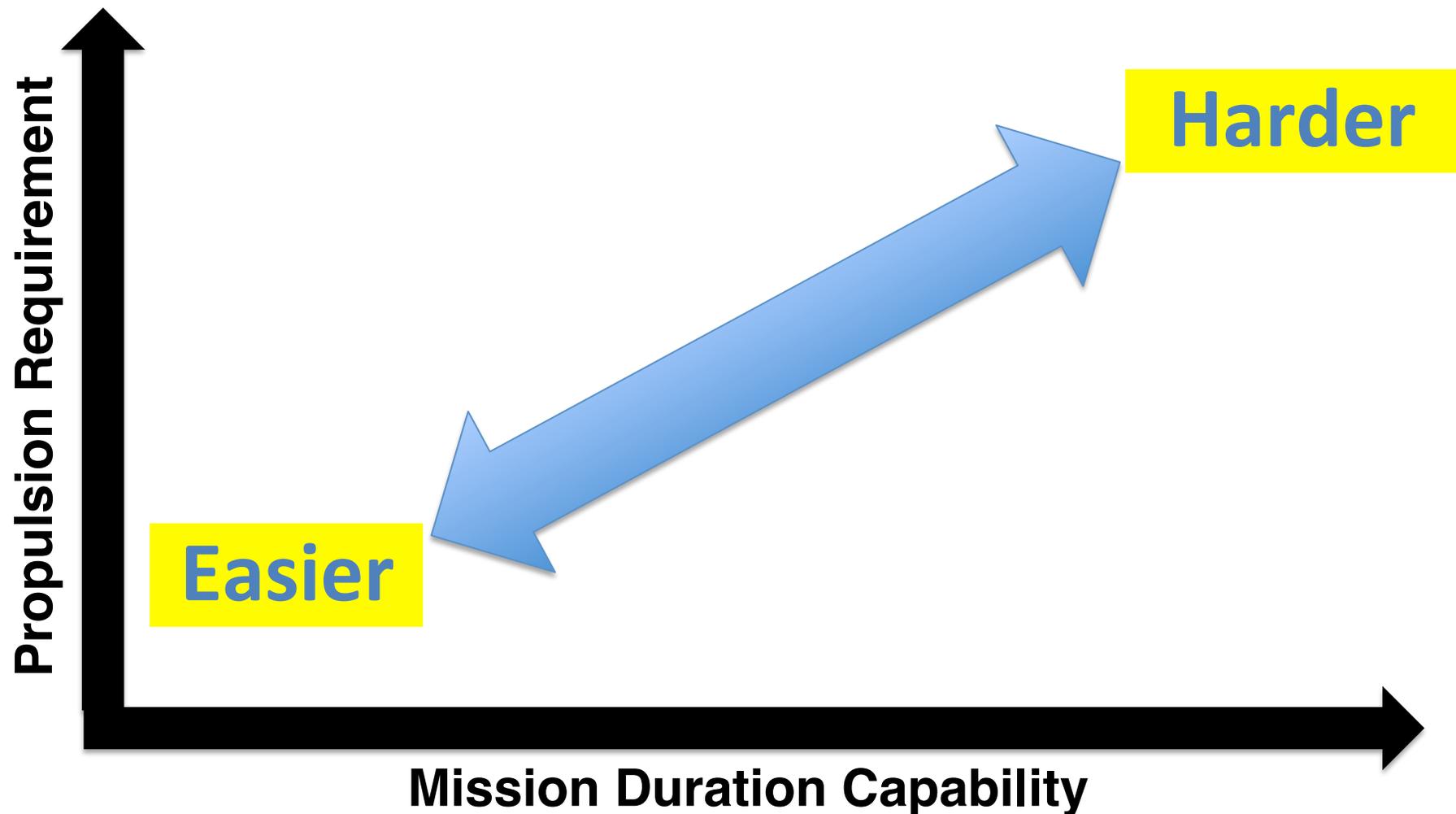
Strong emphasis on finding synergies between Decadal Science and Human Exploration.



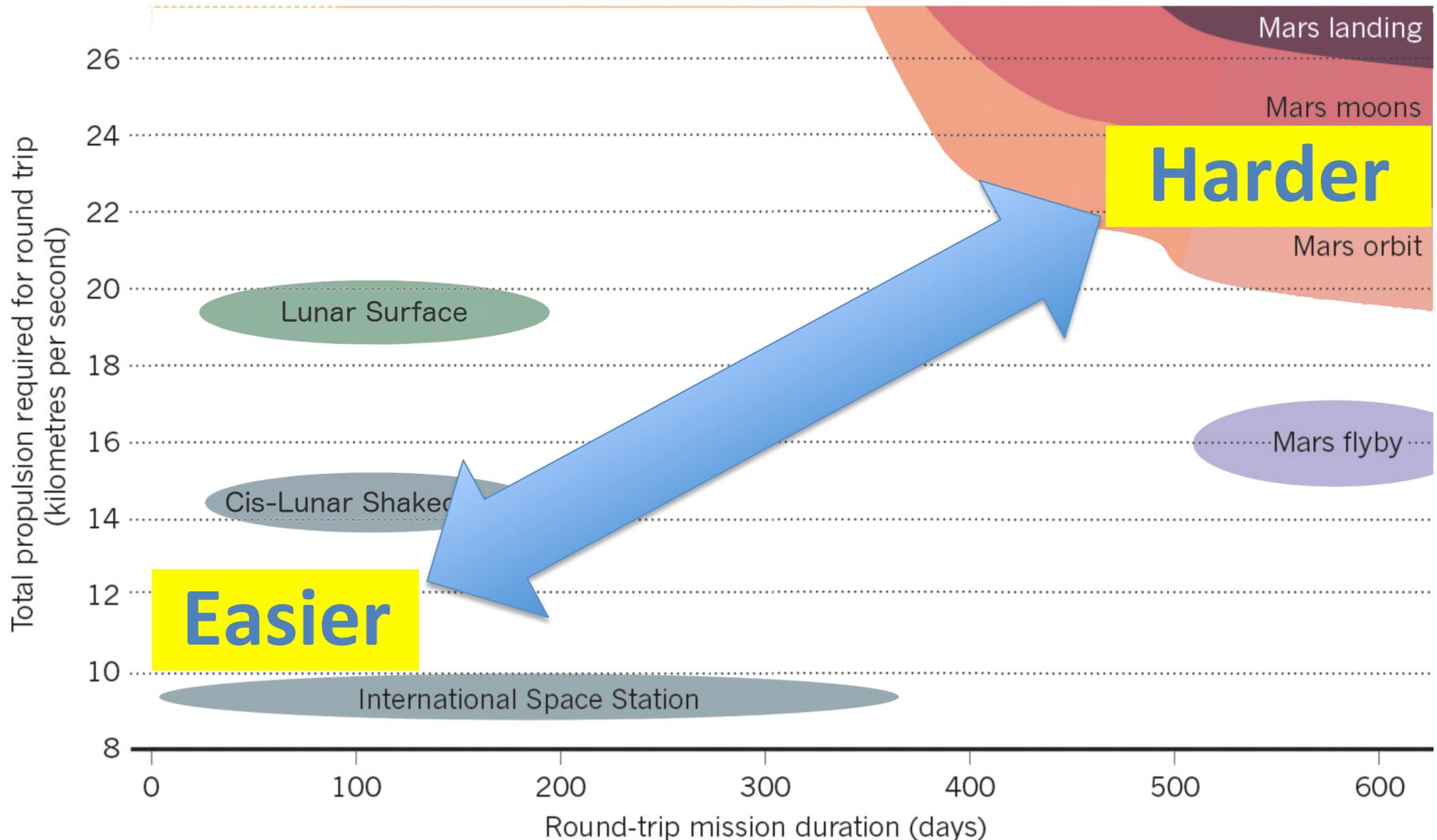
ASTEROID SURVEY



Human Space Flight: Mars horizon goal requires ever increasing capabilities.

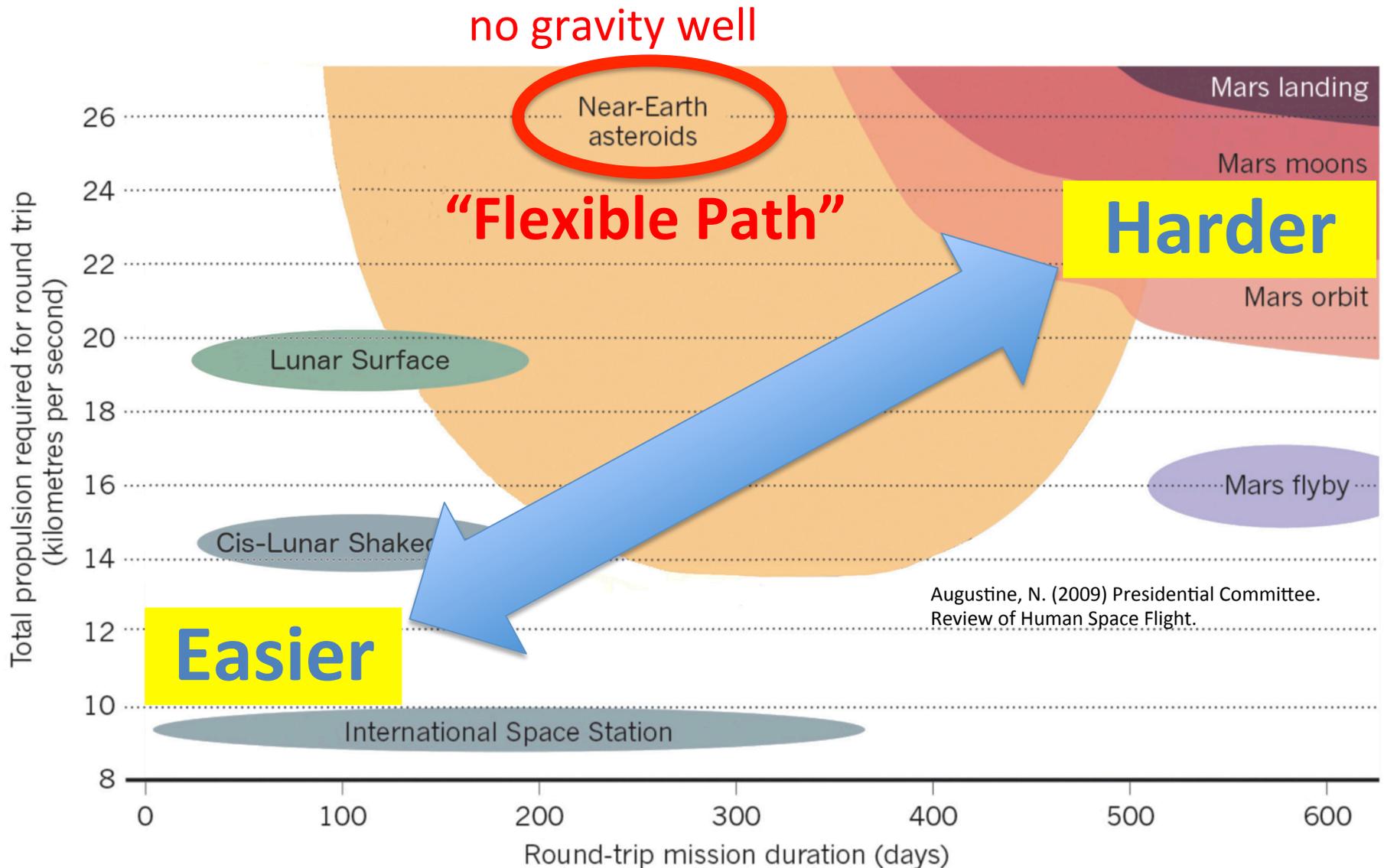


Human Space Flight: Mars horizon goal requires ever increasing capabilities.

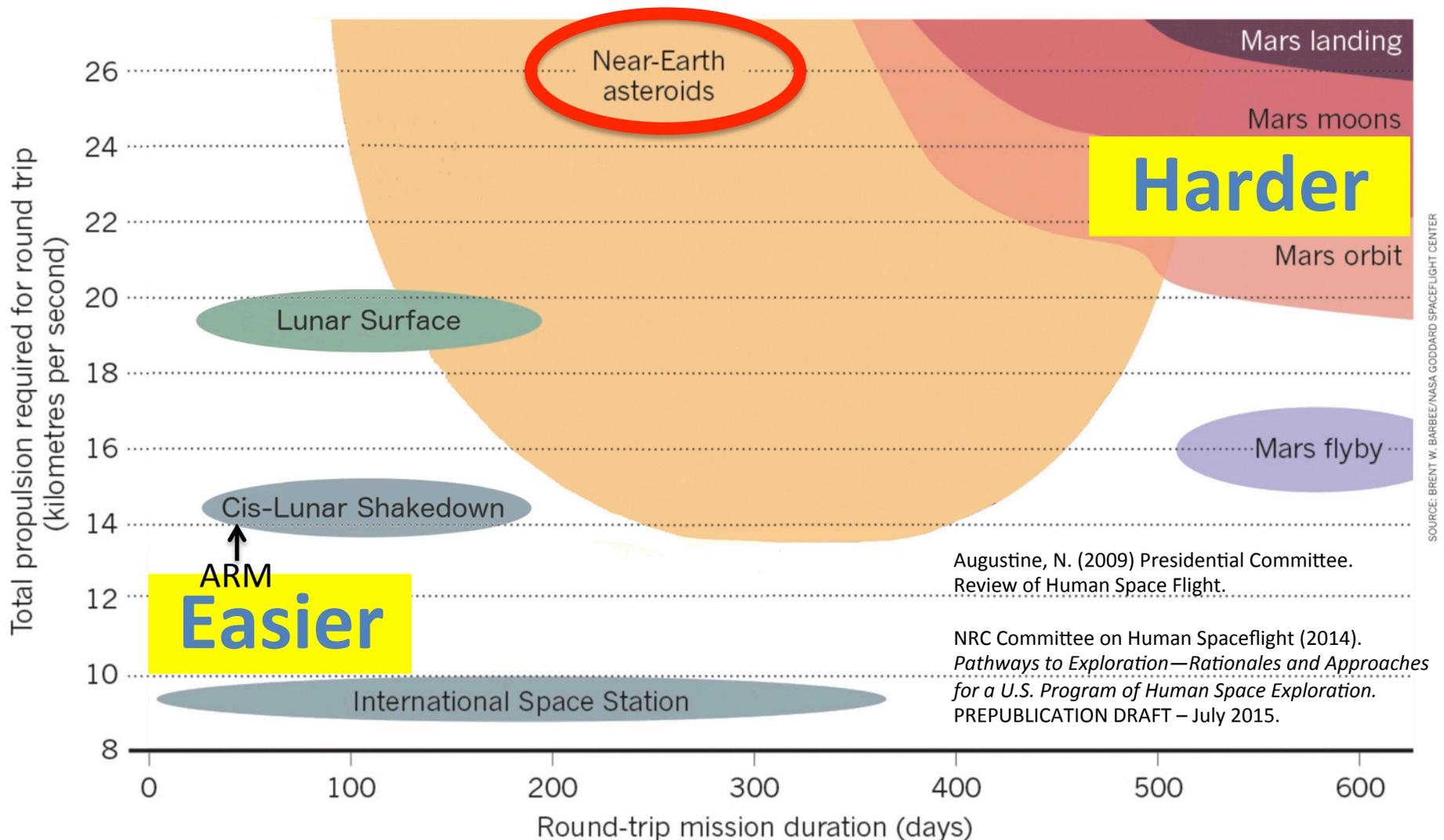


SOURCE: BRENT W. BARBEE/NASA GODDARD SPACEFLIGHT CENTER

Augustine (2009): Near-Earth asteroids (NEAs) identified as intermediate HSF destinations.

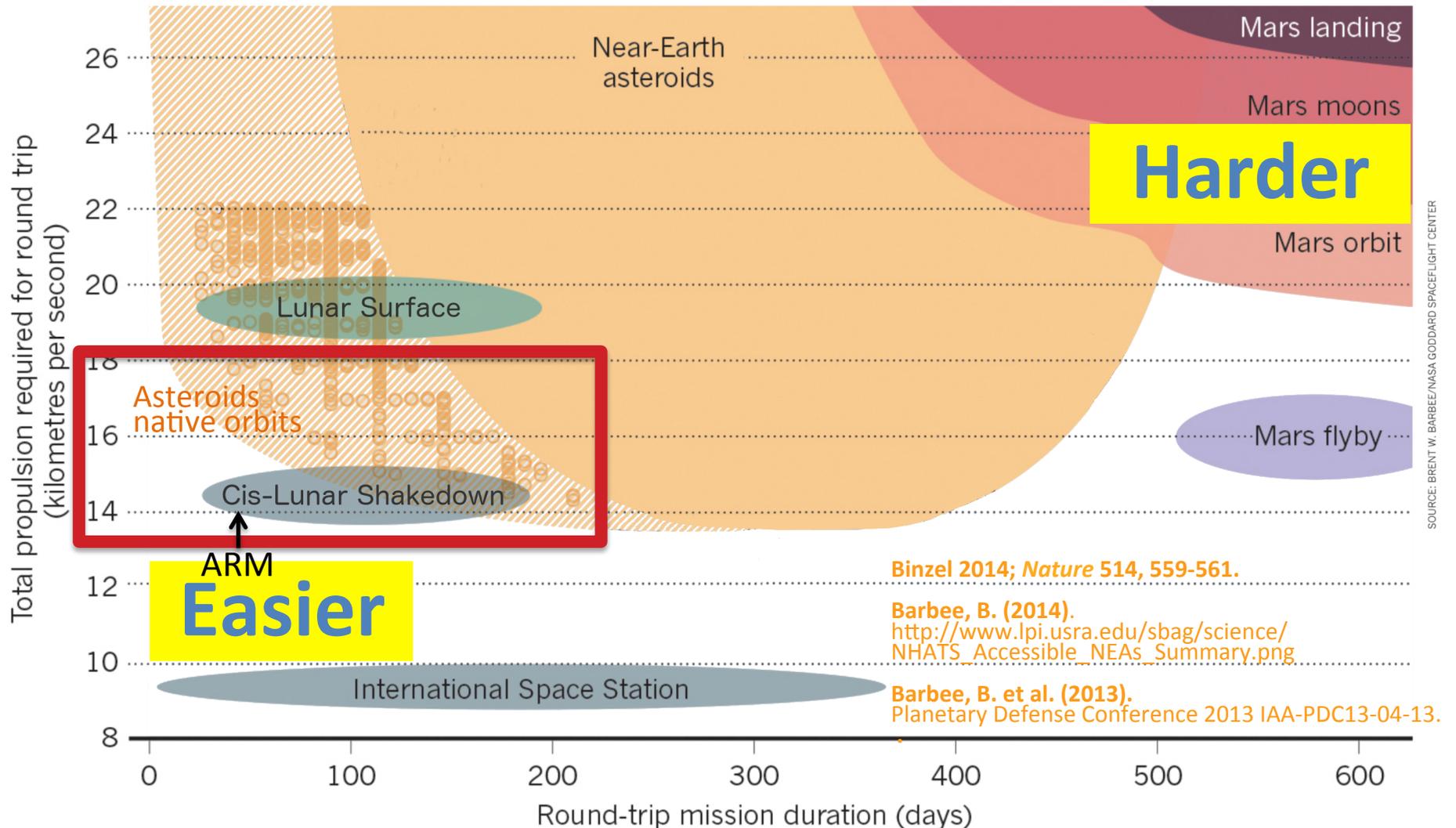


Asteroid Retrieval Mission (ARM) is Born (2012): Near-Earth asteroids deemed “too far” beyond foreseeable emerging HSF capabilities.



“ARM is not a substitute for a mission to an asteroid in its native orbit, which appears possible at a lower launch energy than previously believed.”

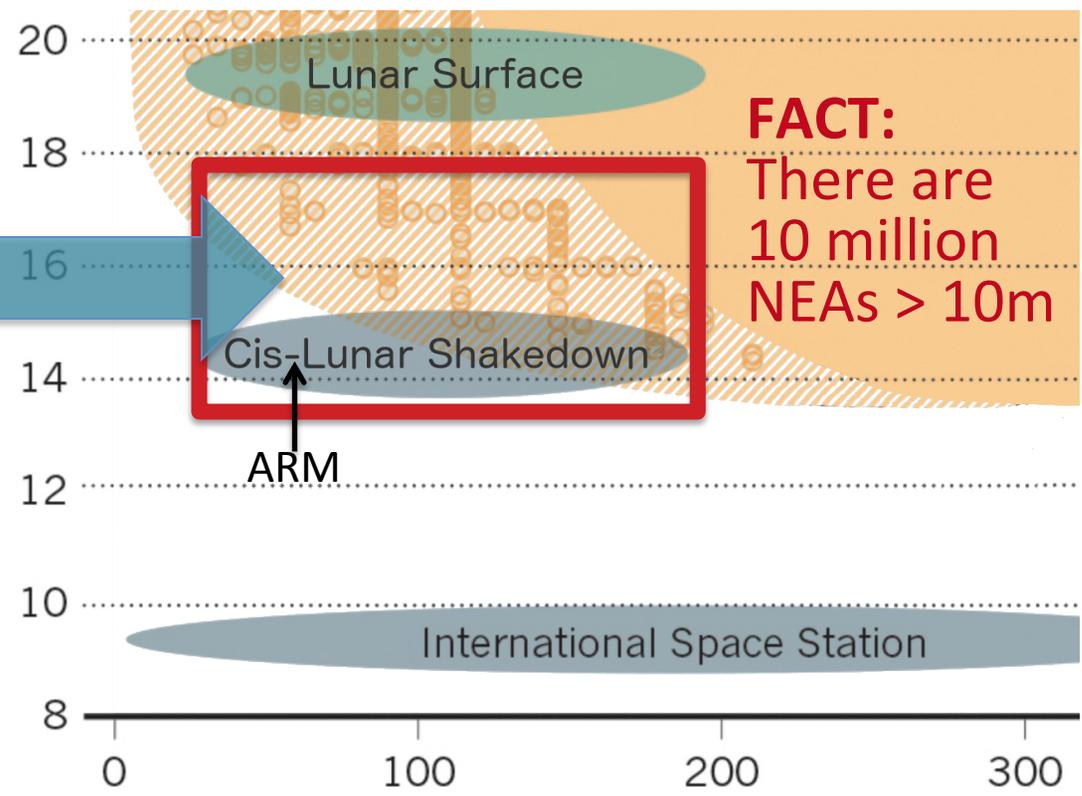
-NAC Squyres to Bolden: 31 July 2014.



SOURCE: BRENT W. BARBEE/NASA GODDARD SPACEFLIGHT CENTER

Binzel's Assertion:

'Native asteroids' are so abundant they *obviate* any need for retrieval.



nature 30 October 2014

COMMENT

Survey adds authors to your team, and work your best work. **ARM** A history of autonomous disease research and its progress. **ARM** John Nigbor back marks 400 years of legal ethics. **ARM** Paris Protocol should not trade its space technology. **ARM**



At least one roughly 10-meter-wide asteroid passes as close as the Moon each week (left's inset).

Find asteroids to get to Mars

Asteroid retrieval is a distraction, says **Richard P. Binzel**. Better steps to interplanetary travel abound.

Interplanetary flight is the next giant leap for humans in space. Yet concern on even the smallest steps forward has proven elusive. In June, a US National Research Council report illuminated many options but offered no recommendations.

Return to the Moon? Head straight to Mars? Pick a boulder off an asteroid and tug it to lunar orbit, just so that life scientists have somewhere to go and something to do? NASA must decide which path to follow before President Barack Obama's

budget announcement in January 2015. Some options are better than others. The cost and complexity of human space exploration demands that each element be measured by its value towards the ultimate goal: Mars.

But NASA's stated next priority will not contribute to that aim. The Asteroid Redirect Mission (ARM) is a multi-billion-dollar stunt to retrieve part of an asteroid and bring it close to Earth where astronauts can reach it. It will require an auxiliary space-craft deploying either a huge capture bag or a Robo-Goldberg contraption resembling a giant aerial-garbage-can. Neither technology is useful for getting humans to Mars.

There is a better way. Thousands of sleeping comets and larger asteroids pass almost as close as the Moon each year. Many, such as September's near-Earth asteroid 2014 RC, come closer. We need to find them in enough advance, and develop opportunities for consideration will sprout.

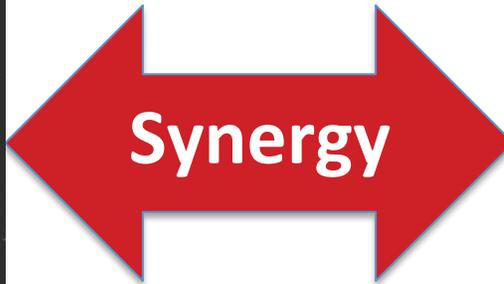
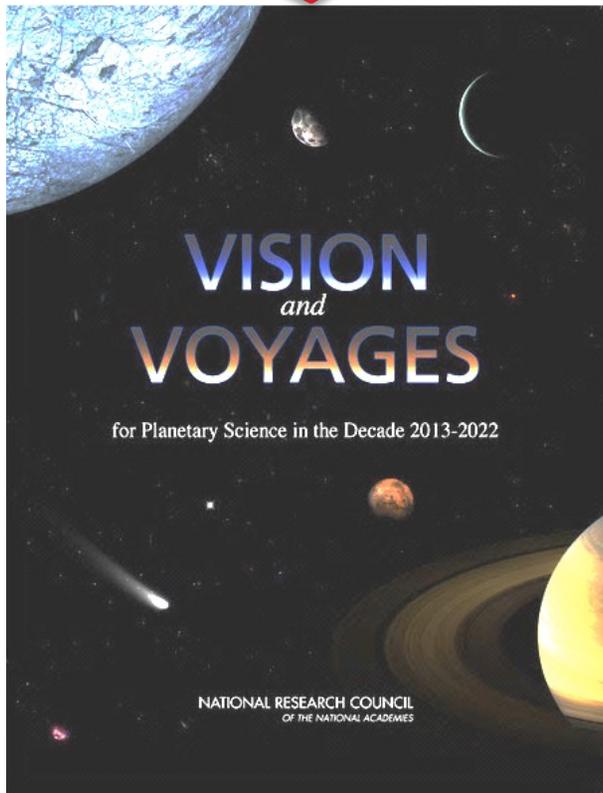
This gateway for human space exploration requires three things: a thorough asteroid survey to find thousands of nearby bodies suitable for asteroids to visit, extending light detection and distance capability to increasing ranges out to Mars and developing better orbital rules for and tools to stabilize asteroids to explore an asteroid regardless of its size, shape or spin. The asteroid survey would also provide a persistent and accurate assessment of future impact hazards.

PROBABILITY Asteroids orbit the Sun, most of them in the asteroid belt between Mars and Jupiter. Jupiter's gravity and other forces nudge a few onto paths that come within 40 million kilometers of Earth. The largest of these near-Earth asteroids (NEAs) is about 30 kilometers across, although most measure in meters. The smallest objects are most numerous and similar. In 1994, thousands of their residual grains and pebbles rained down from space every day, a few were sized up to 10 centimeters.

At about 20 meters across, the asteroid that lit the skies and shattered windows in Chelyabinsk, Russia, in 2013 demonstrated a likelihood for noncometary delivery to Earth, and posing a significant hazard. A Chelyabinsk-like surface occurs somewhere on Earth on average every 50 years, usually over the oceans. A 10-kilometer-wide

You just have to find them first.

ASTEROID SURVEY



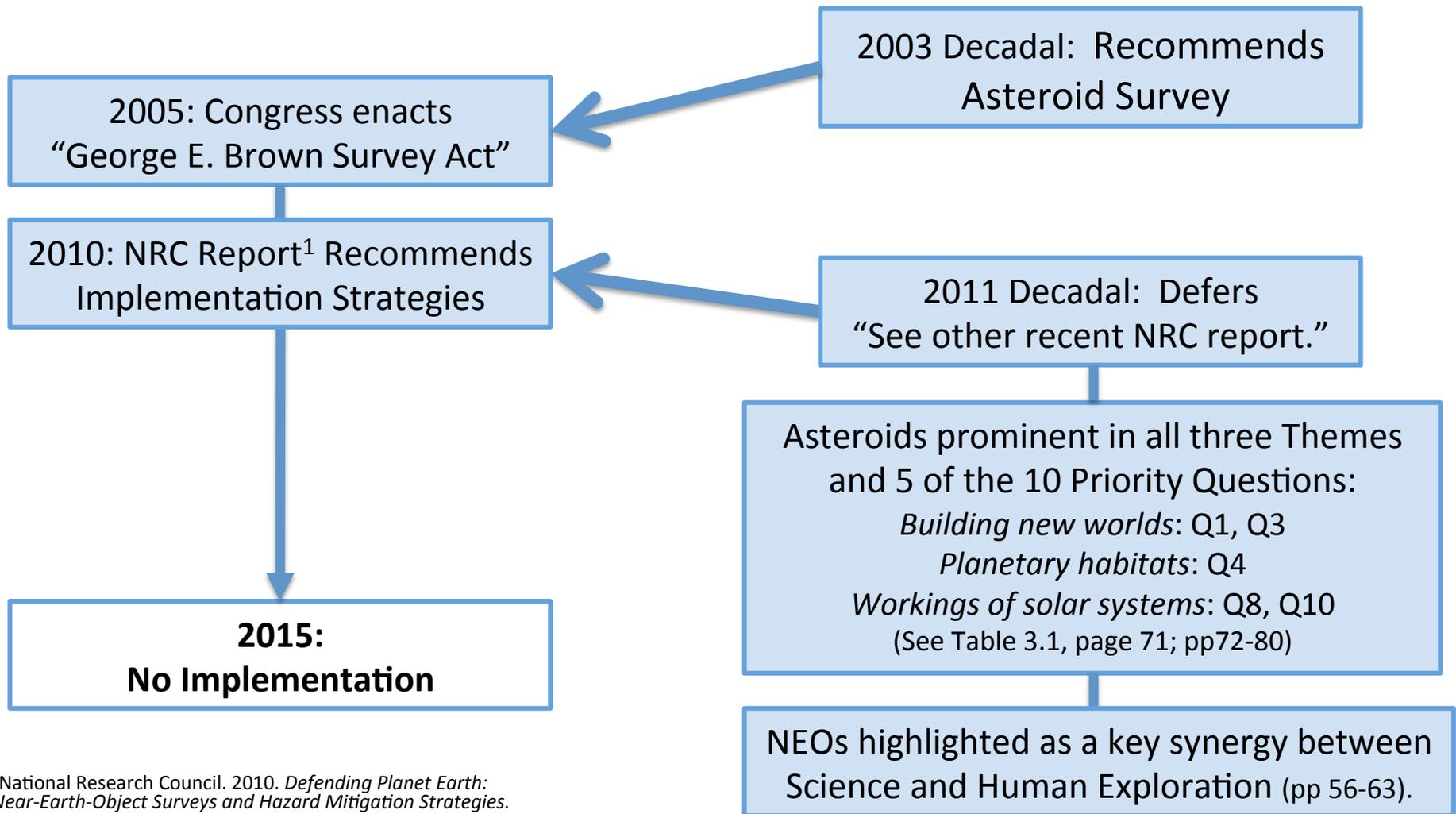
***Finding
Exploration
Destinations***



A Tale of Two Surveys

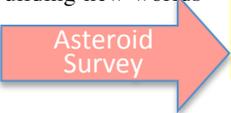
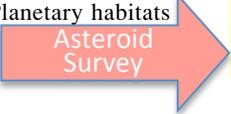
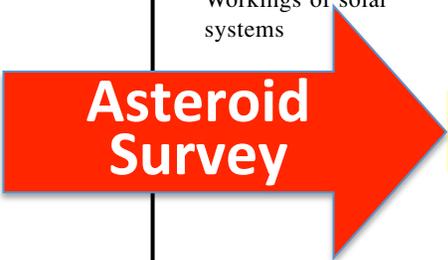
Asteroid Survey

Decadal Survey



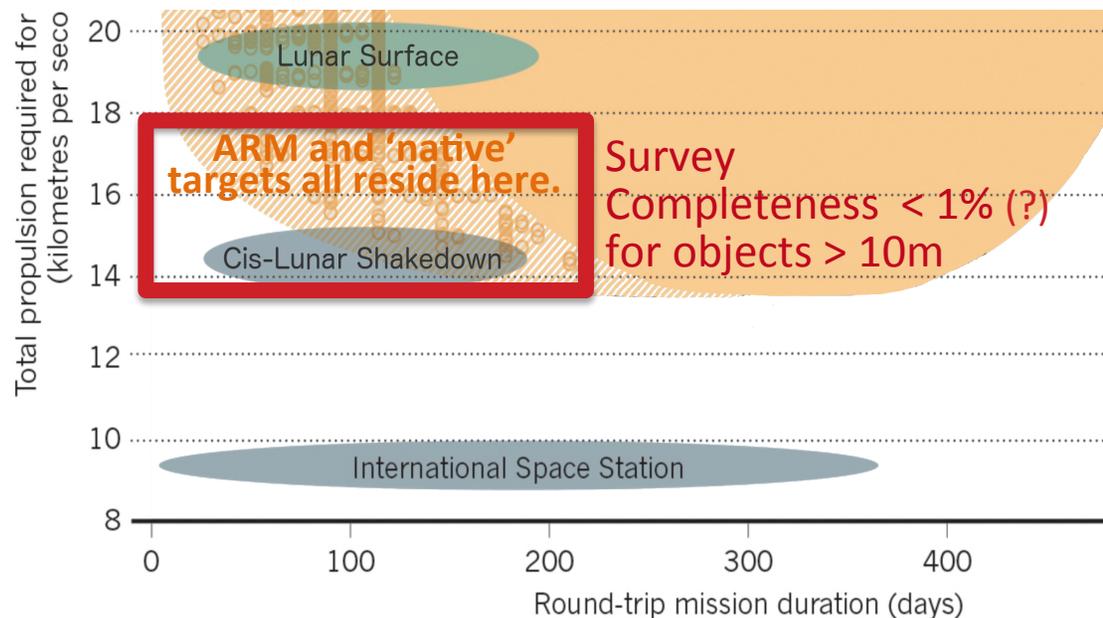
¹National Research Council. 2010. *Defending Planet Earth: Near-Earth-Object Surveys and Hazard Mitigation Strategies*. The National Academies Press, Washington, D.C.

TABLE 3.1 The Key Questions and Planetary Destinations to Address Them

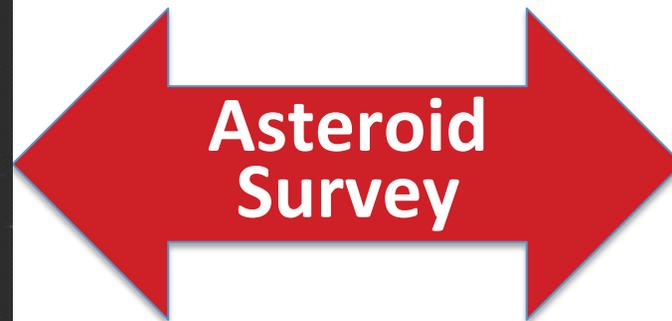
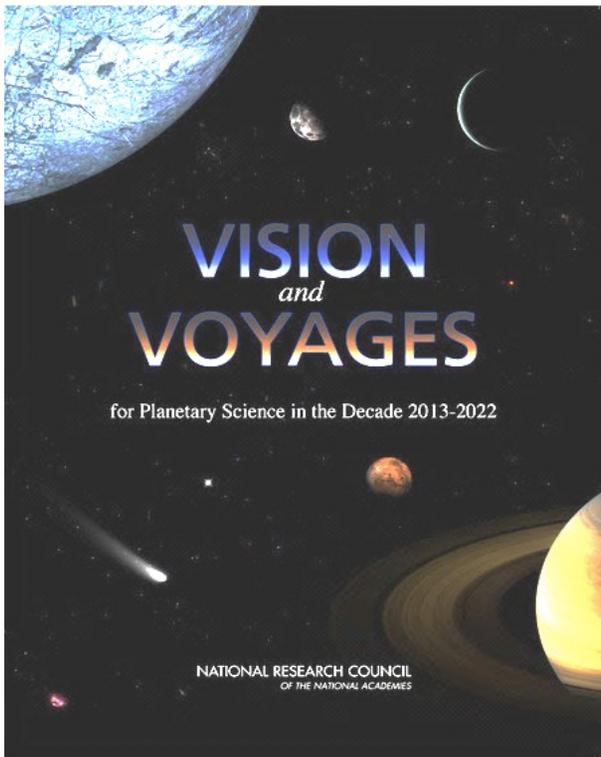
Crosscutting Themes	Priority Questions	Key Bodies to Study
Building new worlds 	1. What were the initial stages, conditions and processes of solar system formation and the nature of the interstellar matter that was incorporated?	Comets, Asteroids, Trojans, Kuiper belt objects (see Chapter 4)
	2. How did the giant planets and their satellite systems accrete, and is there evidence that they migrated to new orbital positions?	Enceladus, Europa, Io, Ganymede, Jupiter, Saturn, Uranus, Neptune, Kuiper belt objects, Titan, rings (see Chapters 4, 7, and 8)
	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?	Mars, the Moon, Trojans, Venus, asteroids, comets (see Chapters 4, 5, and 6)
Planetary habitats 	4. What were the primordial sources of organic matter, and where does organic synthesis continue today?	Comets, asteroids, Trojans, Kuiper belt objects, uraniaun satellites, Enceladus, Europa, Mars, Titan (see Chapters 4, 5, 6, and 8)
	5. Did Mars or Venus host ancient aqueous environments conducive to early life, and is there evidence that life emerged?	Mars and Venus (see Chapters 5 and 6)
	6. Beyond Earth, are there modern habitats elsewhere in the solar system with necessary conditions, organic matter, water, energy, and nutrients to sustain life, and do organisms live there now?	Enceladus, Europa, Mars, Titan (see Chapters 6 and 8)
	7. How do the giant planets serve as laboratories to understand Earth, the solar system, and extrasolar planetary systems?	Jupiter, Neptune, Saturn, Uranus (see Chapter 7)
Workings of solar systems 	8. What solar system bodies endanger Earth's biosphere, and what mechanisms shield it?	Near-Earth objects, the Moon, comets, Jupiter (see Chapters 4, 5, and 7)
	9. Can understanding the roles of physics, chemistry, geology, and dynamics in driving planetary atmospheres and climates lead to a better understanding of climate change on Earth?	Mars, Jupiter, Neptune, Saturn, Titan, Uranus, Venus (see Chapters 5, 6, and 8)
	10. How have the myriad chemical and physical processes that shaped the solar system operated, interacted, and evolved over time?	All solar system destinations. (see Chapters 4, 5, 6, 7, and 8)

Asteroid Survey *immediately* changes the asteroid conversation to “win-win-win.”

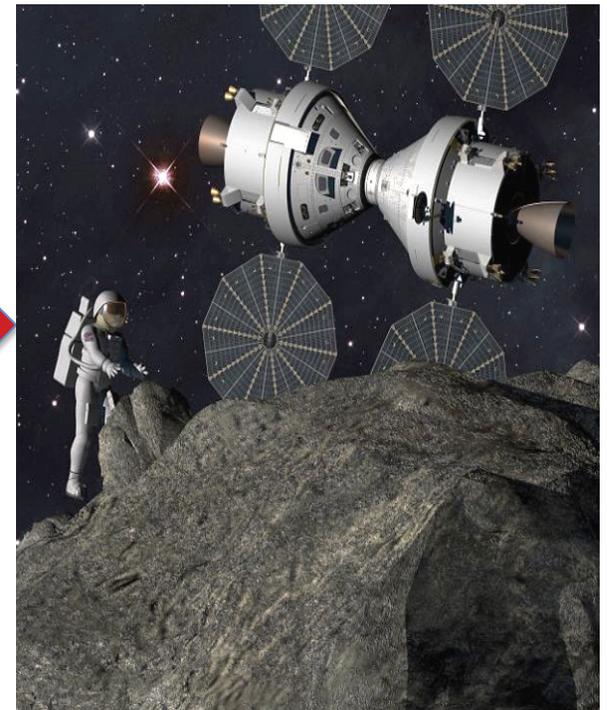
- For Human Space Flight finds ARM targets and ‘native’ asteroids. (Threads the needle on current NAC objections.)
- For NRC, implements decades of Academy reports.
- For Decadal Science: The more abundant the selection of exploration targets, the greater role for **SCIENCE** to engage in the target selection.



Synergies for Human Exploration with Decadal Science Objectives



Abundant destinations bring decadal science objectives into the exploration selection process.



Backup Slides

Asteroid destinations: You have to find them first.

- Number of 'viable' ARM targets discovered in 2014: 1
- We don't have the right tools for the job.
- This is a space-based job, not a ground-based job.

FACT:

There are 10 million NEAs larger than 10m.

