NAC T&I Committee: OCT Update

- **Discussion Topics**
  - **Technology across NASA**
    - **Space technology**
    - **SMD**
    - **HEO**
    - **ARMD**
    - **Center Investment Fund within CAS**
    - **Information Technologies**
  - **STMD / OCT scopes (briefing)**
  - **Next generation roadmapping & STIP**
  - **Agency Grand Challenge (briefing)**
  - **New initiatives**
    - **Foundational Engineering Science**
    - **Future Grand Challenges**

National Aeronautics and Space Administration

A Grand Challenge:
Find and Plan for All Asteroid Threats

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Grand Challenge
Program Executive

30 July 2013

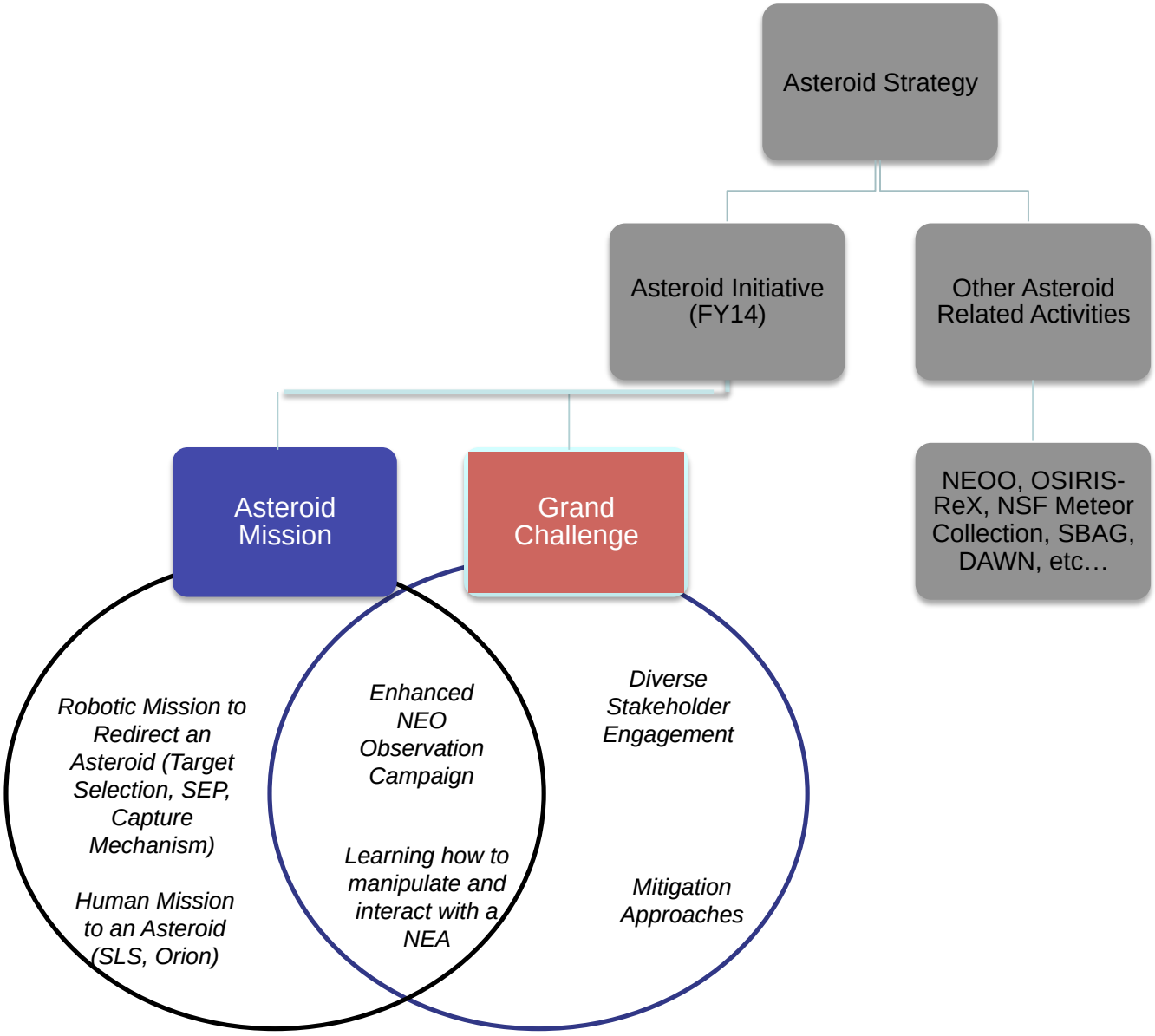
Agency Grand Challenges

- **A large-scale effort that requires activities and contributions beyond NASA's scope--this is a new way of doing business at NASA**
- **Serve as a "North Star" for high-impact, multi-disciplinary collaborations and public-private partnerships**
- **Leverages a variety of sources of partnership and outside collaboration (interagency, international, industry, academia, NGOs, citizens, particularly non-traditional partners)**
- **Requires Agency level leadership to engage across the Mission Directorates and offices within NASA**
- **Presents an opportunity for NASA to communicate its mission and vision to a broader audience**

Asteroid Initiative

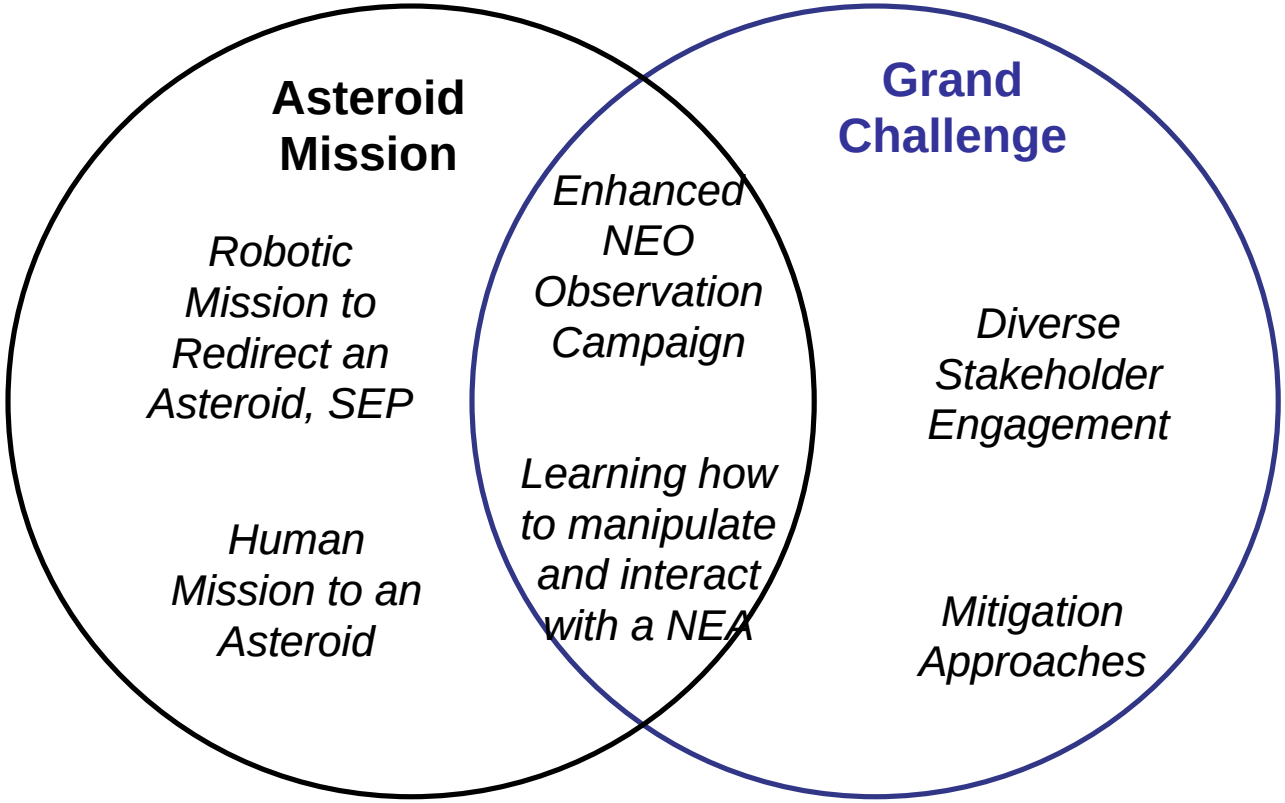
- **NASA has a broad asteroid strategy which aligns relevant portions of NASA's science, space technology, and human exploration capabilities for a human mission, scientific discovery, advanced technology development, efforts to protect the planet, and engages new industrial capability and partnerships**
- **The FY14 Asteroid Initiative consists of two mutually supporting activities, both leveraging on-going activities to:**
  - **Redirect a small asteroid to a stable orbit in trans-lunar space, followed by sampling by astronauts in early operations of Orion and SLS.**
  - **Lead a Grand Challenge to find all asteroid threats to human populations and know what to do about them.**
- **This initiative includes a parallel, forward-looking mission development approach, partnership opportunities (nationally and internationally), open innovation, and participatory engagement.**

Terminology



FY14 Asteroid Initiative: What and How

Asteroid Initiative



Both sets of activities leverage existing NASA work while amplifying participatory engagement to accomplish their individual objectives and synergize for a greater collective purpose.

Overall Grand Challenge Consists of Five Main Segments

Find all asteroid threats to human populations and know what to do about them

Asteroid Initiative FY14 Funding

	SMD	STMD	HEOMD	Total	OCT
Addback	$20M	$45M	$40M	$105M	$1M
Mission Specific		$38M	$40M	$78M	
Mission AGC Overlap	$20M	$4M		$24M	
AGC Focused		$3M		$3M	$1M

- Addback total $105 (plus $1m for OCT)
- SMD- $20M increase to NEOO for enhanced ground based detection. Clear overlap between Mission and AGC Goals
- STMD- $45M total increase. $38M for SEP acceleration for Mission; $7M for AGC focused work ($5M for Early Stage Research and $2M for Centennial Challenges)
- HEOMD- $40M increase to AES for capture mechanism, control aspects, and crew interaction design
- OCT- $1M for AGC coordination and development of a mitigation technology roadmap

Contributors to the Cause

Current Contributors

NASA Contributors

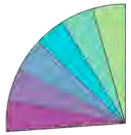
- NEOO (SMD) Program
- NEO Program Office at JPL
- Minor Planet Center (Smithsonian Astrophysical Observatory)
- JRP (HEO) Program
- Asteroid Redirect Mission: Identify, Redirect, and Explore
- STMD (Research Grants, Centennial Challenges)

External Contributors

- Other U.S. Government Agencies
- International Governments (Space Agencies, IWAN, SMPAG)
- European Space Agency (ESA) Space Situational Awareness Initiative NEO element
- Global Coordination Bodies (UN COPUOS)
- Observatories
- Amateur Astronomers
- Universities/Academia
- Non-Profits/Foundations (B612)
- Commercial Space Industry
- Emerging Space Industry
- Space Advocacy

+

Potential Contributors

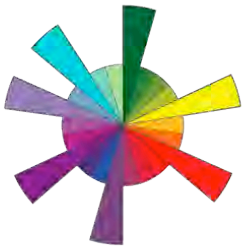


- Entrepreneurs/Small Businesses
- Investing Community/Venture Capitalists
- Maker Community
- Citizen Science
- Media
- Hollywood

Some Examples of Potential Contribution

Light curve Analysis

- NEOO (SMD) Program
- Minor Planet Center (Smithsonian Astrophysical Observatory)
- International Governments
- Amateur Astronomers
- Space Advocacy
- Citizen Science



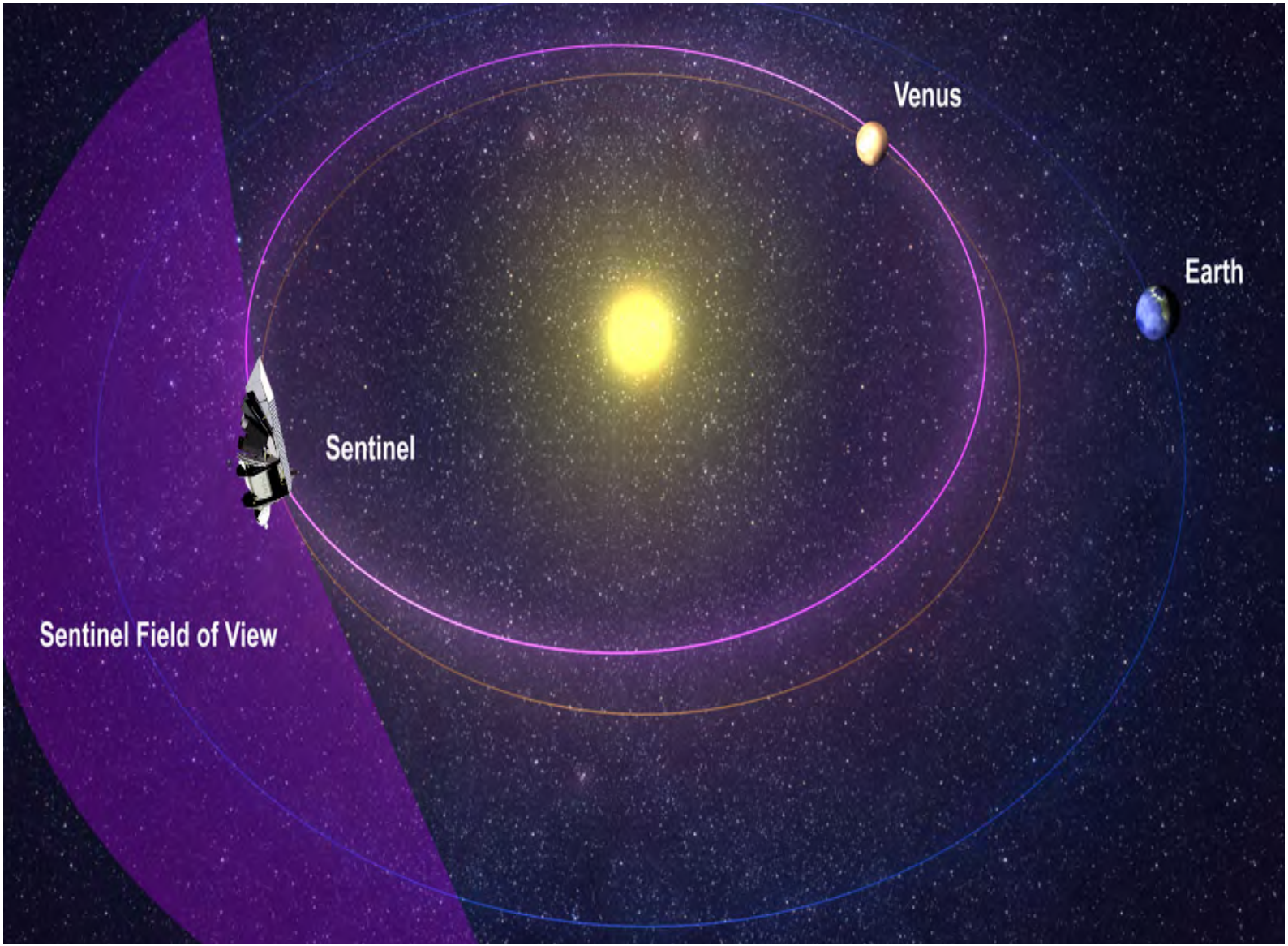
Shape Model Analysis

- NEOO (SMD) Program
- Asteroid Redirect Mission
- International Governments
- Universities/Academia
- Emerging Space Industry
- Investing Community
- Citizen Science

Space Based Observation

- NEOO (SMD) Program
- International Governments
- Global Coordination Bodies
- Observatories
- Universities/Academia
- Non-Profits/Foundations (B612)
- Commercial Space Industry
- Emerging Space Industry
- Space Advocacy
- Entrepreneurs/Small Businesses
- Maker Community
- Citizen Science

Public Private Partnership-
Space Act Agreement with B612



Prizes- Green Flight Centennial Challenge

NASA/Bill Ingalls

Crowdsourcing- GalaxyZoo

Citizen Science

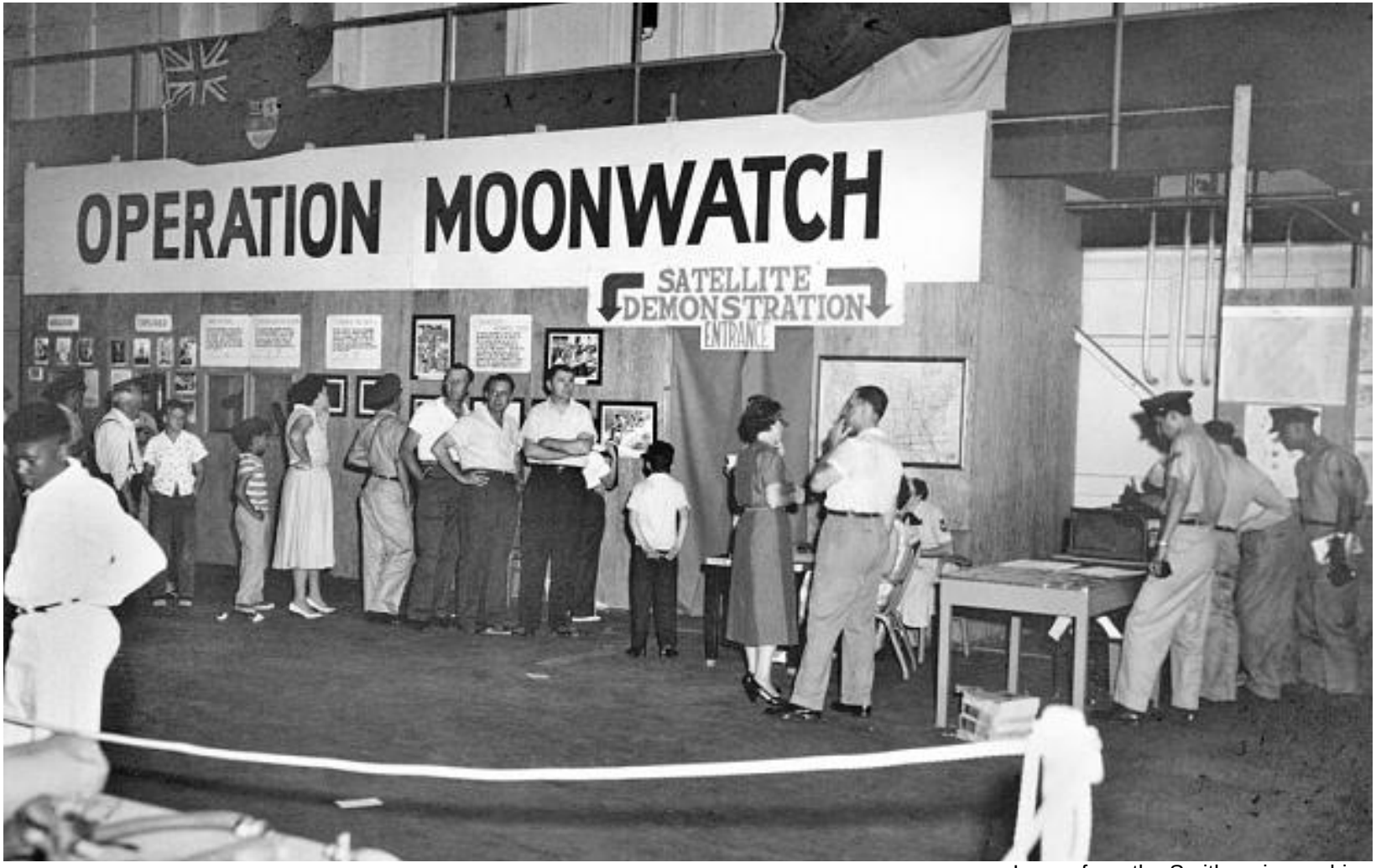
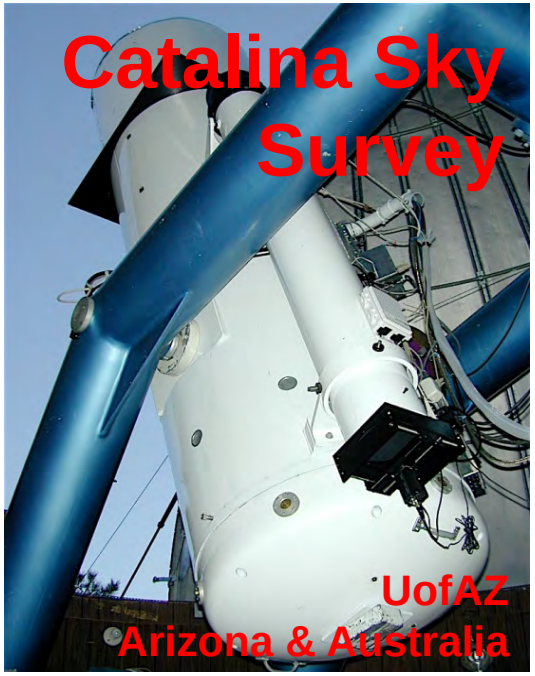


Image from the Smithsonian archive

Existing NASA NEO Leadership

- Since 1998, NASA's Near Earth Object Observation (NEOO) Program has led the global effort to find potentially hazardous asteroids
- Within the last 15 years this effort has successfully found 95 percent of the near-Earth asteroids larger than 1km

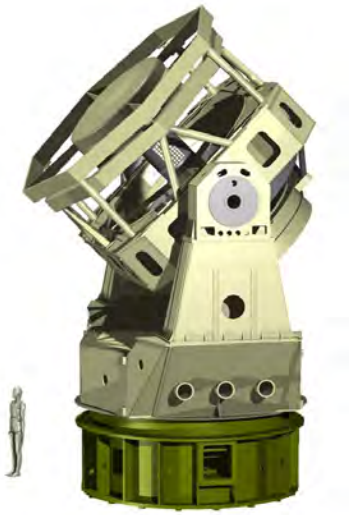


Enhancing Existing Work without the Grand Challenge

- Improvements in the NASA observing network (Upgraded Catalina Sky Survey scopes, Pan-STARRS 2, ATLAS, Space Surveillance Telescope) will result in a higher discovery rate for all NEO types

ATLAS

SST



Current/Potential- STMD Investments

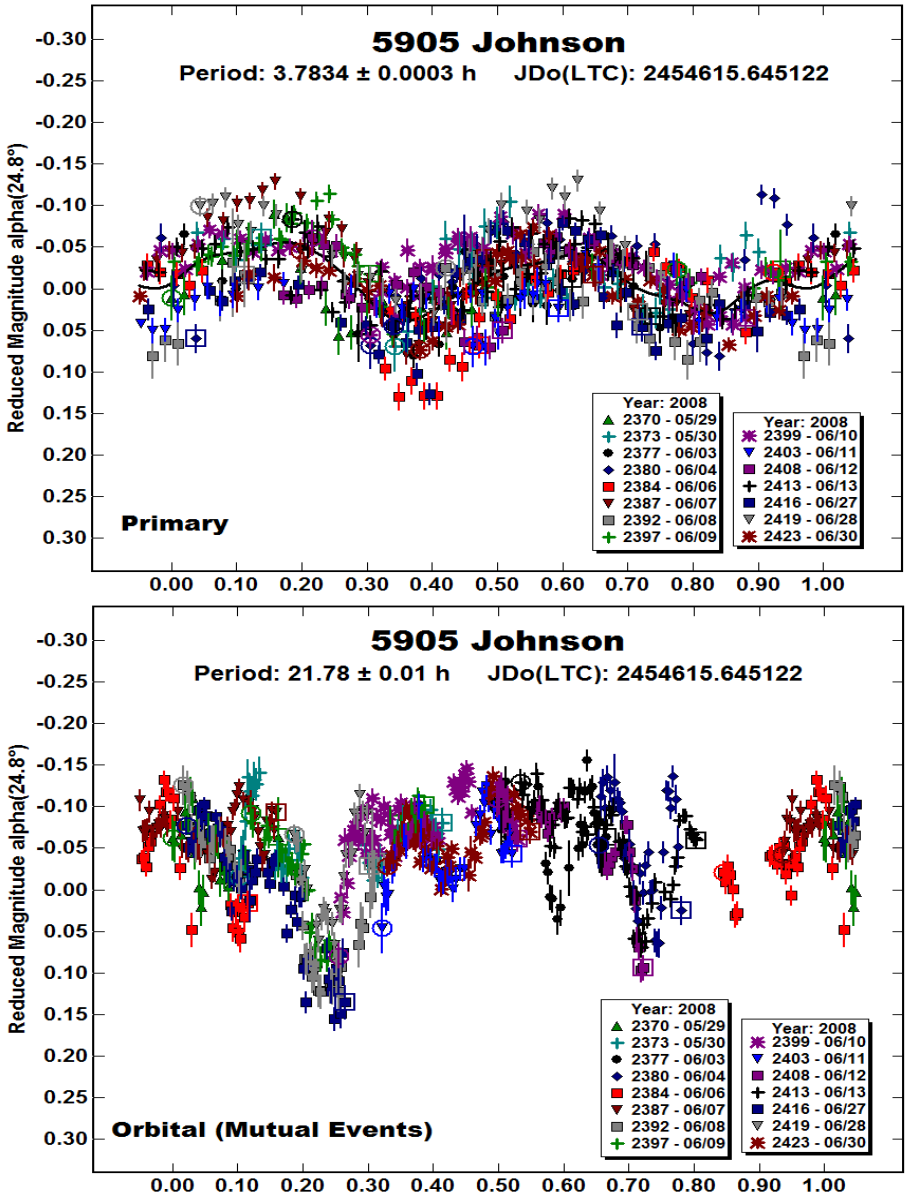
- NASA Innovated Advanced Concepts (NIAC)- requests proposal for concept studies that can advance the state of the art in future space endeavors. Funded awards that address or are related to AGC topics may occur in any given year, but there are no guarantees.
  - In the past NIAC has funded the development of Innovative Solution to NASA's NEO Impact Threat Mitigation
  - Phase II to complete in 2014- A Hypervelocity Asteroid Intercept Vehicle (HAIV) mission architecture for reliably mitigating the most probable impact threat: NEOs with warning times shorter than 10 years
- Space Technology Research Grant (STRG)- released an AGC and ARM related topic area for FY2013 solicitation. Typical award amount is $250K per year. Of the 5 topic areas, one is asteroid focused. (Detect and Mitigate)
- Small Business Innovation Research/ Small Business Technology Transfer (SBIR/STTR)- The timeline for maturing a technology though SBIR is 5-6 years, but there might be the potential to use one of these mechanisms to support the Grand Challenge.

Potential- NASA Tournament Lab (NTL) and Citizen Engagement

- Potentially utilizes existing NTL platform and contract with Harvard/Top Coder to focus on existing datasets for improved asteroid detection by improving the state-of-the-art asteroid detection image processing algorithm

- **Overall expected impact**
  - Enhanced open source algorithm that builds upon the previous improved state-of-the-art algorithm
  - Increase general public contributions to the hunt for new asteroids
  - New active community interested in the advancement of asteroid detection algorithms.

Expanded Amateur Contributions to Light Curve Analysis



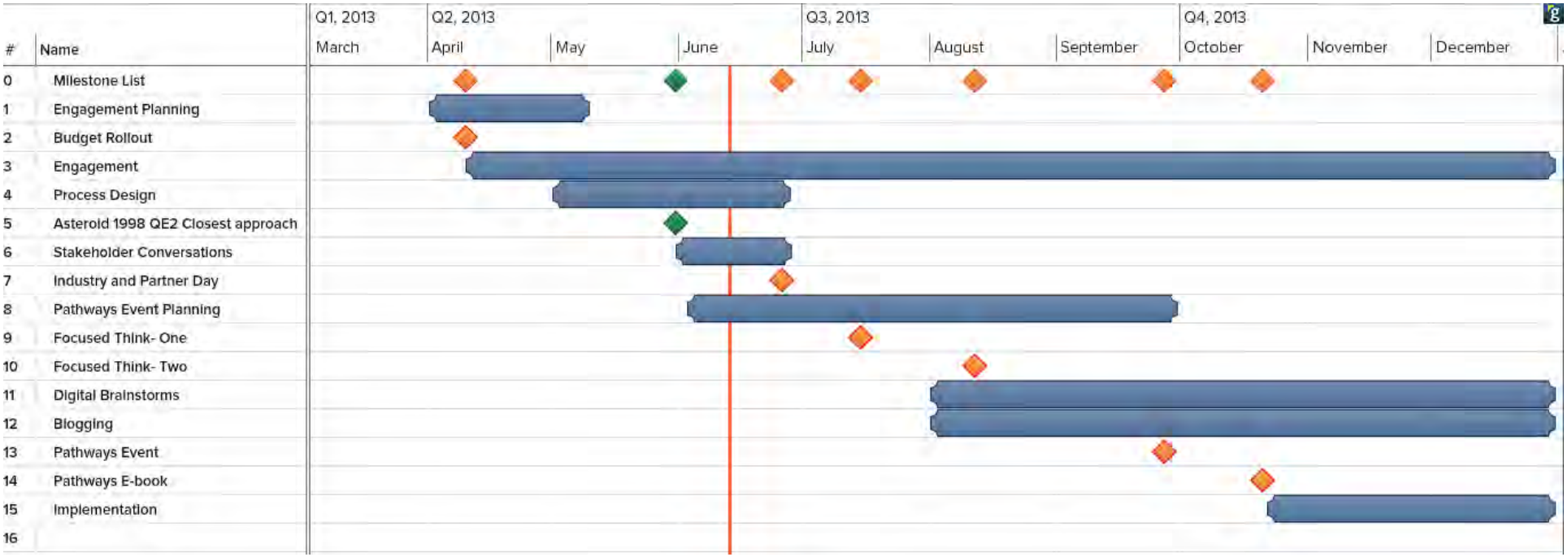
In 2005, amateur astronomer light curve analysis* of 5905 Johnson discovered it was a binary

* Work done by Brian D. Warner

Potential Activities

- There are a number of companies and groups very interested in asteroids for the many reasons that make asteroids important and therefore present opportunities for future public private partnerships possibilities
- Centennial Challenges have proven successful in spurring innovation, so we will explore concepts for challenges to support the resolution of the Grand Challenge
- Additional incentive prizes will also be explored to support detection, characterization, and mitigation solutions

Planning Timeline



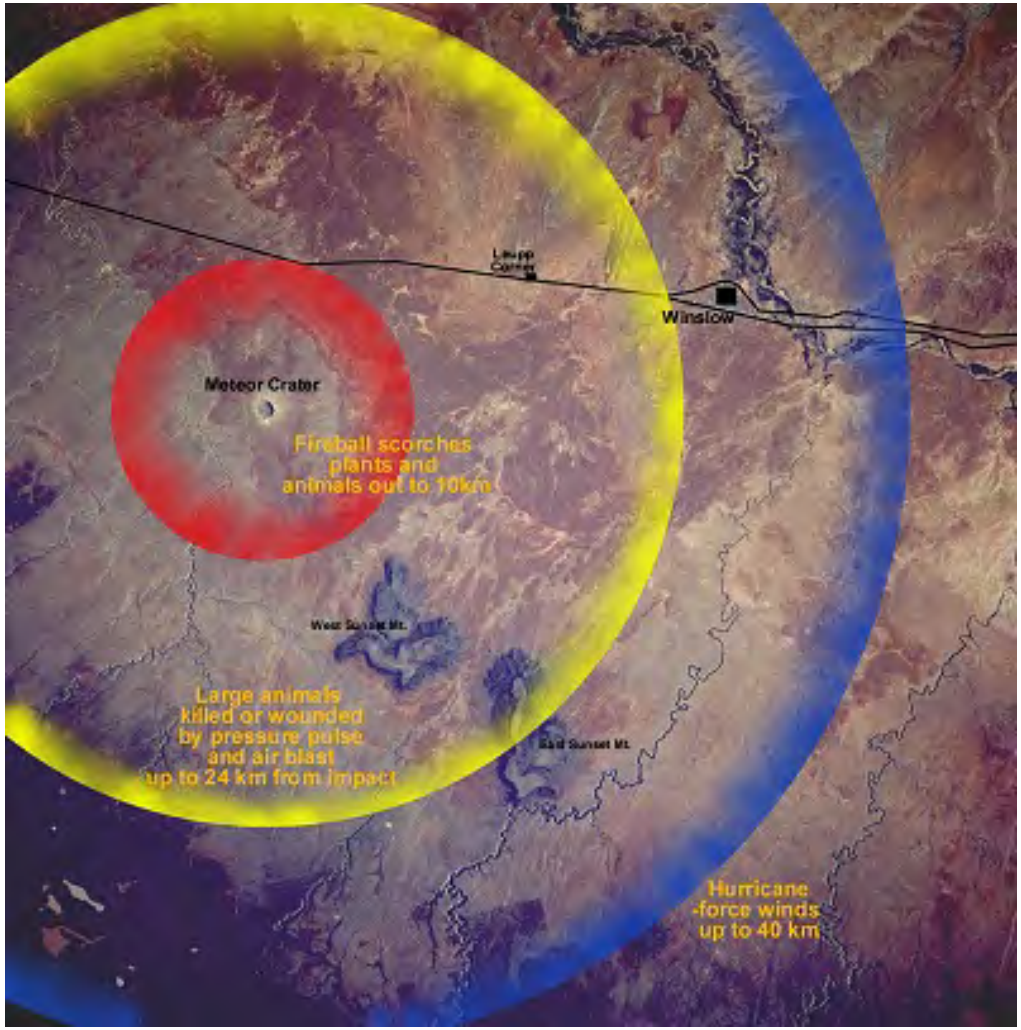
Grand Challenge

Every revolutionary idea seems to evoke three stages of reaction: It's completely impossible. It's possible, but it's not worth doing. I said it was a good idea all along.

-Arthur C. Clarke

Back-Up

Why is this AGC Important?



Barringer “Meteor” Crater
Winslow, Arizona

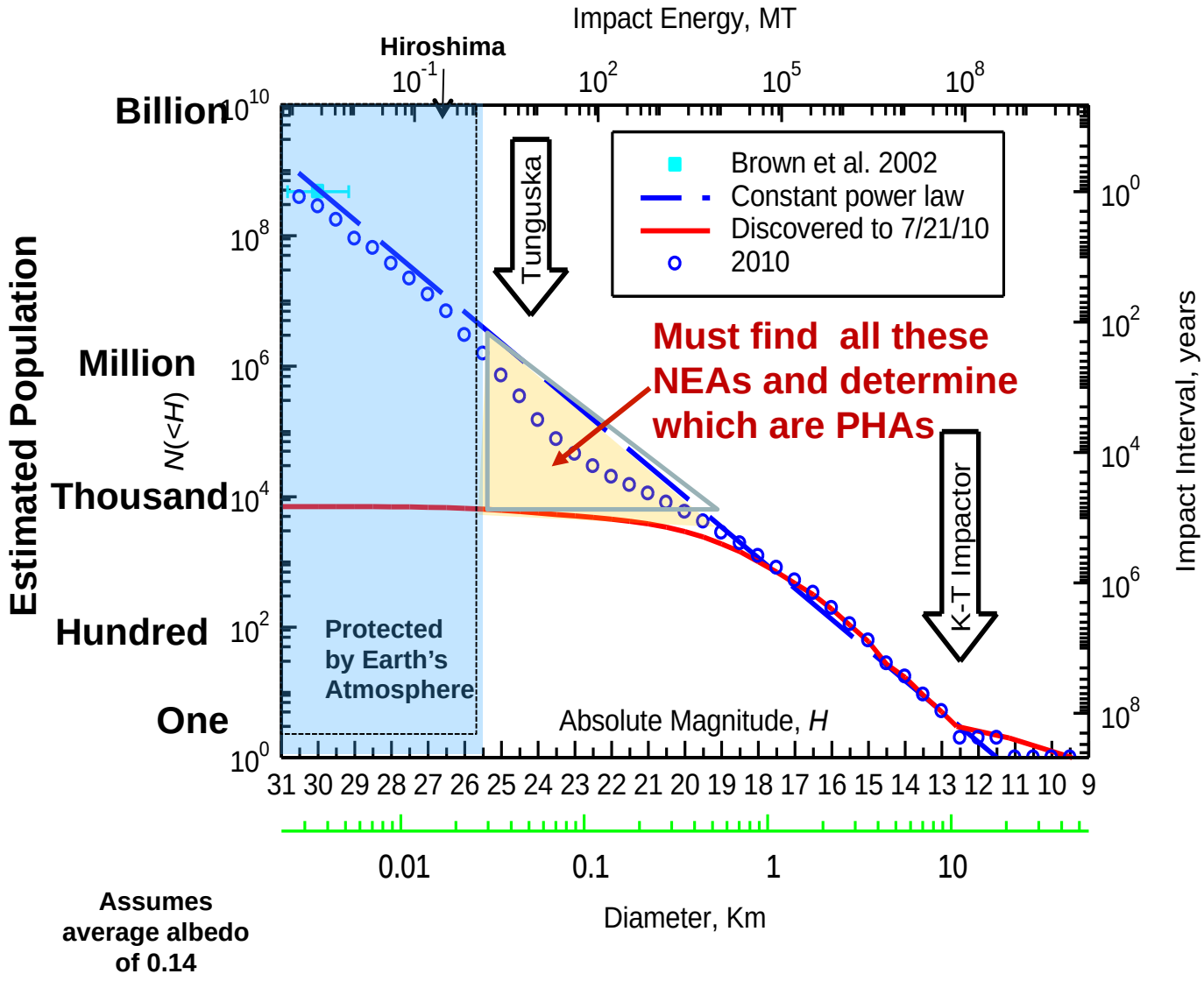
Added this…

Diameter – 1.2 km
Age – 50,000 yrs

Impactor size - ~50m
Energy released = ~10Mt TNT

Impact in modern day would devastate Winslow, AZ, population 10,000. If not warned of impending impact, a 25% casualty rate could be expected. Eastern Arizona is very sparsely populated.

NEAs, PHAs and the Impact Hazard



NEAs – Near Earth Asteroids that come within 30million miles of Earth's orbit

PHAs – Potentially Hazardous NEAs larger than 30 meters in size that could someday impact Earth

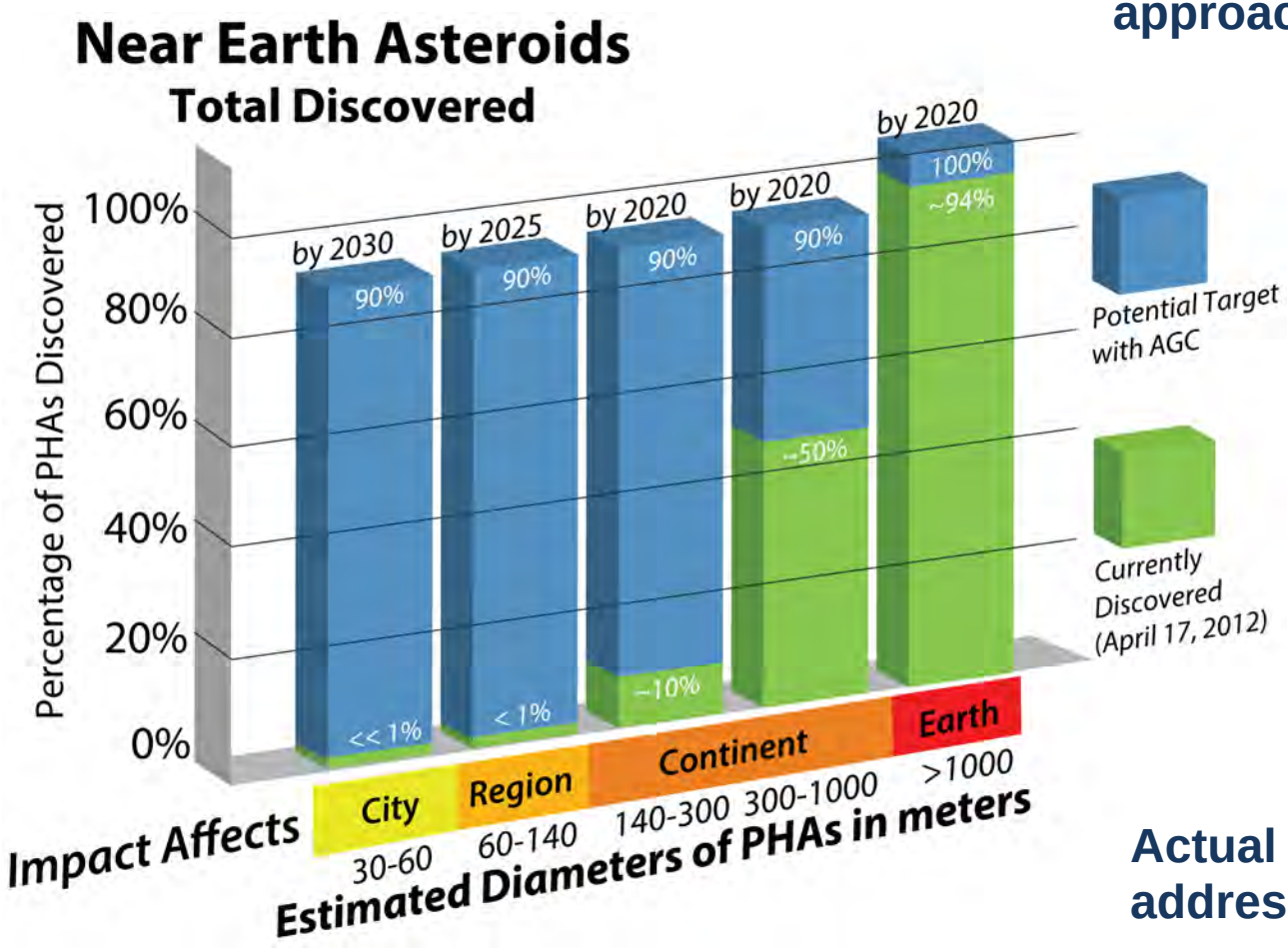
PHAs have been about 15% of all NEAs found to date

NEAs must be tracked for several weeks to determine if they are PHAs

Known PHAs come between the Earth and the Moon about once a month!

Expanding our Knowledge of Near Earth Asteroids

Added this…



The National targets addressed through this approach <u>could be</u>:

- Find 100% of 1000m by 2020 (PHAs of this size are a threat to Earth)
- Find 90% of 140m PHAs by 2020 (PHAs of this size are a threat to continents)
- Find 90% of 60m PHAs by 2025 (PHAs of this size are a threat to regions)
- Find 90% of 30m PHAs by 2030 (PHAs of this size are a threat to cities)

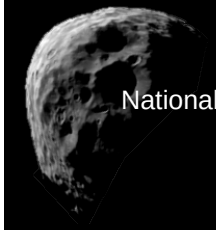
Actual National targets addressed through this approach <u>will be co-defined with partners.</u>

Approach for Grand Challenge

- NASA is developing a **cross-cutting, inclusive approach** for implementing the Grand Challenge.
  - This plan will be co-created over the coming months with key stakeholders in order to maximize buy-in and partner commitments.
  - The planning process will be cross-cutting across NASA mission directorates and offices.
  - The planning process will leverage an innovative engagement strategy to work with non-NASA stakeholders including in-person meetings, online dialogues, industry days, engagement with non-traditional partners, and stakeholder discussions.
- An implementation plan will consider a variety of methods for making progress towards protecting the planet from asteroids, including:
  - Leveraging traditional approaches to drive progress in this area
  - Enhanced ground based observation and potential space based capabilities
  - Public private partnerships (space act agreements and interagency agreements)
  - Citizen science and crowdsourcing
  - Prizes and challenges

Grand Challenge Engagement Channels/ Stakeholders

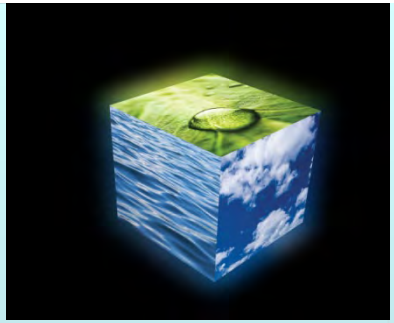
- Public
  - Advocacy Groups
  - Media
  - Amateur Astronomers
  - DIYers
  - Future Scientists (K-12)
- NASA Internal
- Partners
  - Existing Near Earth Object Program Network
  - Academia
  - New Ventures
  - Traditional Industry
- Legislative
- Other Government Agencies
- International



National Aeronautics and Space Administration

Another Grand Challenge:
Massless Exploration

Driving Towards Massless Exploration



Potential Challenge Statements:

- On Demand Living by 2025: Using local resources to manufacture what you need to drastically reduce the mass of supplies required for space exploration.
- Develop a Self Sustaining End-to-End, Local Manufacturing System that Produces Many Times More Mass of Goods than the System Itself by 2025

Why is this Important

- IMAGINE…you have to travel light…only taking your MacGyver box…or using only what is available with minimal resupply from the outside world…needing to develop a self sustaining End-to-End, Local Manufacturing System that Produces More Mass of Goods than the System Itself by 2025
- This challenge is a paradigm change: doing mission architectures and vehicle design differently to account for in-space manufacturing, lowering the overall mass ratio to space
- Makes self reliance on long-distance space missions possible, reduces upmass and launch infrastructure costs, creates more autonomous communities in space and on Earth, and frees humanity from the constraints of limited resources.
- For Earth, advanced manufacturing practices and “living off the land” drives sustainability and equips resource constrained areas of the world
- Production of commodities and supplies from local resources is fundamental to long-term human activity beyond Earth as well as self-sustaining communities here on Earth.
    - Demonstrate a mass ratio of > 1 in 5 years
    - Demonstrate a mass ratio of >3 in 10 years
    - Demonstrate a mass ratio of >10 in 15 years
    - Demonstratepartialautonomyin10years
    - Demonstrate full autonomy in 15 years

How could this AGC work?

Elements of Work

- Enable new Mission Architectures that embrace and leverage advanced manufacturing techniques
- Encourage advanced design methods
- Modernize fabrication instruction development, accessibility of the design file, and communications of it
- Local Resource Mining / Space Mining / Resource Acquisition / Prospecting
- In-Situ materials processing/refining
- Advanced, Autonomous Fabrication & Construction
- Applications/Utilization /Infusion

What NASA is Already Doing?

- Excavation (KSC/JSC/GRC)
- Recycling CO2
- Waste on Station
- Resource Prospector Mission
- RESOLVE Mission Prototype
- GCD HRS Excavation Robots (C2, VIPER, Badger, RASSOR)
- AES / GCD ISRU
- "Solar Decathalon"
- Trash to Gas (AES)
- Biofuels
- Propellants (KSC)
- Extracting Metals
- Traditional ISRU
- Bloom Energy: NASA spinoff
- RegoBricks w/ Syn Bio
- "Burning Man" Demo
- ISS 3D Printing

Potential Partners and Sources of Leverage

- COTS partners
- 3D Printing Industry
- International Space Agencies
- Manufacturing Industry
- Design Thinking Companies
- Architecture & Construction Industry
- Universities
- Energy / Chemical

Industry

- Crowd-Sourcing: e.g. Thingy-verse
- MAKER community
- Mining Industry
- Recycling Industry
- Environmental movement
- State Governments (Hawaii, Florida, et.c.)

Risks

- Mass/power/volume allocation for 'maker systems' can't be reduced enough to be launched efficiently (Must have Mass Ratio >>1)
- Finding suitable resources
- Can not identify economically viable resources; finding and being able to access them; lack of key resources at the prospecting site
- Refinement / processing of resources
- Low TRL Level of technology; without investments we will not be able to meet the challenge in 2025.