NASA’s Near Earth Object Program and Activities

Presentation to
International Academy of Astronautics
3rd Planetary Defense Conference 2013

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NASA HQ
April 2013
2005 YU55 to Approach Earth Nov. 8, 2011

Extensive radar, visual and infrared observations are being planned.

C-type asteroid
Diameter ~400 meters

Earth & Moon close approach
Pass of Asteroid 2005 YU55 Observed with Ground-based Radars

- 2005 YU55 passed by Earth the evening of 8 Nov, 2 at just less than 200,000 miles – within the Moon’s orbit
- Earth based planetary radars at Goldstone, CA and Arecibo, PR, were used to track and image the asteroid
- Planetary radar can be used to determine the size and shape of the asteroid, study its surface properties, and help predict any future encounters with the Earth
- The radar imaging shows the asteroid to be roughly spherical, about 1300 feet across, and rotating with a period of about 18 hours
- This event demonstrates how Near Earth Asteroids could be characterized by planetary radar for studies of potential human spaceflight destinations

This image of asteroid 2005 YU55 with about 12 foot resolution was obtained by Lance Benner at NASA’s Goldstone Radar on Nov. 7, 2011, about one day before closest approach, when the object was at 3.6 lunar distances, which is about 860,000 miles from Earth. NASA/JPL-Caltech

These two radar images were obtained by Patrick Taylor at the Arecibo Planetary Radar on Nov 12. The asteroid was about 2,000,000 miles away and the images show objects of about 25 feet in size. The image on right shows a radar bright feature, possibly a boulder on the asteroid’s surface.

The Arecibo Observatory is operated by SRI International under a cooperative agreement with the National Science Foundation, in alliance with Ana G. Méndez-Universidad Metropolitana, and the Universities Space Research Association. The radar operations are funded by NASA.
US component to International Spaceguard Survey effort
Has provided 98% of new detections of NEOs since 1998

Began with NASA commitment to House Committee on Science
in May, 1998 to find at least 90% of 1 km NEOs
 – Averaged ~$4M/year Research funding 2002-2010
 – Starting with FY2012, now has $20.5 M/year

Program Objective: Discover ≥ 90% of NEOs larger than 140
meters in size as soon as possible

NASA Authorization Act of 2005 provided additional direction)

“...plan, develop, and implement a Near-Earth Object Survey program to detect, track, catalogue, and characterize the physical characteristics of near-Earth objects equal to or greater than 140 meters in diameter in order to assess the threat of such near-Earth objects to the Earth. It shall be the goal of the Survey program to achieve 90 percent completion of its near-Earth object catalogue within 15 years [by 2020].
NASA’s NEO Search Program
(Current Systems)

Minor Planet Center (MPC)
- IAU sanctioned
- Int’l observation database
- Initial orbit determination
www.cfa.harvard.edu/iau/mpc.html

NEO Program Office @ JPL
- Program coordination
- Precision orbit determination
- Automated SENTRY
http://neo.jpl.nasa.gov/

End of Operations Feb 2011, Analysis Of Data Continues
Known Near-Earth Asteroids
1980-Jan through 2012-Dec

- All NEAs
- Large NEAs

Start of NASA NEO Program

Number

Year

15 January 2013
Alan B. Chamberlin (JPL)
Known Near-Earth Asteroids
1980-Jan through 2012-Dec

Number

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Start of NASA NEO Program

15 January 2013
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Known Near Earth Asteroid Population

Known Near-Earth Asteroids
1980-Jan through 2012-Dec

- All NEAs
- Large NEAs

Start of NASA NEO Program

Number

Year

9770
4/12/13
7936
5/1/11
861
4/12/13
827
5/1/11

15 January 2013
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Discovery Rate >1 km
Discovery Rate All NEAs
Known Near Earth Asteroid Population

Near-Earth Asteroids
Total Discovered per Size Bin

Estimated Diameter (m)

- <<1% (<<1%)
- <1% (~10%)
- ~10% (~60%)
- ~95% (~95%)

15 January 2013
Alan B. Chamberlin (JPL)
FY2012 Budget Allocation

Total Budget $20.425M
Fully Competed $17.045M 83.5%
Recent Observations Retired Two “Threats”

- **2011 AG5** (140 meters in size)
  - Impact probability was 1/500 for Feb. 5, 2040
  - Observations in Oct. 2012 allowed refined orbit and eliminated 2040 impact threat

- **2004 MN4 “Apophis”** (325 meters in size)
  - Earth impact was once thought possible for April 13, 2036
  - Optical data in late 2012 and radar date in early 2013 refined orbit and eliminated the 2036 impact threat
  - Next potential threat in 2068 – 1/435,000
  - Highest potential remains 1999 RQ36 in 2182
Increased Radar Studies

Observations on the limited number of accessible objects, but next best thing to a flyby
– Detections/year from Goldstone and Arecibo doubled
– Required for timely precision orbit determination
– Characterization with sufficient signal strength
  • Shape, spin-state, surface structure
  • Satellites (and then derived mass)

Study of Shape, Size, Motion and Mass of 66391 (1999 KW4)
Shape, Size of 4179 Toutatis
Increase in Radar Program

2012 Results
76 Detections
64 New

RADAR DETECTIONS OF NEAR-EARTH ASTEROIDS

New detections per year
Total detections per year
Cumulative new detections

A = Arecibo
G = Goldstone DSS-14
DSS13 = Goldstone DSS-13
GBT = Green Bank Telescope
N = 352

2012 DETECTIONS:

black = previously detected
red = new detection

7341 1901 VK [A, G]
2001 YE4 [A]
2011 YH40 [G]
433 Eros [G]
2012 BX34 [G-DSS13]
2012 KA34 [A]
2006 CJ [G,A]
(96590) 1998 KB [A]
2006 AL3 [A]
2008 QY [A]
162421 2000 ET76 [A,G]
2011 CP4 [A,G]
141018 2001 WC47 [A]
2012 DX [A]
2009 AV [A]
2002 Q7 [A]
2012 DX13 [A]
2012 MU2 [A]
2002 Ojato [A]
2012 DH54 [A]
2012 DW60 [A]
2012 DH4 [A]
2012 EO6 [A]
2010 SV3 [A]
2012 BJ23 [A]
2012 F223 [A]
2004 FG11 [A]

2003 WH166 [A]
2012 HM [G]
2012 HL [A]
1994 NK [A]
2010 KX7 [A]
2001 SZ269 [A]
(29075) 1995 OA [A]
(326290) 1998 HE3 [A,G]
2007 LE [G,A]
2001 CG86 [G,A]
2012 LG71 [A]
(339327) 2006 VT30 [A]
2012 MU302 [A]
2012 KM45 [A]
2012 MV2 [G,A]
(144411) 2004 EW9 [A,G]
(159358) 2002 AM31 [A,G]
2012 MM11 [A]
(320732) 2003 HB30 [A]
1899 P/NEAT [A]
2012 NN [A]
2012 OQ [A]
1865 Toro [A]
329614 2003 KU2 [A]
277475 2005 WK4 [A]
2062 Aten [A]
2002 QQ [G]
2006 CF [G]
65146 1995 TU3 [A]
4081 Donatiplus [A]
37655 Illapa [A]
152421 2000 ET70 [A]
2012 PX [A]
4769 Castalia [A]
2012 QG42 [G,A,A-GBT]
2003 Bacchus [A]
2012 JS11 [A]
136993 1998 ST49 [A,G]
2012 VY16 [A]
214869 2007 PA8 [G]
2012 TG53 [A]
2009 LS [A]
2010 JK1 [G, A]
1994 XD [G]
2012 WH1 [A]
2001 YM2 [A]
4179 Toutatis [G]

http://echo.jpl.nasa.gov/
B612 “Sentinel” Project

- Established NASA Technical Consulting Team (NTCT)
- Supported B612 Project Concept and Integration Review (PCIR)
- NTCT members will also support Sentinel Operations and Data Analysis (SODA) Working Group
- Sentinel Schedule/Milestones:

  - Sentinel SAA signed: June 2012
  - Preliminary Design Review: TBD
  - Critical Design Review: TBD
  - Launch: NET 2018
  - Initial on-orbit data delivery: NLT launch +6 mos

NASA has signed a Space Act Agreement (SAA) to support B612 Project Sentinel
Previews of Coming PDC Attractions

- **Session 2 – NEO Survey**
  - Tim Spahr – Minor Planet Center, SAO/CfA
  - Don Yeomans – NEO Program Office, JPL
  - Eileen Ryan – Magdalena Ridge Observatory
  - John Tonry – ATLAS, UofH/IfA
  - Amy Mainzer – NEOCam Technology, JPL

- **Session 3 – NEO Characterization**
  - Keith Holsapple – University of Washington
  - Dan Scheeres – University of Colorado
  - Catherine Plesko – Los Alamos National Laboratory
  - Lance Benner - NEO Radar, JPL
  - David Trilling – Spitzer Observations, NAU
  - Paul Chodas – 2011 AG5, NEO Program Office, JPL
Previews of Coming PDC Attractions

- **Session 4 – Mitigation**
  - Steve Chesley – NEO Program Office, JPL
  - Shyam Bhaskaran – Solar System Dynamics, JPL
  - Kevin Housen – Boeing
  - Paul Miller – Lawrence Livermore National Laboratory
  - Andy Cheng – AIDA Mission Concept, APL
  - Paul Abell – Johnson Space Center
  - Brent Barbee – NEO Accessibility Study (NHATS), Goddard

- **Session 6 – Consequence Management**
  - Linda Billings – NEO Hazard Communications, NIAC

- NEOO also works with OSIRIS-REx Flight Project, and the concept study teams for Marco-Polo-R, AIDA, and ISIS
UN COPUOS
Scientific & Technical Subcommittee Action Team-14
Recommendations

International Asteroid Warning Network (IAWN)

Observers, dynamacists, modelers...

Impact disaster planning advisory group

Assistance to Disaster response agencies

Space Missions Planning Advisory Group (SMPAG)

Space Agencies and invited reps

OOSA/COPUOS

Inform on cases of credible threat

Established in case of credible threat

Ad-hoc mitigation mission advisory group

Advise on planning and response to the threat

Involved nations

*See A/AC.105/C.1/L.329 21 Dec 2012
Found by La Sagra Observatory, Spain, in Feb 2012.
Asteroid 2012 DA14 passed within about 3.5 Earth radii of the Earth's surface on February 15, 2013. 2012 DA14 passed inside the Earth's geosynchronous orbit ring, located about 35,800 kilometers above the equator.
Images of 2012 DA14 spanning nearly 8 hours on Feb. 16. An elongated object is clearly revealed. Based on the changes the aspect ratio for this object is close to 2:1. Preliminary estimates the pole-on dimensions are roughly 40 x 20 meters.
And Then Chelyabinsk
Since Chelyabinsk

• US House Science Committee Hearing of Threats from Space
  • Part 1 Witnesses: Administer Bolden; Dr Holdren, OSTP; Gen Shelton, AFSPC
  • Part 2 Witnesses: Dr Yeomans, JPL; Dr Lu, B612; Dr A’Hearn, UMD

• US Senate Commerce, Science and Transportation Committee Hearing on Risk of Space Threats
  • Witnesses: Dr. Green, NASA/SMD; Dr. Lu B612; Mr. DalBello, Intelsat; Dr. Johnson-Freese USNWC

• Impact Emergency Tabletop Exercise with US FEMA 3 April
  – Planned before Chelyabinsk, but took on new emphasis

• US President’s FY2014 Budget Submittal 10 April, 2013
  – Proposed Asteroid Retrieval Mission Initiative
Asteroid Mission Would Consist of Three Main Segments

Identify

Asteroid Identification Segment:
Ground and space based NEA target detection, characterization and selection

Redirect

Asteroid Redirection Segment:
Solar electric propulsion (SEP) based asteroid capture and maneuver to trans-lunar space

Explore

Asteroid Crewed Exploration Segment:
Orion and SLS based crewed rendezvous and sampling mission to the relocated asteroid
Asteroid Mission Would Consist of Three Main Segments

**Identify**
Asteroid Identification Segment:
- Ground- and space-based NEA detection, characterization, and selection.

**Redirect**
Asteroid Redirection Segment:
- Solar electric propulsion (SEP) based asteroid capture and maneuver to trans-lunar space.

**Explore**
Asteroid Crewed Exploration Segment:
- Orion and SLS based crewed rendezvous and sampling mission to the relocated asteroid.

Additional Objective for NEO Observation Program:
Near term Options for Increased Capability
Space Surveillance Telescope

- DARPA funded project
- Designed and built by MIT/LL
  - Same division as LINEAR
- Located Atom Peak, WSMR, NM
- 3.6 meter primary mirror
- First Light was Feb 2011
- In testing phase
- Eventual operations by AFSPC
- First of 3 to 4 worldwide sites
- Serendipitous detection of NEOs in background mode to space surveillance
Pan-STARRS 1, and 2

- Increased time for NEO Search on PS-1
- Complete construction of PS-2 in 2014
- Up to 50% dedicated time for NEO Search
Asteroid Terrestrial-impact Last Alert System –ATLAS*: A project to patrol the entire night sky every night in search of incoming asteroids

A geographically dispersed network (4-6 sites) of small coupled telescopes observing “shallow but wide” to provide more complete sky coverage for days to weeks warning of near-term impact threats.

*Courtesy University of Hawaii Institute for Astronomy
Detecting NEOs from GEO

Objective:
Improve the rate of detection of smaller, long synodic period NEAs. Request for Information released in October 2012 showed that several short term, affordable options may exist.

SKGs Addressed: Human spaceflight target detection, orbit determination, size

IR Detector Phase A Studies:
• AO in work to request proposals for Phase A studies for a suite of 3 IR instruments to be hosted on commercial geosynchronous spacecraft
• Goal is to fund 3 Phase A studies with possible down-select for one proposal in 2014.

NEA Detector Concept (Source: Raytheon)
Summation

• Finding NEOs is a continued challenge, but is receiving additional attention and priority
• Finding and Characterizing targets for ARM initiative adds capability for finding PHAs
• NASA NEO Observation Program is a continued evolution of assets and capability
• Next proposal solicitation is ROSES 2013. Proposals due 7 June, 2013