# NASA's Near Earth Object Program and Activities

Presentation to

**International Academy of Astronautics**
**3rd Planetary Defense Conference 2013**

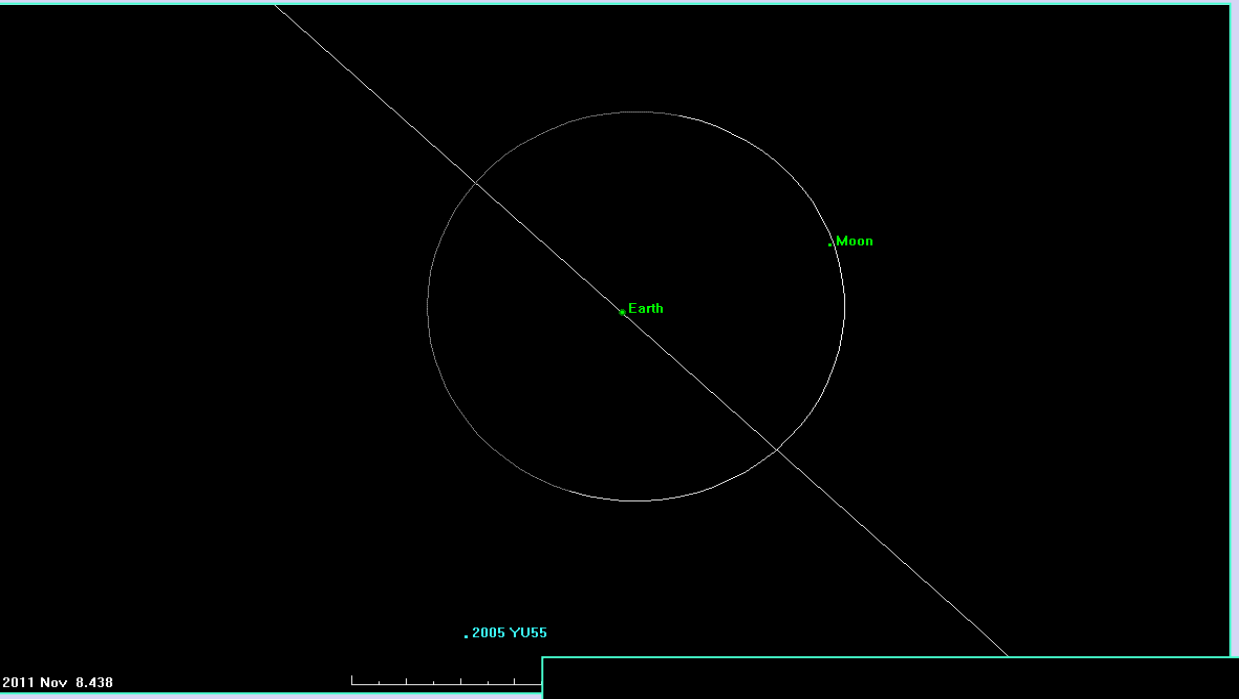
Lindley Johnson

Program Executive

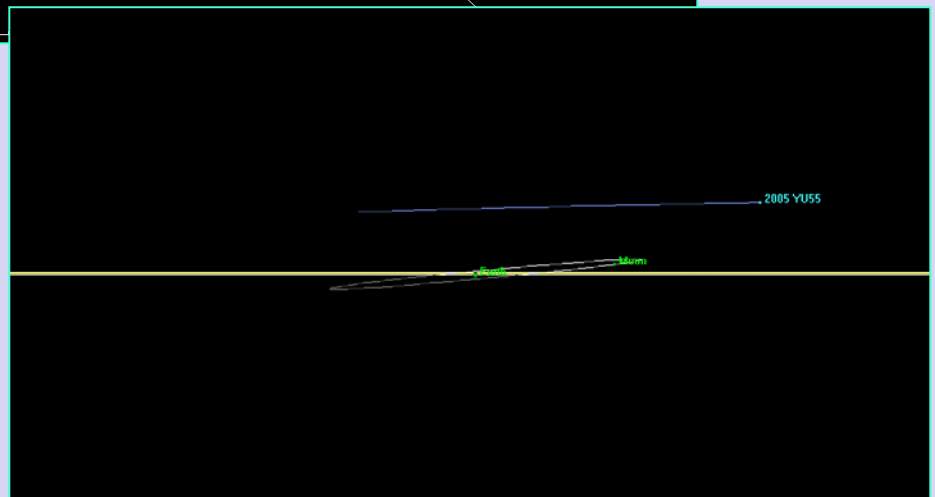
NASA HQ

April 2013

# 2005 YU55 to Approach Earth Nov. 8, 2011



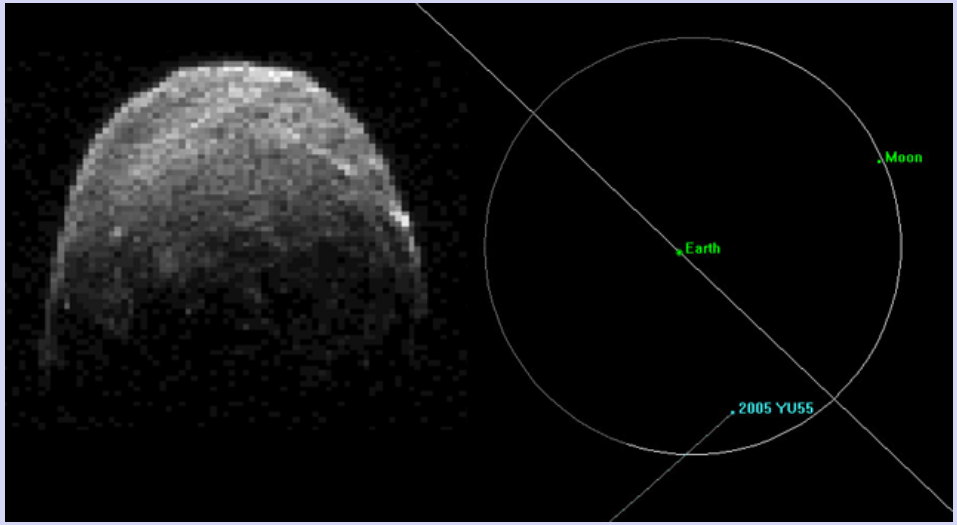

Earth & Moon close approach




Extensive radar, visual and infrared observations are being planned.

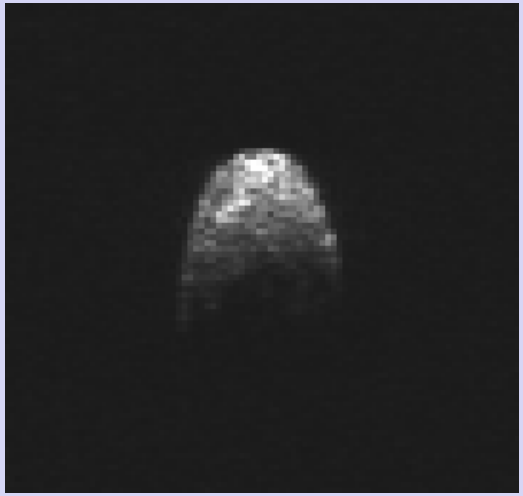
C-type asteroid
Diameter ~400 meters

# Pass of Asteroid 2005 YU55 Observed with Ground-based Radars



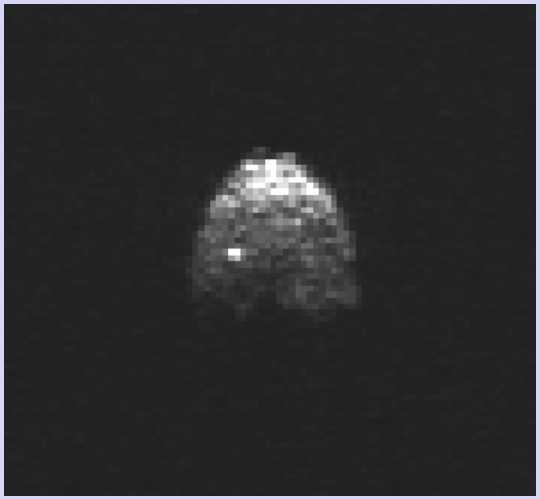

This image of asteroid 2005 YU55 with about 12 foot resolution was obtained by Lance Benner at NASA's Goldstone Radar on Nov. 7, 2011, about one day before closest approach, when the object was at 3.6 lunar distances, which is about 860,000 miles from Earth. NASA/JPL-Caltech

- 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



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.



# NEO Observation Program

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)

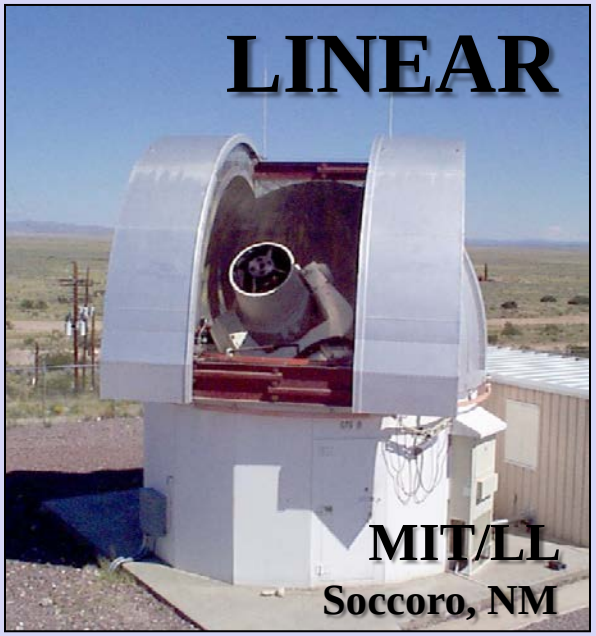
**Minor Planet Center (MPC)**
- IAU sanctioned
- Int'l observation database
- Initial orbit determination

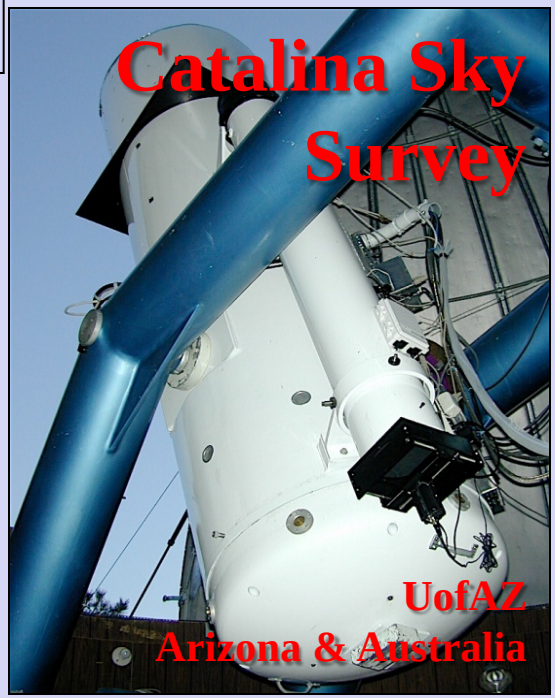
www.cfa.harvard.edu/iau/mpc.html

**NEO Program Office @ JPL**
- Program coordination
- Precision orbit determination
- Automated SENTRY

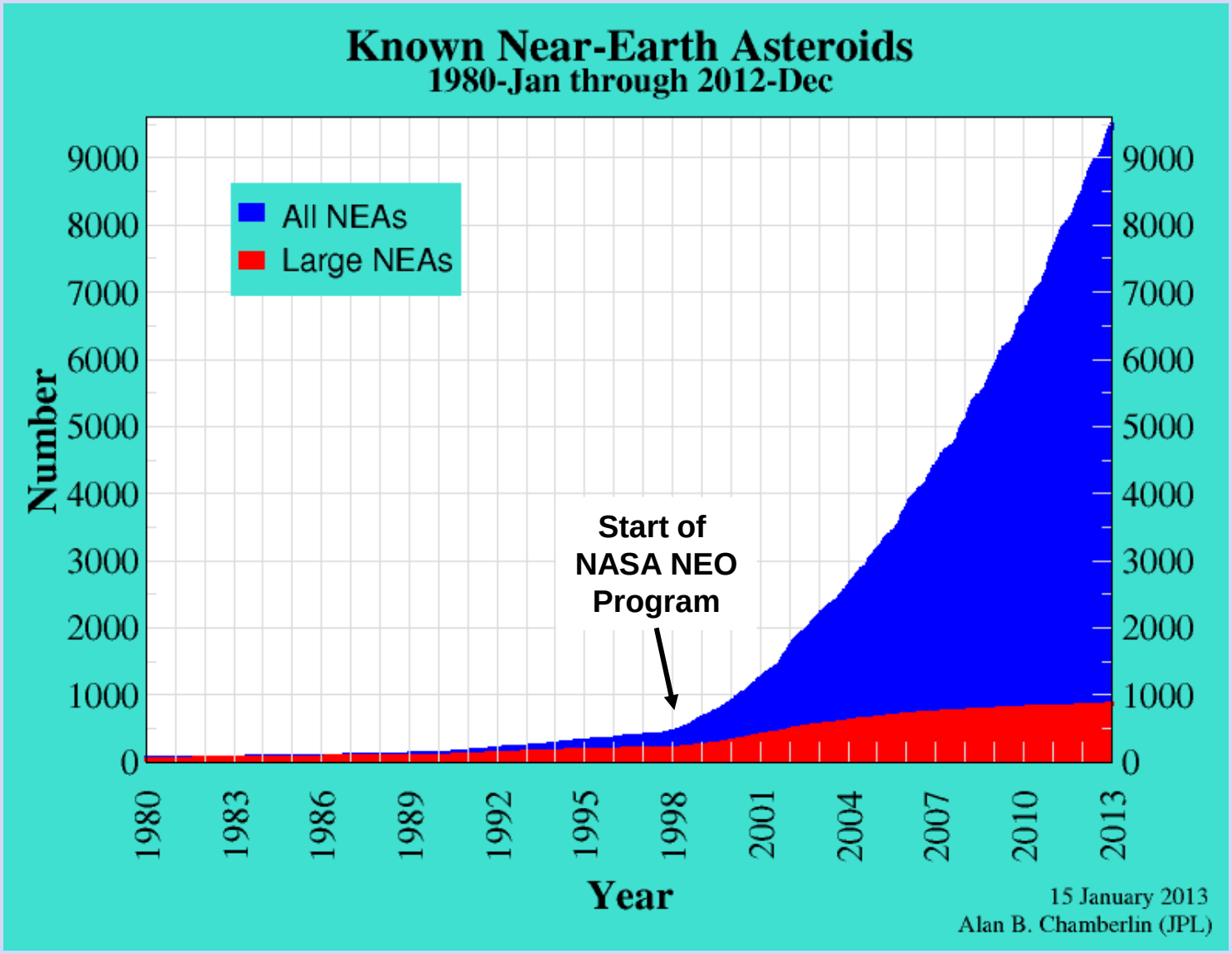
http://neo.jpl.nasa.gov/


**End of Operations Feb 2011, Analysis Of Data Continues**




# Known Near Earth Asteriod Population




**7936**
**5/1/11**

**827**
**5/1/11**

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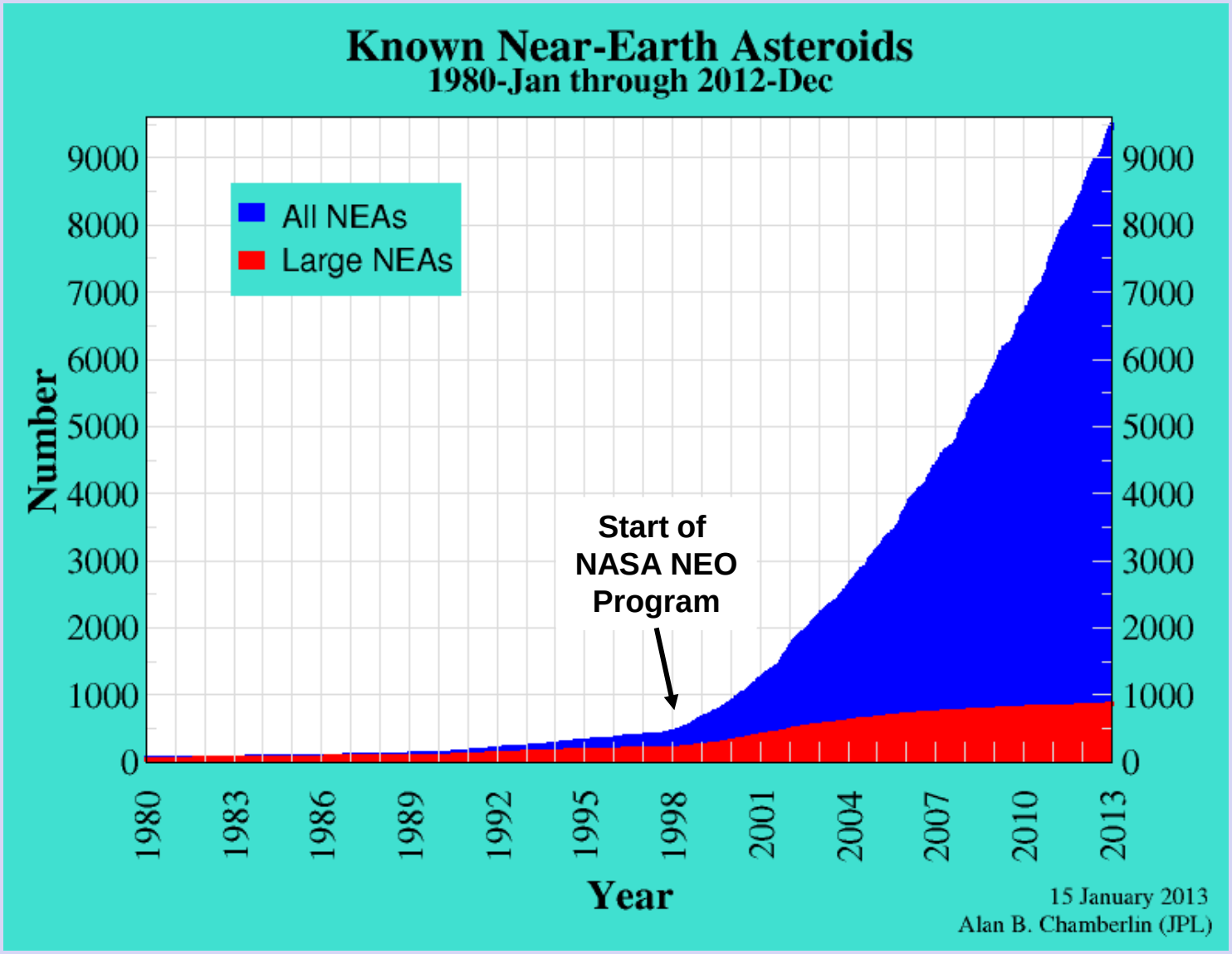


**9770**
**4/12/13**
**7936**
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**861**
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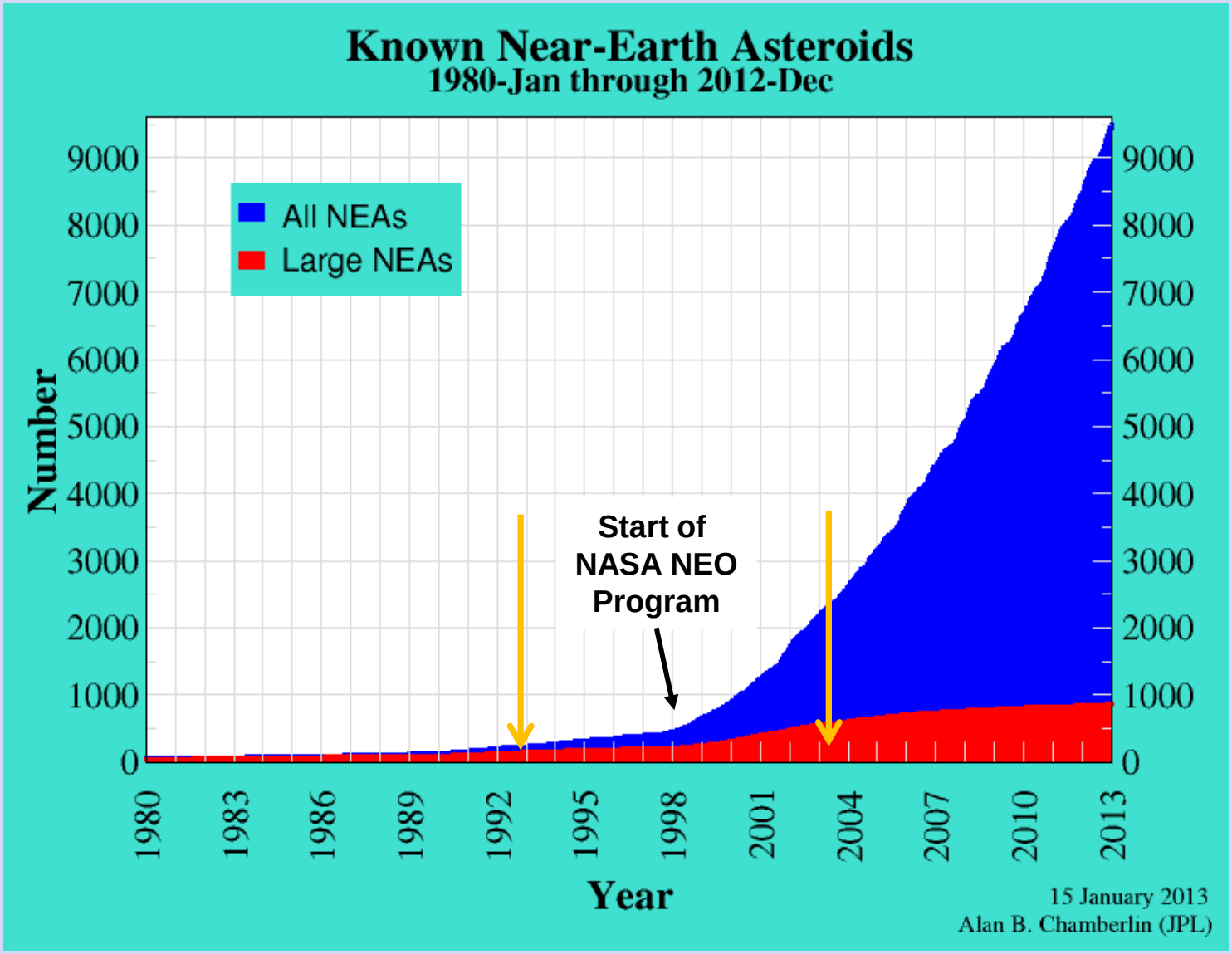


**9770**
**4/12/13**
**7936**
**5/1/11**

**861**
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**827**
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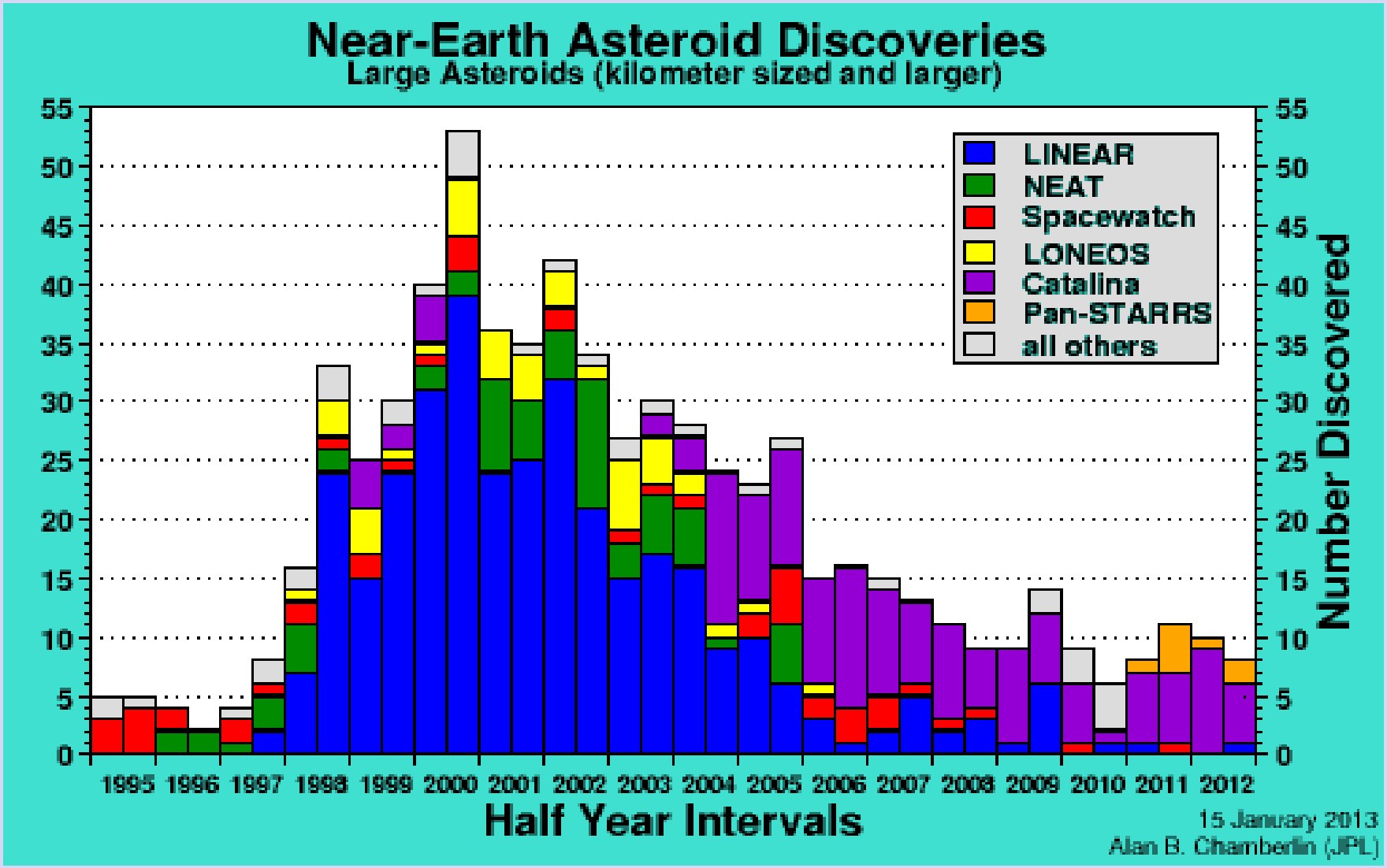
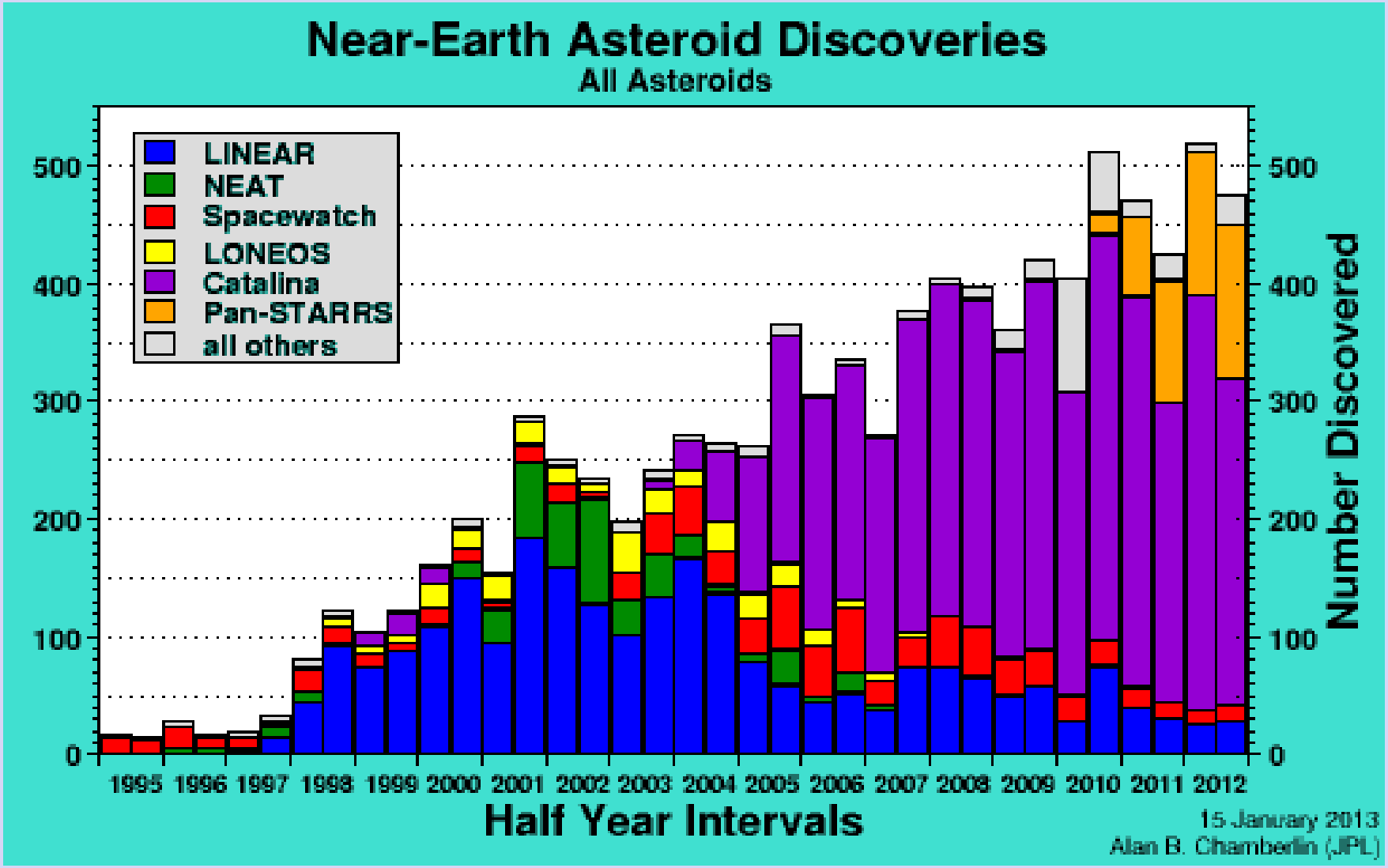
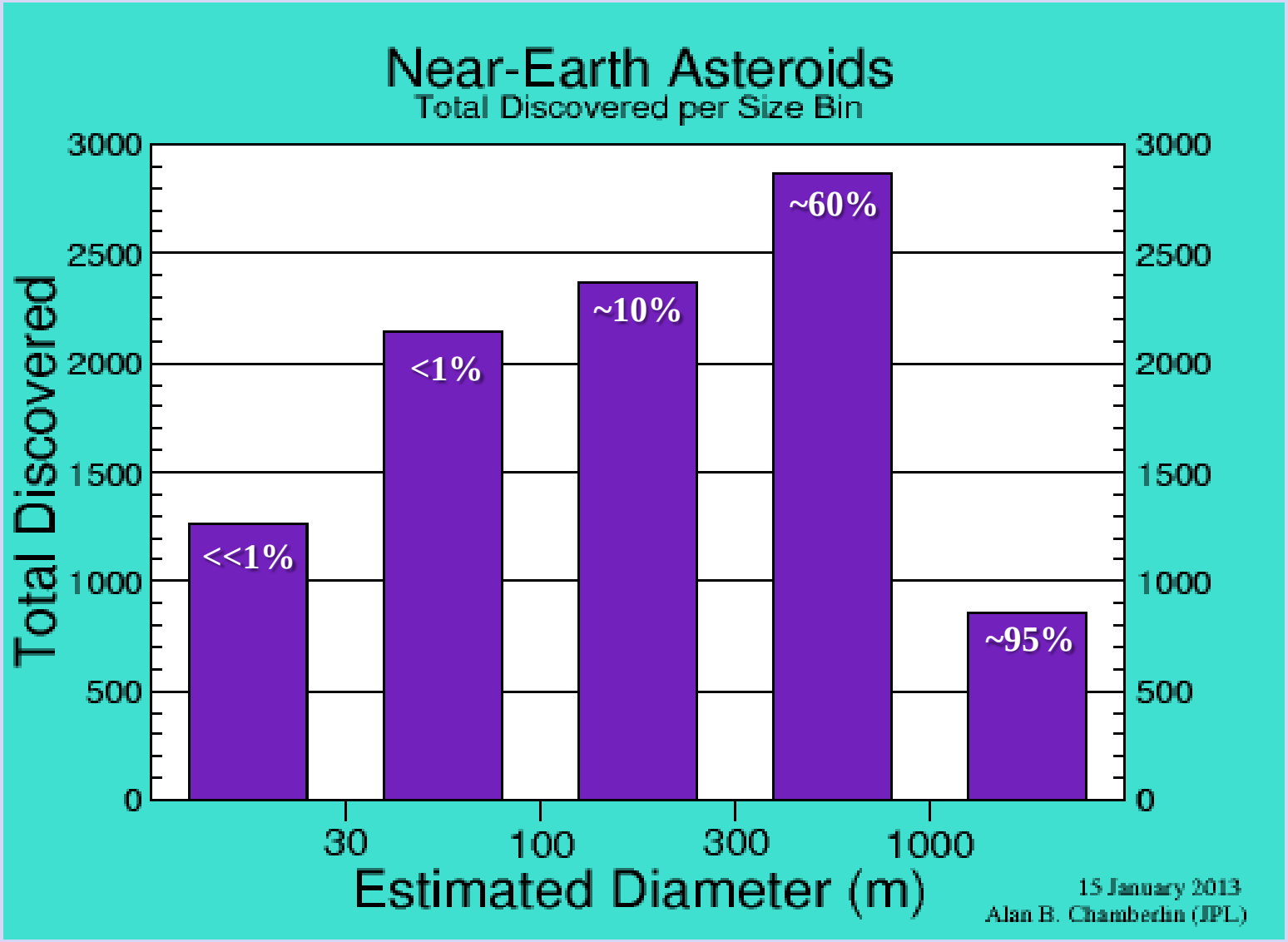
# Discovery Rate >1 km



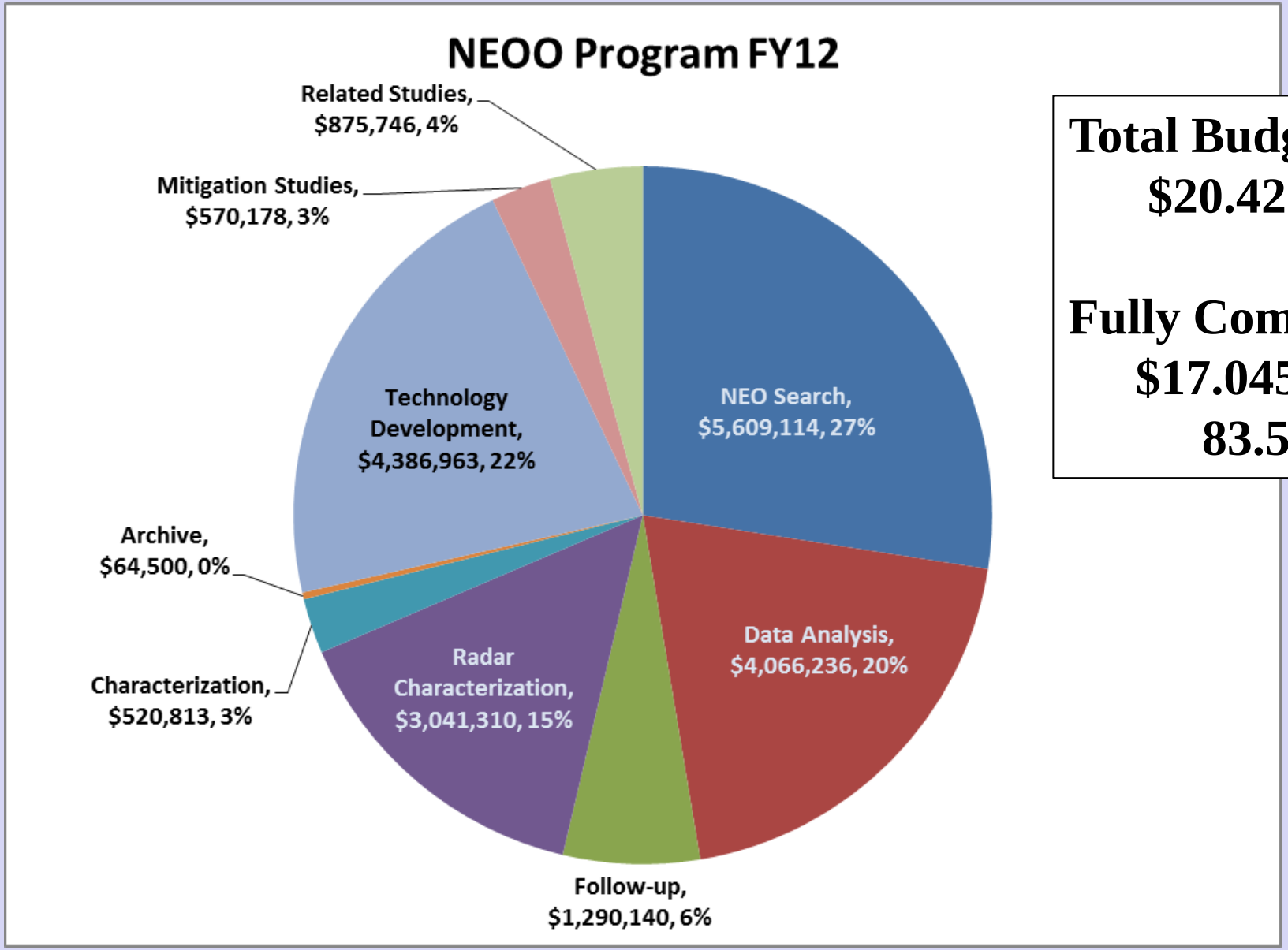
# Discovery Rate All NEAs



# Known Near Earth Asteroid Population



# 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

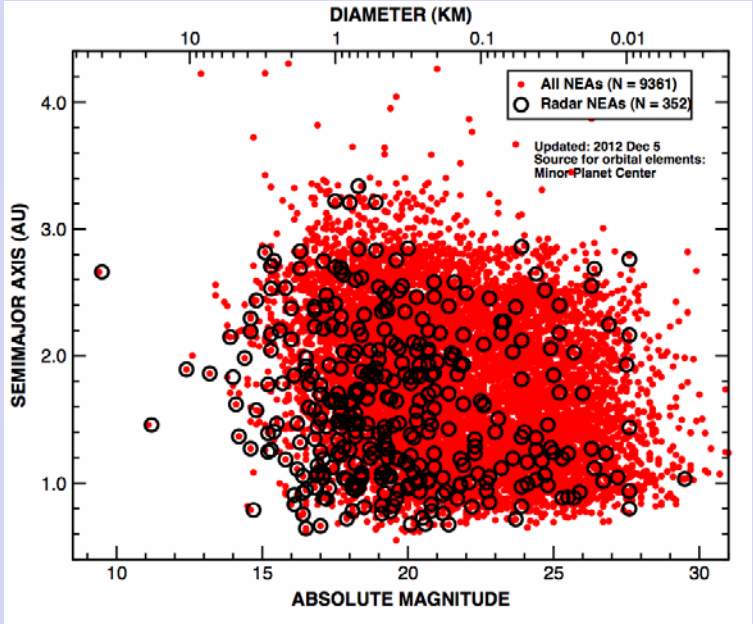
Observations on the limited number of accessible objects, but next best thing to a flyby

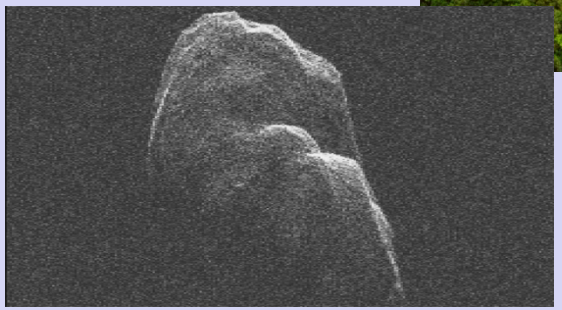
– Detections/year from Goldstone and Arecibo doubled

– Required for timely precision orbit determination

– Characterization with sufficient signal strength

- Shape, spin-state, surface structure
- Satellites (an then derived mass)

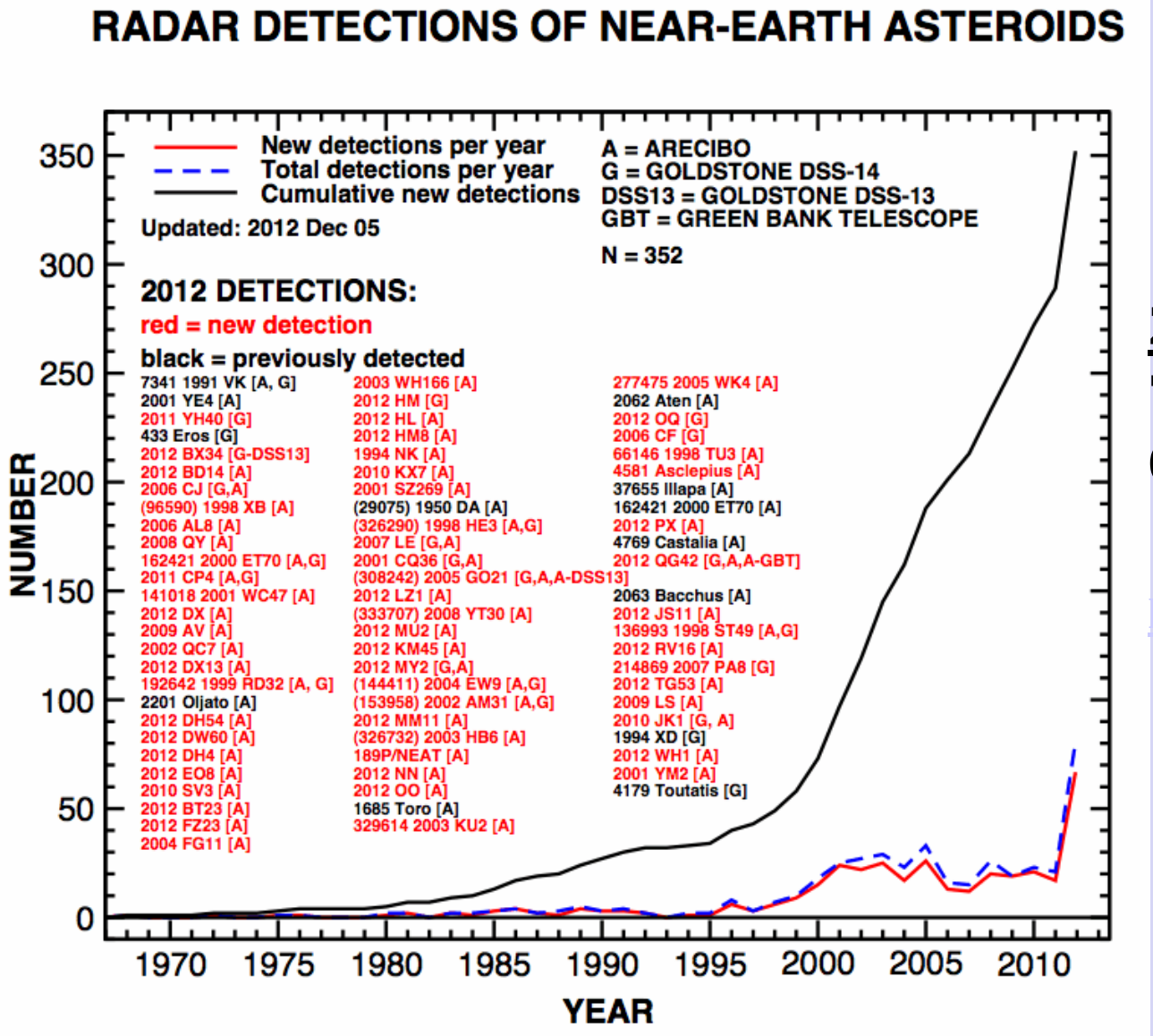


Shape, Size of 4179 Toutatis

Study of Shape, Size, Motion and Mass of 66391 (1999 KW4)

# Increase in Radar Program



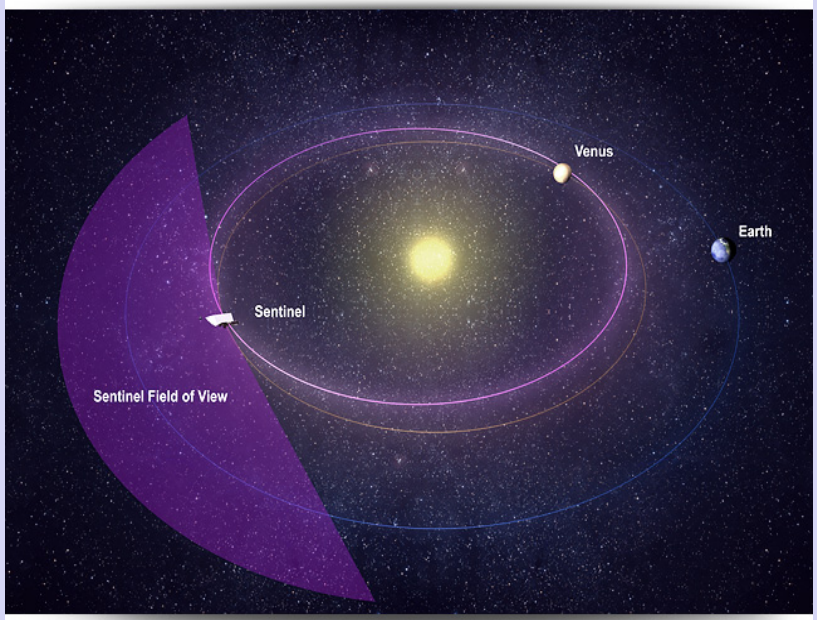

**<u>2012 Results</u>**

**76 Detections**

**64 New**

http://echo.jpl.nasa.gov/

# B612 "*Sentinel*" Project




**NASA has signed a Space Act Agreement (SAA) to support B612 Project Sentinel**

- 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 |

# Previews of Coming PDC Attractions

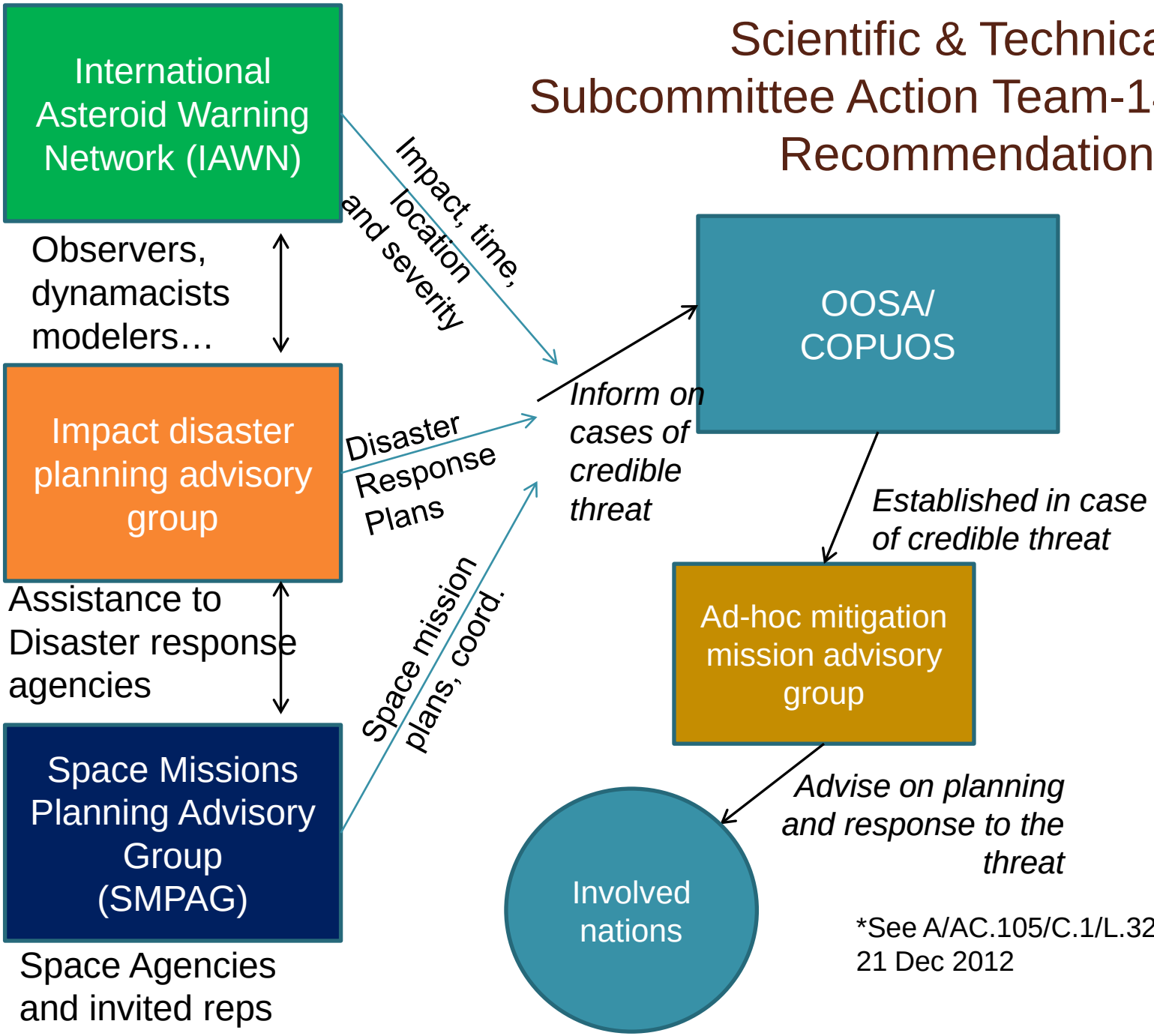
- Session 2 – NEO Survey
  - Tim Spahr – Minor Planet Center, SAO/CfA
  - Don Yeomans – NEO Program Office, JPL
  - Eileen Ryan – Magdalena Ridge Observatory
  - John Tonry – ATLAS, UofH/IfA
  - Amy Mainzer – NEOCam Technology, JPL
- Session 3 – NEO Characterization
  - Keith Holsapple – University of 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

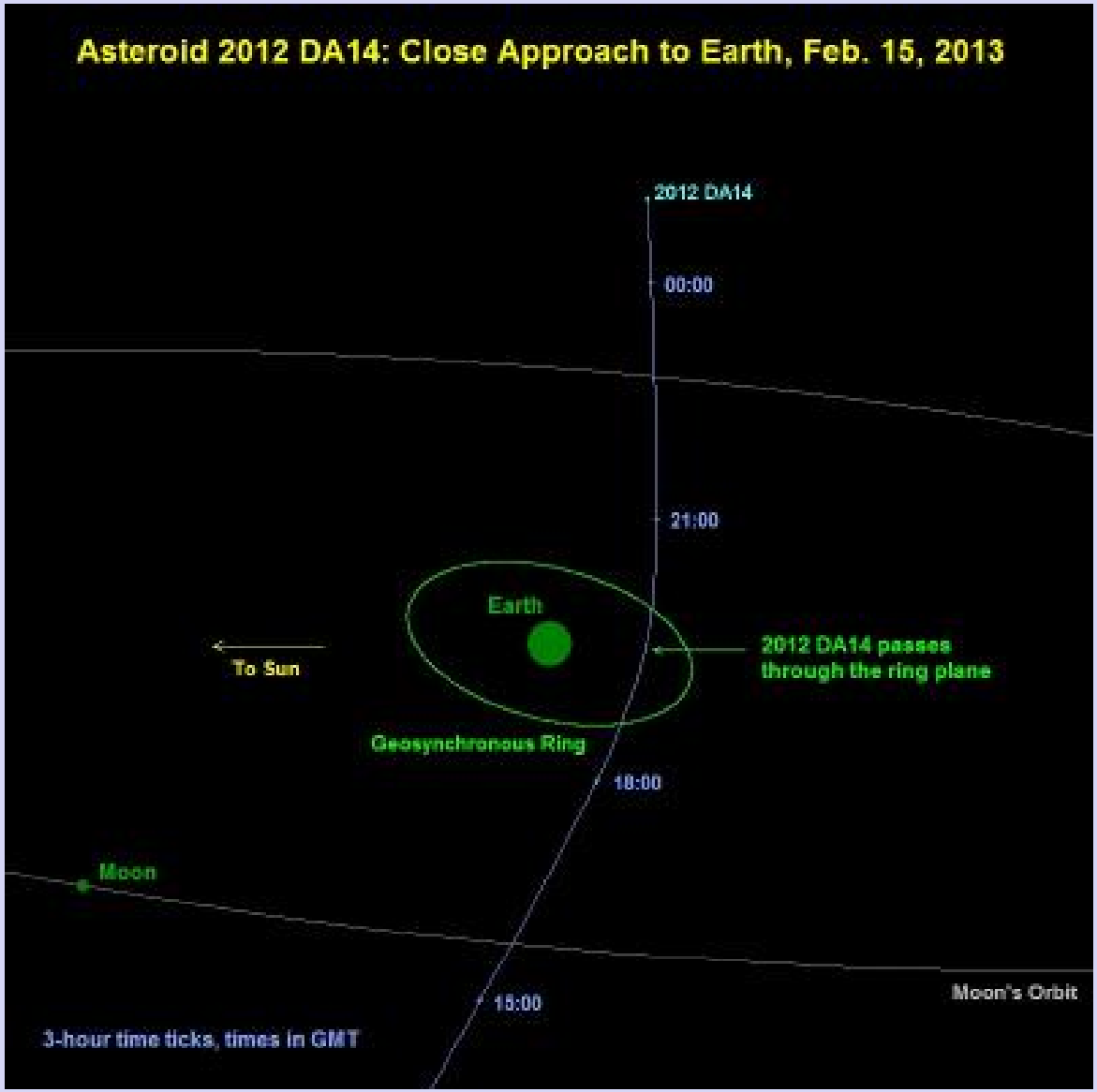
# UN COPUOS Scientific & Technical Subcommittee Action Team-14 Recommendations




*See A/AC.105/C.1/L.329 21 Dec 2012

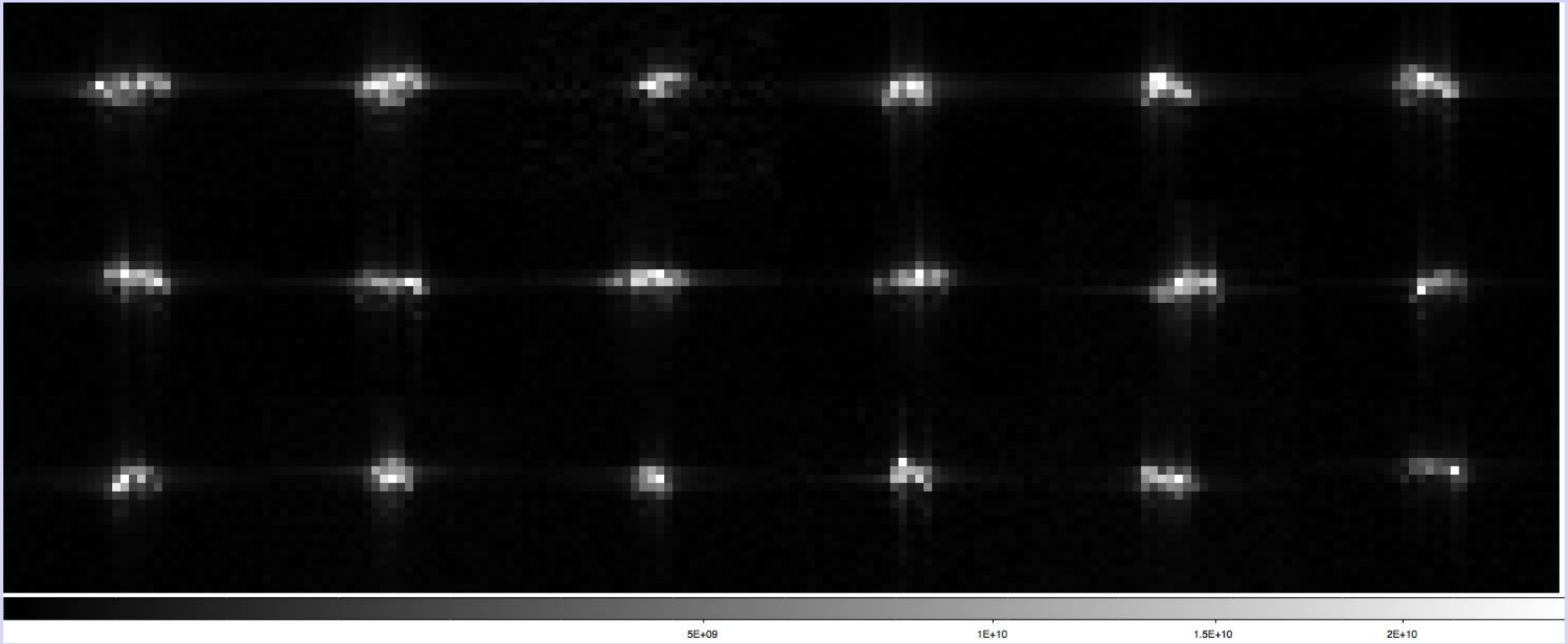
# 2012 DA14 to Approach Earth Feb 15, 2013

**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**



# GSSR RADAR Imaging Results

**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.**




**A collage of the 2012 DA14 rotation obtained with a bistatic setup at Goldstone with DSS-14 transmitting and DSS-13 receiving: Feb 16, 00:46 – 08:31 UTC. The round-trip-time (RTT) to 2012 DSS14 changed from ~0.85 s to ~2 s during observations. Each frame is 320 sec of data integration. One full rotation is about 7 hours.**

# 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

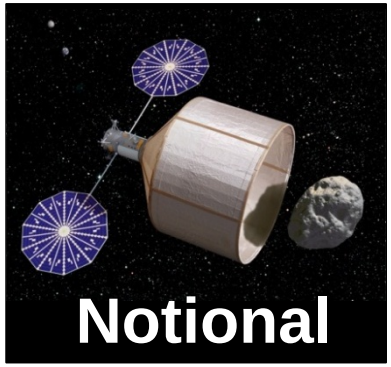
# Asteroid Mission Would Consist of Three Main Segments

## 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
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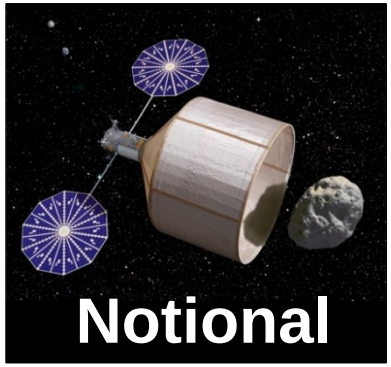
selection

Additional Objective for NEO Observation Program

## Redirect

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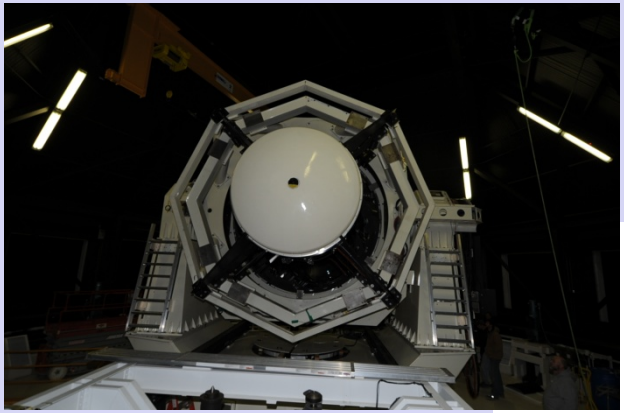
# Near term Options for Increased Capability

# *Space SurveillanceTelescope*

- **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**

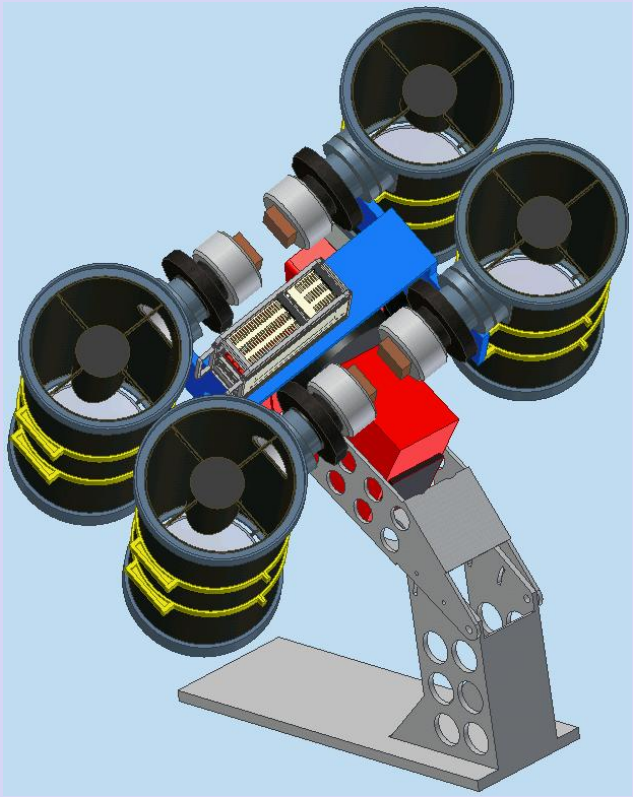


# Pan-STARRS 1, and 2


- Increased time for NEO Search on PS-1
- Complete construction of PS-2 in 2014
- Up to 50% dedicated time for NEO Search

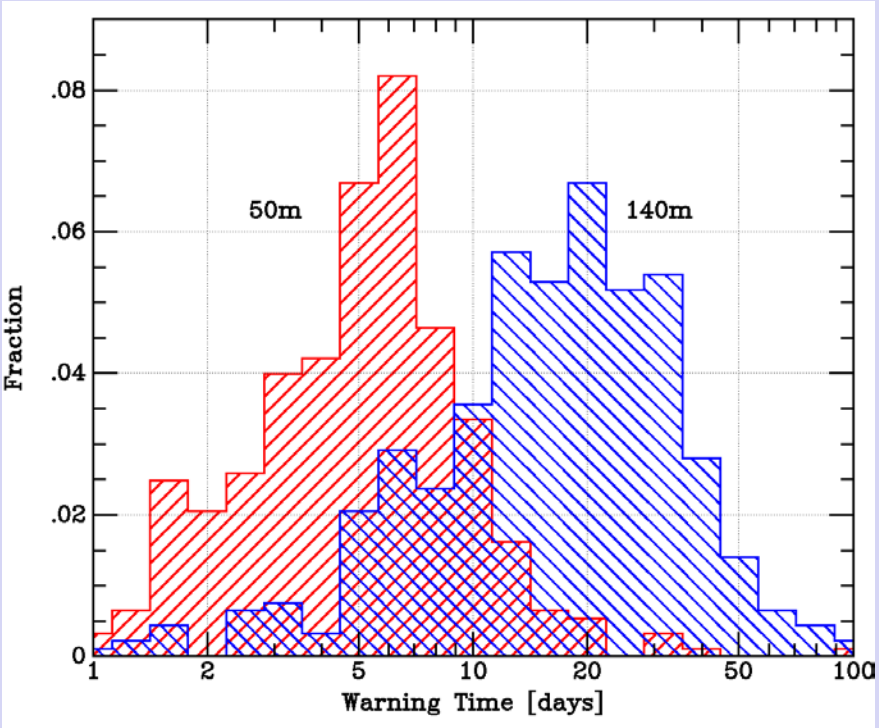
# Near Term Impact Warning

**Asteroid Terrestrial-impact Last Alert System –ATLAS*:**
**A project to patrol the entire night sky every night in search of incoming asteroids**



**Proposed ATLAS telescope design**

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

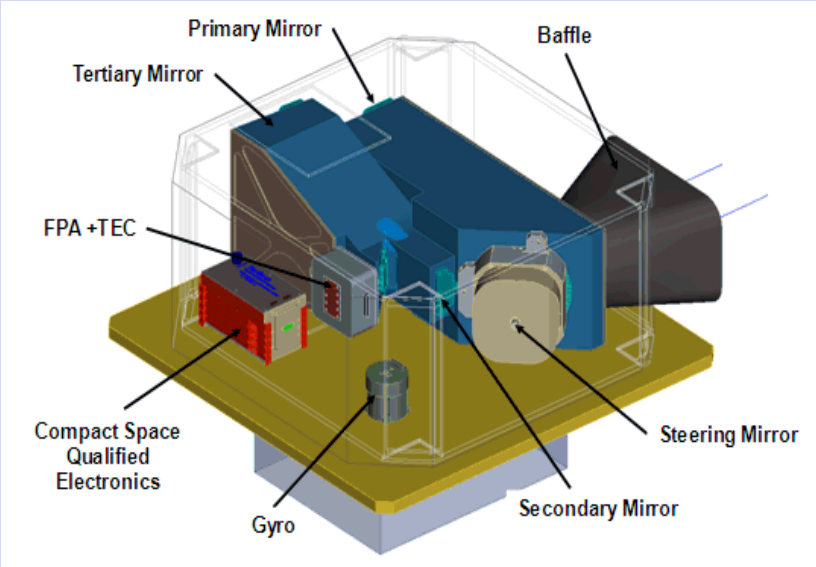



*Courtesy University of Hawaii Institute for Astronomy

# 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




NEA Detector Concept
(Source: Raytheon)

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.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# 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