Near Earth Object Observations Program

Presentation to

Astronomy & Astrophysics

Advisory Committee

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NASA HQ

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Terminology

- "Near Earth Objects (NEOs)"- any small body (comet or asteroid) passing within 1.3 Astronomical Unit (AU) of the Sun
  - 1 AU is the distance from Earth to Sun = ~ 150 million kilometers (km)
  - NEOs are predicted to pass within ~ 45 million km of Earth's orbit
  - Population of:
    - Near Earth Asteroids (NEAs)
    - Near Earth Comets (NECs) – also called Earth Approaching Comets (EACs)
      - 84 currently known
- "Potentially Hazardous Objects (PHOs)" – small body that has potential risk of impacting the Earth at some point in the future
  - NEOs passing within 0.05 AU of Earth's orbit
    - ~ 8 million km = 20 times the distance to the Moon
  - Appears to be about 20% of all NEOs discovered

NEO Observation Program

US component to International Spaceguard Survey effort

Has provided 98% of new detections of NEOs

Began with NASA commitment to House Committee on Science in May, 1998

Scientific Objective: Discover 90% of NEOs larger than 1 kilometer in size within 10 years (1998 – 2008)

NASA Authorization Act of 2005 provided additional direction (but no additional funding)

"...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

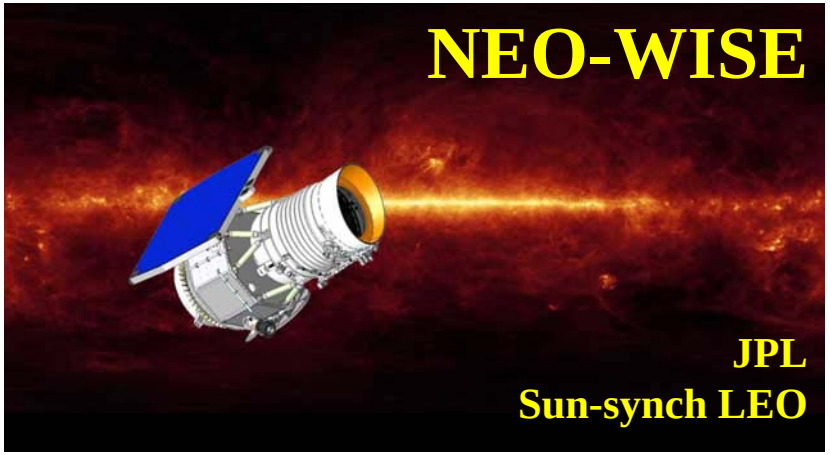
(Current Systems)

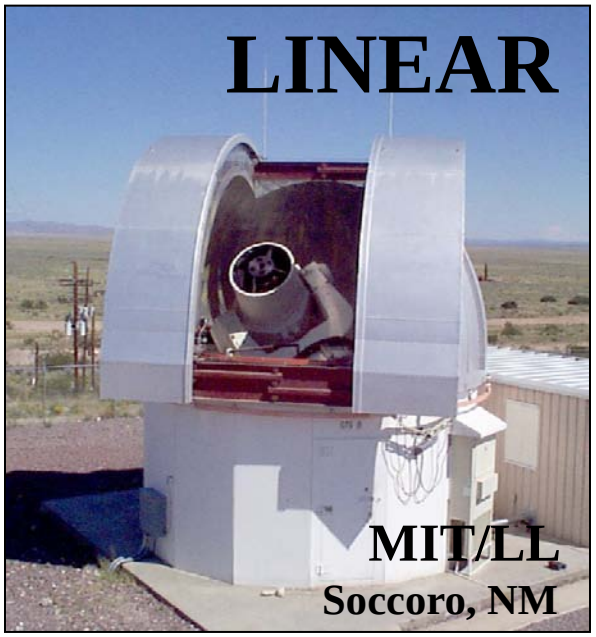
NEO Program Office @ JPL
- Program coordination
- Automated SENTRY

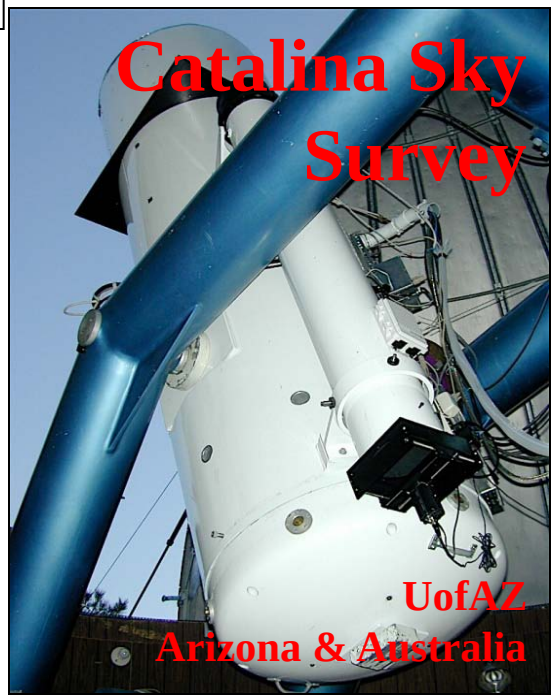
neo.jpl.nasa.gov

Minor Planet Center (MPC)
- IAU sanctioned
- Discovery Clearinghouse
- Initial Orbit Determination

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







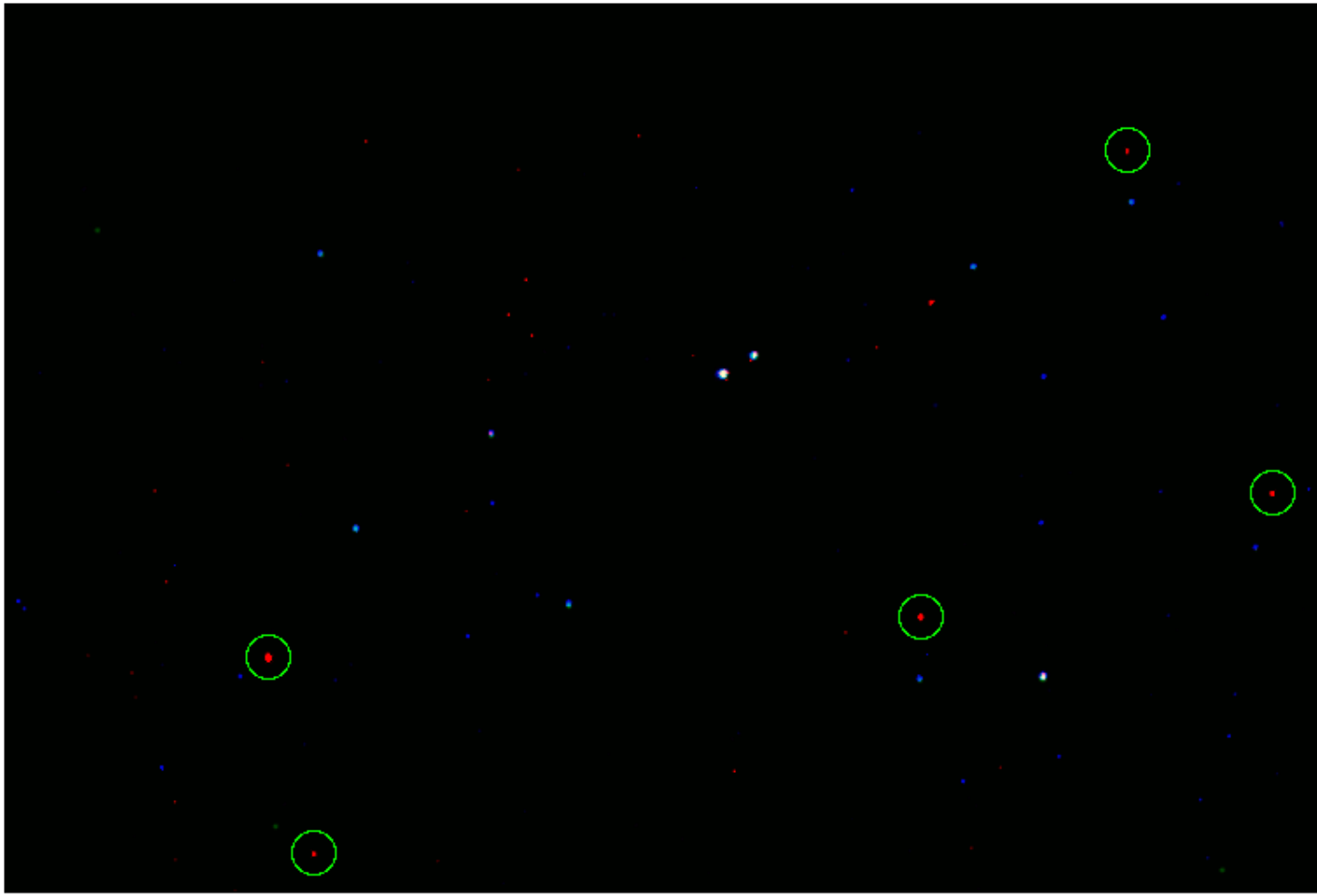
MB Asteroids Observed by WISE

Four frames data taken on 2010 Jan. 8 during on-orbit checkout

Blue = 3.6um
Green = 4.6um
Red = 12um

Circled asteroids are (l to r in the first frame, diameters in km):

17818 MBA D~12.4
153204 MBA D~2.8
22006 MBA D~11.5
87355 MBA D~4.3
80590 MBA D~4.1



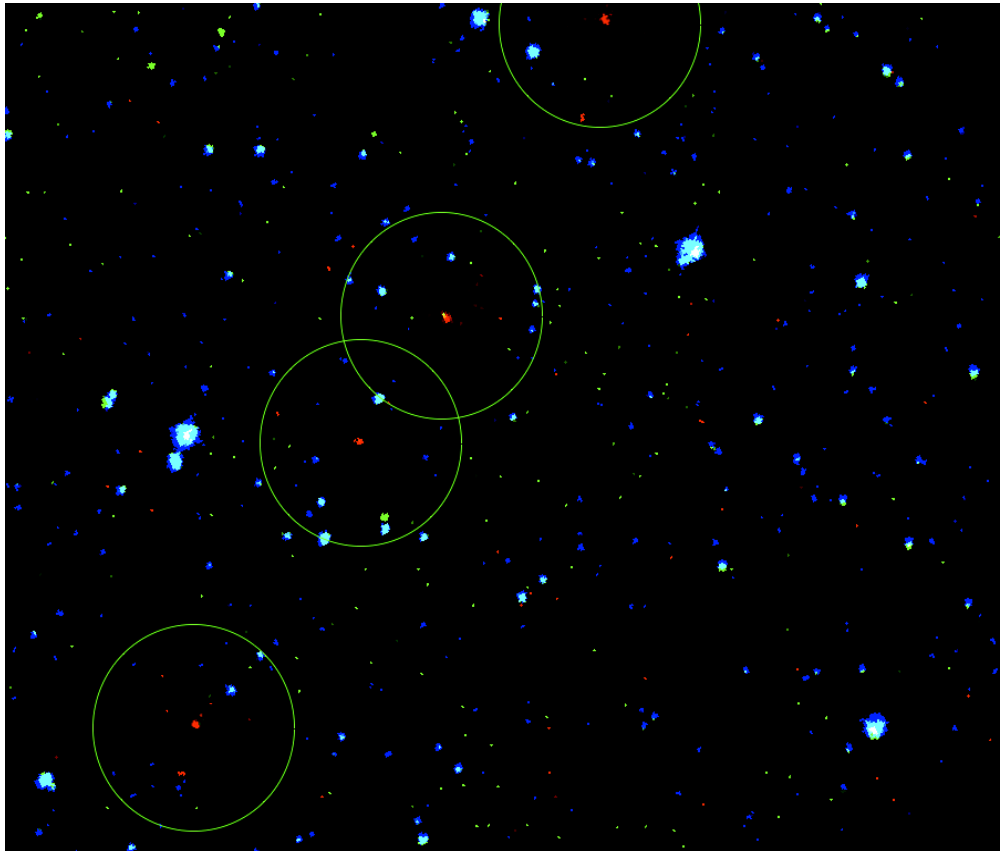
Field of view = 34 x 25 arcmin (whole WISE FOV is 47 x 47 arcmin)

WISE Finds First NEO

First NEO discovered by WISE: 2010 AB78

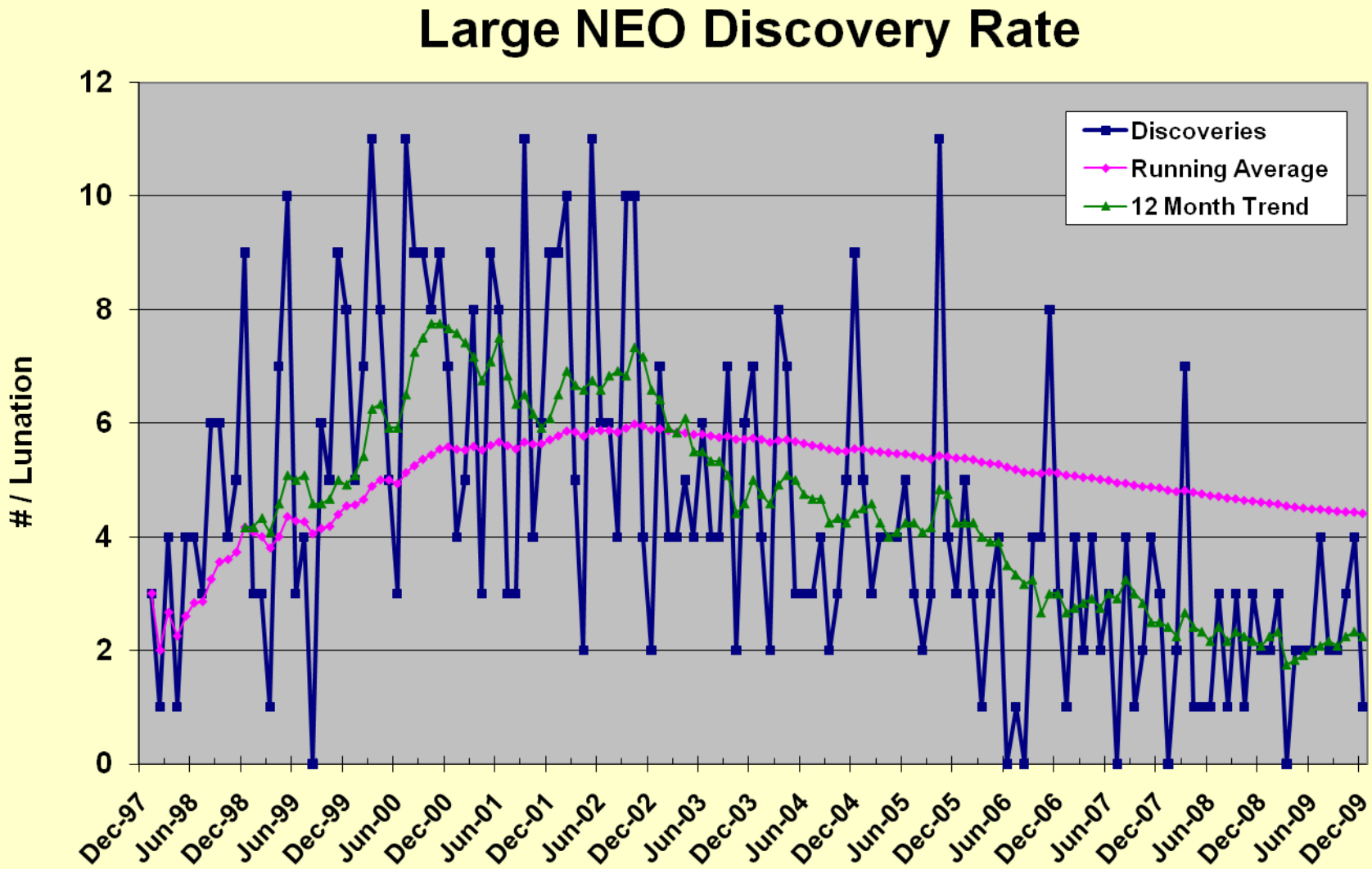
- Diameter ~ 600 m
- Amor (Mars crosser)
- Not a PHO
- Observed by WISE

  1/12/10, before sky survey start

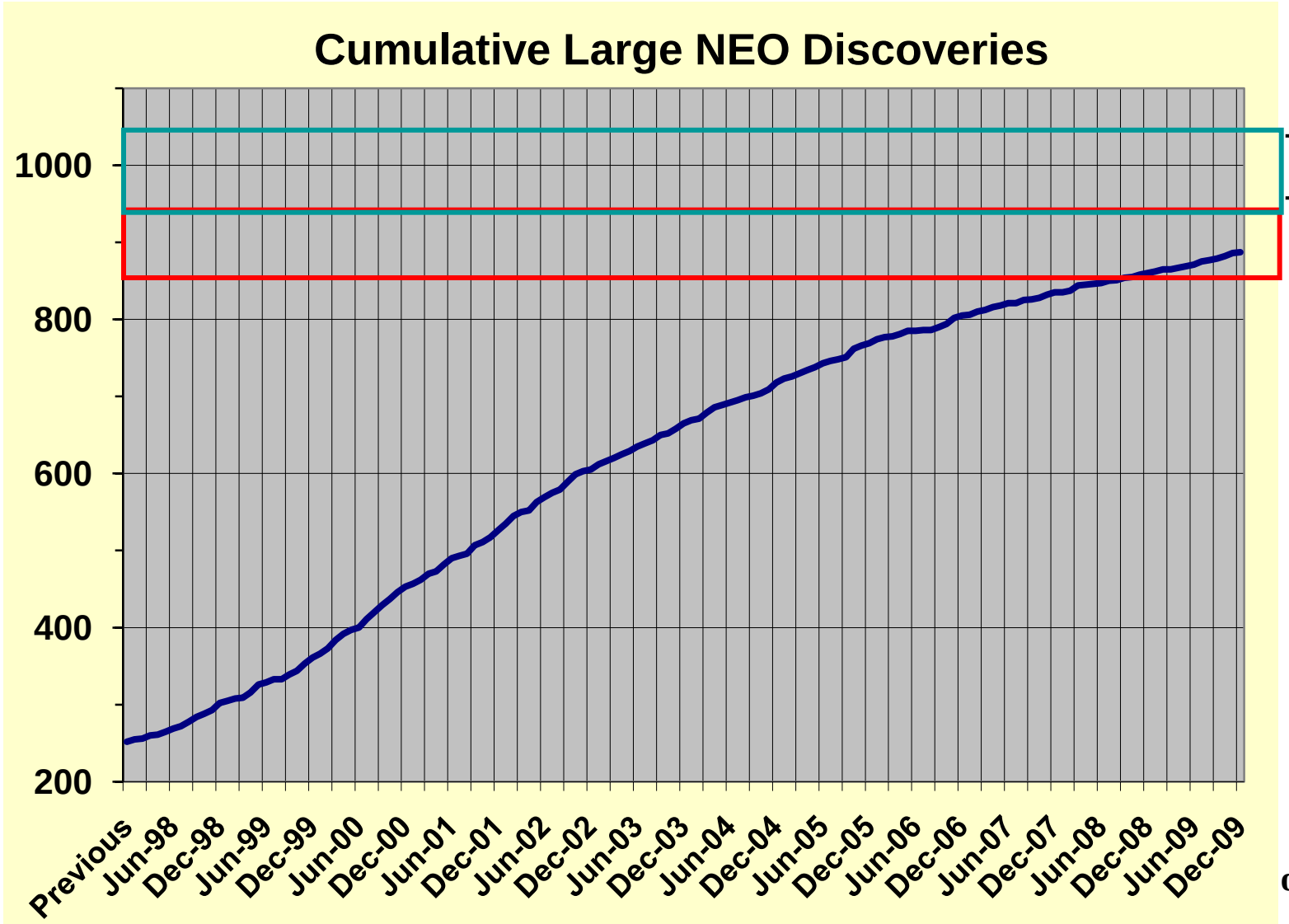


Discovery Metrics

Discovery Rate of >1km NEOs



Discovery Metrics



Estimated Population 940 to 1050

Goal 850 - 940

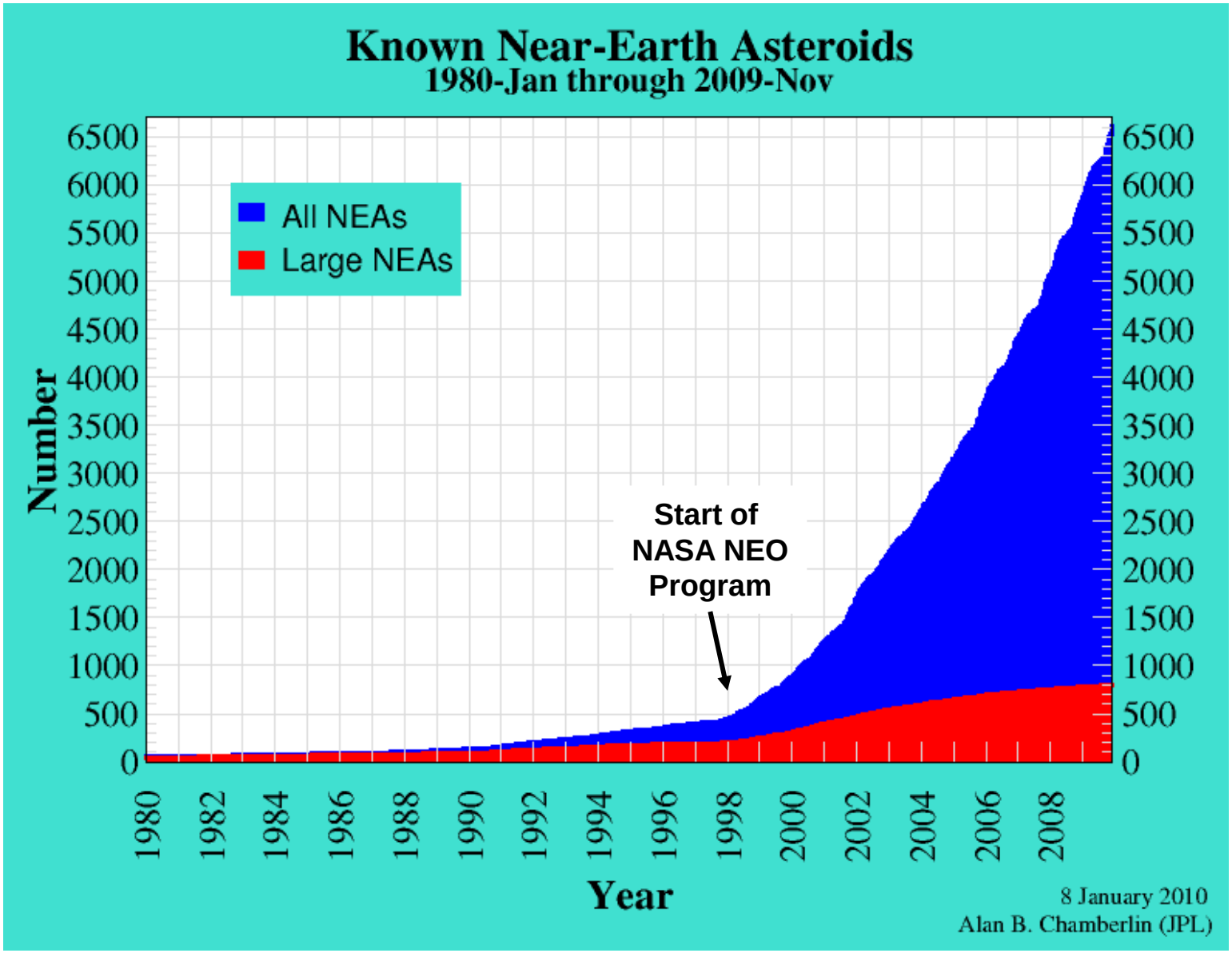
Achieved minimum goal

887*
(84-94%)
as of
1/01/10

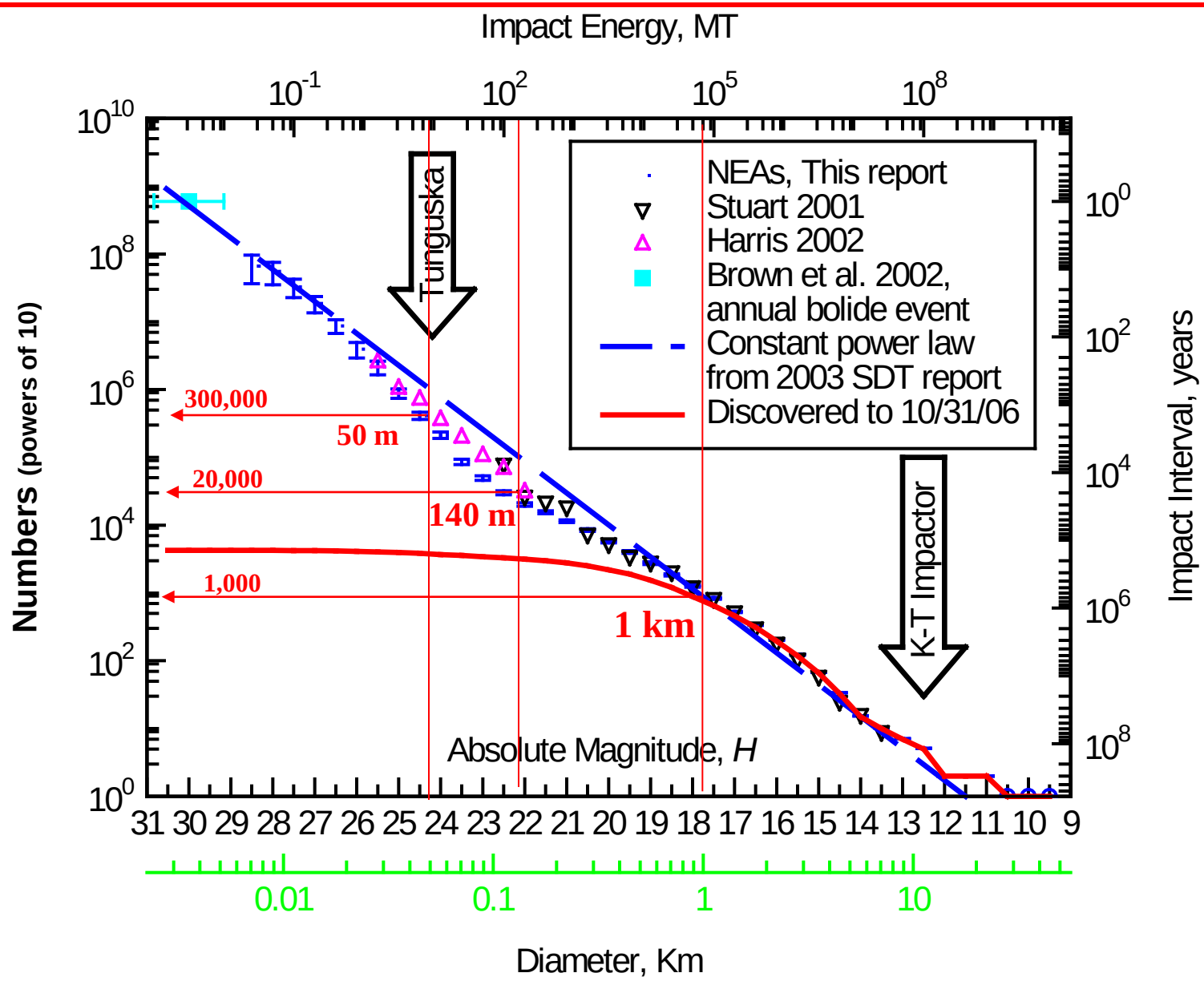
*Includes
84 NECs

5844 smaller objects also found

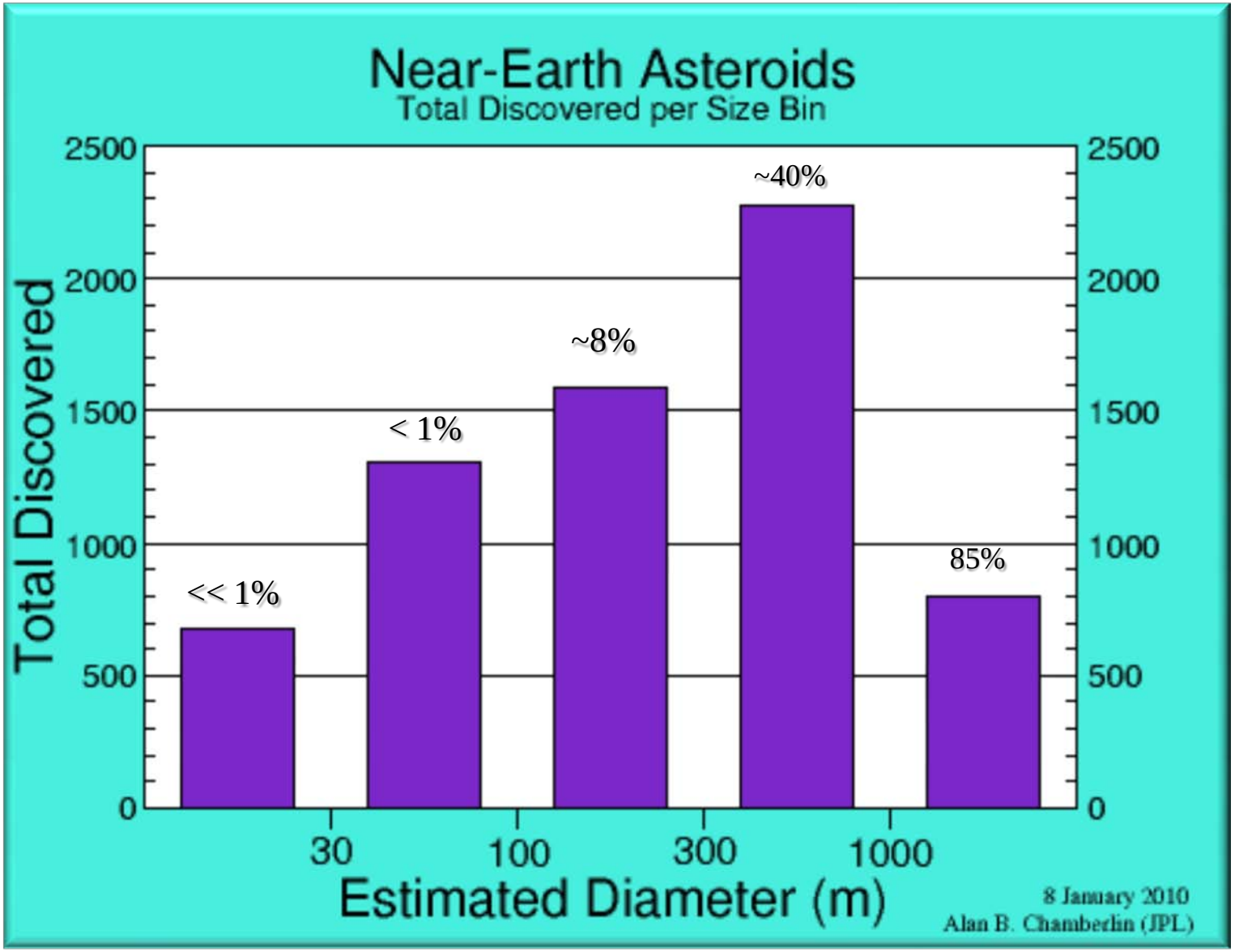
Known Near Earth Asteriod Population



Population of NEAs by Size, Brightness, Impact Energy & Frequency (Harris 2006)



Known Near Earth Asteroid Population



NRC NEO Report
Findings & Recommendations (1 of 2)

SURVEY and DETECTION:

Finding: The current Near-Earth Object surveys cannot meet the goal to discover 90 percent of all NEOs140 meters in diameter or greater by 2020.

Finding: The optimal approach to achieving this NEO Survey goal will depend on nonscientific factors. If time to complete should be minimized, a space-based capability augmented by large aperture ground observatories is most effective. If cost should be minimized, large aperture ground observatories acquired for other purposes could complete survey in under 20 years

Recommendation: Recent studies suggest that objects as small as 30 to 50 meters in size could be highly destructive. Surveys should attempt to detect as many 30- to 50-meter objects as possible.

CHARACTERIZATION:

Finding: The Arecibo and Goldstone planetary radars play a unique role in the characterization of NEOs, providing unmatched accuracy in orbit determination, and insight into size, shape, surface structure

Recommendation: Immediate action is required to ensure the continued operation of the Arecibo Observatory at a level sufficient to maintain and staff the radar facility.

Radar Studies

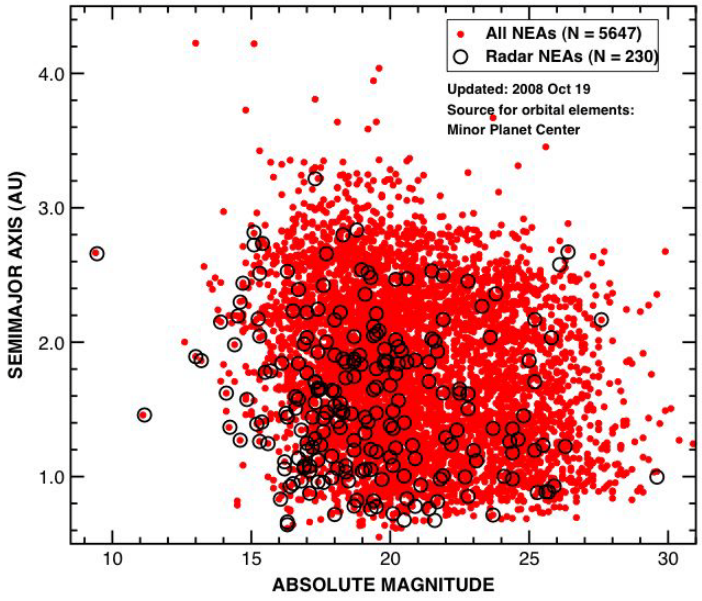
Observations on the limited accessible objects

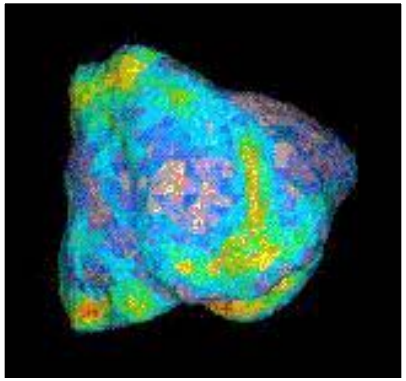
– 20 to 30 NEOs/year from Goldstone and Arecibo

– Required for timely precision orbit determination

– Characterization with sufficient signal strength

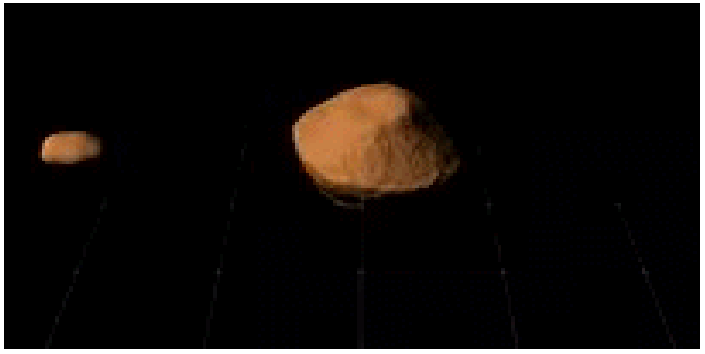
- Shape, spin-state, surface structure
- Satellites (an then derived mass)





Shape, Size of 6489 Golevka

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



NRC NEO Report
Findings & Recommendations (2 of 2)

MITIGATION:

Finding: No single approach to mitigation is adequate to fully prevent the effects of the full range of potential impactors, although civil defense is an appropriate component of mitigation in all cases. With adequate warning, a suite of four types of mitigation [Civil Defense, “Slow Push”, Kinetic Impact, Nuclear Detonation] is adequate to mitigate the threat from nearly all NEOs except the most rare energetic ones

Recommendation: The United States should initiate a peer-reviewed, targeted research program in the area of impact hazard and mitigation of NEOs. The scope should include analysis, simulation, and laboratory experiments.

Recommendation: First priority for a space mission in the mitigation area is a test of a kinetic impactor along with a characterization, monitoring and verification system, such as the Don Quijote mission that was considered by ESA. This mission would produce the most significant advances in understanding and provide an ideal chance for international collaboration in a realistic mitigation scenario.

NATIONAL & INTERNATIONAL COOPERATION:

Recommendation: The United States should establish a standing committee with membership from each of the relevant agencies to develop a detailed plan for treating all aspects of the threat posed to Earth by NEOs, in coordination and collaboration with other nations. The Administration should designate one agency as the lead; the chair of the committee should be the representative from this agency.

Future Years Outlook

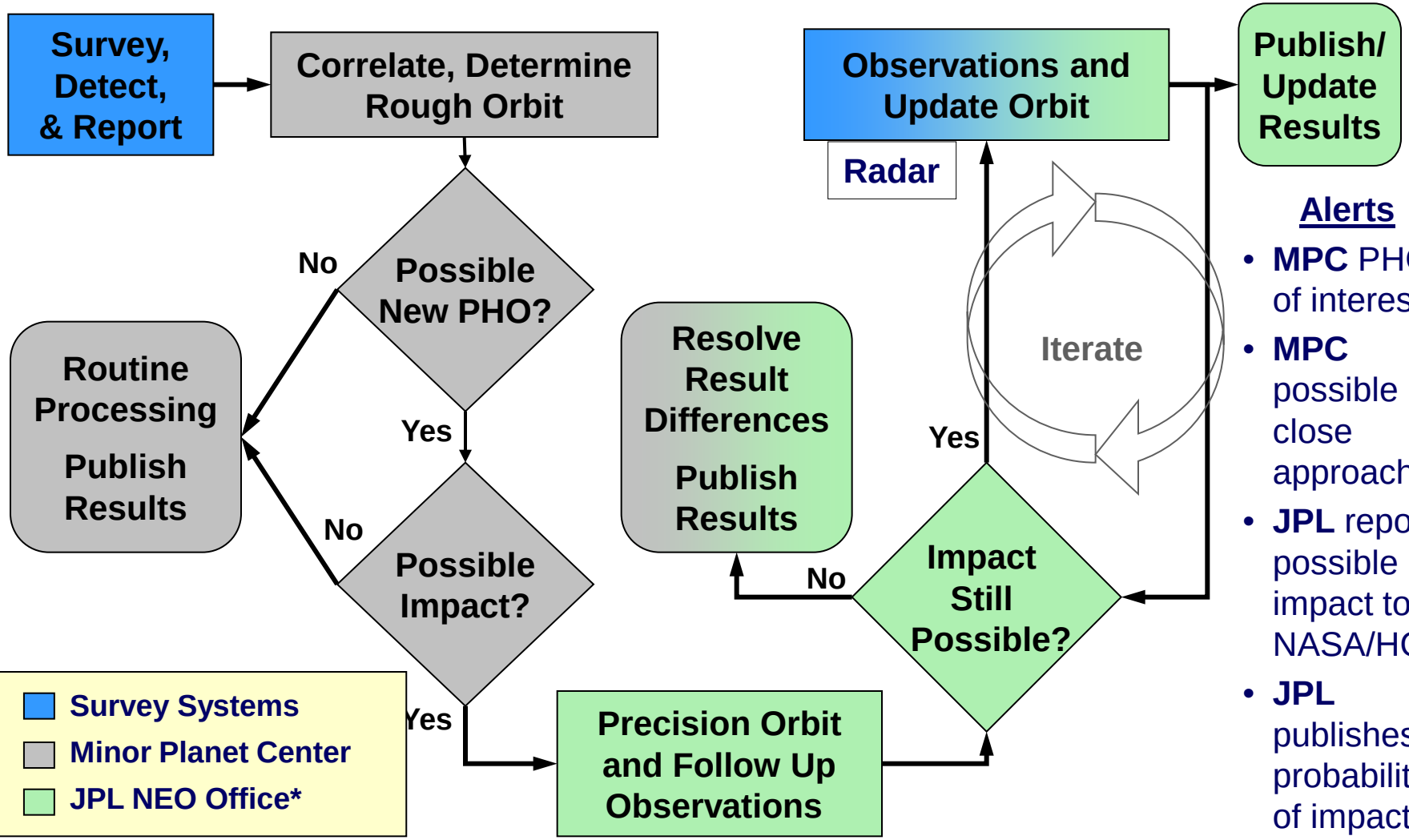
- Funding has been appropriated to support research with Arecibo planetary radar through 2011

- As funding becomes available for the purpose, the United States will continue to upgrade and acquire improved NEO detection/characterization capability and begin more focused research on mitigation methods and strategies.

BACKUPS

Spaceguard Survey Catalog Program

Current Spaceguard Survey Infrastructure and Process



Alerts

- **MPC** PHO of interest
- **MPC** possible close approach
- **JPL** reports possible impact to NASA/HQ
- **JPL** publishes probability of impact

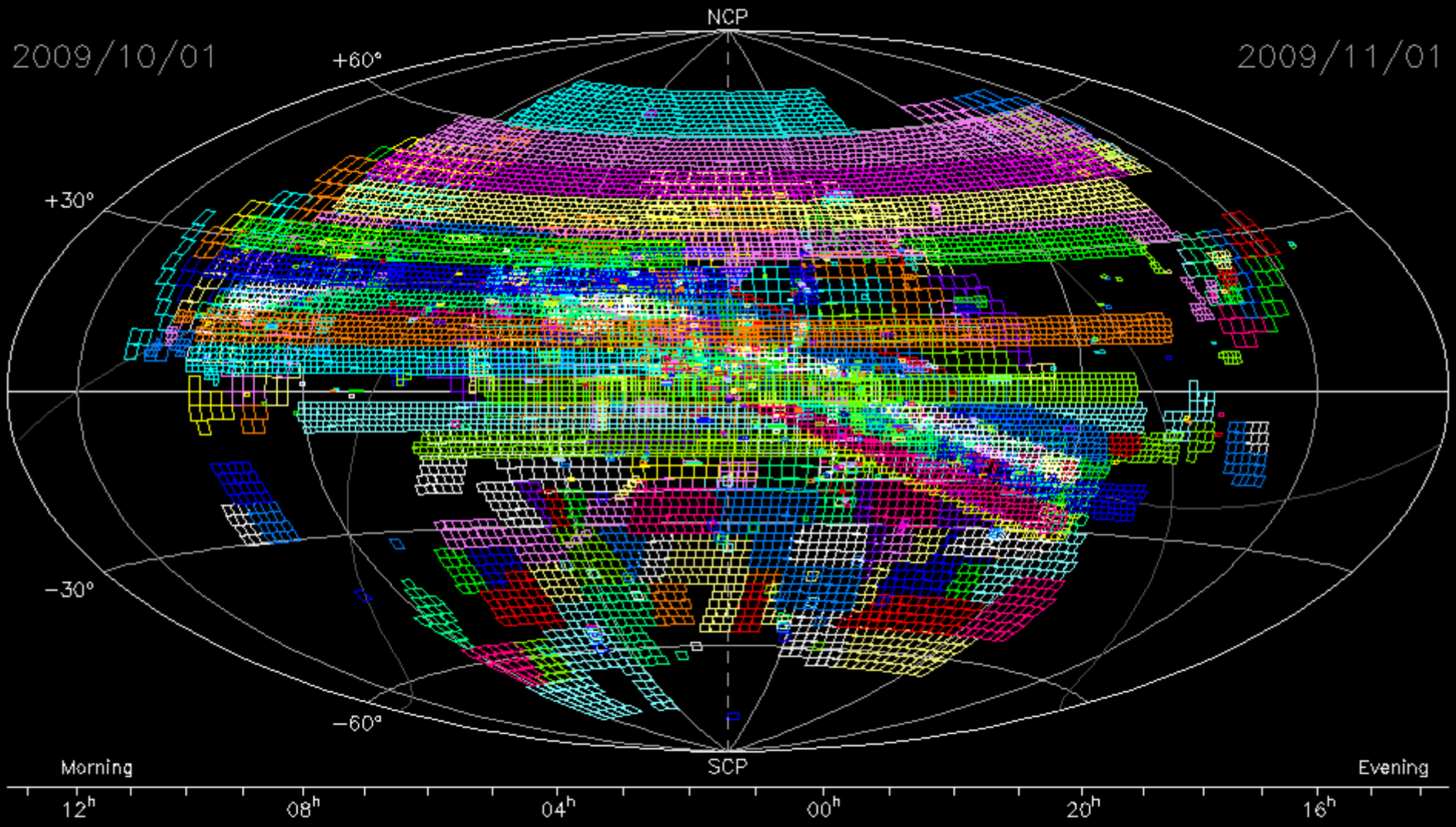
* In parallel with NEODyS

Minor Planet Center Upgrade

- MPC fully upgraded to LINUX-based processors
- Processes all observations received worldwide each night within next day
- Database contains:
  - Over 68,000,000 observations
  - Over 475,000 orbits for minor planets
- NEO observations identified and processed on receipt in near-real-time
- Suspected discoveries automatically posted to NEO Confirmation Page
- Adequately prepared for next generation search systems

SKY COVERAGE

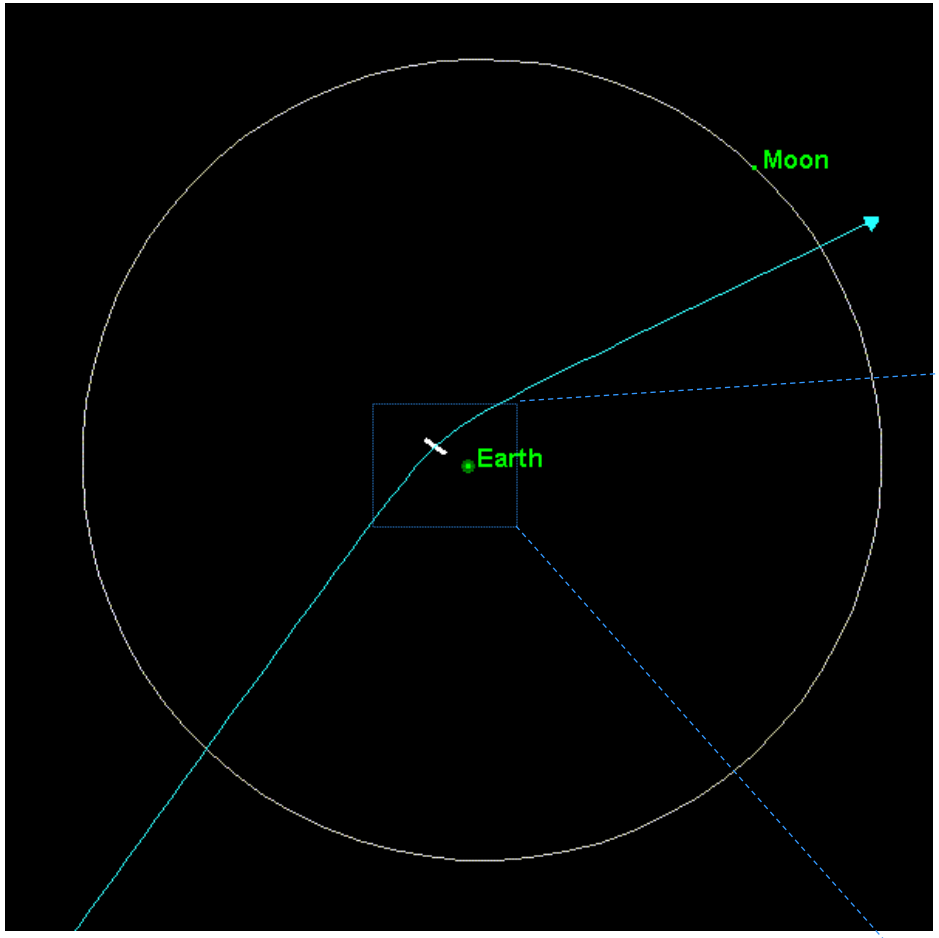
Plot prepared 17 Nov 2009 14:17:18 by the Minor Planet Center



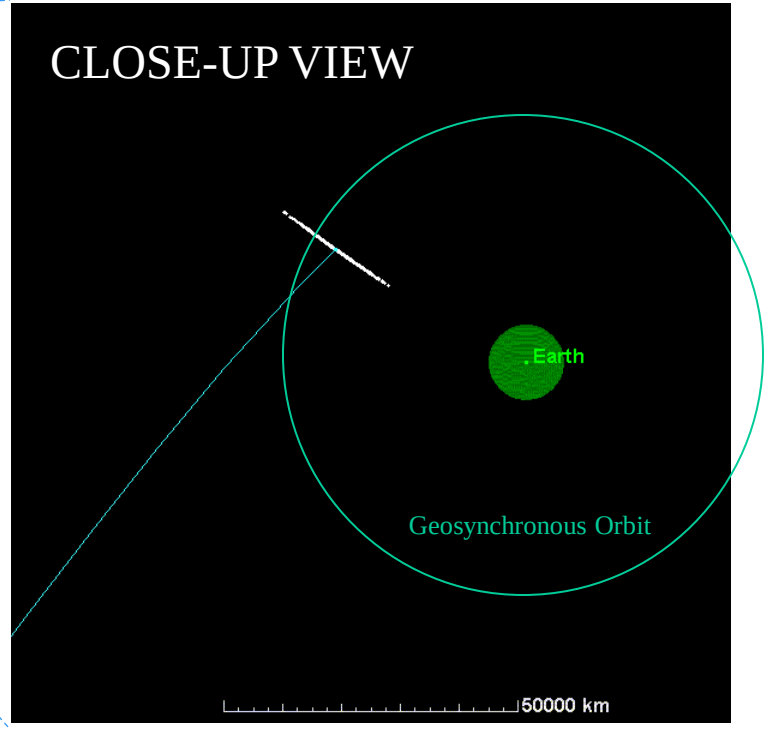
Opposition Point = 01 25.6,+08 59. Fields reaching fainter than V = 18.0.

2009/11/01 (2009 305)	2009/10/31 (2009 304)	2009/10/30 (2009 303)	2009/10/29 (2009 302)	2009/10/28 (2009 301)
2009/10/27 (2009 300)	2009/10/26 (2009 299)	2009/10/25 (2009 298)	2009/10/24 (2009 297)	2009/10/23 (2009 296)
2009/10/22 (2009 295)	2009/10/21 (2009 294)	2009/10/20 (2009 293)	2009/10/19 (2009 292)	2009/10/18 (2009 291)
2009/10/17 (2009 290)	2009/10/16 (2009 289)	2009/10/15 (2009 288)	2009/10/14 (2009 287)	2009/10/13 (2009 286)
2009/10/12 (2009 285)	2009/10/11 (2009 284)	2009/10/10 (2009 283)	2009/10/09 (2009 282)	2009/10/08 (2009 281)
2009/10/07 (2009 280)	2009/10/06 (2009 279)	2009/10/05 (2009 278)	2009/10/04 (2009 277)	2009/10/03 (2009 276)

Update on Apophis



Predicted Close Approach
of 2004 MN4 “Apophis”
(a ~270 meter object)
on April 13, 2029



With improved processing of acquired observations the probability of threat on the subsequent 2036 pass has dropped from 1 in 43,000 to less than 1 in 250,000