Near Earth Object Observations Program

Presentation to

Planetary Defense Task Force

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Program Executive
NASA HQ

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Outline

- NEO Program Basics
- The Current Search Effort
  - NEO Discovery Statistics
- Close Approachers & Impacts
- Addressing NRC Recommendations
  - Importance of Planetary Radar
- FY2011 Proposed Budget

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 US Congress in May, 1998
Since 2002, funding has averaged ~$4M per year

Scientific Objective: Discover 90% of NEOs larger than one 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

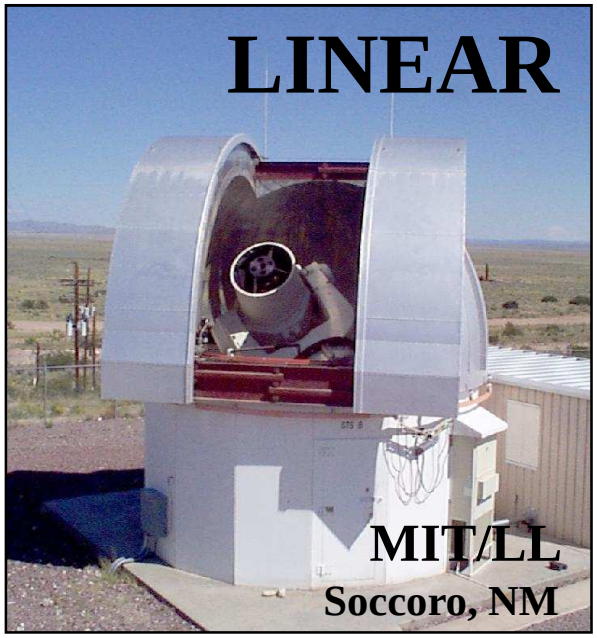
(Current Systems)

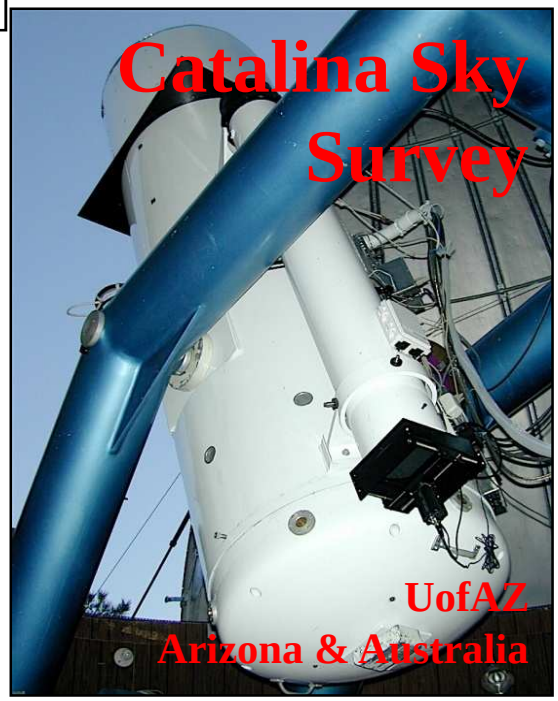
NEO Program Office @ JPL
- Program coordination
- Automated SENTRY

www.neo.jpl.nasa.gov

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

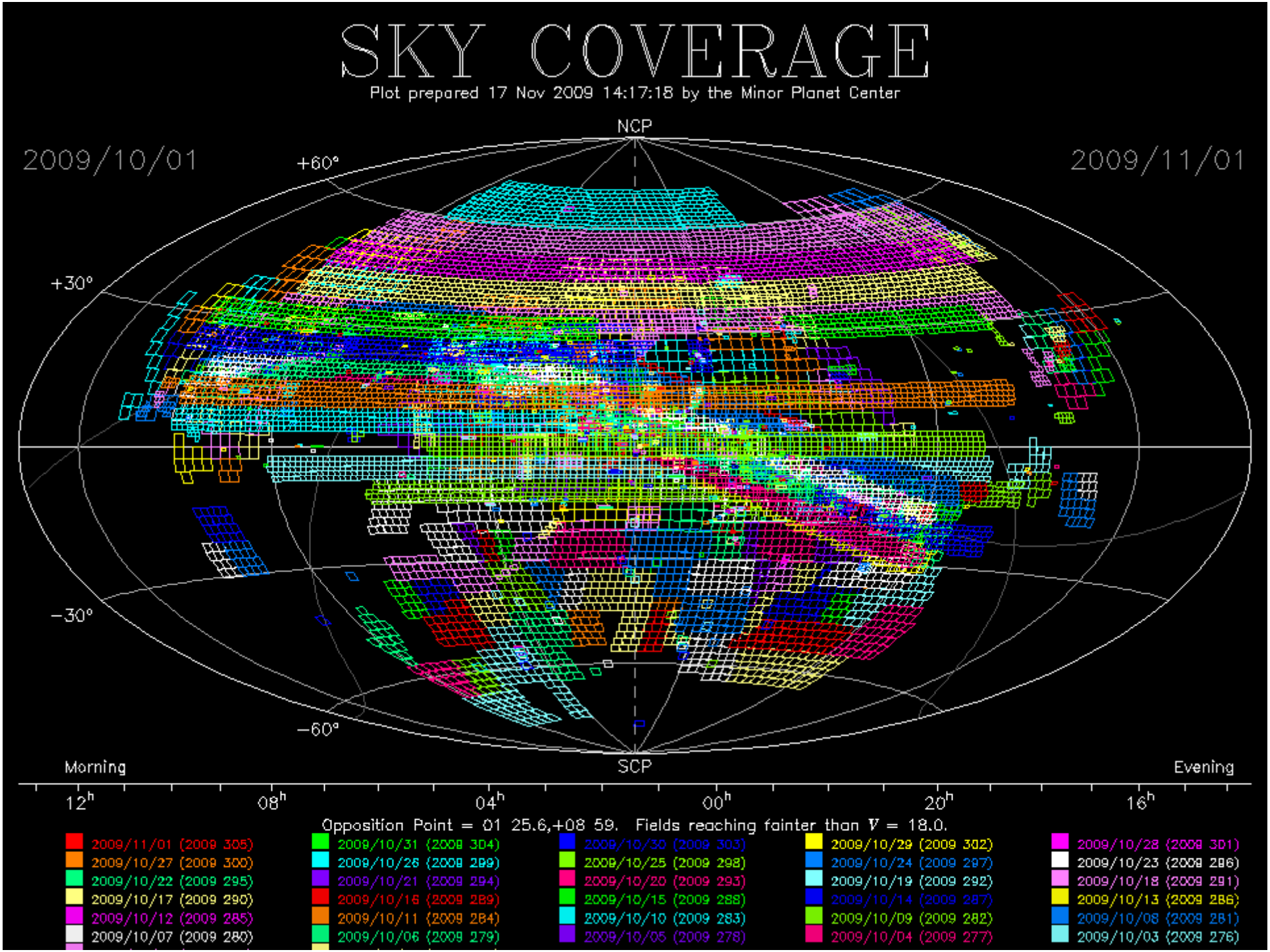
www.cfa.harvard.edu/iau/mpc.html





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
NCP
2009/10/01
2009/11/01
+60°
+30°
−30°
−60°
SCP
Morning
Evening
12h
08h
04h
00h
20h
16h
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)
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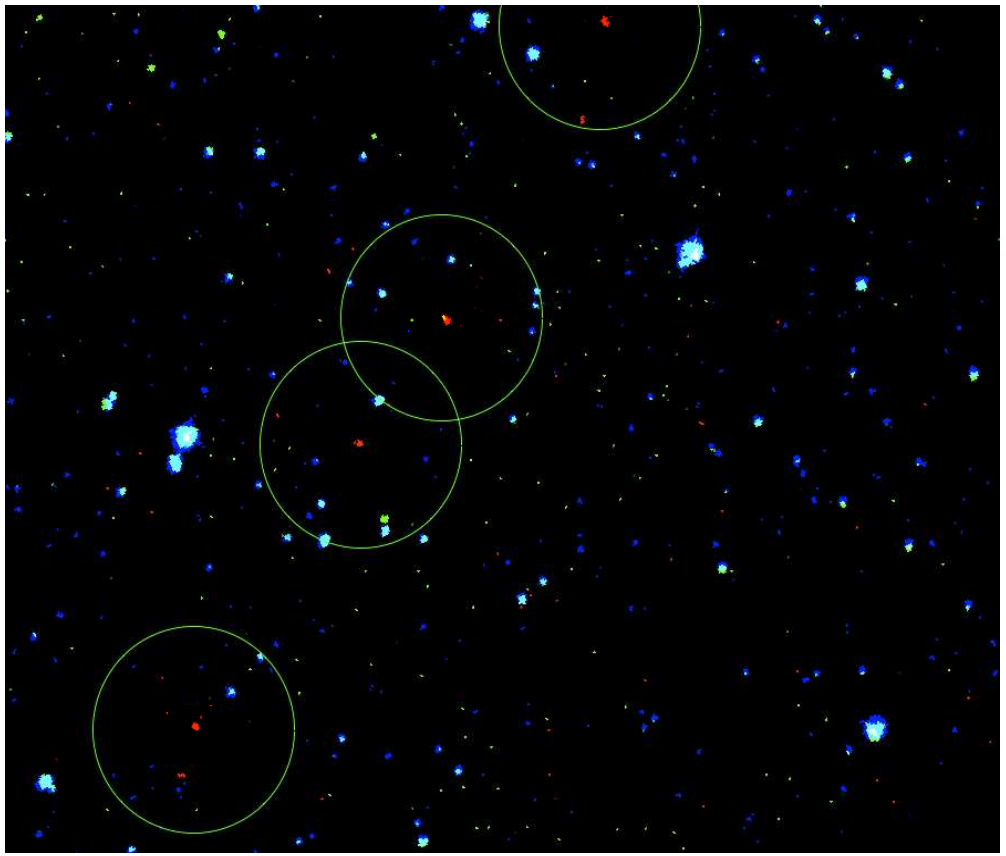
2009/10/22 (2009 295)
2009/10/21 (2009 294)
2009/10/20 (2009 293)
2009/10/19 (2009 292)
2009/10/18 (2009 291)
2009/10/17 (2009 290)
2009/10/16 (2009 289)
2009/10/15 (2009 288)
2009/10/14 (2009 287)
2009/10/13 (2009 286)
2009/10/12 (2009 285)
2009/10/11 (2009 284)
2009/10/10 (2009 283)
2009/10/09 (2009 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)

NEO-WISE Finds NEOs

Credited with 34 NEAs to date (4/12/10)

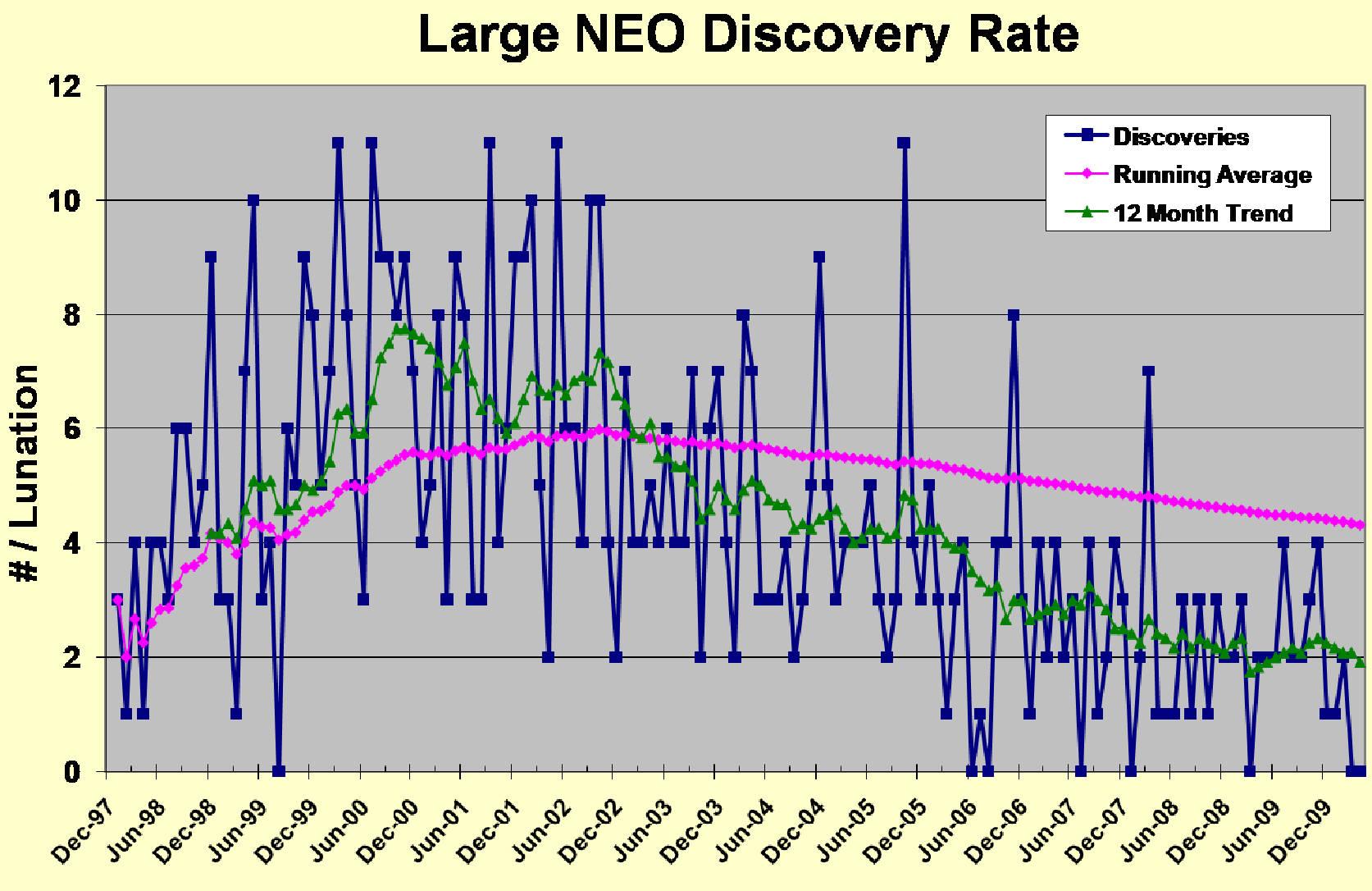
- 3 months ops (~1/3 life)
- Largest ~750 m
- Smallest ~40m
- 5 are PHOs
- 7 comets also found
- None ≥1km to date



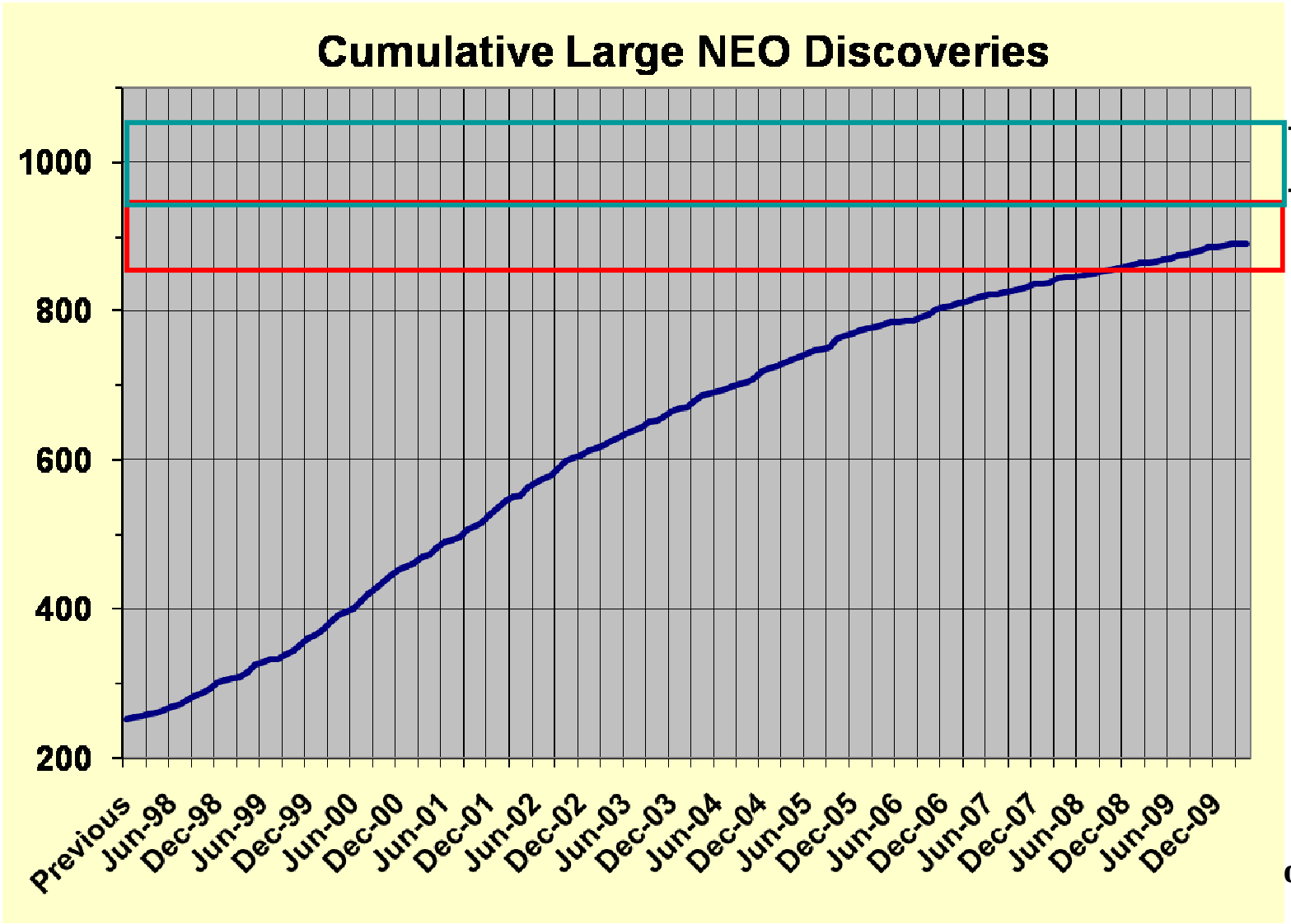
First NEO discovered by WISE: 2010 AB78, ~600 meters in size

Discovery Metrics

Discovery Rate of >1km NEOs



Discovery Metrics



Estimated Population 940 - 1050

Goal 850 - 940

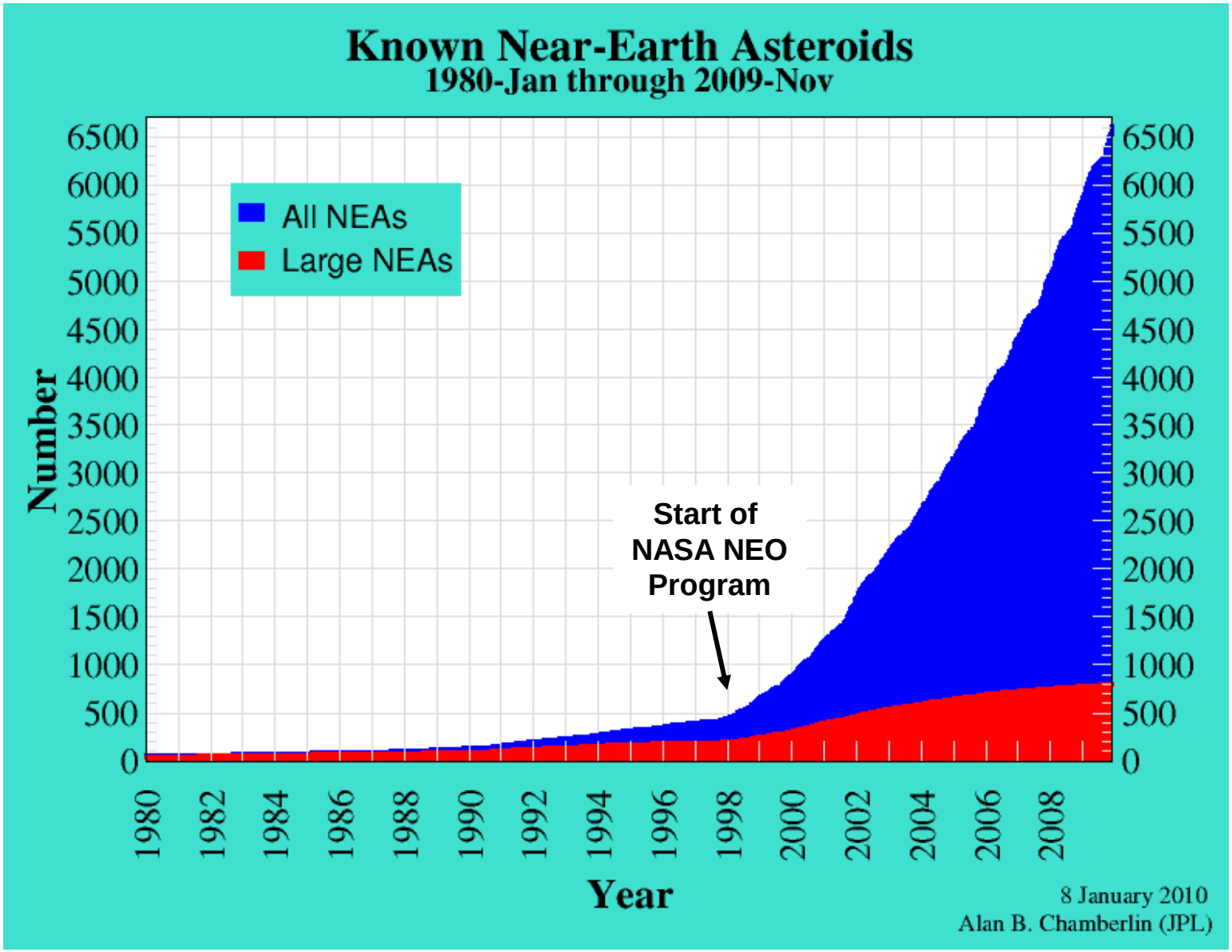
Achieved minimum goal

890*
(85-95%)
as of
4/10/10

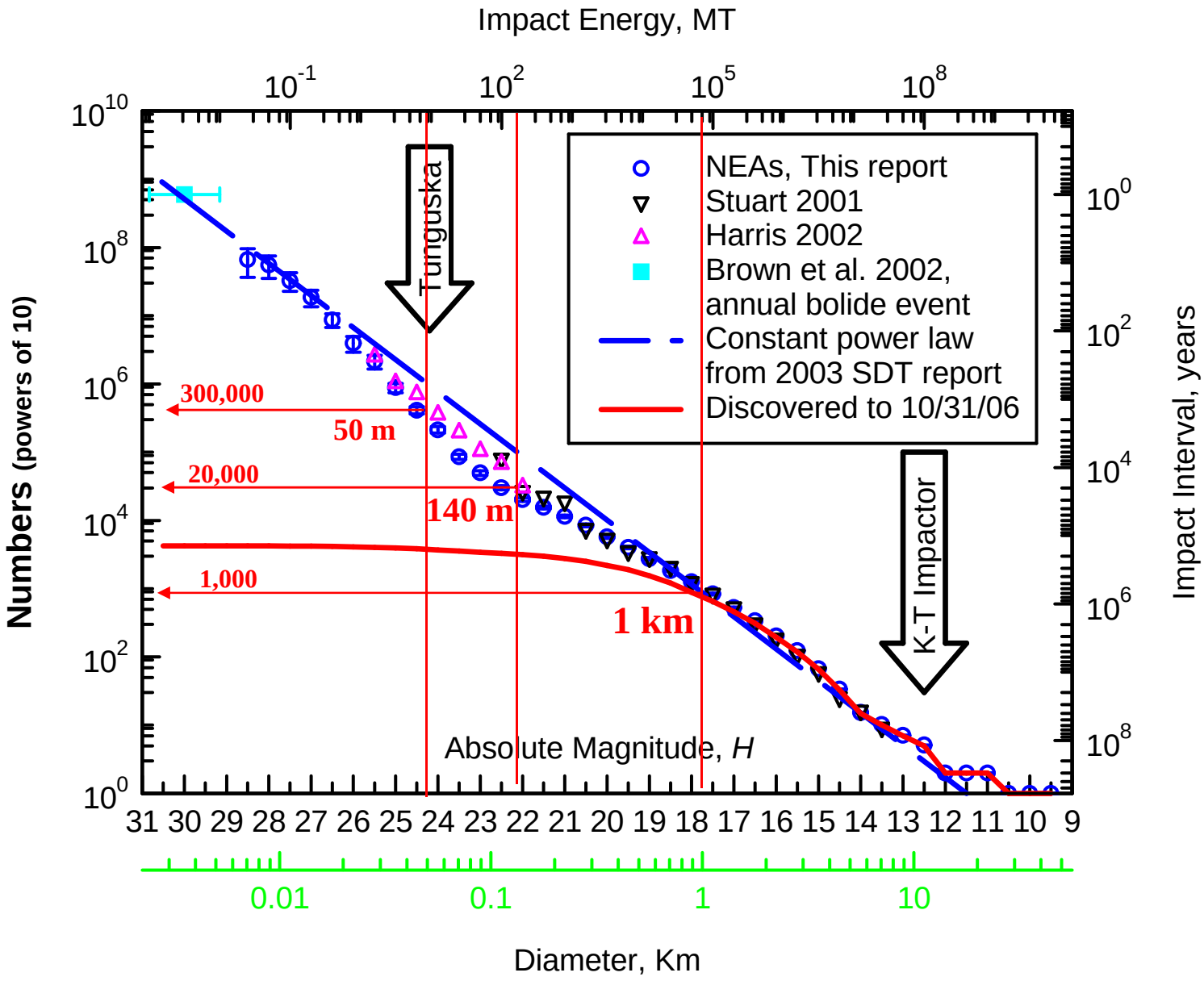
*Includes
84 NECs

6081 smaller objects also found

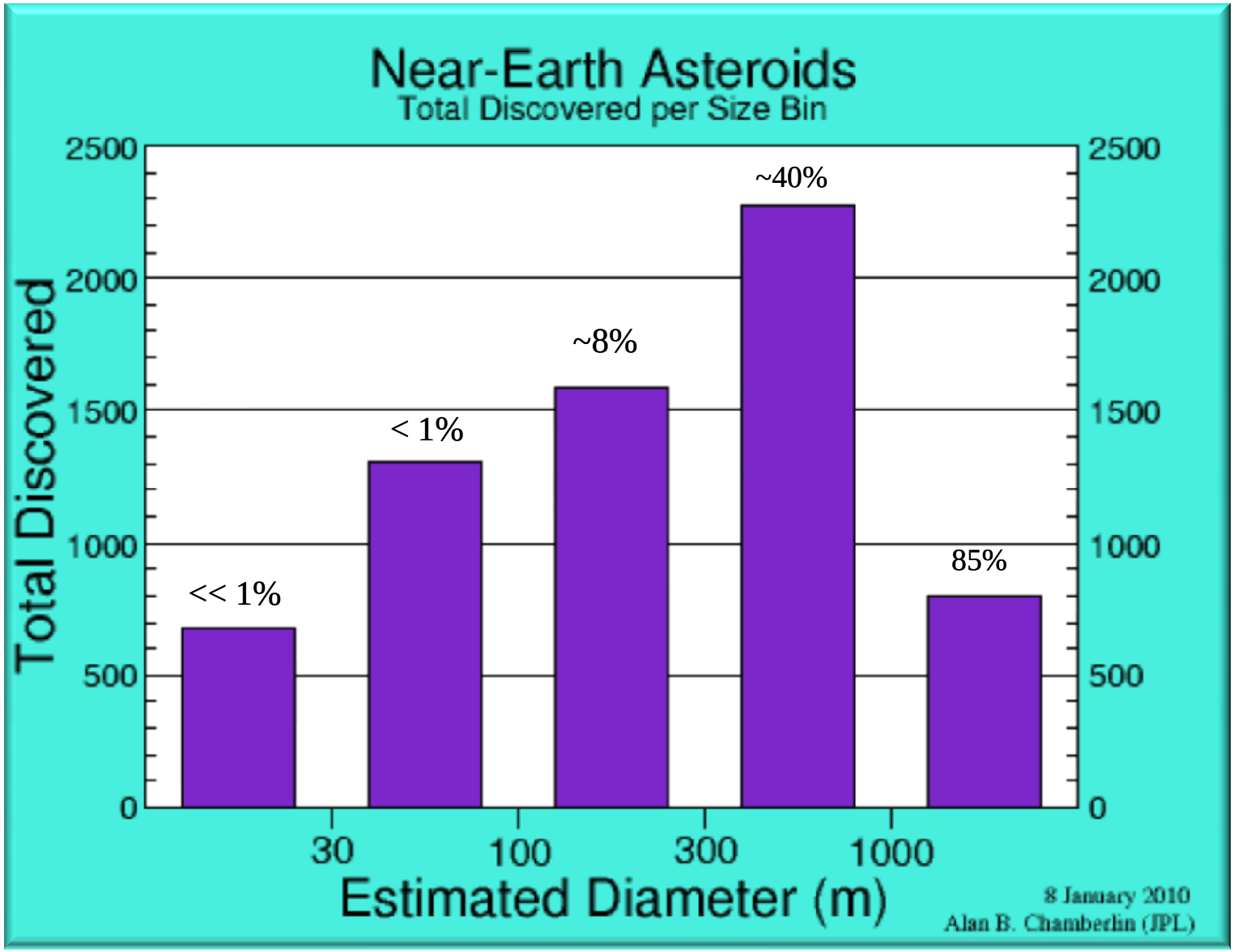
Known Near Earth Asteroid Population



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

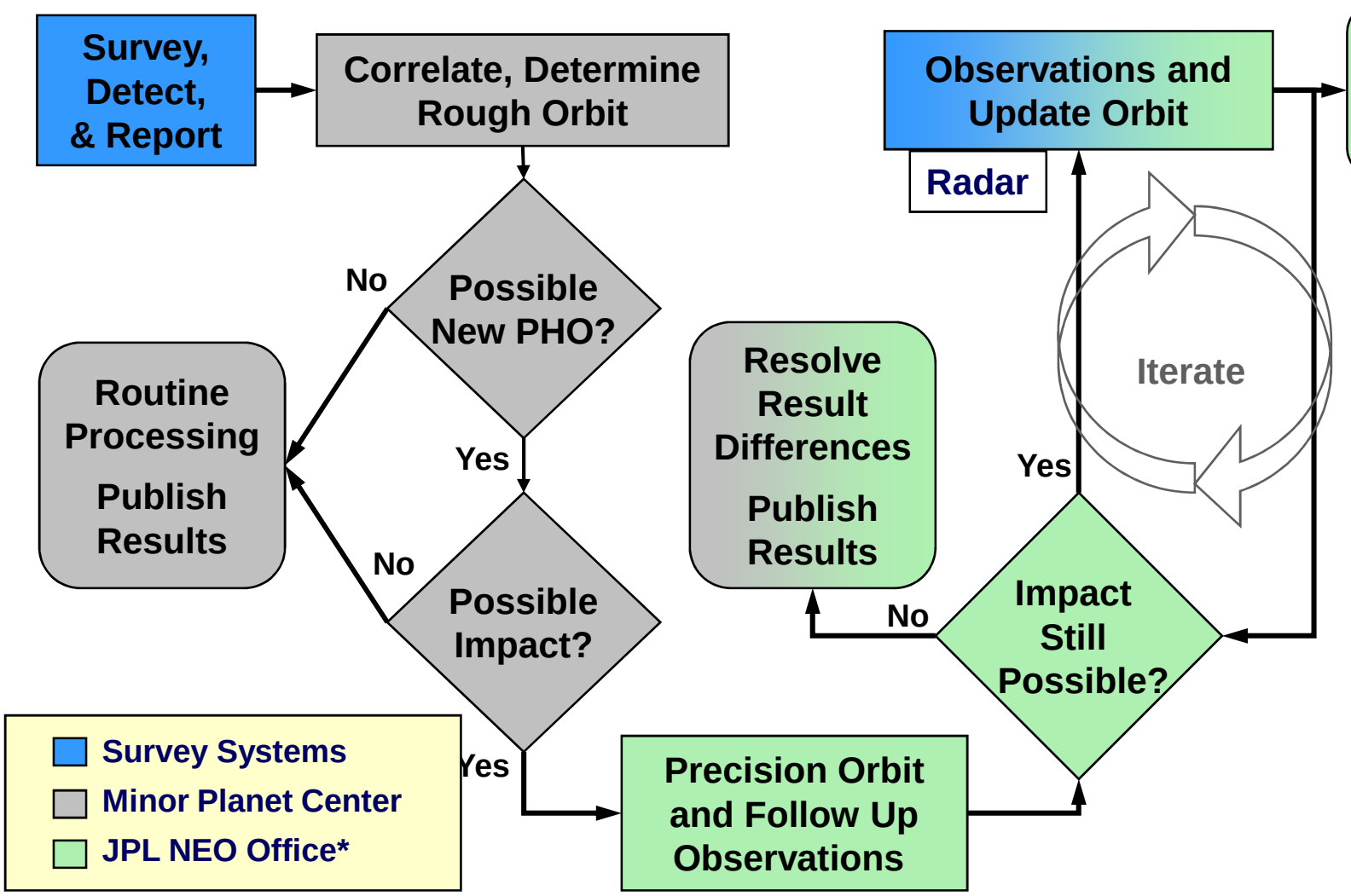


Known Near Earth Asteroid Population



Spaceguard Survey Catalog Program

Current Spaceguard Survey Infrastructure and Process

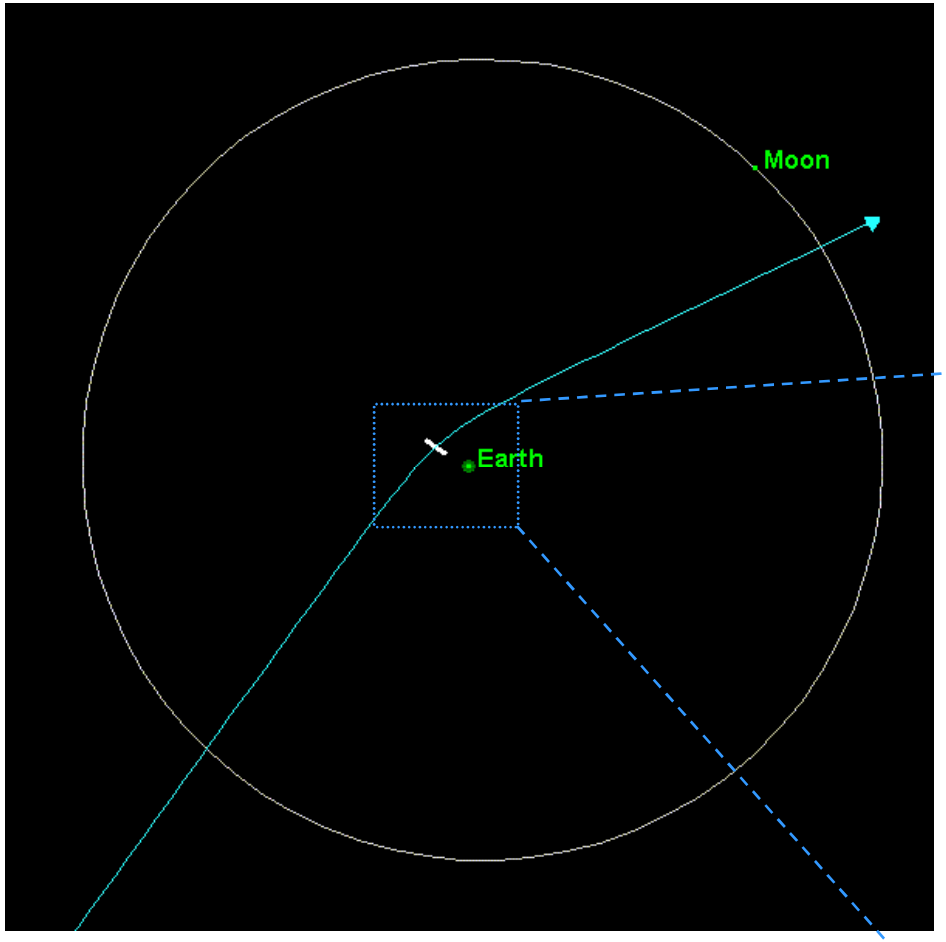


Alerts

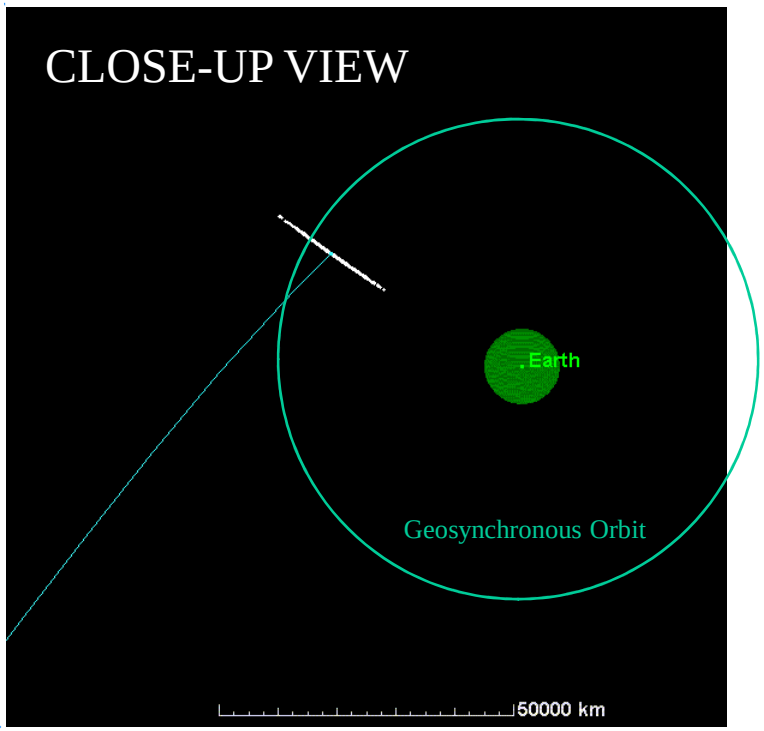
- **MPC** PHO of interest
- **MPC** possible close approach
- **JPL** reports possible impact to NASA/HQ
- **JPL** publishes probability of impact

* In parallel with NEODyS

Close Approaches



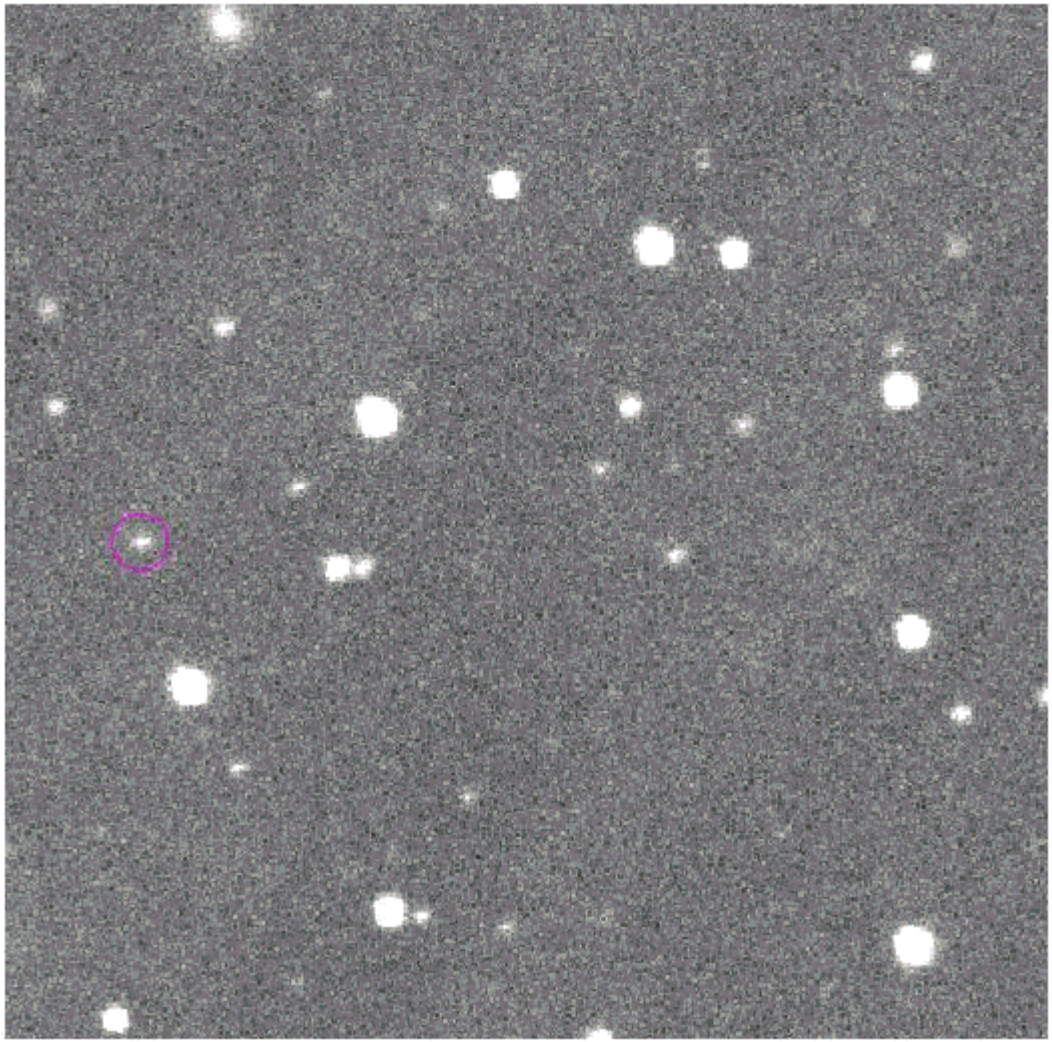
Predicted Close Approach
of 2004 MN4 “Apophis”
(an ~270m Object)
on April 13, 2029



Impact probability in 2036 < 1 in 250,000.

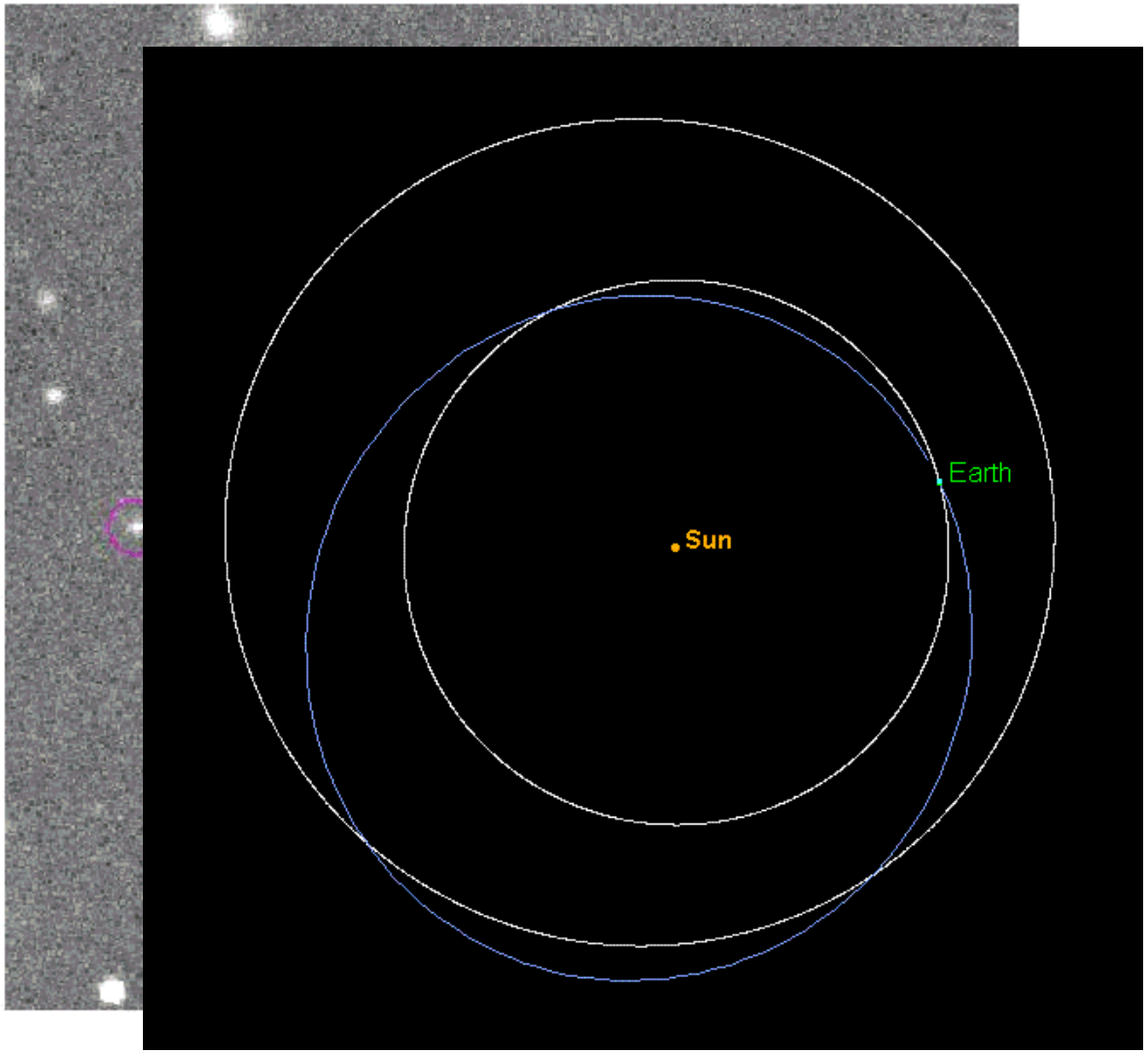
So far, six other PHOs of >100m size have >1:10^6 potential for impact in next 50 years

The Short Life of 2008 TC_3



Discovered by
Catalina Sky Survey
Mt Lemmon Survey
Telescope (1.5m) at
0640 UT on Oct
6, 2008, at ~19 Mv

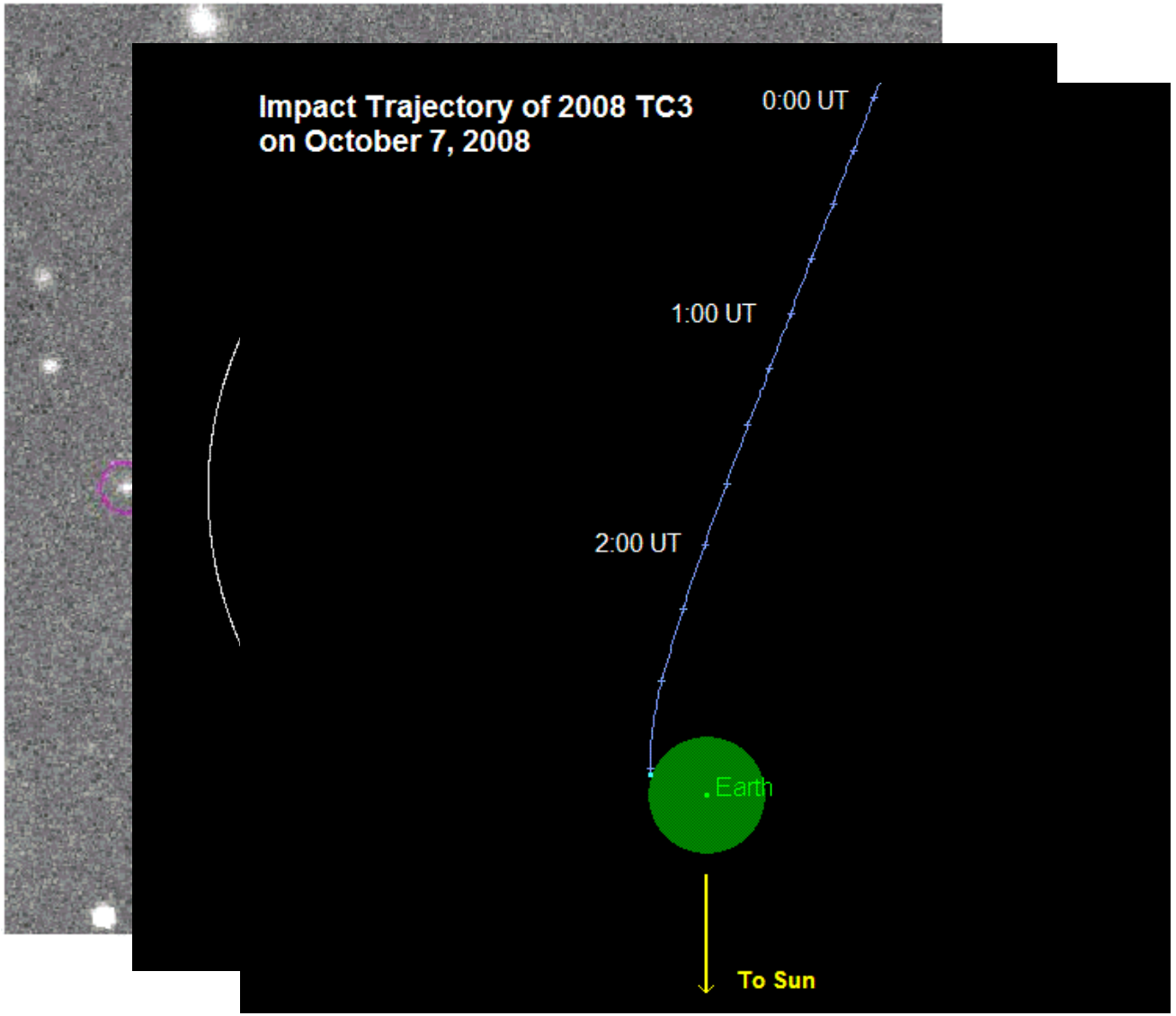
The Short Life of 2008 TC_3



Initial MPC orbit determination finds object will impact Earth within 24 hrs.

MPC alerts JPL NEO Program Office and HQ NASA

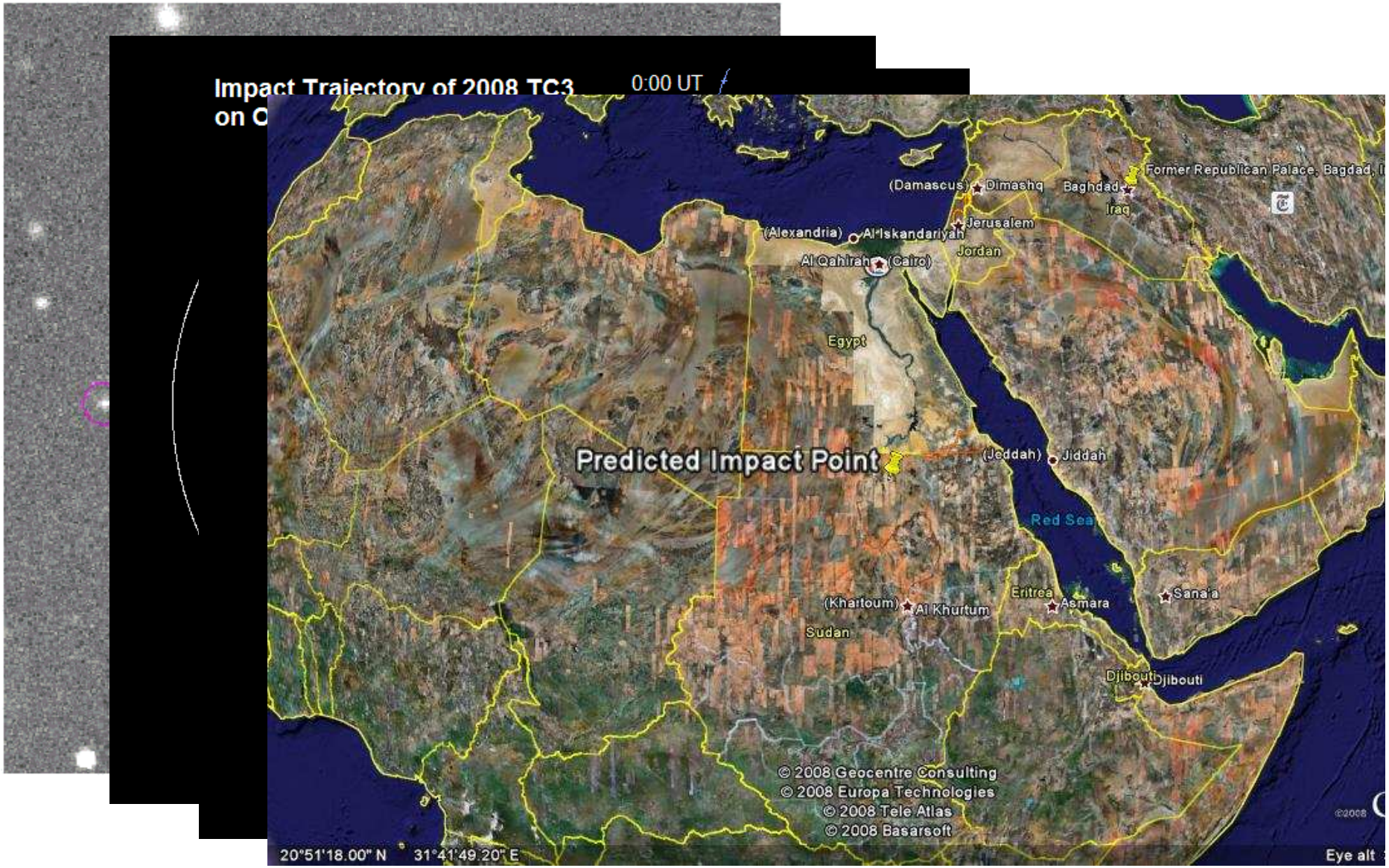
The Short Life of 2008 TC_3



JPL SENTRY run predicts impact at 0245 on 7 Oct, 2008 over northern Sudan

International observer community responds with 570 observations from 27 observers

The Short Life of 2008 TC_3



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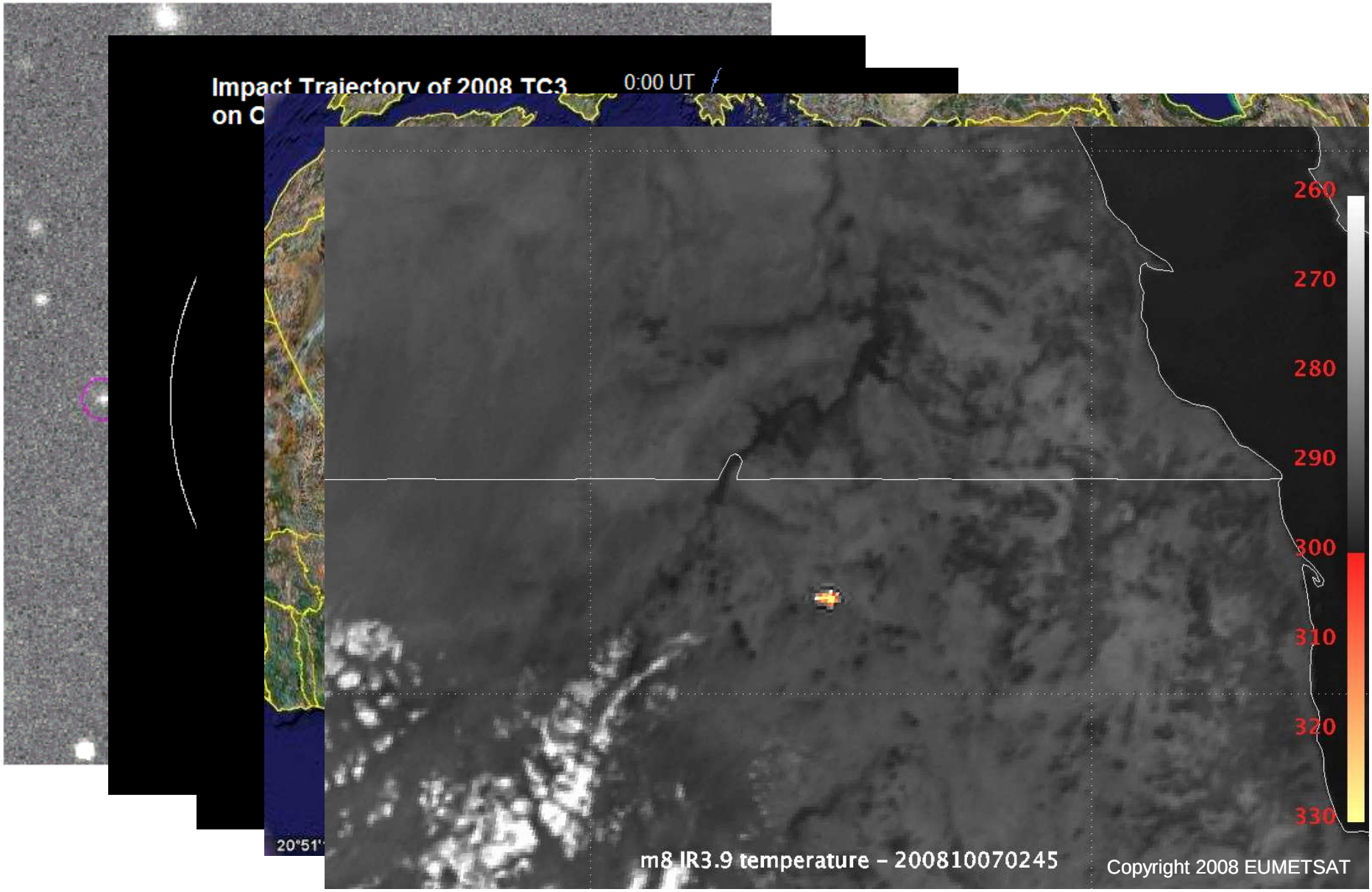

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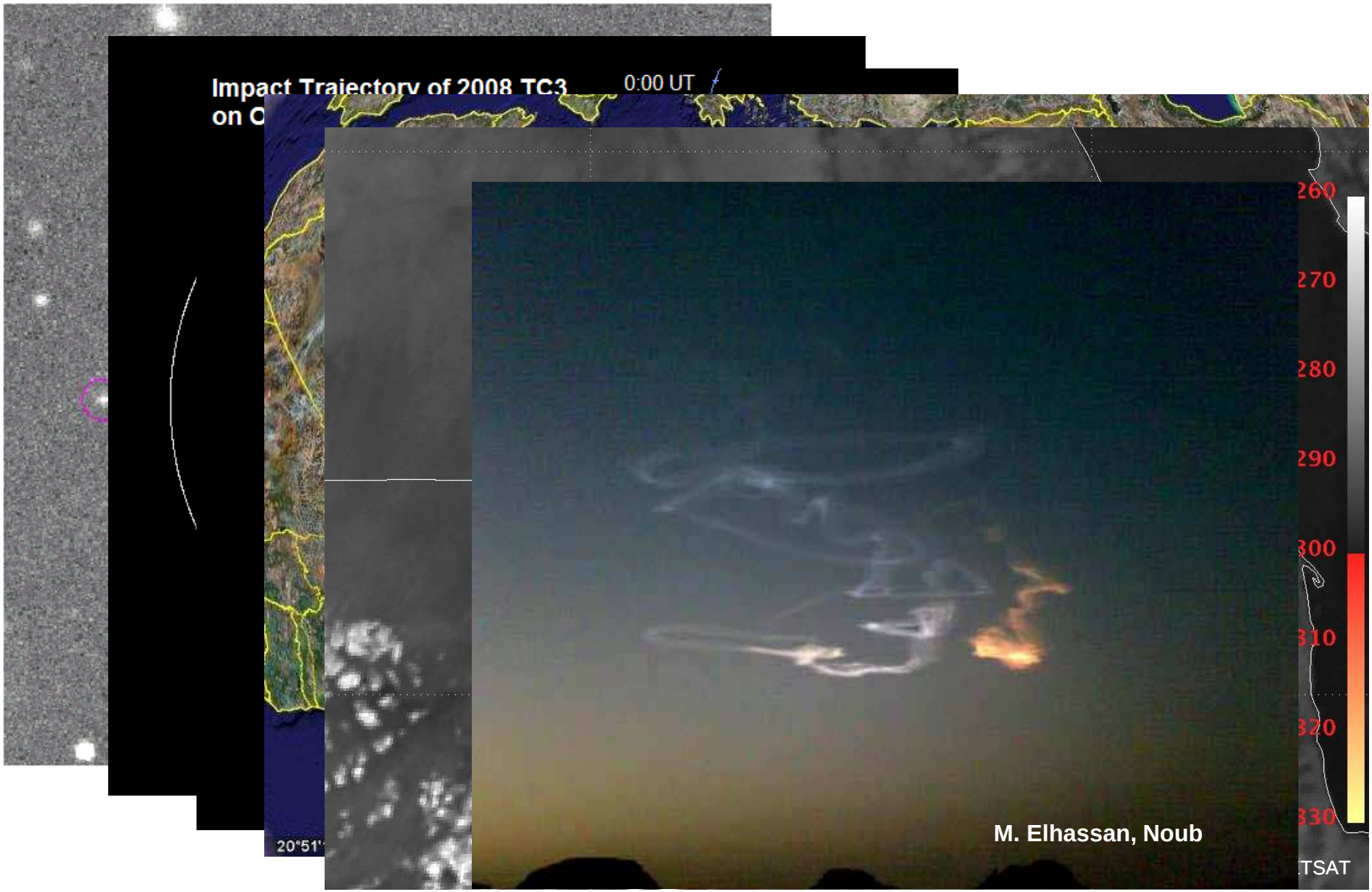


Recovery of 2008 TC_3 Fragments

Courtesy of Dr Petrus Jenniskens, SETI Institute

Discovery of TC_3 fragment by University of Khartoum students led by Dr. Muawia Shaddad with data supplied by NASA

Enlarged image of TC_3 fragment

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 NEOs 140 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

*National Research Council : "Defending Planet Earth: Near Earth Object Surveys and Hazard Mitigation Strategies", Jan 22, 2010

Radar Studies

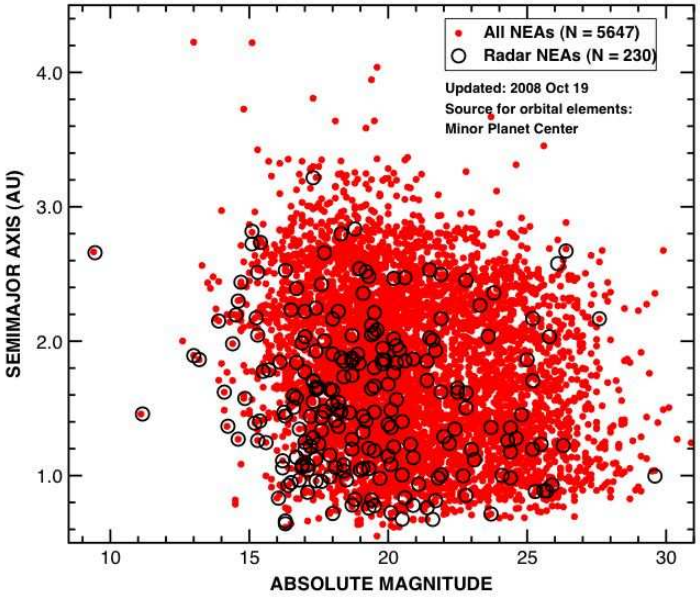
Observations on the limited accessible objects

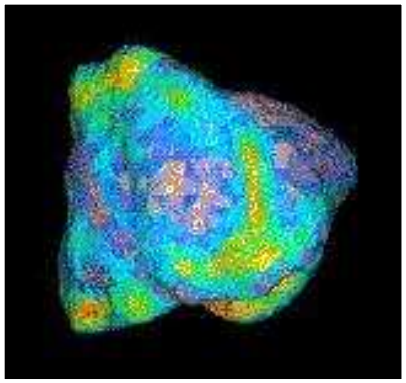
– 20 to 30 NEOs/year from Goldstone and Arecibo

– Required for timely precision orbit determination

– Characterization with sufficient signal strength

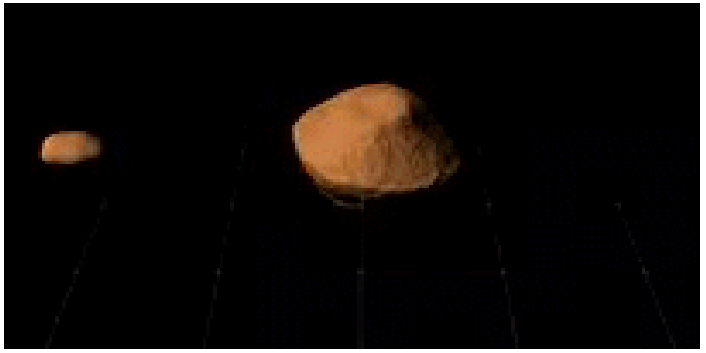
- Shape, spin-state, surface structure
- Satellites (an then derived mass)





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

INTERNATIONAL COOPERATION:

Recommendation: The United States should play a significant role in organizing and empowering a suitable international entity to participate in developing a detailed plan for dealing with the NEO hazard

*National Research Council : "Defending Planet Earth: Near Earth Object Surveys and Hazard Mitigation Strategies", Jan 22, 2010

Future NEO Observation Program

- Objective: To detect and track at least 90 % of NEOs (asteroids and comets) that come within 1.3 AU of the Sun, and find those to at least 140 meters in size which have any potential to collide with Earth
- In the course of this survey many objects which present viable targets for future exploration will be found and initially characterized
- A significant increase in effort is planned for the program with the proposed 2011 budget, in accordance with the recommendations of the recent NRC study on the NEO hazard, issued January 2010
- While the program continues to fund existing network of 1-meter class ground-based telescopes and supporting data processing and analysis at the Minor Planet Center and JPL, it will seek to improve the current capability with upgrades and modifications to existing and planned ground and space-based observatory missions.

Planned Additional NEOO Effort

With the additional $16M starting in FY2011, the NEOO Program will:

- Extend the collection, archive and analysis of small body data collected by NASA's WISE mission, and support increased follow-up and analysis of this data
- Enable collection of NEO detection and characterization data by the USAF's Pan-STARRS project, and investigate the use of other USAF space surveillance assets for this mission
- Support the continued operation of planetary radar capabilities at the NSF's Arecibo and NASA's own Goldstone facilities
- Investigate use of both ground and space-based concepts for dedicated capacity to detect, track and characterize Potentially Hazardous Objects (PHOs) down to sizes 140 meters and below
- Initiate study to determine characterization parameters of PHOs important for possible mitigation actions against an impact threat

Future Years Outlook

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

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