Association of Space Explorers

SWF-ASE-ESA
NEO Workshop - MPOG
27-29 October 2010

Scenario 1
(modified Apophis)

Rusty Schweickart
ASE-NEO Committee

Association of Space Explorers

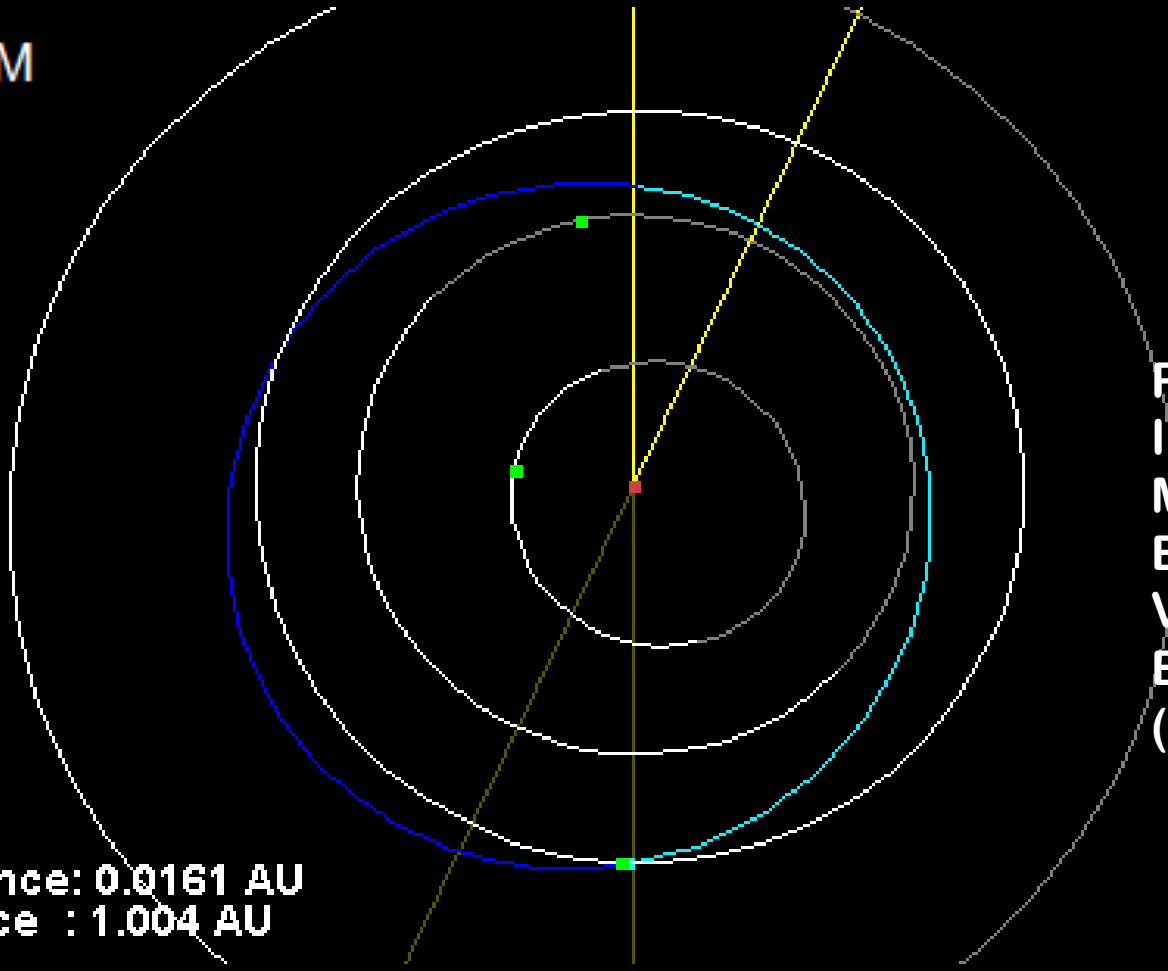
Scenario 1

1) Scenario description
2) Additional background information
3) Issues and Questions
   a) Technical
   b) Institutional

Note: Current date = 22 January 2013

Association of Space Explorers

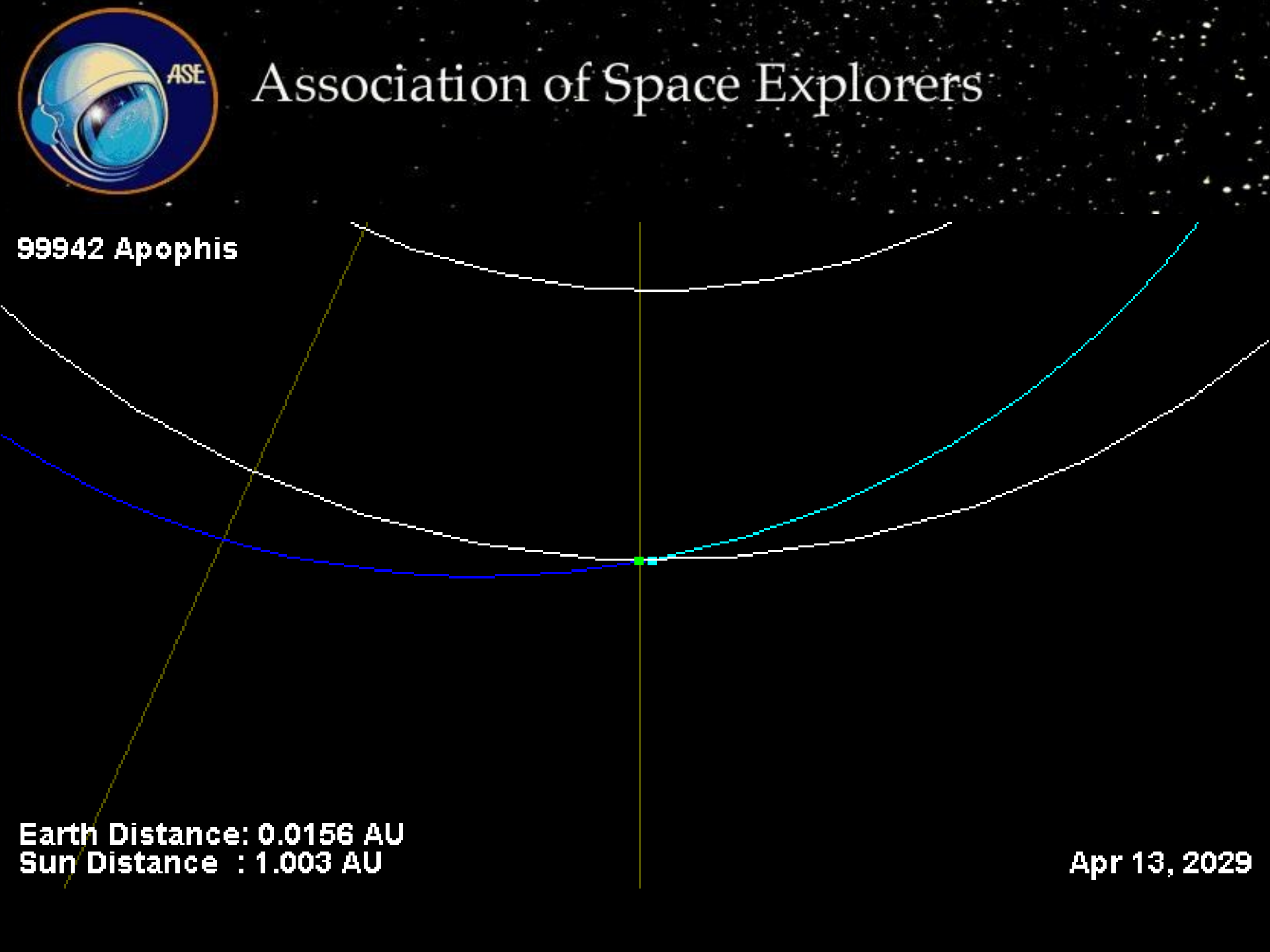
Apophis-M



Period: 0.866 yr
Inclination: 3.33 deg
Mass: 2.7e10 kg
Est. diameter: 270 m
Vimp: 12.59 km/sec
Energy: 510 MT
(= 34,000 Hiroshimas)

Earth Distance: 0.0161 AU
Sun Distance : 1.004 AU

Apr 13, 2029


Association of Space Explorers
99942 Apophis
Earth Distance: 0.0156 AU
Sun Distance : 1.003 AU
Apr 13, 2029

Association of Space Explorers

99942 Apophis (2004 MN4)

Earth Impact Risk Summary

Torino Scale (maximum)	0
Palermo Scale (maximum)	-3.08
Palermo Scale (cumulative)	-2.97
Impact Probability (cumulative)	7.4e-06
Number of Potential Impacts	6

V_{impact}	12.59 km/s
$V_{infinity}$	5.87 km/s
H	19.7
Diameter	0.270 km
Mass	2.7e+10 kg
Energy	5.1e+02 MT

ove are mean values
d by impact probability

Orbital Elements at Epoch 2455400.5 (2010-Jul-23.0) TDB
Reference: JPL 144 (heliocentric ecliptic J2000)

Element	Value	Uncertainty (1-sigma)	Units
e	.191110297656661	3.6436e-08	
a	.9223399011158424	7.6573e-09	AU
q	.7460712480729785	3.8986e-08	AU
i	3.33173591830871	1.5069e-06	deg
node	204.4320062353886	3.0199e-05	deg
peri	126.418616993867	3.0821e-05	deg
M	202.4952515361516	2.5296e-05	deg
t_p	2455542.055279947231 (2010-Dec-11.55527995)	2.4422e-05	JED
period	323.5451710378104 0.89	4.0291e-06 1.103e-08	d yr
n	1.112673073887199	1.3856e-08	deg/d
Q	1.098608554158706	9.1207e-09	AU

Orbit Determination Parameters

# obs. used (total)	640
# delay obs. used	2
# Doppler obs. used	5
data-arc span	1395 days (3.82 yr)
first obs. used	2004-03-15
last obs. used	2008-01-09
planetary ephem.	DE405
SB-pert. ephem.	SB-BIG16-1
condition code	0
fit RMS	.48956
data source	ORB
producer	Steven R. Chesley
solution date	2009-Oct-23 11:54:34

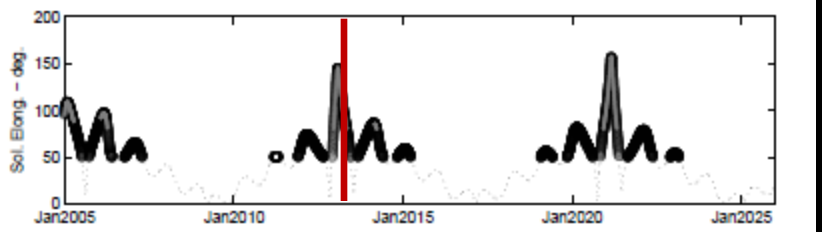
Additional Information

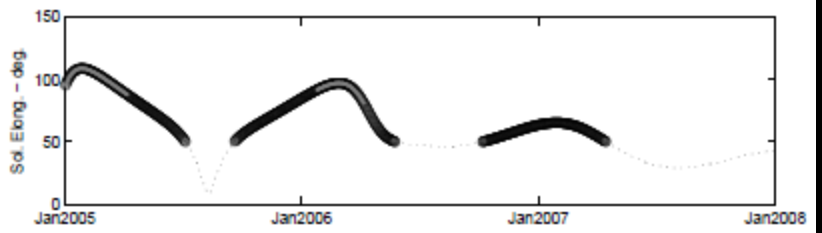
Earth MOID = 8.12667E-5 AU
T_jup = 6.467

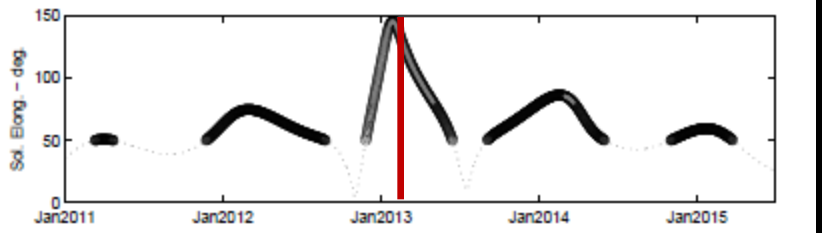
Association of Space Explorers

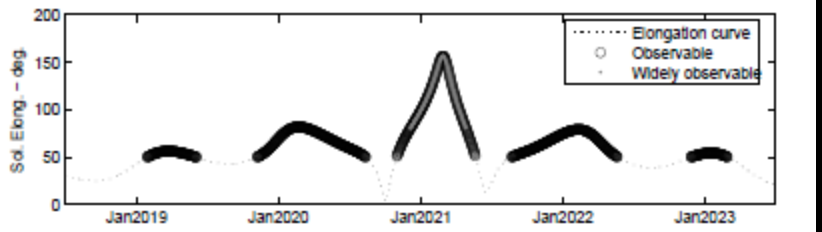
Episodic Tracking

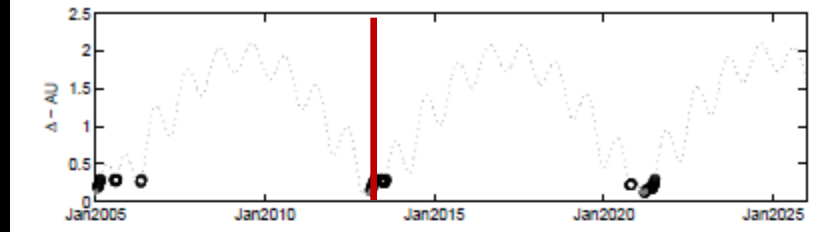
Potential Impact Detection

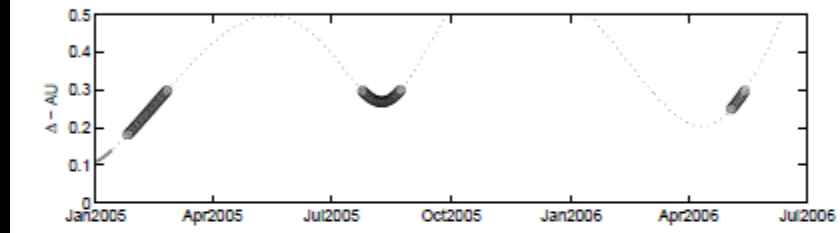


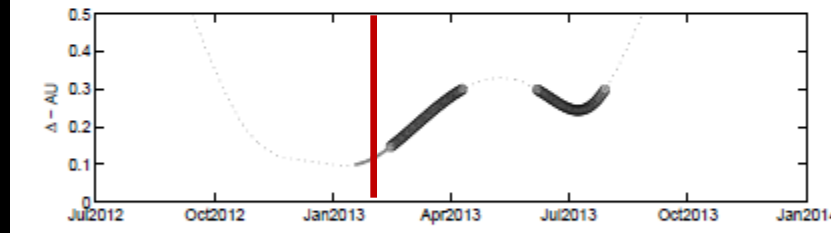


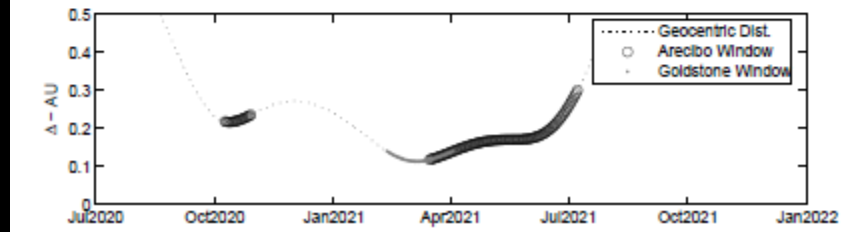












Association of Space Explorers

Episodic Tracking

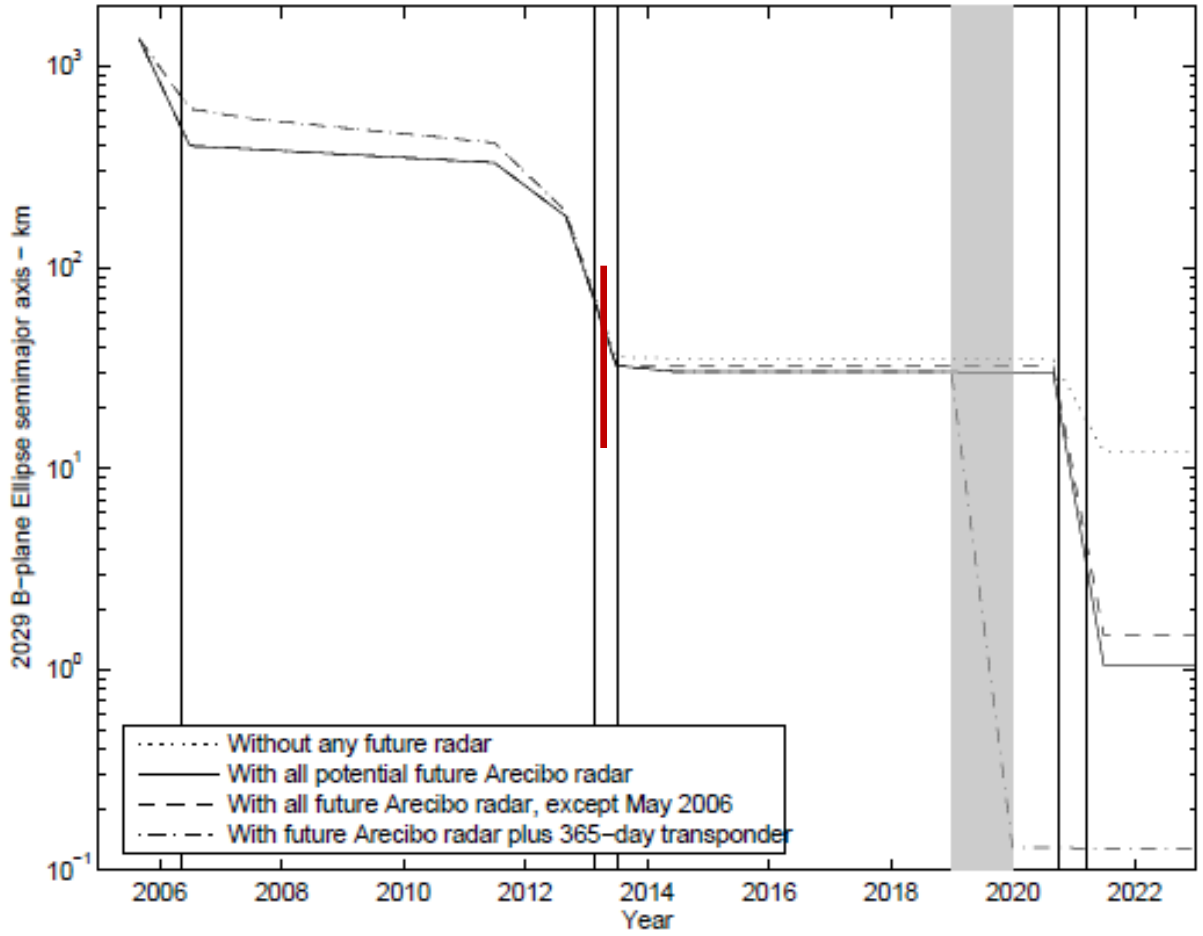


Figure 7. Predicted evolution of the uncertainty extent on the 2029 b-plane for 99942 Apophis. The four curves represent various observation scenarios. The contribution of the uncertainty in Yarkovsky modeling is included as described in the text. The vertical lines indicate the epoch of future Arecibo ranging opportunities. The gray region demarcates the time of a possible radio tracking mission, as described in the text.

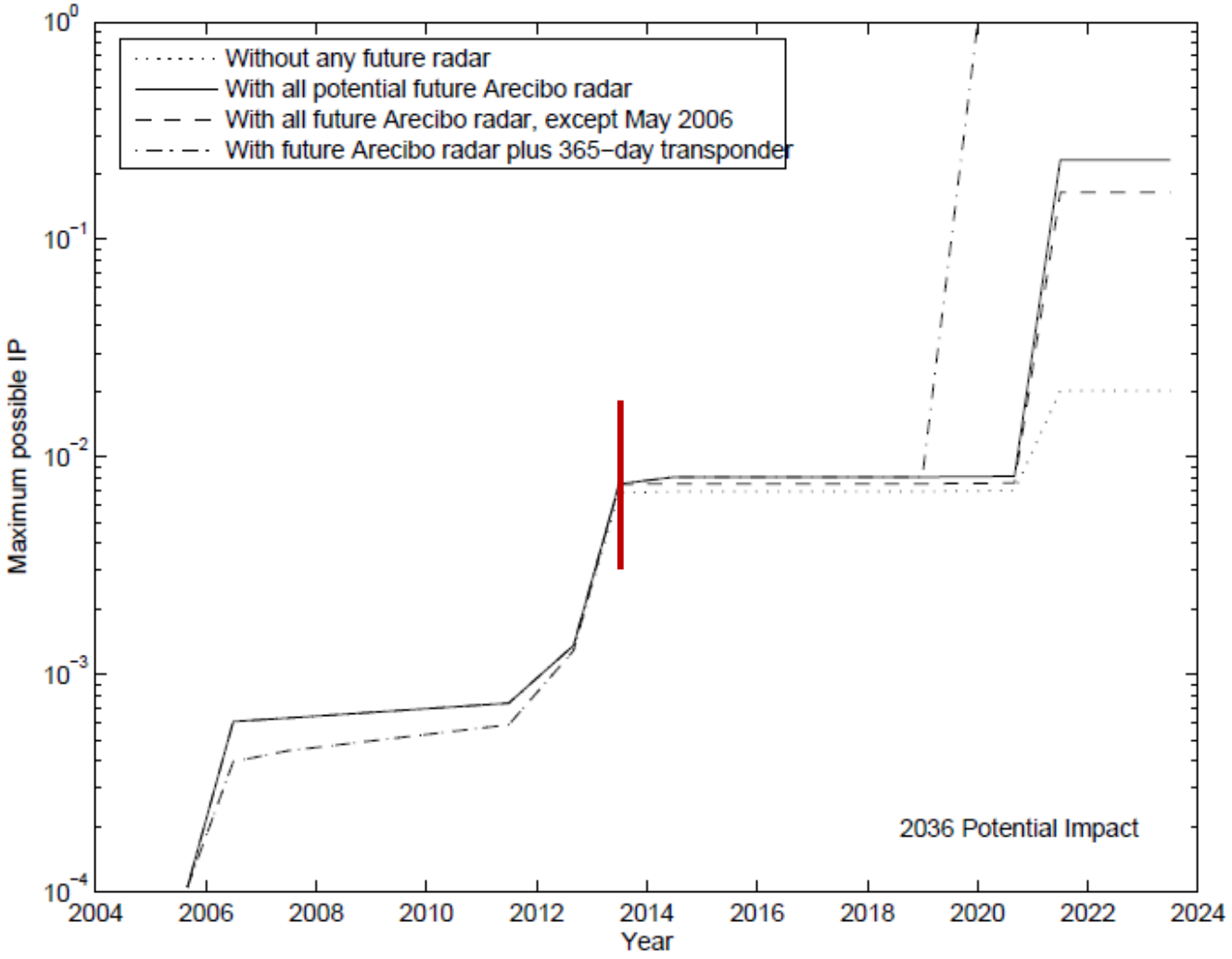


Figure 10. Maximum possible impact probability for the 2036 potential impact, based on the uncertainties depicted in Fig. 7.

Association of Space Explorers

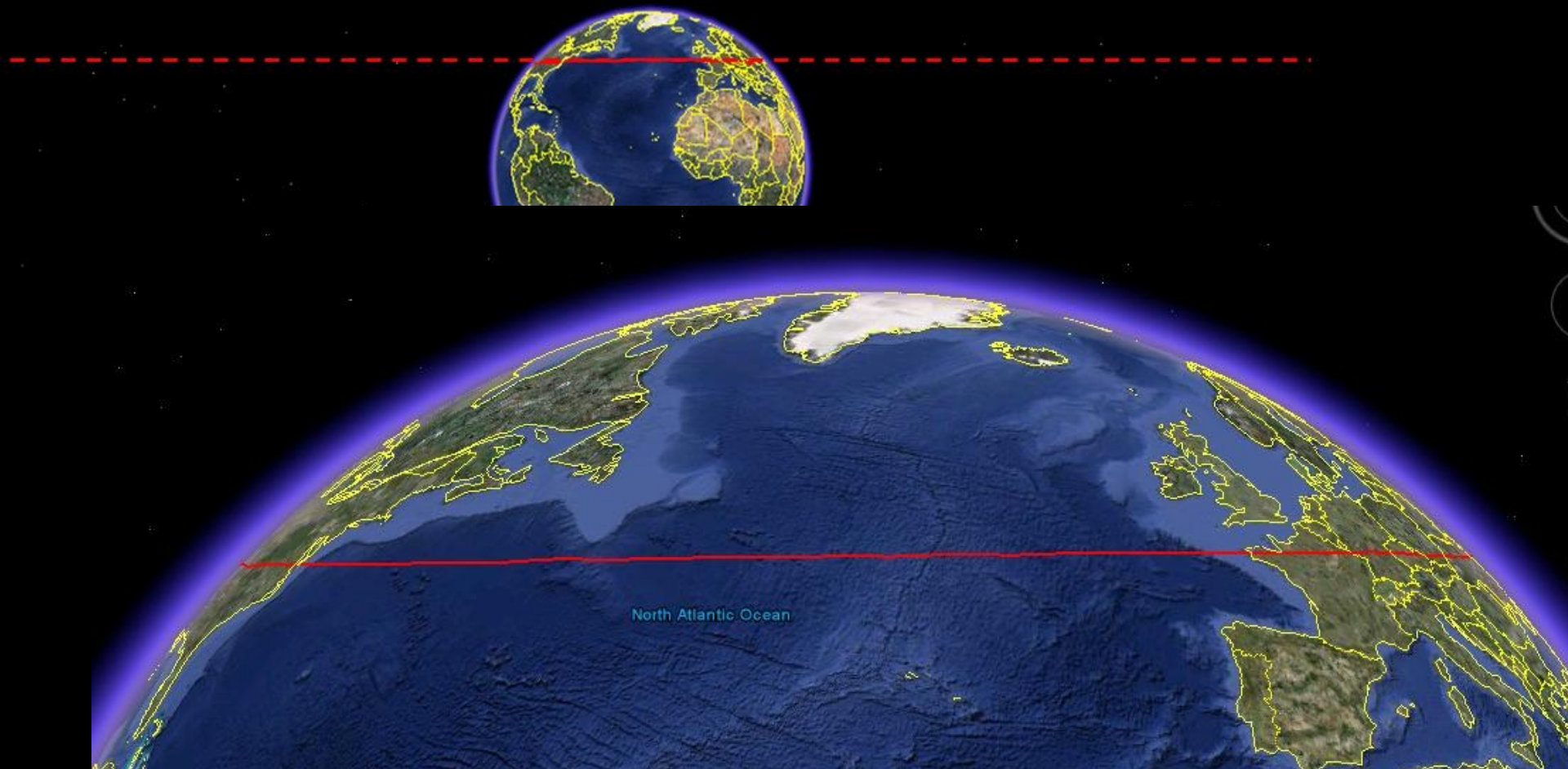
2036 LOV & Risk Corridor
Impact Probability 1:250

120 Earth radii

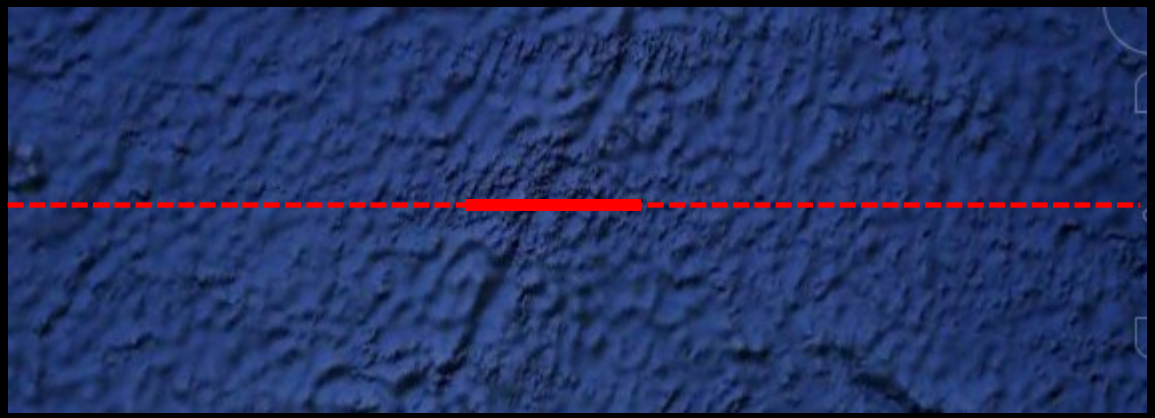
200 Earth radii

Association of Space Explorers

Apophis-M risk corridor

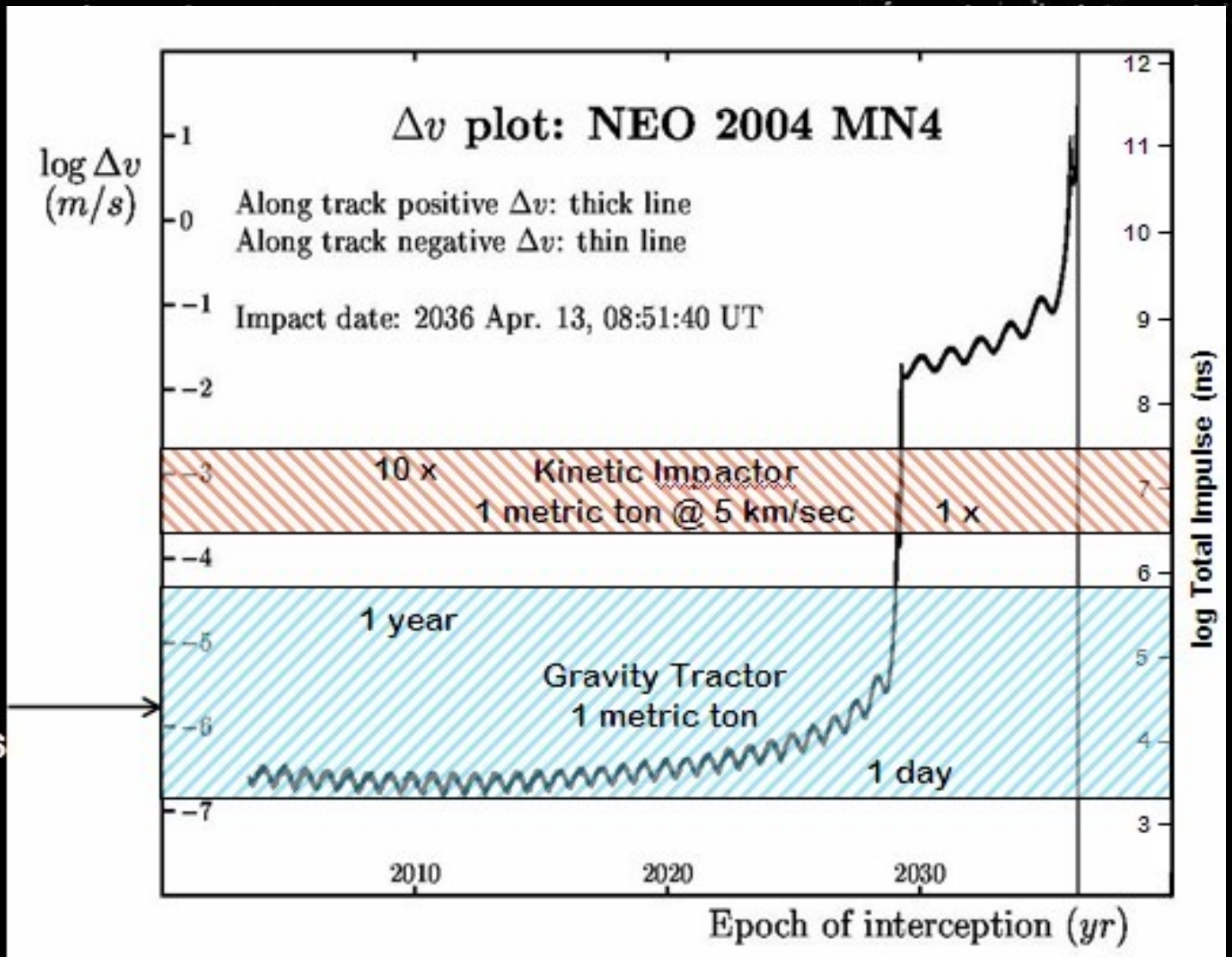


Association of Space Explorers



Association of Space Explorers

Δ V requirement



Association of Space Explorers

Questions & Issues

Scenario 1

1) What criteria should guide the binary choice of deflecting the NEO ahead of or behind the Earth? (Minimum people along risk corridor?; minimum infrastructure value?; shortest distance?; lowest cost?; minimum time to completion?; etc.)

2) What considerations should guide the final targeted miss distance beyond the Earth's surface? (Roche limit? i.e. potential breakup?; future close approach planning?; cost minimization?; etc.)

Questions & Issues

Scenario 1

3) What tracking and/or analytical information is required from the IAWN for MPOG to perform its mission? What timing requirements (re planning) should be levied on IAWN to insure MPOG can address the mission planning issues?
4) Should there be levels of alerting or warning provided by IAWN, and if so, how should they be defined? E.g. preliminary mission planning advised as in Scenario#1?
5) What deflection techniques are available? What criterion should apply, if any, to the use of various techniques?

Questions & Issues

Scenario 1

6) Who deflects? What are the options for selection and the basis to be applied for such selection? Who makes the determination, and how? **(MPOG, MAOG, Security Council, first on scene, maximum self-interest)**
7) **Who pays? How is cost determined and by what process is it approved and allocated?**
8) Are there liability and/or other legal issues that must be addressed as MPOG moves ahead? What are they?

Association of Space Explorers

Questions & Issues

Scenario 1

9) **What oversight and/or control of the deflection planning and execution is required or appropriate?**

10) Will national security (e.g. export control issues; ITAR & equivalent) preclude international cooperation in a deflection campaign? Can this be avoided?

11) How should MPOG be structured? Should this be integrated into ISECG in any way? Other existing structure?

Association of Space Explorers

Questions & Issues

Scenario 1

12) Should membership in MPOG be limited to the launch capable nations? Should nations specify which of their national space organizations will represent them in MPOG? Should MPOG representatives be able to commit their governments? If not, then in what higher forum should this occur?

Association of Space Explorers

Discussion