99942 Apophis (2004 MN4)
Earth Impact Risk Summary

Torino Scale (maximum)	0
Palermo Scale (maximum)	-2.42
Palermo Scale (cumulative)	-2.41
Impact Probability (cumulative)	2.3e-05
Number of Potential Impacts	3

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

all above are mean values weighted by impact probability

Analysis based on 2 radar delay, 5 Doppler, and 731 optical observations spanning 884.52 days (2004-Mar-15.10789 to 2006-Aug-16.626954)

Orbit diagram and elements available here.

These results were computed on May 06, 2008

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Earth Impact Table

Date	Distance	Width	Sigma Impact	Sigma LOV	Stretch LOV	Impact Probability	Impact Energy	Palermo Scale	Torino Scale
YYYY-MM-DD.DD	(r_{Earth})	(r_{Earth})			(r_{Earth})		(MT)		
2036-04-13.37	0.53	1.19e-03	0.000	-2.43132	1.60e+03	2.2e-05	5.06e+02	-2.42	0
2037-04-13.64	0.63	1.11e-03	0.000	4.12074	1.58e+03	8.1e-08	5.06e+02	-4.87	0
2069-04-13.08	0.46	0.00e+00	0.000	2.02831	1.85e+05	4.9e-07	5.06e+02	-4.41	0

Summary Table Description

The Summary Table includes basic information about the hazard for this object. The maximum Torino and Palermo Scale values are listed, as well as the number of tabulated potential impacts and their corresponding cumulative Palermo Scale value and cumulative impact probability. The observation set used for the analysis is also listed. Certain parameter values depend upon the specific impact event in question, but they change little among the various table entries. For this reason we tabulate only mean values for these parameters:

- **V_{impact}** - Velocity at atmospheric entry.
- **$V_{infinity}$** - Relative velocity at atmospheric entry neglecting the acceleration caused by the Earth's gravity field, often called the hyperbolic excess velocity. ($V_{infinity}^2 = V_{impact}^2 - V_{escape}^2$, where V_{escape} = ~11.2 km/s is the Earth escape velocity.)
- **H** - Absolute Magnitude, a measure of the intrinsic brightness of the object.
- **Diameter** - This is an estimate based on the absolute magnitude, usually assuming a uniform spherical body with visual albedo $p_V = 0.154$ (in accordance with the Palermo Scale) but sometimes using actual measured values if these are available. Since the albedo is rarely measured, the diameter estimate should be considered only approximate, but in most cases will be accurate to within a factor of two.
- **Mass** - This estimate assumes a uniform spherical body with the computed diameter and a mass density of 2.6 g/cm^3. The mass estimate is somewhat more rough than the diameter estimate, but generally will be accurate to within a factor of three.
- **Energy** - The kinetic energy at impact: 0.5 * Mass * V_{impact}^2. Measured in Megatons of TNT.

Impact Table Legend

See our Introduction for a more extensive explanation of these terms.

Date
The calendar date (UTC) of the potential impact.

Distance
The minimum distance on the target plane (scaled *b*-plane) from the LOV to the geocenter, measured in Earth radii. For these purposes the radius of the Earth, 6420 km, includes some allowance for the thickness of the atmosphere.

Width
The one-sigma semi-width of the LOV uncertainty region, measured in Earth radii.

Sigma Impact
The lateral distance in sigmas from the LOV to the Earth's atmosphere. Zero indicates that the LOV intersects the Earth. It is computed from (Distance - 1)/Width.

Sigma LOV
The coordinate along the Line Of Variations (LOV). This value is a measure of how well the impacting orbit fits the available observations. Zero indicates the best-fitting, central (nominal) orbit and the further from zero, the less likely the event: Roughly 99% of all the uncertainty region lies between -3 and +3. Sentry explores out to Sigma LOV = +/-5.

Stretch LOV
The stretching is the semimajor axis of the local linear uncertainty region. It describes how fast one moves across the target plane as Sigma LOV changes, and is measured in Earth radii per sigma. The local probability density varies inversely with the stretching, and thus larger stretching values will generally lead to lower impact probabilities.

Impact Probability
The probability that the tabulated impact will occur. The probability computation is complex and depends on a number of assumptions that are difficult to verify. For these reasons the stated probability can easily be inaccurate by a factor of a few, and occasionally by a factor of ten or more.

Impact Energy
The kinetic energy at impact, based upon the computed absolute magnitude and impact velocity for the particular case, and computed in accordance with the guidelines stated for the Palermo Technical Scale. Uncertainty in this value is dominated by mass uncertainty and the stated value will generally be good to within a factor of three.

Palermo Scale
The hazard rating according to the Palermo Technical Impact Hazard Scale, based on the tabulated impact date, impact probability and impact energy.

Torino Scale
The hazard rating according to the Torino Impact Hazard Scale, based on the tabulated impact probability and impact energy.