The Torino Impact Scale

What is it for?

The Torino Scale is a "Richter Scale" for categorizing the Earth impact hazard associated with newly discovered asteroids and comets. It is intended to serve as a communication tool for astronomers and the public to assess the seriousness of predictions of close encounters by asteroids and comets during the 21st century.

Why is the Torino Scale needed?

When a new asteroid or comet is discovered, predictions for where the object will be months or decades in the future are naturally uncertain. These uncertainties arise because the discovery observations typically involve measurements over only a short orbital track and because all measurements have some limit in their precision.

Fortunately, for the majority of objects, even the initial calculations are sufficient to show that they will not make any close passes by the Earth within the next century. However, for some objects, 21st century close approaches and possible collisions with the Earth cannot be completely ruled out.

How does the Torino Scale Work?

The Torino Scale utilizes numbers that range from 0 to 10, where 0 indicates an object has a zero or negligibly small chance of collision with the Earth. (Zero is also used to categorize any object that is too small to penetrate the Earth's atmosphere intact, in the event that a collision does occur.) A 10 indicates that a collision is certain, and the impacting object is so large that it is capable of precipitating a global climatic disaster.

The Torino Scale is color coded from white to yellow to orange to red. Each color code has an overall meaning:

White - "No Hazard" meaning they are virtually certain to miss Earth or are so small that any impact would almost certainly dissipate in the atmosphere. White corresponds to category 0.

Green - "Normal" refers to objects that have predictable close approaches with some very small, but not seriously concerning, chance of a collision. Nonetheless, prudence dictates their orbits should be tracked closely so that the collision chance becomes refined, and probably in all cases, will ultimately be reclassified within Torino Scale category zero. Green corresponds to category 1.

Yellow - "Meriting attention by astronomers" are close approaches by objects that have higher collision chances than the Earth typically experiences over a few decades. These are object for which refinement of the orbit is of high priority. Yellow corresponds to categories 2, 3, 4.

Orange - "Threatening" refers to close encounters with objects that are large enough to cause regional or global devastation, where the chance of collision greatly exceeds the level that typically occurs within a given century. These are objects for which refinement of the orbits are an extreme priority. Orange corresponds to categories 5, 6,7.

Red - "Certain collisions" refers to objects that are certain to collide with Earth having sufficient size to likely penetrate the atmosphere with the capability to cause either local damage, regional devastation, or a global climatic catastrophe. Red corresponds to categories 8, 9, 10.

THE TORINO SCALE

Assessing Asteroid/Comet Impact Predictions

No Hazard	0	The likelihood of collision is zero, or is so low as to be effectively zero. Also applies to small objects such as meteors and bolides that burn up in the atmosphere as well as infrequent meteorite falls that rarely cause damage.
Normal	1	A routine discovery in which a pass near the Earth is predicted that poses no unusual level of danger. Current calculations show the chance of collision is extremely unlikely with no cause for public attention or public concern. New telescopic observations very likely will lead to re-assignment to Level 0.
Meriting Attention by Astronomers	2	A discovery, which may become routine with expanded searches, of an object making a somewhat close but not highly unusual pass near the Earth. While meriting attention by astronomers, there is no cause for public attention or public concern as an actual collision is very unlikely. New telescopic observations very likely will lead to re-assignment to Level 0.
	3	A close encounter, meriting attention by astronomers. Current calculations give a 1% or greater chance of collision capable of localized destruction. Most likely, new telescopic observations will lead to re-assignment to Level 0. Attention by the public and by public officials is merited if the encounter is less than a decade away.
	4	A close encounter, meriting attention by astronomers. Current calculations give a 1% or greater chance of collision capable of regional devastation. Most likely, new telescopic observations will lead to re-assignment to Level 0. Attention by the public and by public officials is merited if the encounter is less than a decade away.
Threatening	5	A close encounter posing a serious, but still uncertain threat of regional devastation. Critical attention by astronomers is needed to determine conclusively whether or not a collision will occur. If the encounter is less than a decade away, governmental contingency planning may be warranted.
	6	A close encounter by a large object posing a serious, but still uncertain threat of a global catastrophe. Critical attention by astronomers is needed to determine conclusively whether or not a collision will occur. If the encounter is less than three decades away, governmental contingency planning may be warranted.
	7	A very close encounter by a large object, which if occurring this century, poses an unprecedented but still uncertain threat of a global catastrophe. For such a threat in this century, international contingency planning is warranted, especially to determine urgently and conclusively whether or not a collision will occur.
Certain Collisions	8	A collision is certain, capable of causing localized destruction for an impact over land or possibly a tsunami if close offshore. Such events occur on average between once per 50 years and once per several 1000 years.
	9	A collision is certain, capable of causing unprecedented regional devastation for a land impact or the threat of a major tsunami for an ocean impact. Such events occur on average between once per 10,000 years and once per 100,000 years.
	10	A collision is certain, capable of causing a global climatic catastrophe that may threaten the future of civilization as we know it, whether impacting land or ocean. Such events occur on average once per 100,000 years, or less often.

Fig. 2. Public description for the Torino Scale, revised from Binzel (2000) to better describe the attention or response that is merited for each category.

How does an object get its Torino Scale number?

An object is assigned a 0 to 10 value on the Torino Scale based on its collision probability and its kinetic energy (proportional to its mass times the square of its encounter velocity). Categorization on the Torino Scale is based on the placement of a close approach event within a graphical representation of kinetic energy and collision probability . An object that is capable of making multiple close approaches to the Earth will have a separate Torino Scale value associated with each approach. (An object may be summarized by the single highest value that it attains on the Torino Scale.) There are no fractional values or decimal values used in the Torino Scale.

Can the Torino Scale value for an object change?

Yes! It is important to note that the Torino Scale value for any object initially categorized as 1 or greater _will_ change with time. The change will result from improved measurements of the object's orbit showing, most likely in all cases, that the object will indeed miss the Earth. Thus, the most likely outcome for a newly discovered object is that it will ultimately be re-assigned to category 0. Any object initially placed in category 0 is unlikely to have its Torino Scale value change with time.

How did the Torino Scale get its name?

The Torino Scale was created by Professor Richard P. Binzel in the Department of Earth, Atmospheric, and Planetary Sciences, at the Massachusetts Institute of Technology (MIT). The first version, called "A Near-Earth Object Hazard Index", was presented at a United Nations conference in 1995 and was published by Binzel in the subsequent conference proceedings (Annals of the New York Academy of Sciences, volume 822, 1997.)

A revised version of the "Hazard Index" was presented at a June 1999 international conference on near-Earth objects held in Torino (Turin) Italy. The conference participants voted to adopt the revised version, where the bestowed name "Torino Scale" recognizes the spirit of international cooperation displayed at that conference toward research efforts to understand the hazards posed by near-Earth objects. ("Torino Scale" is the proper usage, not "Turin Scale.)

The Torino Scale

For an object making a close approach to Earth, its categorization on the Torino Scale is dependent upon its placement within this plot showing kinetic energy versus collision probability. (One MT = 4.3 x 10^15 J.) The left-hand scale also indicates approximate sizes for asteroidal objects having typical encounter velocities. For an object that makes multiple close approaches over a set of dates, a Torino Scale value should be determined for each approach. It may be convenient to summarize such an object by the greatest Torino Scale value within the set.

Recommended parameters to be quoted in any public announcement of a future close approach. Responsible communication about a potential close approach should include the following information:

Name of the object:
Size estimate for the object:
Date(s) of close encounter(s):
Collision probability for each close encounter date:
Torino Scale value for each encounter date:

More thorough guidelines and procedures for public announcement of future close approaches by near-Earth objects are being developed under the auspices of the International Astronomical Union (IAU) Working Group on Near-Earth Objects.