Asteroid Apocalypse

A Data Visualization by James Round

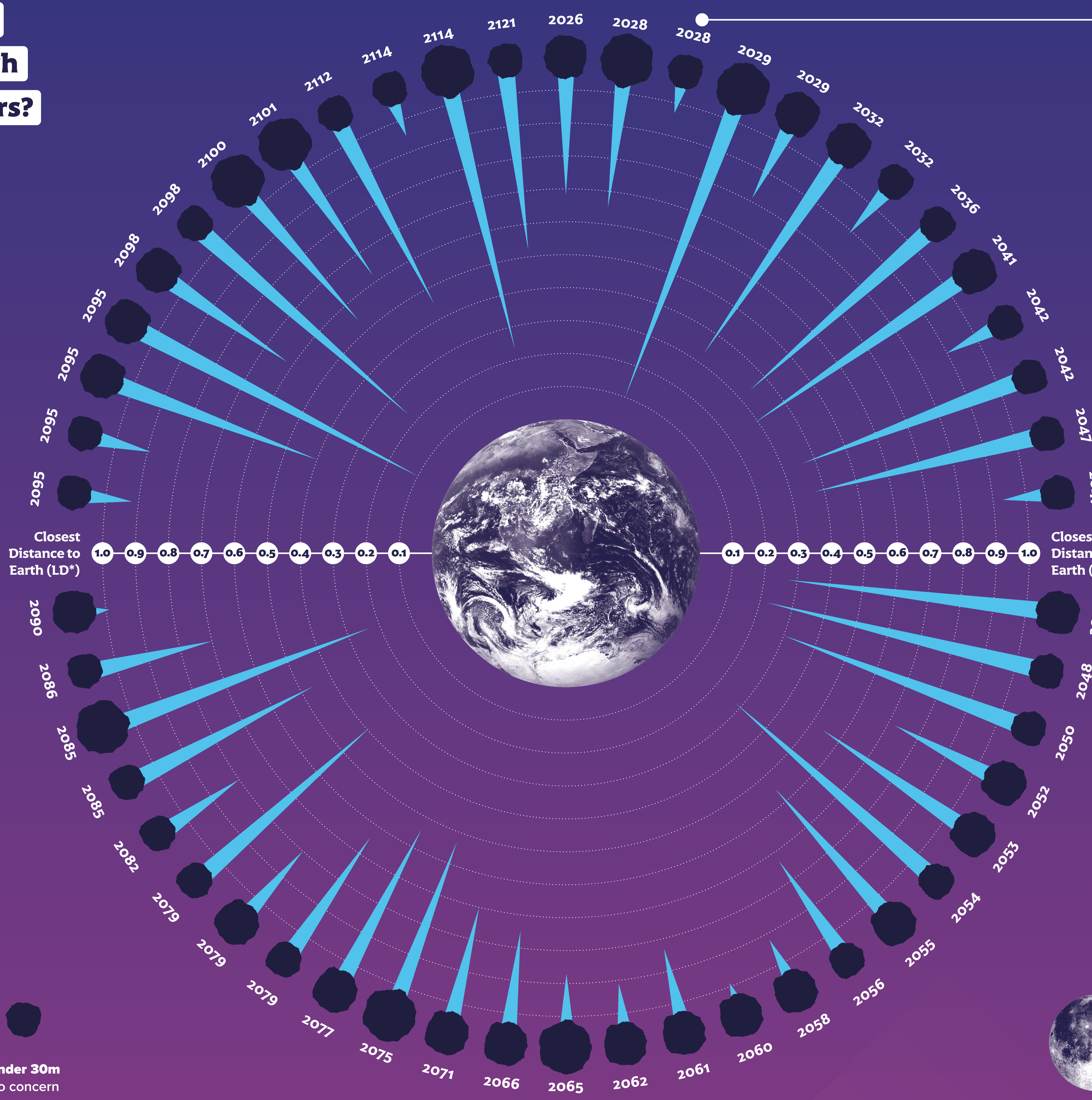
How much danger do asteroids pose to Earth over the next 100 years?

Let's start with the good news—of every known near-Earth asteroid, none are currently on track to collide with our planet. And the precision through which astronomers can track these objects means that we can be fairly confident that this is true over the course of the next century and some time beyond.

But there is some bad news, because while we are gaining an increasingly clear picture of the asteroids we share our solar system with, we haven't found them all. It's estimated that we have eyes on over 98% of asteroids bigger than a kilometre; those large enough to cause a global catastrophe. This impressive number is a credit to astronomers all over the world, however it's possible, albeit very unlikely, that we could still one day find ourselves in the cross-hairs of an asteroid we haven't discovered yet.

Of those we do know about, 50 will travel uncomfortably close over the next 100 years—within the distance between Earth and the moon. These celestial neighbours provide a useful reminder of just how close asteroids get to our planet, and also offer the means to imagine something a little more sobering; what if the orbit of one of these objects was slightly different, and it was heading straight for Earth?

On the right is every known asteroid that will travel within one lunar distance (LD*) of Earth over the next century. Asteroids are arranged chronologically by the date of their closest approach. The blue spike shows how close they'll get to Earth, while size of each asteroid represents the scale of devastation that would occur if they did collide with our planet.



Apophis

After its discovery in 2004, initial observations suggested that there was a 2.7% chance of Apophis impacting Earth in 2029. It briefly scored a four on the Torino Scale (explained below), the highest rating ever given. Additional observations helped to reduce the rating to a one, and in 2021, the asteroid was declared to no longer be considered a risk.

The Torino Scale

Astronomers use this scale to categorize and communicate the potential dangers posed by near-Earth objects, such as asteroids, over the course of the next 100 years. Newly discovered asteroids are often rated a one, while further observations are made. Currently no asteroids register on the scale.

- **0 — No Hazard**: No chance of collision.
- **1 — Normal**: No cause for alarm.
- **2, 3, 4 — Needs Attention**: Very unlikely chance of impact. Public attention needed if the event is less than a decade away.
- **5, 6, 7 — Potential Threat**: A serious but uncertain threat. Governmental contingency planning may be warranted.
- **8, 9, 10 — Certain Collision**: Impact is inevitable, with the potential for either local, regional or global catastrophe.

*Lunar distance is the average distance between the Earth and the Moon, and is a common unit of measurement in astronomy. One LD is approximately 400,000 km, or 250,000,000 miles; roughly thirty times Earth's diameter.

So, what would happen if a large asteroid impacted the Earth?

The odds of an asteroid posing an existential threat over the next century are incredibly small; estimated to around 1 in a million. It's much more likely that you'll die in a car accident (1 in 106), choking on food (1 in 2,618), or even being struck by lightning (1 in 180,746). But one in a million isn't nothing. So, what would an impact of that magnitude be like? What would happen in the seconds, minutes and hours afterwards?

Let's imagine that a huge asteroid has avoided detection. A little over 6 hours ago it slipped past the orbit of the moon. 24 seconds ago it moved silently past the International Space Station. And in a few seconds time it will collide with London. The destruction at the point of impact is of a scale unlike anything humanity has ever experienced; London simply ceases to exist. But this is just the beginning, and chaos spreads around the planet in three distinct waves. First come the seismic effects, with the impact manifesting a powerful earthquake that shakes cities to their foundations. Next the ejecta arrives, as the huge amount of matter displaced by the impact descends, huge fragments giving way to dust as the distance from impact increases. Finally comes the airblast, which sends powerful, destructive winds raging across the Earth's surface.

And while this damage is almost incomprehensible, it's not yet an extinction level event. This is still to come. As the ejecta spreads around the planet, it remains in our atmosphere for years, darkening the skies and blocking out essential heat and light from the sun. We find ourselves without the ability to grow food, in a strange, hostile environment. It's the asteroid's legacy, not the collision itself, that seals our fate.

The data below is calculated using the following parameters.

Object size
5km diameter

Collision site
Sedimentary rock

Impact angle
45 degrees

Time after impact

Point of impact

Asteroid Velocity

17km / second

It takes just three seconds for the asteroid to speed through the stratosphere and down to the Earth's surface.

Collision Force

68m megatons of TNT

The asteroid slams into our planet with a force 1.3 million times larger than the most powerful human-made detonation.

Impact Crater

60km wide / 1km deep

The asteroid creates an initial crater that's over 10km deep. However it quickly collapses in on itself, resulting in the figures above.

100km away

The devastation at this distance is total and immediate. Almost every living thing is killed within a matter of seconds. The seismic effects collapse most buildings, shortly followed by the air blast which brings wind speeds close to 5000mph, destroying anything still left standing.

Seismic effects
20 seconds

Ejecta
2 minutes

Air blast
5 minutes

Damage
- All buildings are destroyed
- Trees and grass catch fire
- 90% of trees are blown over
- People suffer 3rd degree burns

500km away

The devastation at this distance is still catastrophic. Seismic effects are manageable, but wind speeds exceed 550km/h. The fastest wind speeds ever previously recorded on Earth are hurricane gusts of 408km/h. The sound from the blast reaches an ear-splitting 99 decibels.

Seismic effects
2 minutes

Ejecta
6 minutes

Air blast
25 minutes

Damage
- Most buildings collapse
- Trees and grass catch fire
- 90% of trees blow over
- People suffer 3rd degree burns

1,000km away

At this distance, the effects begin to lessen, however the impact still causes a considerable amount of chaos and fatalities. The earthquake shakes cars, damages buildings and displaces household items. And just under an hour after impact, the air blast arrives with wind speeds over 150km/h.

Seismic effects
3 minutes

Ejecta
8 minutes

Air blast
50 minutes

Damage
- Buildings damaged
- Windows shatter
- 30% of trees blow over

5,000km away

Even at this distance, the effects of the impact are still felt. Those on the upper floors of buildings would feel the seismic effects. After several hours, in which time people would be well aware of the events unfolding across the word, winds would pick up accompanied by a loud noise.

Seismic effects
17 minutes

Ejecta
26 minutes

Air blast
4 hours

Damage
- Windows may shatter

London, UK

Portsmouth, UK

Edinburgh, UK

Marseille, France

New York, USA

Sources Center for NEO Studies, NASA, The Earth Impact Effects Program by Imperial College London, The Planetary Society and Wikipedia. Data correct as of March 2022. Impact data has a large degree of uncertainty and cities are located at roughly the distances used.