

ASTEROIDS

...are nature's way of asking:



“How’s that space
program coming along?”

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The threat of asteroids



The dinosaur killing event: 65 million years ago



An asteroid of at least 10km hit in what is now the Yucatan.)

Have any asteroids hit recently?



Yes: Chelyabinsk

February 15, 2013

- Airburst @ ~ 30km equivalent to ~ 400 – 500 kiloton nuclear blast
- 20m asteroid
- Velocity ~ 19km/s
- 1500 people injured
- 7200 buildings damaged



Image credit: Alex Alisherovskikh
()

Tunguska Event

30 June 1908



1927 Expedition
1961 Expedition



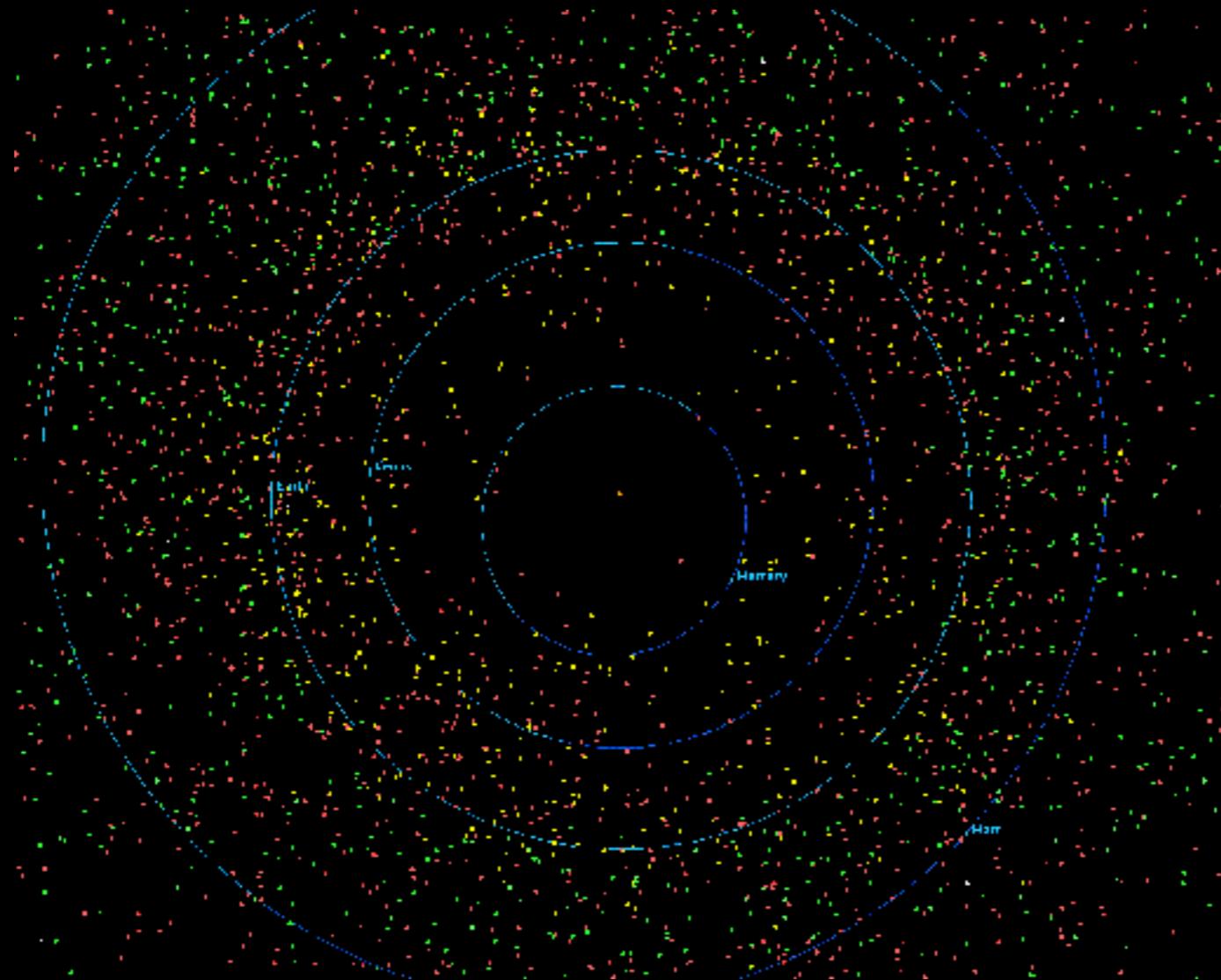
Testimony of S. Semenov, as recorded by Leonid Kulik's expedition in 1930:
At breakfast time I was sitting by the house at Vanavara Trading Post [65 kilometres/40 miles south of the explosion], facing north. [...] I suddenly saw that directly to the north, over Onkoul's Tunguska Road, the sky split in two and fire appeared high and wide over the forest [as Semenov showed, about 50 degrees up—expedition note]. The split in the sky grew larger, and the entire northern side was covered with fire. At that moment I became so hot that I couldn't bear it as if my shirt was on fire; from the northern side, where the fire was, came strong heat. I wanted to tear off my shirt and throw it down, but then the sky shut closed, and a strong thump sounded, and I was thrown a few meters. I lost my senses for a moment, but then my wife ran out and led me to the house. After that such noise came, as if rocks were falling or cannons were firing, the earth shook, and when I was on the ground, I pressed my head down, fearing rocks would smash it. When the sky opened up, hot wind raced between the houses, like from cannons, which left traces in the ground like pathways, and it damaged some crops. Later we saw that many windows were shattered, and in the barn, a part of the iron lock snapped.



Where do these asteroids come from?



The near-Earth asteroids or “NEAs”: They come within 30 million miles of us



[https://www.nasa.gov/images/content/321251main_EarthRide2008\[1\].gif](https://www.nasa.gov/images/content/321251main_EarthRide2008[1].gif)



ASTEROID COMES WITHIN 65,000 MILES OF EARTH

By **Blaine P. Friedl** and **er Jr.**

December 12, 1994

An asteroid about the size of a small school bus narrowly missed striking Earth Friday, a University of Arizona astronomer said.

How much damage the object would have caused had it collided with Earth is unclear and would have depended upon the composition of the asteroid, named 1994 XM1, and where it hit.

James V. Scotti, a University of Arizona astronomer, discovered the asteroid early Friday, about 14 hours before it passed within 65,000 miles of the planet -- the astronomical equivalent of a near collision of two cars in an intersection.

Scotti used the Spacewatch telescope at Kitt Peak, Ariz., to view what is the closest encounter between Earth and an asteroid that astronomers have observed as it happened -- in real time. He and other astronomers there systematically scope the heavens for roaming asteroids and comets that appear to be headed close to Earth.



How can we find all the threats?



NASA Spaceguard
Survey Program

- Spaceguard started in 1998
- Goal: find and track asteroids >1km in diameter
- These larger asteroids are the ones that could cause global damage



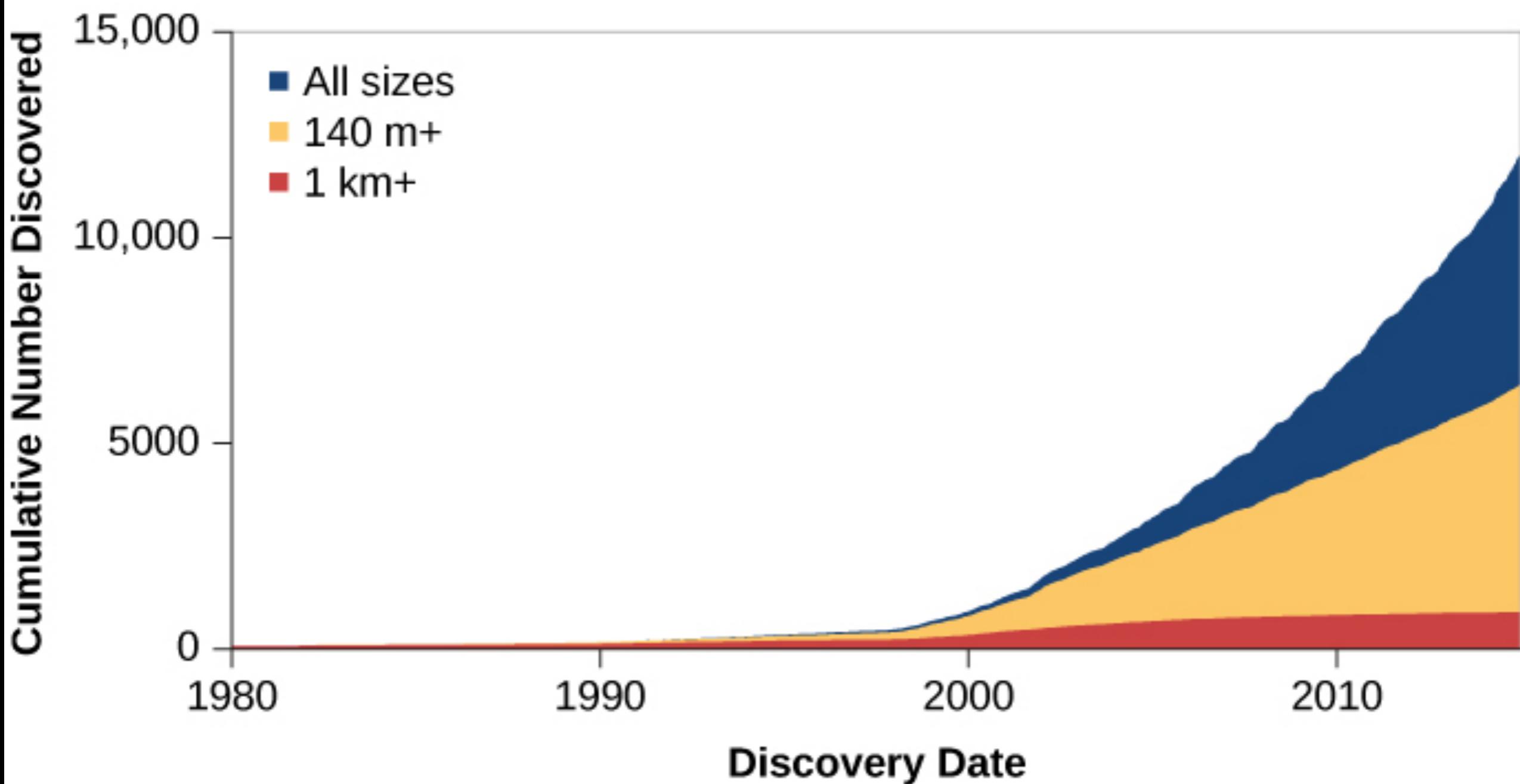


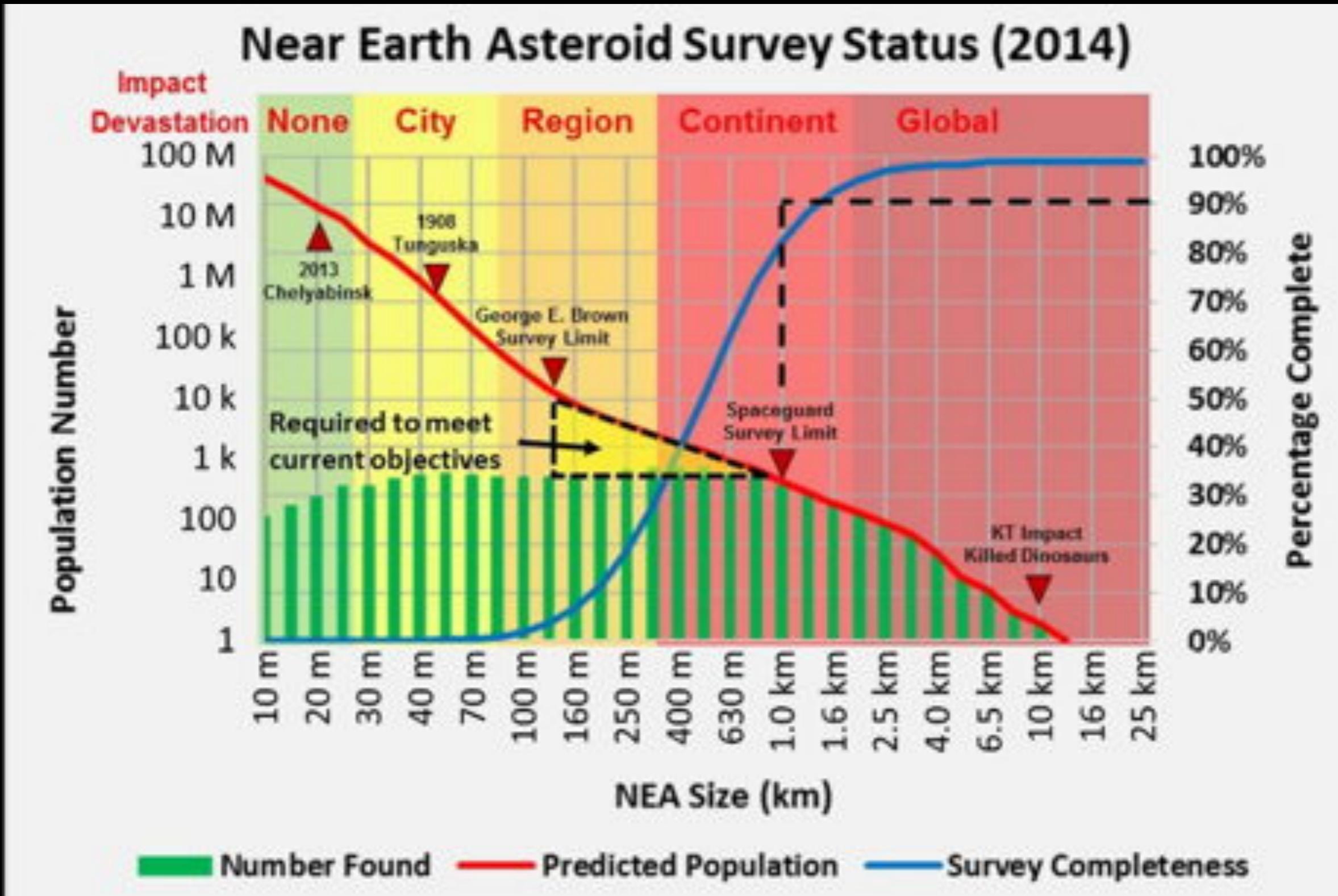
NASA Spaceguard Survey Program

- By 2012, Spaceguard had found what we think is 90% of all >1km asteroids
- Total identified and tracked: ~1,000 near-Earth asteroids at 1km and ~10,000 smaller objects
- Our guess at the total number out there is set by cratering rates on the maria of the moon



Near-Earth Asteroids Discovered





Summary of what has (and has not) been found

- NONE of the NEAs discovered thus far are on a trajectory to hit Earth
- There could be 1 million NEAs <1km but still large enough to destroy a city; we have found less than 10% of them
- If one of those smaller undiscovered asteroids is on a collision course with Earth, we won't see it until it hits our atmosphere ☹



NEOWISE Survey



NEOWISE Survey: 2013-2017

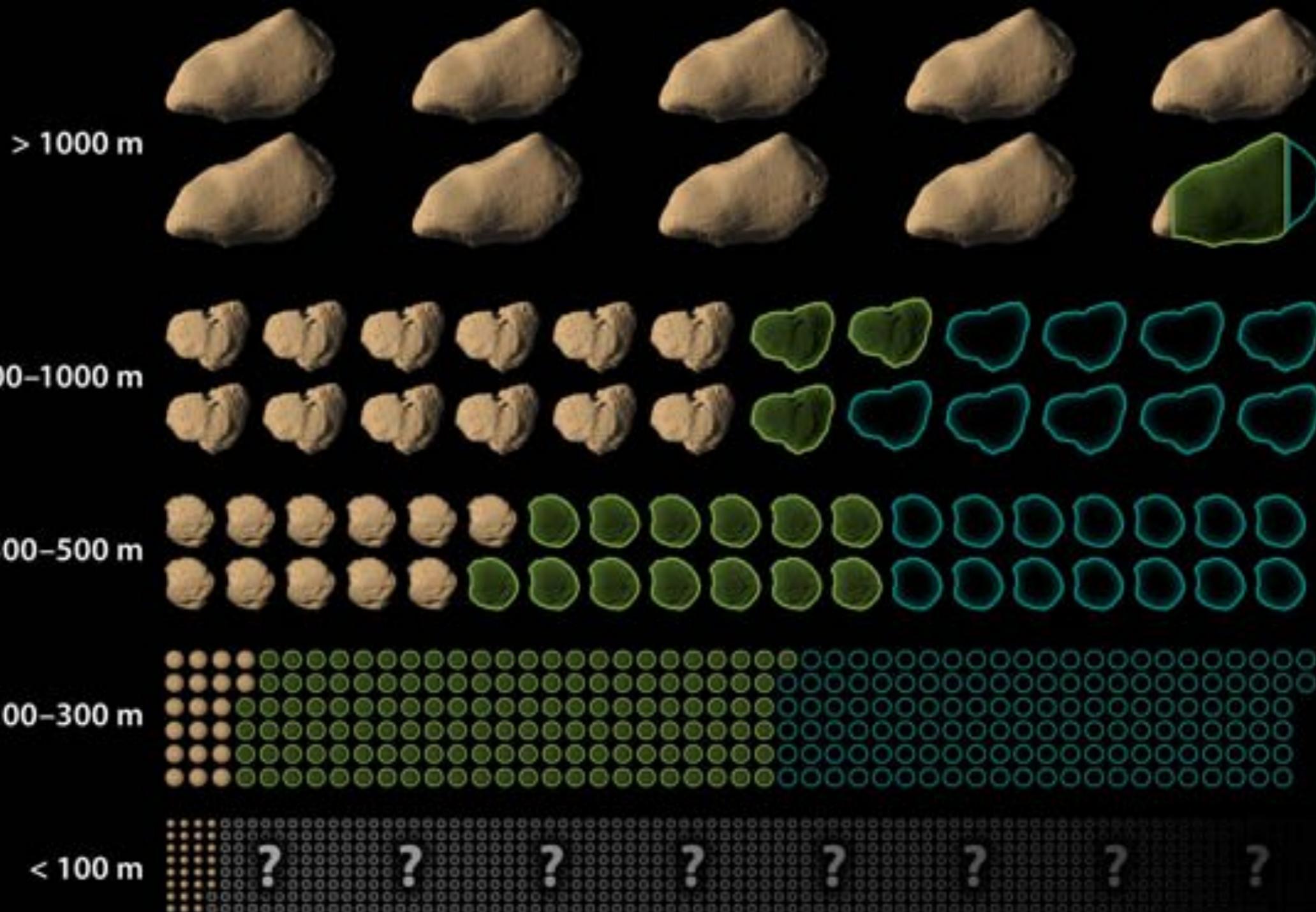
- NASA's Wide-field Infrared Survey Explorer (WISE) spent 4 years looking for near-Earth asteroids and comets
- It found more than 29,000 asteroids in infrared light
- 788 of these were near-Earth objects



A Near-Earth Asteroid Census

Each image represents 100 objects

Known Asteroids ●
New Predicted Total (WISE) ○
Old Predicted Total (pre-WISE) □



Next Five Close Approaches

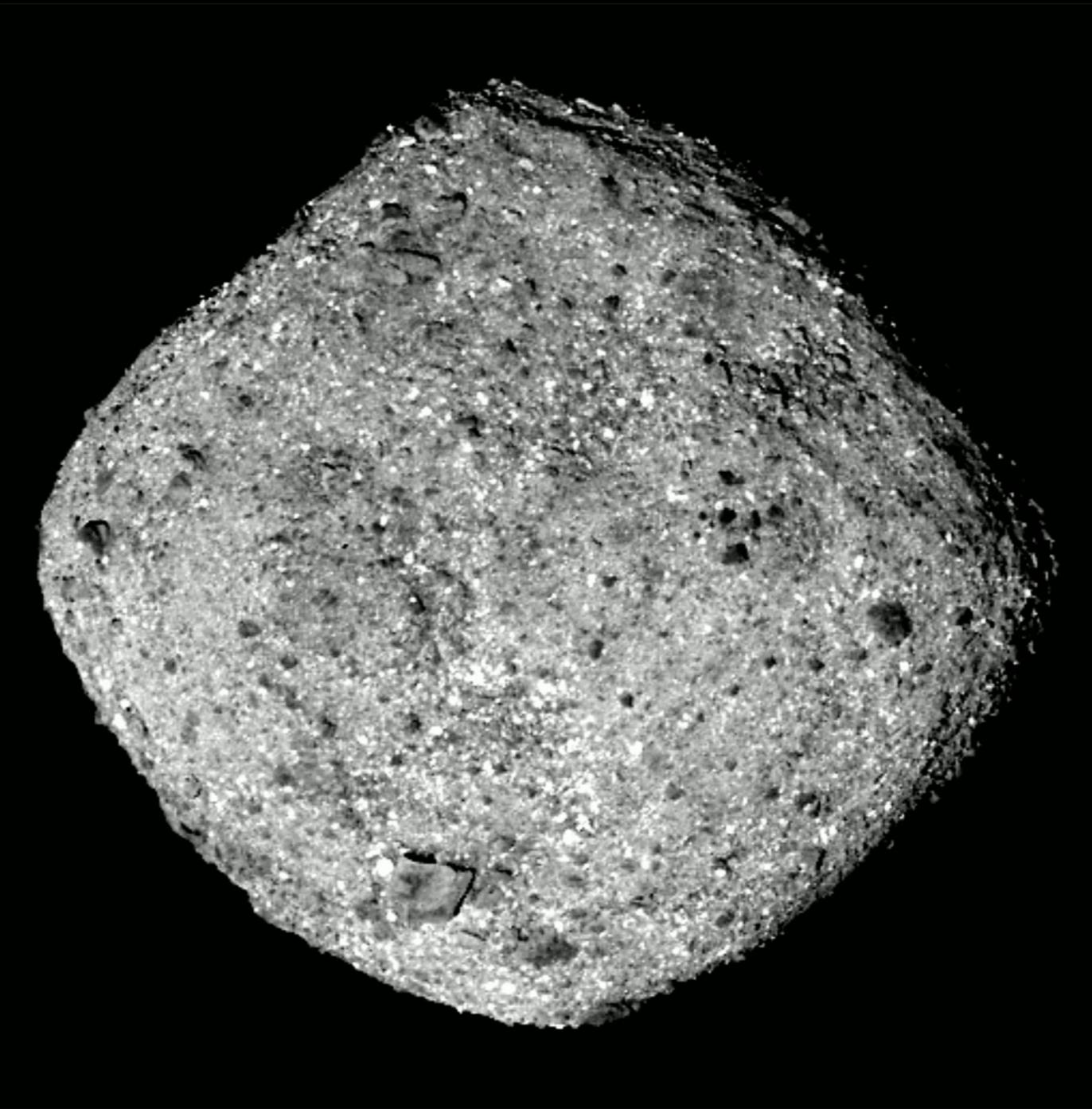


Average distance between Earth and the moon is about 239,000 miles (385,000 kilometers).

<https://www.nasa.gov/planetarydefense/>



Portrait of a near-Earth asteroid



Bennu



What's the deal with Bennu?

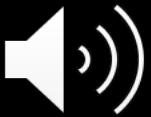
- It is one of the “primordial” asteroids containing material from the early solar system
- It may have broken off a larger carbon-type asteroid in the main belt some 1 billion years ago
- It then drifted closer to Earth because of gravitational interactions with the giant planets
- Bennu now has a close approach to Earth every 6 years
- It has a 1 in 2,700 chance of impacting Earth during one of its approaches in the late 22nd century



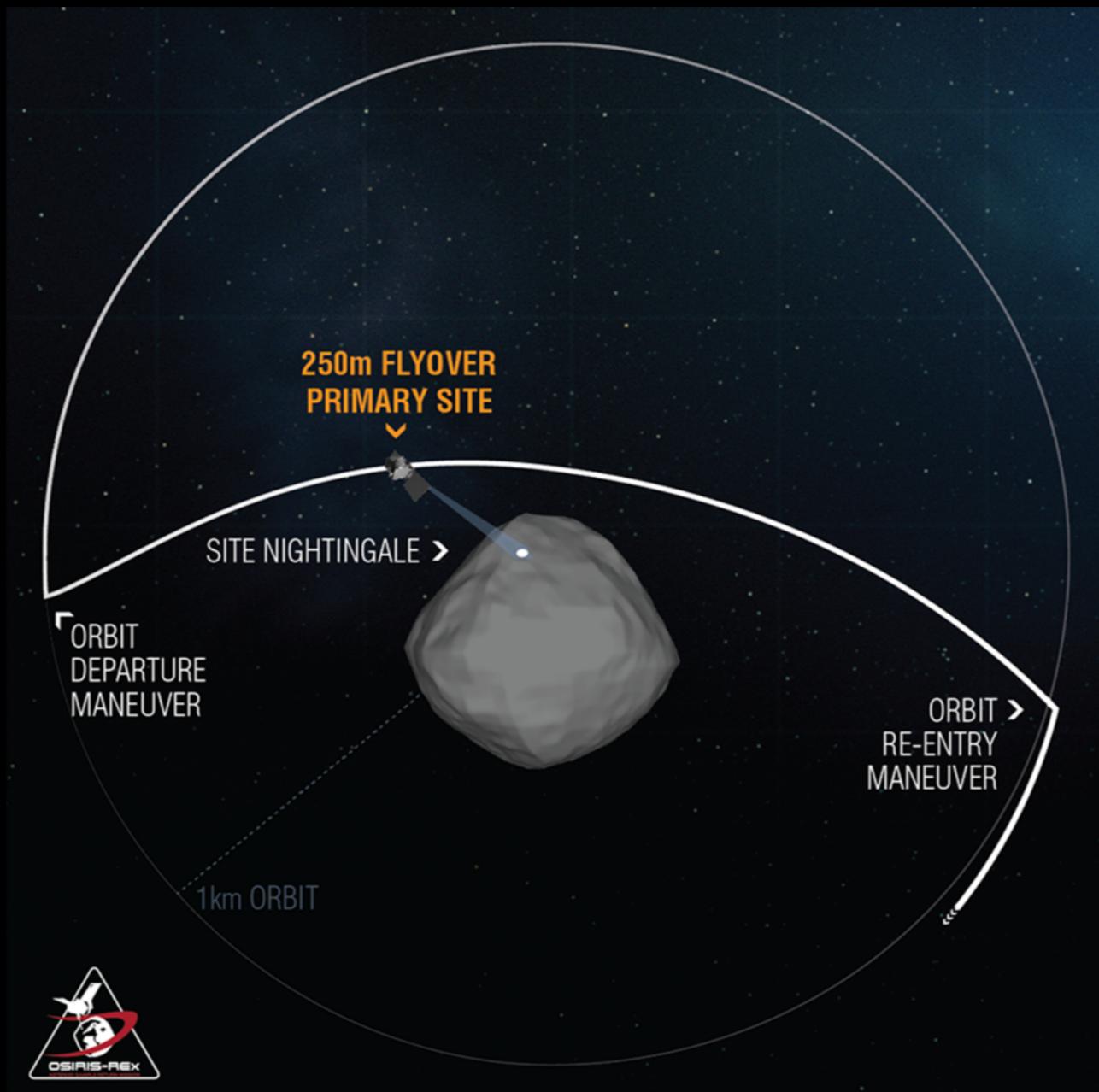
OSIRIS-REx mission to Bennu



NASA has sent a space probe there to obtain a sample!
<https://www.asteroidmission.org/>



OSIRIS-REx mission to Bennu



Flyovers happening now; sample acquisition
will take place this summer! Return to Earth in 2023. 🔊

Why do we need to know about asteroid composition and structure?



... in case we need to deal with the
threat of one headed straight for us!



Assessing threats

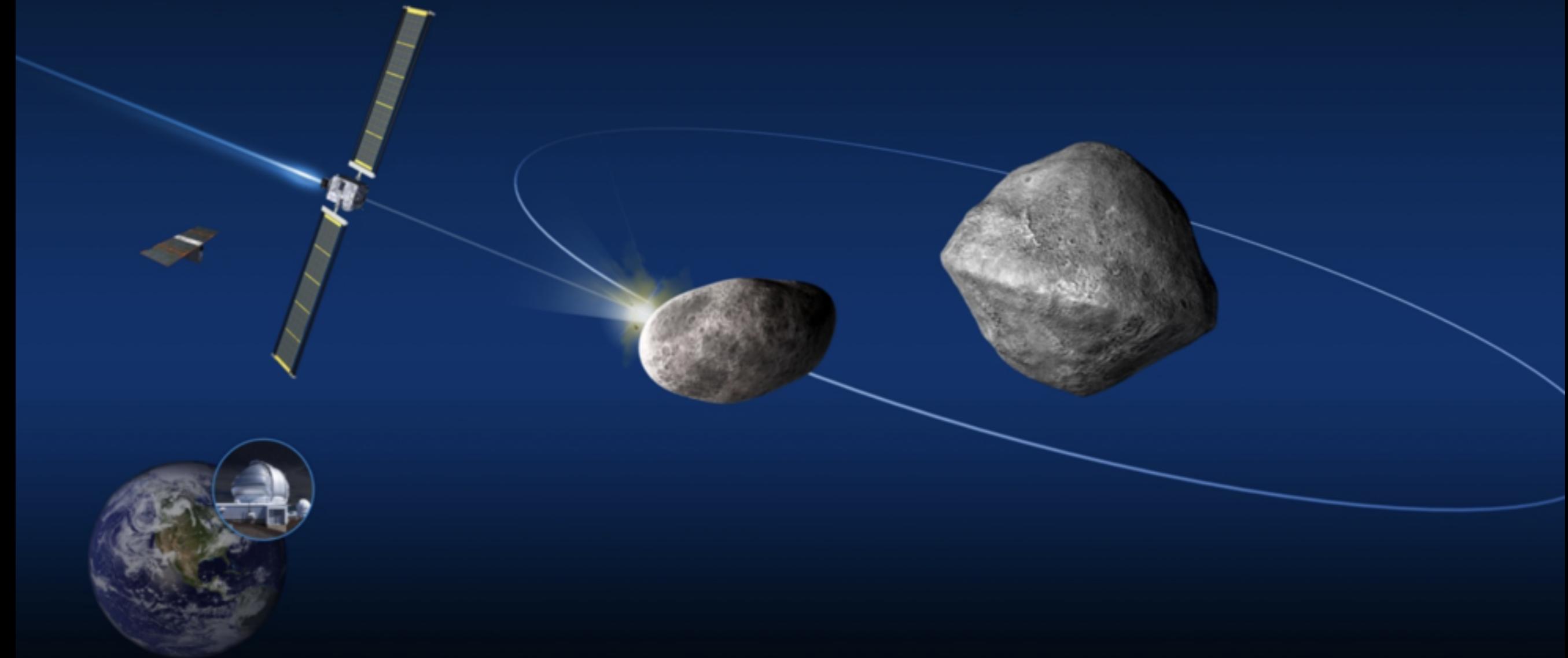
- Not all near-Earth asteroids will stay in our vicinity: Some could hit the Sun, while others could be ejected out of the inner solar system
- Need to keep monitoring all known NEAs, as their orbits are not stable
- New NEAs are also getting ejected from the main asteroid belt all the time
- If we do detect a real threat (i.e., Earth-crossing object), we may need to deflect it with a space craft



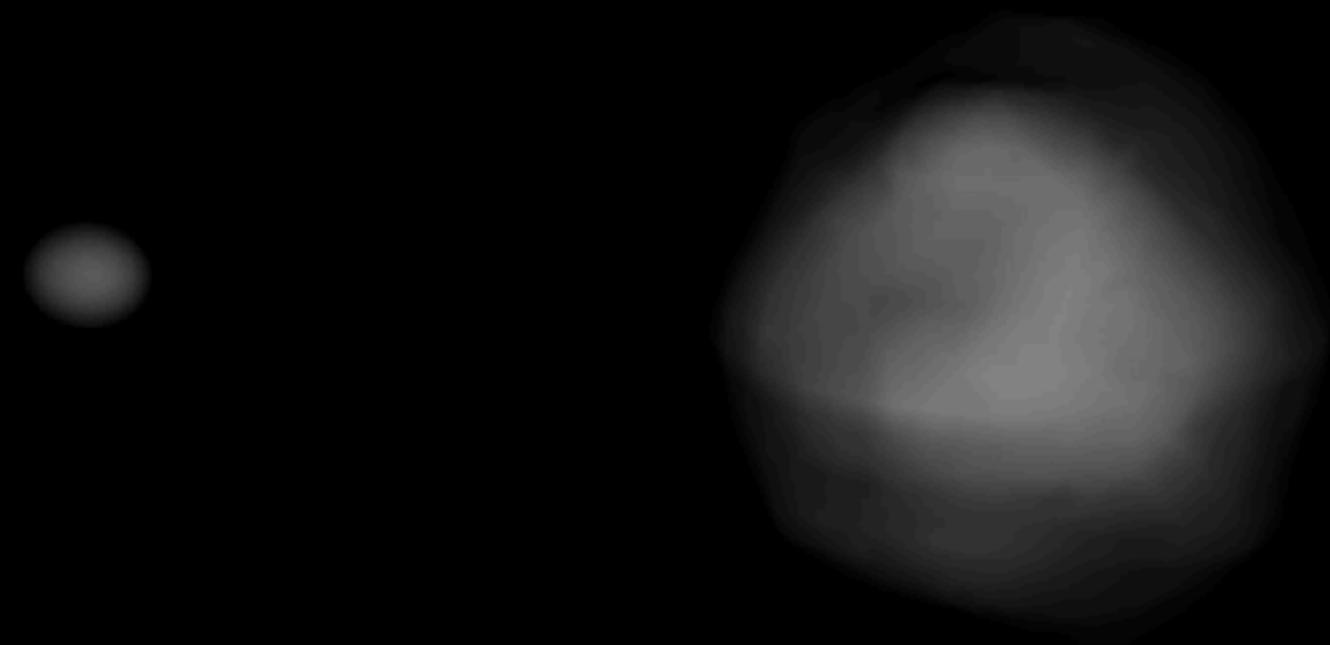
Asteroid Impact & Deflection Assessment \ AIDA

DART

Double Asteroid Redirection Test



DART mission to the Didymos system



In 2022, the 160m moonlet around an asteroid will be intentionally hit by a space probe. Goal is to measure how much its orbit changes as a result.

