NOT JUST "ROCKS FROM SPACE"—
Communicating the Conceptual Foundations of the NEO Hazard to Non-Science Professionals Through Short Videos

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What and Why

Discussions of NEO hazards involve professionals in diplomacy, defense, emergency management, and other fields, who may lack the foundational knowledge in astronomy that underlies the subject. Most multimedia materials, especially those for broadcast, emphasize the drama and perpetuate misconceptions, and do not help these people gain a better understanding.

"Asteroid Hazards: The View from Space" is a series of short videos that introduce time-constrained viewers to the key aspects of orbital dynamics, NEO observation, and impact prediction. They incorporate accurately computed orbits into computer-generated animations, which use strategically choreographed fly-arounds to develop a 3-dimensional perspective. While avoiding formal mathematics, they use correct quantitative concepts to encourage intuitive understanding of the spatial and temporal scales.

Chapter 1: Earth and Orbits (4 min)

Summary: Zoom-outs establish the sizes of Earth, the Sun, and Earth's orbit. Basic properties of planet orbits. Ceres compared with Earth; Ceres's orbit and why Main Belt asteroids are not hazardous. Orbits of Sisyphus and Midas distinguish between Earth-crossing and Earth-intersecting orbits. Size comparison of Geographos with Washington DC. Close-up on Midas and Earth orbits distinguish between potential and imminent hazards. Size of Earth relative to its orbit determines how precisely we must know NEO orbits (~ 0.01%) to predict impacts.

Key Concepts: Physical scales in the Solar System. Planets and asteroids orbit the Sun. An asteroid is hazardous only if its orbit intersects Earth's orbit, and only if both objects arrive at the intersection at the same time.

Misconceptions Confronted: That sizes of planets & asteroids are comparable to the distances between them; that Earth's orbit is highly elliptical; that asteroids impact Earth because they "fall out of their orbits".


Orbits of Earth and Sisyphus viewed so as to show that the orbits never meet; it's only when orbits intersect that an asteroid is a hazard.

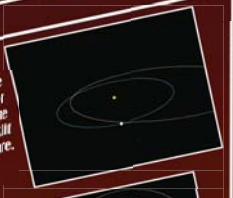

Orbits of Earth and Midas intersect, making Midas a potentially hazardous asteroid (PHA).

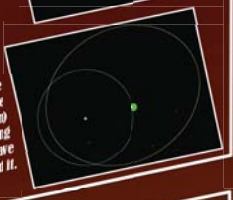
Chapter 2: The Challenge of Detection (6.5 min)

Summary: The orbit of the Chelyabinsk impactor and its approach to Earth, showing how relative orbital motions caused it to approach from the direction of the Sun. How an asteroid is seen by reflected sunlight, why it can be seen at greater distances when lit face-on than when lit from the side or backlit, and the "discoverable zone" around Earth, within which an object of given size and albedo can be detected by current searches. The impactor's orbit did not bring it into this zone at any time in past 30 years. Larger objects have larger discoverable zones; but even an object >4 times larger than Chelyabinsk, with ~100 times the impact energy, could, even now, be undetectable until impact.

Key Concepts: Small asteroids need to be close to Earth, and not in the direction of the Sun, to be discovered by current optical searches. Opportunities for discovery or observations can be separated by years, simply because the orbital motions do not bring Earth and the asteroid into close proximity.

Misconceptions Confronted: That PHAs are easily found and will always be visible in the night sky before impact; that PHAs that are discovered years before impact are at Jupiter-like distances.


In its final approach, the Chelyabinsk impactor seemed to dive from the direction of the Sun, backlit and lost in the glare.


In the months before impact, it never came into the zone (green) where operating surveys could have discovered it.

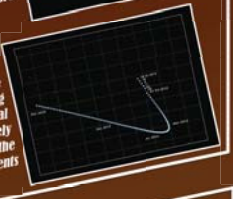
Chapter 3: Finding the Path (5 min)

Summary: Determining whether orbits intersect and when the asteroid will arrive at the intersection requires knowing its orbit precisely. Meaning of the 6 orbital elements; knowing the elements lets us calculate an asteroid's sky position. For a newly discovered object (2012 UE_{34} is the example), we find the elements that match calculated positions with observations. This reveals 2012 UE_{34} as a PHA; but discovery observations could not rule out impact in 2041. Follow-up in 2013 was critical in determining that 2041 is a near miss. This follow-up could not be done today, as 2012 UE_{34} is on the opposite side of the Sun. Earth moves its own diameter in 7 minutes; computing the arrival of an asteroid at a point in space to within a few minutes years in advance challenges our best techniques.

Key Concepts: Orbital elements define the orbit; they are determined by matching computed positions to observations. Additional follow-up observations refine the determination and make predictions more precise.

Misconceptions Confronted: That we need only measure how far away an asteroid is to determine when it will impact; that an impact can be predicted at the time of discovery.

If we know its orbital elements precisely, we can predict where an asteroid would be found in the sky at any time in the past or future.


Follow-up observations, in the months following discovery, are critical for precisely determining the orbital elements

Chapters 4 & 5: (in the works, suggestions welcome)

Likely Key Concepts: Orbits change slowly due to the weak gravitational pull of distant planets, oblateness of the Sun, general relativity, and radiation recoil (Yarkovsky). Orbits can change quickly in a close encounter with a planet, including Earth. So asteroid hazards can change over time. Predicting where on Earth an impact may occur requires extremely precise knowledge of the orbit. Radar measurements of distance and velocity on previous close encounters are instrumental in refining predictions.

Plans for Completion & Dissemination:

An unfamiliar disembodied voice can't be a trust agent. Produce a "Chapter 0" introduction to the series that puts a face to voice and a purpose to the series.

Chapters 0, 1, 2, 3 can stand together; add 4 & 5 later.

The goal is to provide accurate information, not advocacy.

Disseminate as an independent product, not a NASA product.

Discussions in progress (NASA may provide tech help) on optimal format for streaming video.

NASA NEO program can encourage broad use by providing links from high-traffic NEO web pages.