NEO Disaster Response and Recovery in the Context of Other Natural Hazards

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mit·i·ga·tion

- A little lesson in terminology

mit·i·ga·tion
/ˌmitəˈgāSHən/

Noun: The action of reducing the severity, seriousness, or painfulness of something.

Synonyms: allay, alleviate, assuage, ease, help, mollify, palliate, relieve, soothe

mit·i·ga·tion **DOES NOT really mean**

pre·ven·tion
/priˈvenCHən/

Noun: The action of stopping something from happening or arising.

So it DOES NOT really mean **de·flec·tion**

Purpose of this Presentation

- It is OK to consider deflection as a kind of mitigation, in that attempts to deflect may not be 100% successful.
- But my purpose is to convince you that 99.9% of NEO <u>mitigation</u> will have <u>nothing</u> to do with "deflection" (or "destruction") but instead with "disaster management," "civil defense," "risk management," "emergency preparedness," "risk communication," etc.
- I don't mean that "deflection" is not important, for it is necessary to prevent the worst disasters…it is just ***<u>not</u>*** what emergency managers will be dealing with almost every time there is a NEO crisis.

Mitigation = Reducing Consequences of a Hazard

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http://www.fema.gov/what-mitigation

***Deflection** is (at most) just one (rare) type of NEO mitigation*

FEMA

"Mitigation is the effort to reduce loss of life and property by lessening the impact of disasters."

- **"Mitigation" is taking actions long in advance of a potential disaster to lessen the consequences on human lives.**
- **Searching for NEOs, calculating chances that one might hit, and planning actions like deflecting the NEO or evacuating ground-zero are elements of a NEO mitigation plan.**
- **Many kinds of natural hazard mitigation measures (e.g. making housing earthquake tolerant) are focused on regions prone to particular disasters (faults, tornado-alley, coasts)…but NEO strikes are rare and can happen anywhere, so analogous mitigation measures are not cost-effective.**
- **NEO mitigation most often will mean accurate forecasting of a possible strike so that people can be warned in time to evacuate or shelter in place.**

Most Effects of a Modest NEO Impact are Familiar from other Natural Hazards

Meteorite punctured roof in Canon City, CO

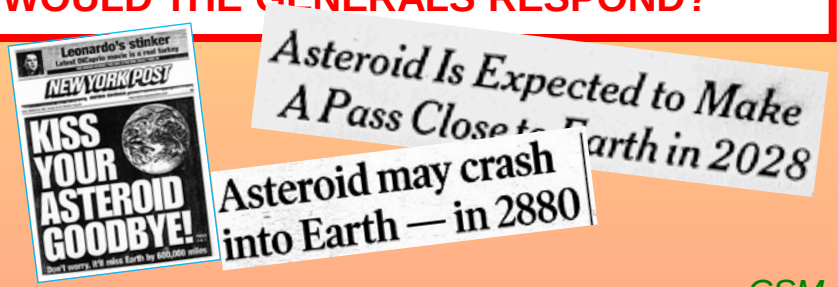
- Shock wave, strong winds
- Falling rocks, avalanches
- Seismic shaking
- Brilliant light and heat, maybe fire
- **So a NEO impact resembles, in some ways, an earthquake, a wildfire, a landslide, a volcanic eruption, and/or a windstorm.**

Russia starts meteor clean-up

All effects happen nearly simultaneously and act synergistically. Nevertheless, normal emergency response measures should generally apply.

Consequences from Small, Likely Impacts

OVER KOREA? OVER ISRAEL? HOW WOULD THE GENERALS RESPOND?



"…the other half prefer to believe in an assortment of bizarre explanations, including that the blast was a secret US weapon test, an off-course ballistic missile, a message from God, a crashing alien spaceship, or even an extraterrestrial trojan horse carrying a deadly space virus to wipe out the Earth…" CSM

- **Damage and casualties are at most like a minor natural disaster (e.g. tornado, wildfire).**
- **Public and national over-reaction after 9/11 (**stock market, homeland security hysteria, Iraq war**) could be replicated by a modest but unexpected impact disaster… but it *didn't happen in Chelyabinsk*.**
- **An otherwise harmless but brilliant bolide (fireball) could be mistaken for an atomic attack, causing a dangerous response…**
  - **but it d*idn't happen in Chelyabinsk***
  - **But if it happened today in Korea?**
- **Very rare events are poorly understood: only half of Russians polled believe the Chelyabinsk event was caused by a meteor.**

Consider Responsibilities of a Local Emergency Manager

- ***If there is advance warning*** *(of a near-term or future impact in the locality)*: **plan, prepare for human and infrastructure consequences, warn and advise, assist in evacuation and/or other appropriate responses…In other words *mitigate* potential injury and damage.**
- ***If there is NO warning*:**
  - **Use existing disaster response plans and protocols since effects will likely be similar to other disasters.**
  - **Calm anxieties by explaining to citizens that, despite the unusual nature of the disaster, there will not be unusual radioactivity; moreover, follow-on impacts are extremely unlikely.**
  - **Proceed with social and infrastructure recovery in the usual way, emphasizing that another NEO impact in that locality is extremely unlikely.**
  - **So unlike cases of earthquakes, floods, forest fires, etc., an impact disaster is not a wake-up call for retrofitting buildings, etc. to be prepared for the next NEO impact. (Protective mitigation against more common disasters is, of course, generally warranted.)**

The Torino Scale: NEO Scientists Attempt to Communicate Risk

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Inspired by XF11: 1999

THE TORINO SCALE

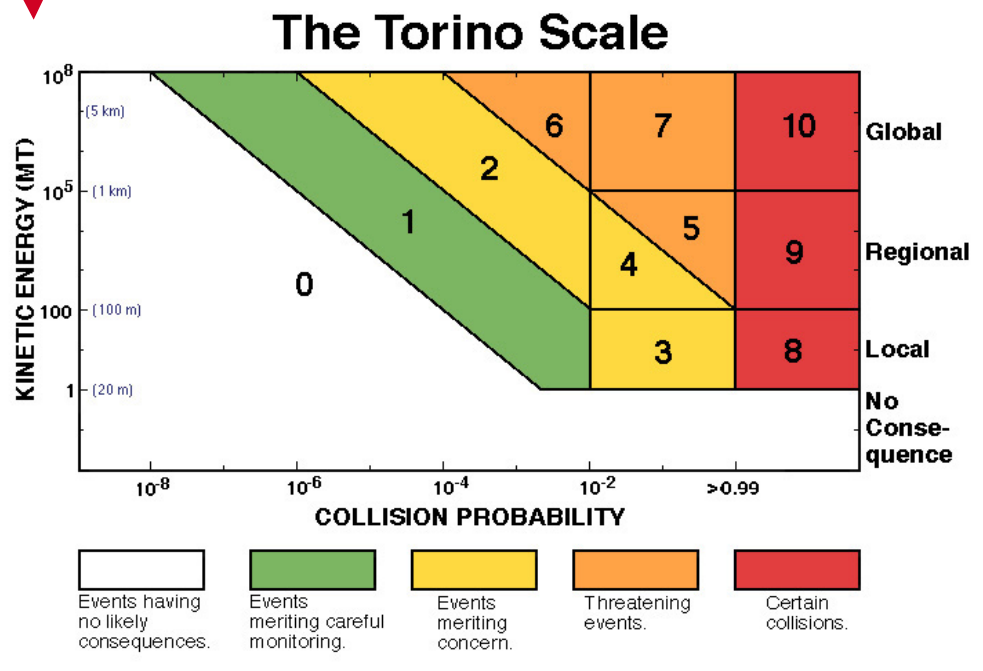
Assessing Asteroid and Comet Impact Hazard Predictions in the 21st Century

The actual Torino Scale

Events Having No Likely Consequences	0	The likelihood of a collision is zero, or well below the chance that a random object of the same size will strike the Earth within the next few decades. This designation also applies to any small object that, in the event of a collision, is unlikely to reach the Earth's surface intact.
Events Meriting Careful Monitoring	1	The chance of collision is extremely unlikely, about the same as a random object of the same size striking the Earth within the next few decades.
	2	A somewhat close, but not unusual encounter. Collision is very unlikely.
Events Meriting Concern	3	A close encounter, with 1% or greater chance of a collision capable of causing localized destruction.
	4	A close encounter, with 1% or greater chance of a collision capable of causing regional devastation.
	5	A close encounter, with a significant threat of a collision capable of causing regional devastation.
Threatening Events	6	A close encounter, with a significant threat of a collision capable of causing a global catastrophe.
	7	A close encounter, with an extremely significant threat of a collision capable of causing a global catastrophe.
	8	A collision capable of causing localized destruction. Such events occur somewhere on Earth between once per 50 years and once per 1000 years.
Certain Collisions	9	A collision capable of causing regional devastation. Such events occur between once per 1000 years and once per 100,000 years.
	10	A collision capable of causing a global climatic catastrophe. Such events occur once per 100,000 years, or less often.

Many journalists actually used this scale. But Homeland Security turned such scales into a joke. Effectiveness of Torino/Palermo scales is unclear.

Diagram scientists use to determine value in particular case



How to Recover from a NEO Impact

Holistic Disaster Recovery

See Chap. 2: The Disaster Recovery Process

Ideas for Building Local Sustainability After a Natural Disaster (2006)

Produced by the Natural Hazards Center with funding from the Public Entity Risk Institute (PERI).

The 2006 version of *Holistic Disaster Recovery* (140 pp., $35.00) is currently only available from PERI; (703) 352-1846 ; http://www.riskinstitute.org/.

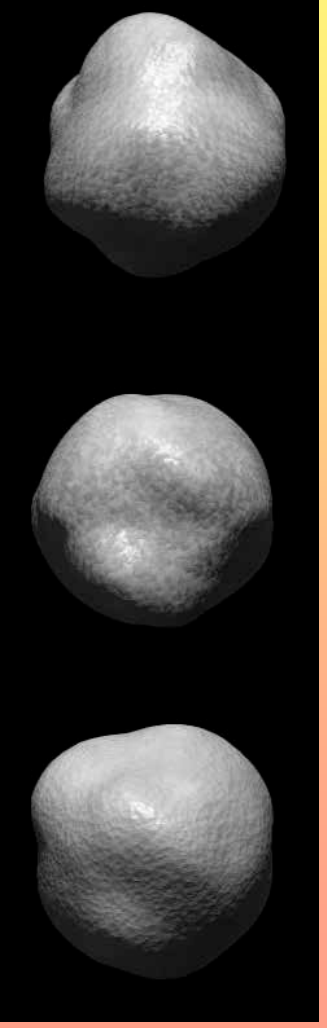
This handbook was originally produced in 2001 as a guide for local practitioners on how to build sustainability into a community during the recovery period after a disaster. In the fall of 2005, after witnessing the catastrophic devastation of the Gulf Coast of the United States from Hurricanes Katrina and Rita, and as the nation was embarking on a recovery period of unprecedented scale in its history, the Natural Hazards Center took a second look at *Holistic Disaster Recovery* and how it could be improved to help communities take a comprehensive and long-term approach to recovery.

- **Recovery is about people: restoring individual lives, social elements that sustain a community**
- **Recovery is also about restoring infrastructure**
- **Recovery takes time, costs lots of money**
- **This handbook is an example of the widely accepted practices, based on social science and experience**
- **Recovery from NEO impact resembles recovery from more common disasters**

What is the Smallest NEO that is Dangerous? [2008]

THEN THERE WAS CHELYABINSK

Model of 30 m NEA 1998 KY26 (radar)



This will be a vital issue for decision-makers

- **2003 SDT report said that the smallest truly dangerous non-metallic impactor is ~50 m diameter.**
- **Boslough** (2007)**: downward momentum from atmospheric blasts** è **Tunguska caused by ~40 m (not 70 m) NEO.**
- **25 m NEOs impact ~10 times as often as 50 m NEOs, once per century.** (They may merit deflection, surely evacuation.) **A 10 m NEO strikes 1,000 times as often as a 100 m NEO.**
- **There are many uncertainties in how big/massive an NEO is and thus its likely damage…so a prudent emergency management official might choose to issue a warning to evacuate or shelter in place for even much smaller NEOs.**
  - **Anomalous 2007 impact explosion in Peru by ~1-2 m NEO.**
  - **Child may have been killed (indirectly) by ~10 m NEO impact above Indonesia on 8 Oct. 2009.**
- **Officials must make decisions and act prudently once the new surveys start discovering thousands of smaller NEOs and some appear (within uncertainties) likely to impact.**

What is the Smallest NEO that is Dangerous? [2013]

- Chelyabinsk ***was*** dangerous, even though nobody was killed.
- It would have been even ***more*** dangerous if it hit at a steeper angle.
- If a future impact is ***predicted*** to be as big as Chelyabinsk, uncertainties in mass, density, diameter, and albedo mean it ***could*** be 10-20 times as energetic, ***or*** something thought to be 10-20 times less energetic ***could*** be as bad as Chelyabinsk.
- Rare ones (metallic, aerodynamic shape) just meters in scale ***could*** hit at high velocity.
- **So: a prudent emergency manager would *warn* about an NEO *estimated* to be >5-10 m diameter and *evacuate* if *estimated* to be >15-20 m.**

2008 TC3 & Short-Term Warnings

Discovery and short-term warning enables: (a) pre-impact telescopic observations, (b) bolide observations, (c) meteorite recovery, and (d) warning to evacuate or shelter in place

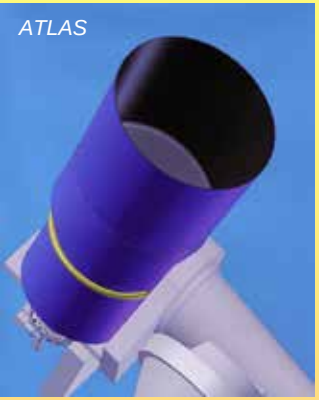
- **2008 TC3 was the first NEA ever discovered** (Catalina Sky Survey, 7 Oct. 2008) **that was then predicted, for sure, to strike the Earth. It was then observed with many telescopes before it hit.**
- **19 hours after discovery, the predicted impact occurred and was recorded, and many resulting meteorites were later collected on the ground.**
- **This first-ever event was not a fluke: we must expect future predictions of small NEA strikes, even from the existing Spaceguard Survey. But there are "next generation" surveys.**
- **The most likely warning of an actual hazardous NEA impact will be one of these "final plungers," providing hours to weeks of warning.**
- **Evacuation, not NEA deflection, will be by far the most likely kind of "mitigation" we must plan for.**

ATLAS-like Surveys Could Detect up to Half of "Final Plungers"

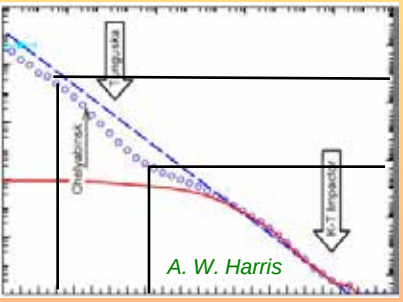
As search programs like ATLAS get underway, the number of NEO near-misses and actual strikes making news, meriting warnings…plus many more tinier, iffy ones, will vastly increase.

- **The "Asteroid Terrestrial-impact Last Alert System"** (Univ. of Hawaii)
- **Two small telescopes are being designed to search for tiny asteroids as they get unusually bright during the last days and weeks before they hit.**
- **The 50% coming from roughly the direction of the Sun could <u>not</u> be detected.**
- **Late detection is much too late for deflection, but for these very small asteroids <u>warning</u> and <u>evacuation</u> would be made possible.**
- **ATLAS: NASA funded (inexpensive) and may be operational in 2015.**

The Overwhelmingly Most Likely Kind of Mitigation: Civil Defense, **Not** Deflection



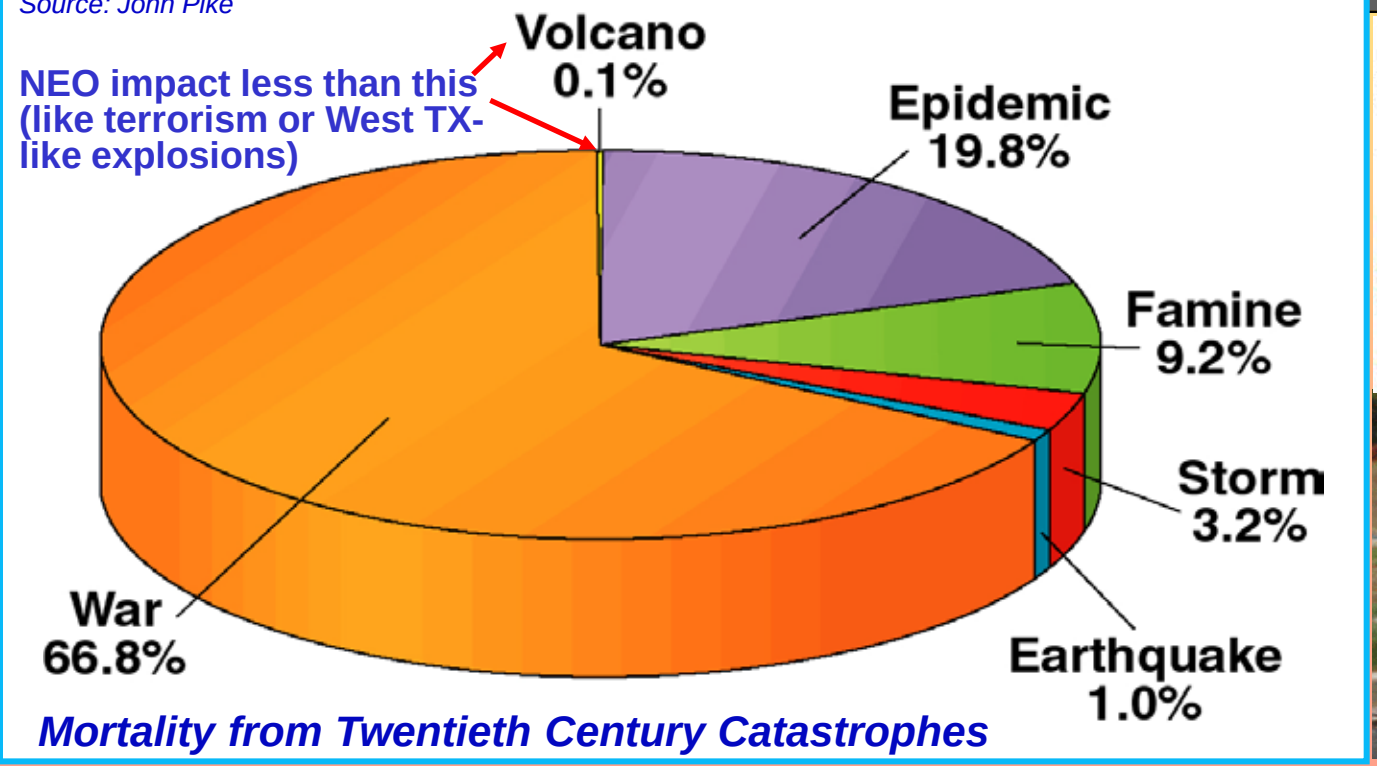
- Let's say prudent emergency managers should ***warn*** of an impending impact for NEOs > 10 m diameter.
- Let's say that a ***deflection*** mission would typically be merited only for NEOs > 100 m diameter.
- Because of the power-law size-frequency distribution, there would be 1,000 warnings for every deflection if all were found.
  - Of course, we now know <20% of 100 m NEOs and <<0.1% of 10 m NEOs, so in both cases the first warning would likely be a superbolide in the sky and an explosion… perhaps requiring emergency response measures.
  - But fairly soon, deployment of ATLAS-like searches will find maybe tens of percent of >10 m NEOs on impact paths; searches like Sentinel will find most >100 m NEOs, replacing emergency responses with warnings and, very rarely, a deflection mission.
- For every actual impact or deflection attempt, there will be ***many*** significant impact ***possibilities***, until orbits are refined, so NEO threats will be in the news.
- And emergency managers will be busy issuing warnings!



How Important is NEO Threat? We've Many Other Things to Worry About!

9/11

Source: John Pike



Mortality from Twentieth Century Catastrophes

But Natural Hazards (& NEOs) Command our Attention

- Consider the consequences of Katrina, the Japanese earthquake and tsunami, the Indian Ocean tsunami, storm Sandy…think back to what Vesuvius did to Pompeii.
- Consequences may involve mass mortality, but even lesser events can topple governments and change the way we think of ourselves in relation to nature.
- The impact hazard is commanding much attention lately…it is a very minor hazard compared with others, but it has the nearly unique trait that we can ***predict*** when and where an NEO might hit so that we *can* warn people to get out of the way. In very rare cases that is not enough, but we *can* then deflect the oncoming NEO so it does not hit.

Civil Defense: Mitigation, Preparedness, Warning, Response, Recovery

- **The End**