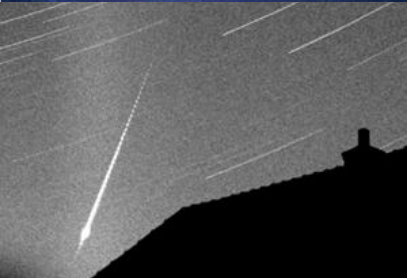


Pat Rawlings, SAIC



# An Asteroid Scientist's Perspective on how the Media has Handled NEOs Over the Years

**Clark R. Chapman**  
*Southwest Research Institute*  
*Boulder, Colorado, USA*

*NEO Media/Risk Working Group*  
*Secure World Foundation/ASE*  
*LASP, University of Colorado at Boulder*  
*14 November 2011*

# Menace of Meteors Like Huge Bombs from Space

## HURRICANE OF FLAME BLAZING BOLTS FIRE FORESTS MANKIND'S LUCK

Another colossal bombardment of the earth from outer space has just been revealed.

Three great meteors, falling in Brazil, fired and depopulated hundreds of miles of jungle.

NEWS of this catastrophe has only now reached civilisation because the meteors fell in the remote South American wilderness.

It was yet another lucky escape of mankind from an appalling and unfeared peril.

The last great meteor fell in Siberia in 1908. In a district so remote that only last year were details of its destruction given to the world.

Had either of these two meteor falls chanced to strike a city in a densely-populated country, frightful loss of life and damage would have been caused.

"A meteor," Mr. C. J. P. Cave, an expert of the Royal Meteorological Society, stated recently, "carries in front of it a mass of compressed and ionised air."

"When it strikes the earth, this air 'splashes' in a hurricane of fire."

The Brazilian meteors are reported (says the Central News) by Father Fidelio, of Aviana, writing from San Paulo de Olivenca, in the State of Amazonas, to the papal newspaper, "Osservatore Romano."

### BLAZING FOREST

The meteors fell almost simultaneously during an amazing storm.

Terrific heat was engendered. Immediately they struck the ground the whole forest was ablaze.

The fire continued uninterrupted for some months, depopulating a large area.

The fall of the meteor was preceded by remarkable atmospheric disturbances.

At 11 o'clock in the morning the sun became blood-red, and a penumbra spread all over the sky, producing the effect of a solar eclipse.

Then an immense cloud of reddish powder filled the air and it looked "as if the whole world was going to blow up."

WHISTLING SOUND

THE DAILY HERALD  
(LONDON, ENGLAND)  
6 MARCH 1931

There were ancient fears of comets



## 80 Years Ago...

- Only four Near Earth Asteroids had been discovered by 1931
- So there had been almost no thinking about the impact threat
- This report of "meteors" exploding in the Brazilian jungle, burning down vast regions, cannot be confirmed
- But such an event is certainly possible, like Tunguska in 1908
- Treatment in this British newspaper was certainly sensational
  - "menace", "huge bombs", "hurricane of flame", "blazing bolts"

# 4581 Asclepius = 1989FC, 23 Mar. 1989: “Near Miss Day”

## Big Asteroid Passes Near Earth Unseen In a Rare Close Call

By WARREN E. LEARY, Special to the New York Times  
 Published: April 20, 1989

**The New York Times**

In cosmic terms, it was a close call.

A large asteroid capable of wreaking widespread damage if it collided with Earth passed within half a million miles last month, the closest approach of such an object in 50 years, astronomers said today.

The asteroid, a collection of rock and dust half a mile or more in diameter, crossed Earth's orbit undetected March 23 at a distance equal to twice that between Earth and the Moon. Object Will Return

Scientists later calculated that the asteroid, traveling at 46,000 miles an hour, is orbiting the Sun once a year on an elliptical path that regularly brings it back toward Earth.

"It can come this close or closer in the future," said Dr. Henry Holt, the Northern Arizona University astrogeologist and astronomer who discovered the object in photographs taken March 31 using the 18-inch Schmidt telescope at the Mount Palomar Observatory in California. "We'd like to know more about it and when it's coming."

*Now They Tell Us!  
 But Where Would  
 You Run, Anyway?*

\* \* \*

Asteroid Big Enough to Level  
 A City Was in 'Near Miss'  
 With Earth on March 23

By BOB DAVIS

Staff Reporter of THE WALL STREET JOURNAL  
 WASHINGTON—Whew!

An asteroid big enough to destroy all of New York City and a good part of Long Island skirted as close to Earth on March 23 as any large asteroid has in at least a century, the National Aeronautics and Space Administration reported.

**“The passage of  
 1989FC was the  
 closest to Earth  
 since 1937.”**

Google

near miss day

Search

About 197,000,000 results (0.21 seconds)

Everything

Images

Maps

Videos

News

Shopping

More

[Near Miss Day at Holiday Insights](#)

[www.holidayinsights.com/moreholidays/March/nearmissday.htm](http://www.holidayinsights.com/moreholidays/March/nearmissday.htm)

**Near Miss Day** commemorates the day a huge Asteroid nearly missed hitting the earth.

[March 23 - Near Miss Day](#)

[www.goatview.com/march23.htm](http://www.goatview.com/march23.htm)

List of saints celebrating feast **days** on March 23 plus some famous birthdays.

[Near Miss Day!](#)

[oddlivescompany.com/blog/2011/03/near-miss-day/](http://oddlivescompany.com/blog/2011/03/near-miss-day/)

Mar 23, 2011 – **Near Miss Day** commemorates the day a huge Asteroid nearly missed hitting the earth.

Boulder, CO

Change location

[Near Miss Day: Information from Answers.com](#)

[www.answers.com > Library > History, Politics & Society](http://www.answers.com > Library > History, Politics & Society)

**Near Miss Day** Mar 23, 1989. A mountain-sized asteroid passed within 500000 miles of Earth, a very close call according to NASA.

All results

Sites with images

Related searches

More search tools

[National Near Miss Day March 23rd | Facebook](#)

[www.facebook.com/group.php?gid=126761435315](http://www.facebook.com/group.php?gid=126761435315)

Sign UpNational **Near Miss Day** March 23rd is on FacebookSign up for Facebook to connect with National **Near Miss Day** March 23rd. National **Near Miss Day** ...

[Society: EVENTS: Near Miss Day \(March 23rd\), History of Near Miss ...](#)

[www.altiusdirectory.com > Society > Events > Famous Events](http://www.altiusdirectory.com > Society > Events > Famous Events)

Mar 3, 2009 – **Near Miss Day** celebrates the day a colossal Asteroid almost missed hitting the earth. On 23rd March, 1989, an asteroid the dimension of the ...

[My Vintage Addiction » Happy Near Miss Day :: Vintage Asteroids](#)

[myvintageaddiction.com/.../happy-near-miss-day-vintage-asteroids/](http://myvintageaddiction.com/.../happy-near-miss-day-vintage-asteroids/)

Mar 23, 2010 – Today we celebrate **Near Miss Day**, the anniversary of March 22, 1989- the day the 4581 Asclepius asteroid passed by the Earth at a distance ...

[Did the Earth almost ... - Archive of Astronomy Questions and Answers](#)

[www.astronomycafe.net/qadir/q2879.html](http://www.astronomycafe.net/qadir/q2879.html)

Mar 23, 1989 – ... 22-23 there was a **near miss** which went un noticed by strong moonlight but the object was detected 8 **days** later and cataloged as 1989FC. ...

# 2005 YU55: Passed Close Last Week!



## ● Multi-hundred meter NEO passed Earth at 0.84 lunar distance last Tuesday p.m.

### ● “aircraft carrier-sized asteroid” [400m]

- in length, possibly, but masses of aircraft carriers are 100x less
- actual astronomical data aren't formally published, inconsistent; probably it is <300 m diameter [preliminary results: ~300 m]
- “4000 megaton,” “mag. 7 quake”: well, less than that...but experts' mistake

### ● “within 0.8 lunar distances” [0.84]

### ● “closest approach [of an NEO] this size in over 30 years”

- but 1976 NEO wasn't known then
- and many NEOs this size aren't yet known today

### ● Next time: “2028... 0.6 lunar dist.”

### ● “it will be a daylight object until... November 8.”

- “daylight object” can mean “so bright you can see it in the daytime”: no way!

EDITION: U.S. | INTERNATIONAL | MÉXICO | ARABIC  
TV: CNN | CNNI | CNN en Español | HLN

**Nov. 3**

CNN

Home Video NewsPulse U.S. World Politics Justice Entertainment Tech Health LI

light years

MAIN NEWS IN SPACE ON EARTH

Seen through a radar telescope, the 1,300-foot wide asteroid will come within 202,000 miles of Earth -- closer than the moon.

**November 3rd, 2011**  
01:13 PM ET

Share  
Comments (451 comments)  
Permalink


**Asteroid to pass closer to Earth than the moon**

An aircraft carrier-sized **asteroid**, a little over four football fields in diameter, is heading toward Earth and it will pass closer to our planet than the moon.

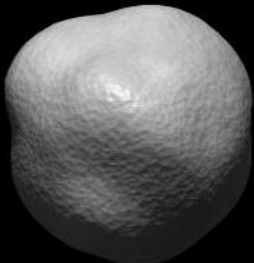
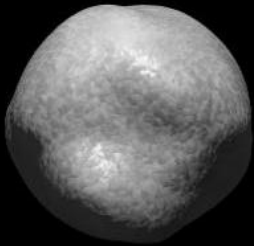
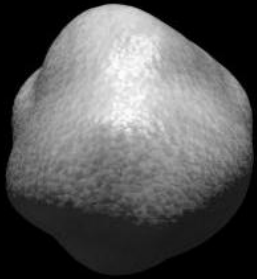
Recommend 2k

# Scientists Read a News Item Critically ...as Though it were a Scientific Paper

(Not that they should, but they do...and I do, too)

- **Minor Mistakes:** names, dates, numbers inexact
- **More Serious:** fundamental facts wrong, important caveats missing
- **Most Egregious:** the main story is highly misleading, greatly exaggerated, or just plain bogus
- **Sources of error:**
  - scientists screw up, have agendas, communicate poorly
  - reporters are untrained, hastily on deadline, or sloppy
  - fewer science journalists, more weathercasters
  - pressures to sensationalize
  - improper, biased, erroneous institutional press releases
  - 24/7: failures to place specifics into the broader context
  - cheap, simplified graphics mislead or are wrong
  - headlines or sound-bites misrepresent the larger story
  - reporters may go to highly biased or quack sources
  - readers/viewers lack scientific literacy (uneducated), so they misinterpret implications of even accurate stories
  - nature teaches us, so the science changes, too rapidly
  -  media-to-media serial accumulation of mistakes

Model of 30 m  
NEA 1998  
KY26 (radar)



# Serial Mistakes (?) by the Media

Tucson, Sunday, December 10, 1989

The Arizona

## Geophysicists suggest steps Earth can take to reduce disastrous tolls of natural hazards

By Lee Siegel  
 The Associated Press

SAN FRANCISCO — Earth is racked by quakes, floods, slides, storms and volcanoes — not to mention an occasional 100,000-megaton whack from an asteroid. But sitting ducks can fight back, geophysicists say.

As the American Geophysical Union ended its five-day fall meeting Friday, suggestions for reducing death and destruction from natural hazards included requiring tornado shelters in mobile-home parks, planning land use to avoid quake and slide damage, and steering incoming asteroids away from Earth.

An asteroid two-thirds of a mile wide hits Earth about every 300,000 years, and today it could kill more than half Earth's population because of climate and direct effects of a blast equal to 7.7 million Hiroshima-sized atomic bombs, said Clark Chapman of the Planetary Science Institute in Tucson and David Morrison of the National Aeronautics and Space Administration's Ames Research Center in Mountain View, Calif.

Conservatively assuming a 50-year human lifespan, that means any person has about a 1-in-6,000 chance of being killed by an asteroid during his or her lifetime, compared with an American's 1-in-20,000 chance of dying on a plane crash or 1-in-50,000 chance of being killed by a tornado, said the pair, who wrote the book "Cosmic Catastrophes."

"This is, in fact, a real hazard," Chapman said. "We're in a shooting gallery."

Even a small asteroid impact "could be mistaken for a nuclear attack," he said. "It might trigger a nuclear attack."

One asteroid passed within 500,000 miles of Earth this year, about twice the moon's distance, and a small one devastated an uninhabited part of Siberia in 1908. So it makes sense for society to better evaluate likely consequences of a collision and use telescopes to provide years' notice of incoming asteroids, Chapman said.

"It's within our technical capabilities to design a space mission to nudge the asteroid out of the way" by using special rocket engines or perhaps hydrogen

bombs, although bombs might break an asteroid into more deadly fragments, he said. "It would be an Apollo-project level of expense."

Most scientists discussed more common natural disasters during Friday's session.

"It's absolutely imperative we insist mobile-home parks have secure underground shelters" in tornado and hurricane-prone regions, said Joseph Golden, senior meteorologist for the National Oceanic and Atmospheric Administration.

Golden said home designers need to pay more attention to wind-resistant cladding for buildings, and build homes with interior closets and bathrooms, which often are the only parts of a house left standing after a bad hurricane.

Better effort also is needed to predict hurricane tracks and intensities, and to learn if building codes are adequate for typical wind speeds, he added.

Robert Tilling, a U.S. Geological Survey volcanologist, said 25,000 people died during the Nevado del Ruiz volcano eruption in Colombia in 1985 because local officials ignored hazard maps, signs of impending eruption and formal warnings by scientists.

He called for better communication between scientists and officials, increased monitoring of volcanoes that now go unwatched in developing nations, and improvements in predicting volcanic activity.

Earl Brabb, a Geological Survey geologist, said it is "a national disgrace" that there is a lack of aerial photographs to identify areas prone to deadly landslides, which cause tens of billions of dollars damage globally each year.

Geological Survey seismologist William Ellsworth said researchers are getting better at making long-term forecasts of which segments of faults are prone to destructive quakes.

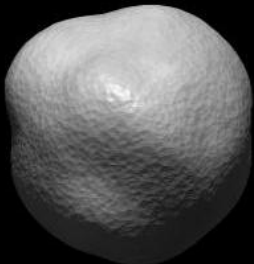
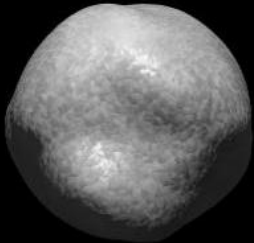
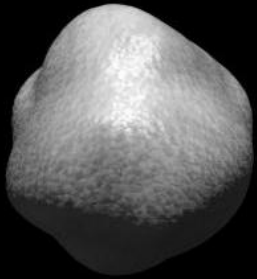
He said emergency officials believe public safety during the deadly Oct. 17 San Francisco Bay area quake was improved because people made preparations after scientists warned in 1988 that the San Andreas Fault was due for a jolt near the bay's south end.

- Professional talk by Chapman & Morrison at AGU meeting in 1989
- An OK Assoc. Press story
- Picked up by New China News Agency, broadcast as leading story on Chinese evening television newscast, saying asteroid will strike China next week
  - reportedly, crying women carry their babies into the streets
  - *N.Y. Times* reports theory by U.S. foreign policy experts that this is NOT a mistake but a policy decision by the Chinese government to provide a reason for China to retain its nuclear missiles

Just 2 months after Loma Prieta earthquake

# Scientists Read a News Item Critically ...as Though it were a Scientific Paper

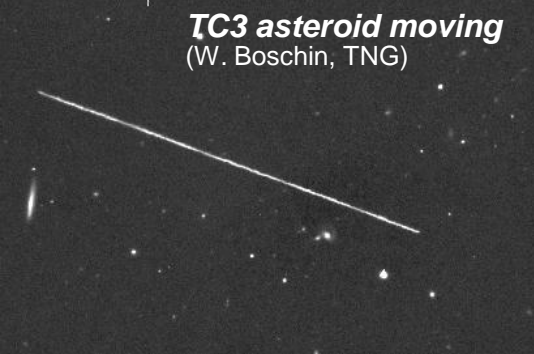
Model of 30 m  
NEA 1998  
KY26 (radar)



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  - ● nature teaches us, so the science changes (rapidly)
  - media-to-media serial accumulation of mistakes



*TC3 asteroid moving*  
(W. Boschin, TNG)



*TC3 atmospheric train* (M. Mahir)



*Almahata Sitta fragment on the ground in Sudan* (P. Jenniskens)



## 2008 TC3 & Short-Term Warnings

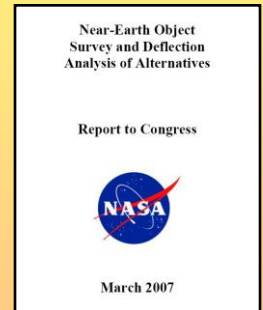
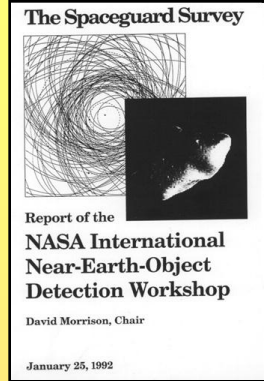
- 2008 TC3 was the first Near Earth Asteroid ever discovered (Catalina Sky Survey, 7 Oct. 2008) that was then predicted, for sure, to strike the Earth. It was then observed telescopically before it hit.
- 20 hours after discovery, the predicted impact occurred and was recorded, and hundreds of resulting meteorites were later collected on the ground (in a Sudan desert near Egypt's border).
- This kind of event was thought to be impossible, but it was not a fluke: we must expect future predictions of small NEO strikes, even from the existing Spaceguard Survey, without waiting for the “next generation” surveys.
- The most likely warning of an actual hazardous NEO impact will be one of these “final plungers,” providing hours to weeks of warning.
- **Evacuation, not NEO deflection, will be the most likely kind of “mitigation” we need to plan for.**

**But the event taught us that we have much to learn: Conventional wisdom had said that TC3-like events weren't possible!**



# Short-Term Warnings: Spaceguard Survey does Better than We Thought!

- Was it a miracle that telescopes saw what was plausibly the largest NEA to impact Earth in 2008? No! Capability to see “final plungers” was overlooked.
- Analyses in the 1990s of the “Spaceguard Survey” only considered cataloging of Near-Earth Asteroids; short-term warning was evaluated only for rare comets.
- So it was thought that there was only a tiny chance that a dangerous in-bound 30-m NEO would be seen, let alone a 3-m “TC3”.
- The short-term hazard warning was evaluated (NASA SDT 2003) for the “next generation” surveys, but *not* for small NEOs and meteorite recovery.



“Consider a 30–40-m office-building-sized object striking at 100 times the speed of a jetliner.... Even with the proposed augmented Spaceguard Survey, it is unlikely that such a small object would be discovered in advance; impact would occur without warning.” – C. Chapman, *EPSL* (2004).



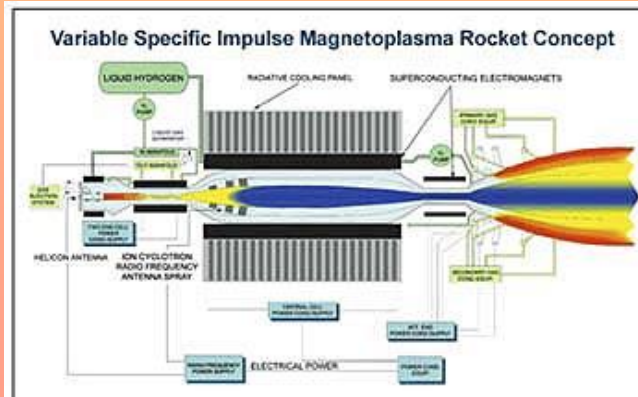
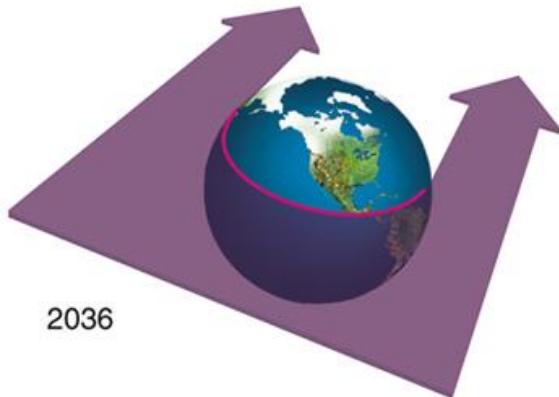
“a short lead time for an NEO is extremely unlikely – we can expect either decades of warning or none at all” – Morrison, Harris, Sommer, Chapman & Carusi (“Asteroids III” 2002)

# Scientist's Jargon and Non-Intuitive Concepts

## Conclusions from a Single Simulation (statistics of one...)

- A 140 m sized, coherent NEA could be deflected via a 1150 kg kinetic impactor striking the NEA in 2028 ( $\Delta V \sim 4$  mm/s) - some 21 years in advance of the threatening Earth encounter in 2049.
- 4.00 mm/s  $\Delta V$  in 2028 produces asteroid deflection of 80,000 km in 2049 (all is well) but 4.69 mm/s  $\Delta V$  in 2028 drops asteroid into 6.5 keyhole for an impact in 2054 (oops...)
- The 6.5 keyhole in 2049 is only 6 km wide and the 6 others are also narrow so the likelihood of a keyhole passage in 2049 - 2074 is only ~ 0.02% but, due to fairly large uncertainties in the asteroid's 2049 ephemeris positions (~200 km), the likelihood of having to worry about a keyhole passage is ~100 times larger.
- In our case, 2028 knowledge of actual keyhole passage in 2049 is ~1%.
- Because of intervening approaches to Earth and Venus, the dynamics are very non-linear and the optimal time for tractoring is not right after the realization that the kinetic energy impact dropped the asteroid into a 6:5 resonant return keyhole. The optimal time for tractoring is ~2036 when 200 days of tractoring provides ~1500 km motion on the 2049 impact plane - more than enough to ensure the NEA's 3 $\sigma$  uncertainty ellipse is moved off the relatively tiny keyhole. Each impactor case is likely to be very different.
- In 200 days of tractoring, the asteroid's uncertainty region (3-6 sigma) is moved completely off the 2049 keyhole.

- “virtual impactors”
- “keyholes”
- Very tiny probabilities (1-in-ten-million)
- Huge consequences (10,000 megatons)
- “Rocket science”
- Uncertainties and “error bars”
- Asteroids orbit the Sun, don't head “straight toward” Earth



OBJECT DIAM.	IMPACT ENERGY	CHANCE PER 100 YR	CHARACTER OF DAMAGE
>3 km	1.5 mil. MT	1 in 50,000	Global climate disaster, most killed, civilization destroyed
>1 km	80,000 MT	0.02%	Devastation of large region or an entire ocean rim
>300 m	2,000 MT	0.2%	5 km crater; huge tsunami or destruction of small nation
>100 m	80 MT	1%	Exceeds greatest H-bomb; 1 km crater; locally devastating
>30 m	2 MT	40%	Stratospheric explosion; damage within tens of km
>10 m	100 kT	6 per century	Broken windows, little serious damage on ground
>3 m	2 kT	2 per year	Blinding flash, could be mistaken for atomic bomb

# A Tiny Chance of an Asteroid Strike in the Distant Future

THE BOSTON GLOBE • WEDNESDAY, APRIL 14, 1999

## Survey: 7 new asteroids could threaten Earth

July 31, 1997

Web posted at: 2:32 p.m. EDT (1832 GMT)

BOSTON (CNN) -- Seven previously unknown asteroids that are close enough and large enough to threaten the Earth have been found by astronomers scanning the heavens for potentially dangerous space rocks.



## Nation

*A report posted on the Web cites a one-in-a-billion chance that the asteroid could hit the Earth in 2039.*

# Scientists say asteroid may tango with Earth

By David L. Chandler  
GLOBE STAFF

In a discovery eerily reminiscent of one made just a year ago, astronomers have found an asteroid that will come quite close to Earth in a few decades, and that even has a real but mi-

# The New York Times

VOL. CXLVII . . . No. 51,094

THURSDAY, MARCH 12, 1998

## Asteroid Is Expected to Make A Pass Close to Earth in 2028



By MALCOLM W. BROWNE

An asteroid is likely to pass within 30,000 miles of Earth on Oct. 28, 2028, a Thursday, and there is a very slight possibility that it might hit Earth, the international astronomical agency that tallies the orbits of asteroids and comets announced yesterday.

Dr. Brian G. Marsden, director of the Central Bureau for Astronomical Telegrams at the Smithsonian Astrophysical Observatory, Cambridge, Mass., cautioned in an interview that calculations of the asteroid's progress are approximate and that there is no immediate cause for alarm.

It is impossible to calculate the

### Estimate Tentative — Chance of Impact Seen as Slight

odds of an impact, Dr. Marsden said. But he appealed to astronomers with large telescopes to measure the asteroid's brightness and size, estimated to be as large as a mile in diameter, and to refine measurements of its orbit.

There is ample evidence that Earth has been frequently bombarded by asteroids and comets, some of which may have contributed to mass extinctions.

Many scientists say they believe that the impact of an asteroid or comet about six miles in diameter on the coast of the Yucatan Peninsula 65 million years ago (releasing some 5 billion times more destructive energy than the atomic bomb that leveled Hiroshima) contributed to the extinction of the dinosaurs.

The impact of an asteroid one mile in diameter would have devastating global effects, including tidal waves, continent-size fires and an eruption of dust that could cause global cooling and long-term disruption of agriculture. But Dr. Marsden said such an asteroid impact would not necessarily be severe enough to wipe out the human race.

The scale of devastation could

be gauged from the effects of a more recent impact. On June 30, 1908, a stony meteorite hit near the Tunguska River in Siberia. That object, later estimated as less than 100 yards across, exploded six miles above Earth. It flattened trees over nearly 900 square miles, ignited forest fires, and caused damage equivalent to that of a 15-megaton hydrogen bomb.

Asteroid 1997 XF11, as the current object is named, was discovered on Dec. 6 by Dr. James V. Scotti of the University of Arizona.

Scientists use a 36-inch-diameter telescope equipped with special instruments atop Kitt Peak, Ariz., to maintain a watch for all small objects in the solar system, especially asteroids and comets that approach Earth at dangerous close distances.

Two Japanese amateur astronomers later noticed the object, and on the strength of the combined measurements, the asteroid was added to a list of 108 known "potentially hazardous objects," or "P.H.O.s."

Thereafter, astronomers in several countries refined measurements of the orbit and concluded that the asteroid would come particularly close to Earth in 2028. Their estimate was that it would

Continued on Page A15

2A FRIDAY, APRIL 5, 2002

## Asteroid may crash into Earth — in 2880

DALLAS MORNING NEWS

A large asteroid has up to a 1-in-300 chance of hitting Earth in the year 2880, astronomers will announce today.

But future observations could reduce uncertainties about the asteroid's path, possibly bringing the odds of a collision to zero.

"It's not something to worry about because it's so far in the future," said engineer Jon Giorgini, lead author of the study that appears today in the journal Science. "Eight hundred and seventy-eight years — that's 35 generations from now."

Steven Chesley, an asteroid expert at NASA's Jet Propulsion Laboratory in Pasadena, Calif., said he is sure that the asteroid will never actually make it to Earth.

"Either it will miss all by its own, or future generations will have enough knowledge and technology to deflect it," he said.

The asteroid, known as 1950 DA, measures two-thirds of a mile across, big enough to cause worldwide havoc if it hit. It currently lies on the other side of the sun, a safe 325 million miles from Earth.

Between now and the year 2880, the asteroid will swoop by Earth and Mars 15 times. Each time, the gravitational tug of the planets and other factors will alter the asteroid's orbit slightly. There is a 0.33 percent maximum chance that those orbit changes could send the asteroid directly into Earth on March 16, 2880, said Giorgini, also of the Pasadena lab. □

# Asteroids Found After Their “Near Misses” with Earth

A12 SUNDAY, JANUARY 27, 1991 THE WASHI

## Asteroid Hurtles Near Earth Jan. 18

Scientists Call Space Boulder's Approach Closest in Modern Times

By Blaine P. Friedlander Jr.  
Special to The Washington Post

As if Scud missiles were not enough. On Jan. 18, the Earth barely missed a direct hit from an asteroid, according to a report released this week by the International Astronomical Union.

Discovered by researcher David Rabinowitz of the University of Arizona, this asteroid appears to have set two cosmic records. Not only is it the smallest such object ever seen, Rabinowitz said, but its approach was the closest to Earth in modern times.

Designated 1991-BA by the astronomical union in Cambridge, Mass., it approached within .001 astronomical units. An astronomical unit is about 93 million miles, the distance between Earth and the sun.

diameter and passed at 10 times the distance to the moon. Generally, an Earth-grazing asteroid is hard to anticipate, since

*Astronomers think the asteroid measured between 16½ feet and 33 feet in diameter, the size of a three-story boulder.*

the object is hurtling toward this planet and does not reflect sunlight well. Astronomers compare it to

using a flashlight to watch a bullet travel in the dark.

From its velocity, astronomers can calculate the impact of this asteroid had it struck the Earth. Considering its speed of almost 12 miles per second, it might have had the explosive equivalent of 75 kilotons of TNT, according to Geoff Chester of the Smithsonian's National Air and Space Museum.

However, Rabinowitz said, if the hurtling boulder had hit Earth, it might have burned in the atmosphere.

The Spacewatch telescope that Rabinowitz used, at Kitt Peak near Tucson, is a 36-inch reflector dedicated to searching for asteroids—objects that may be fragments of shattered planets—during the moonless part of a month. It is used to search for planets in other solar systems in the bright portion of a month.

## Big Asteroid Passes Near Earth Unseen In a Rare Close Call

By WARREN E. LEARY, Special to the New York Times  
Published: April 20, 1989

The screenshot shows the top of a CNN Tech webpage. The navigation bar includes categories like 'Justice', 'Entertainment', 'Tech', 'Health', 'Living', 'Travel', 'Opinion', 'iReport', 'Money', and 'Sports'. The article title is 'Whew! Stealth asteroid nearly blindsides Earth' by Richard Stenger, dated March 19, 2002. Below the title are social media sharing buttons for 'Share', 'Twitter', and 'Email', along with a 'Recommend' button. The article text begins with 'A sizable asteroid zipped near our planet this month without anyone noticing because it traveled through an astronomical blind spot, scientists said.'

- Just as likely to see them going as coming...most likely not to see them at all!
- These typical stories are explicitly or implicitly critical of the NEO surveys
- They say there is a “blind spot”
- But whether discovered before or after a close passage, an NEA is unlikely to actually strike Earth for decades or centuries



**“Peiser, a European scientist”:  
Just who is he?**

# The Odd Career of Benny Peiser



## Benny J. Peiser:

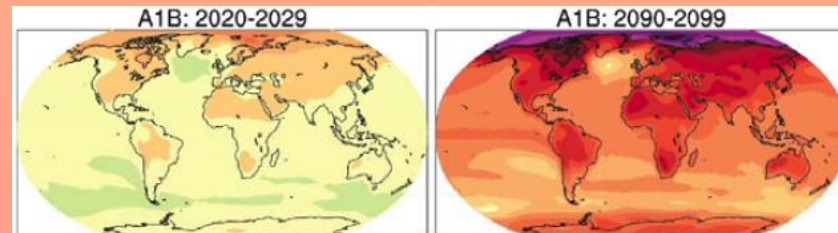
Was:

Senior Lecturer in  
the School of Sport  
and Exercise  
Sciences, Liverpool  
John Moores Univ.

Now:

Director of “Global  
Warming Policy  
Foundation”

- A non-scientist (historian of ancient sports), he began in 1997 to comment on asteroid threats in an on-line newsletter (CCNet)
- He became a prime source for journalists about impending asteroid impacts
- He was regularly quoted as an NEO “expert” by the media, when he actually badly misunderstood the science
- An argumentative guy, he often seemed to be trying to stage fights between people
- Half-a-dozen years ago, he stopped covering NEOs and has become a prominent and controversial denier of climate change and global warming.



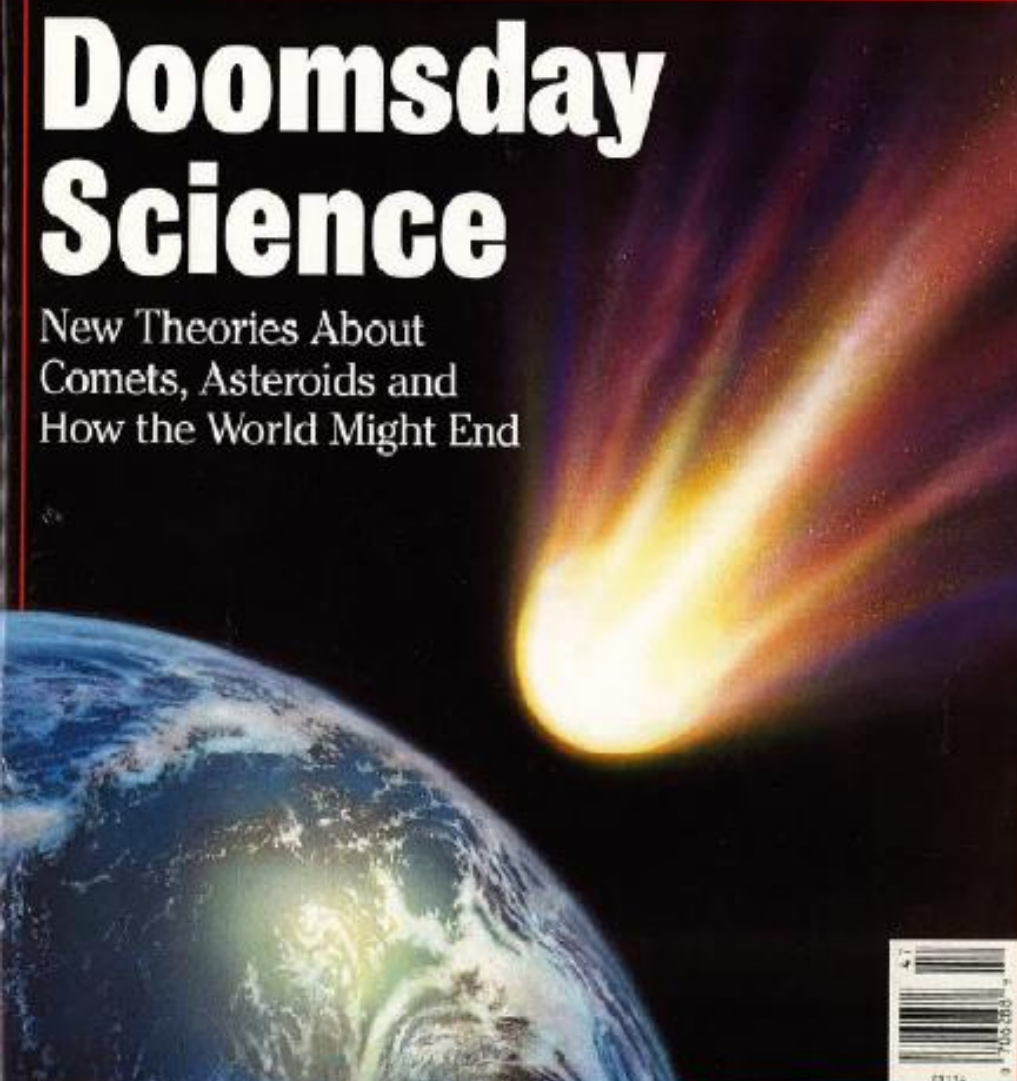
GAYS VERSUS THE PENTAGON

# Newsweek

November 23, 1992 - \$2.95

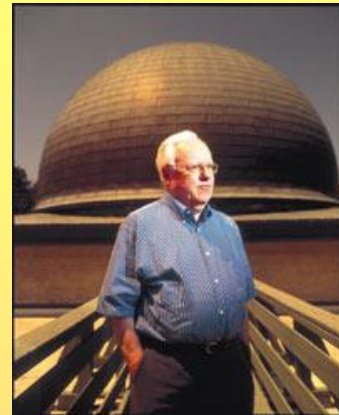
## Doomsday Science

New Theories About Comets, Asteroids and How the World Might End



## Comet Swift-Tuttle: Never was a Problem...

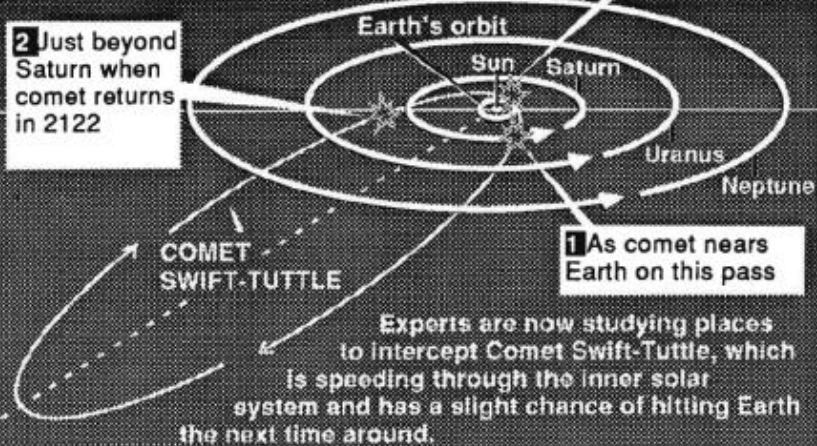
- MPC Director Brian Marsden did a faulty back-of-the-envelope calculation while talking with science reporter David Chandler...



### Avoiding Doomsday

2 Just beyond Saturn when comet returns in 2122

3 When comet makes closest approach to Sun in 2126



The New York Times

## Comet worries doomsday thinkers

Arizona Daily Star  
By William J. Broad 11/05/92  
© 1992 The New York Times

Theoreticians of doom have long pondered the odds of cosmic bombardment and whether a way might be found to save the planet from destruction. Suddenly they have a real case study

"One in 10,000 is not an infinitesimal risk," said Clark R. Chapman, an astronomer at the private group Planetary Science Institute in Tucson.

Skeptics say the current interest in the comet, known as Swift-Tuttle, is a result of scheming by astronomers and bomb makers to drum up business by practicing the kind of threat inflation the Pentagon excelled at in the Cold War. But doomsday enthusiasts insist the threat is real, saying space is swarming



# The Torino Scale: NEO Scientists Attempt to Communicate Risk

Inspired by  
XF11: 1999

## THE TORINO SCALE

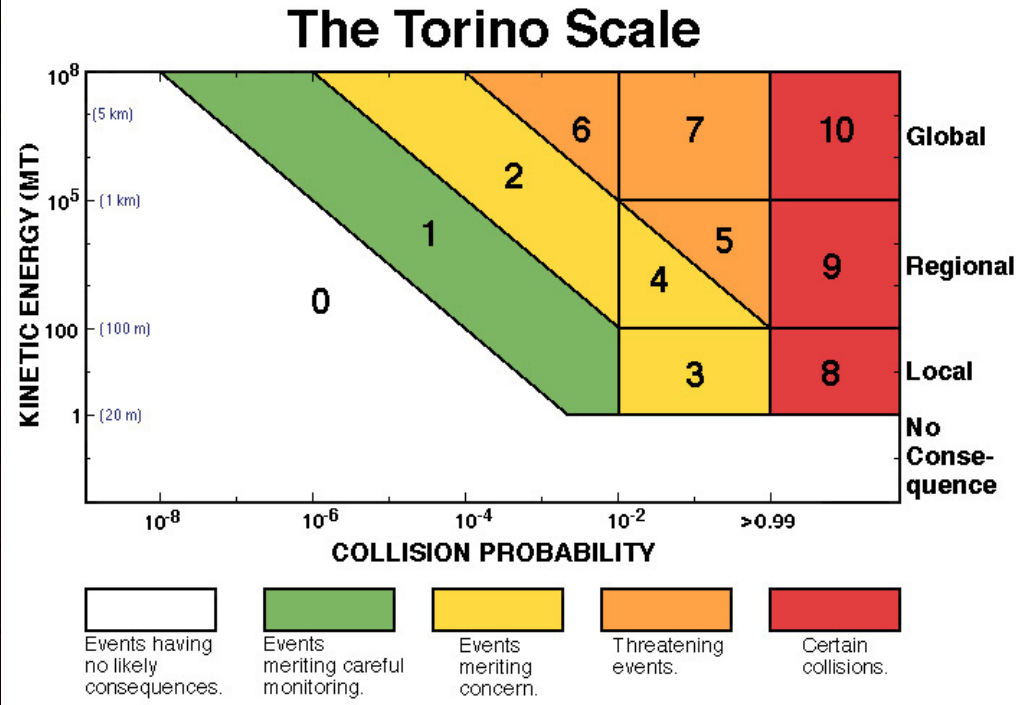
Assessing Asteroid and Comet Impact Hazard Predictions in the 21st Century

← The actual Torino Scale

Many journalists actually used this scale. Introduction of the "Palermo Scale" confused things. Homeland Security turned scales into a joke.

Diagram scientists use to determine value in particular case

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.
	9	A collision capable of causing regional devastation. Such events occur between once per 1000 years and once per 100,000 years.
Certain Collisions	10	A collision capable of causing a global climatic catastrophe. Such events occur once per 100,000 years, or less often.





## Sometimes, Difficult to Distinguish Between Supermarket Tabloids and Mainstream Media

- Clipping below is from an actual supermarket tabloid (perhaps the “*National Enquirer*”)
  - Actually, content is OK...only the headline is bogus
- But the same bad headline actually repeated text from a piece written by a BBC science journalist [next slide]:

### ***Killer asteroid heading straight for Earth***

SCIENTISTS ARE so fearful a deadly runaway asteroid will slam into the Earth and wipe out all life they're seeking government support to nuke it.

They say even a "tiny" asteroid only a few miles wide could strike such a devastating blow that it would destroy the planet's population.

"It's a long shot, but we could take a hit," says David Morrison, chief of the Space Science Division at NASA Ames Research Center in Mountain View, California.

The Galileo spacecraft recently photographed a potato-shaped asteroid called Gaspra from less than 1,000 miles away, in the first close encounter of its kind.

Gaspra is relatively small — about 6 miles wide and 11 miles long.

But experts warn that a doomsday rock of even this relatively small size could strike the Earth with such force that the resulting dust and debris tossed

into the atmosphere would block out sunlight.

And it would wipe out the Earth's people, just as the dinosaurs are now believed to have been wiped out by an asteroid striking the Earth 65 million years ago.

Keeping track of about 10,000 asteroids that have orbits approaching the Earth would require at least six \$12 million telescopes distributed throughout North and South America, he says.

"With proper tracking techniques, astronomers could spot a potentially catastrophic one decades before it would hit the Earth," says Morrison.

"The next step would be to go out and meet the meteor, deflecting it from its collision course with the planet.

"The simplest way, we think, to give it that shove is to set off a nuclear bomb next to it.

"Changing the asteroid's speed by even one centimeter a second could avert catastrophe."



**EARTH COULD be destroyed by the asteroid.**

# “...on an impact course with Earth”: What does that Mean?

**BBC NEWS** WORLD EDITION

You are in: [Science/Nature](#)  
 Wednesday, 24 July, 2002, 02:29 GMT 03:29 UK

[News Front Page](#)



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## Space rock 'on collision course'



It has been called the most threatening object in space

**By Dr David Whitehouse**  
 BBC News Online science editor

An asteroid discovered just weeks ago has become the most threatening object yet detected in space.

A preliminary orbit suggests that 2002 NT7 is on an impact course with Earth and could strike the planet on 1 February, 2019 - although the uncertainties are large.

**BBC SPORT**  
**BBC WEATHER**  
**SERVICES**  
 Daily E-mail

- This asteroid was NOT on a nominal collision path with Earth (in 2019)
- Indeed, its calculated chances of hitting Earth were  $< 1/100,000$ .
- Morrison and I criticized BBC science reporter David Whitehouse for these faulty words.
- Probably based on the BBC report, this non-event became headline news around the world
- Whitehouse justified his words:
  - “It is pedantry to say that the probability of such an impact was so low that it is misleading to use the words ‘collision course’...”
  - “You are completely and utterly wrong in saying that because NT7 had a Torino scale of 1 it merited only minor concern by the news media.”

# Journalism Awards Given for Egregious Treatment of NEOs



- Annual European Online Journalism (EOJ) Awards: In 2003, Dr. David Whitehouse, online science correspondent of the BBC, “won the best news story broken on the net...for his news story ‘Space Rock on Collision Course’ about the 2002 discovery of an asteroid which could hit the Earth in 2019.” [BBC, 4 Jul. 2003]



- In 2010, the American Association for the Advancement of Science (AAAS) presented its prestigious Kavli award for best TV documentary of the year to Doug Hamilton of “WGBH/NOVA” for an appalling show, “The Last Extinction,” in which NOVA paid for an expedition to Greenland by (pseudo-) scientists, who claimed to prove that a 4-km wide comet struck Earth just 13,000 years ago, a preposterous claim with no valid evidence.

- The show was based on no paper published in the professional literature
- A chief “scientist” involved apparently has no degree, and recently changed his name to avoid linkage with being found guilty of fraudulent practices in California

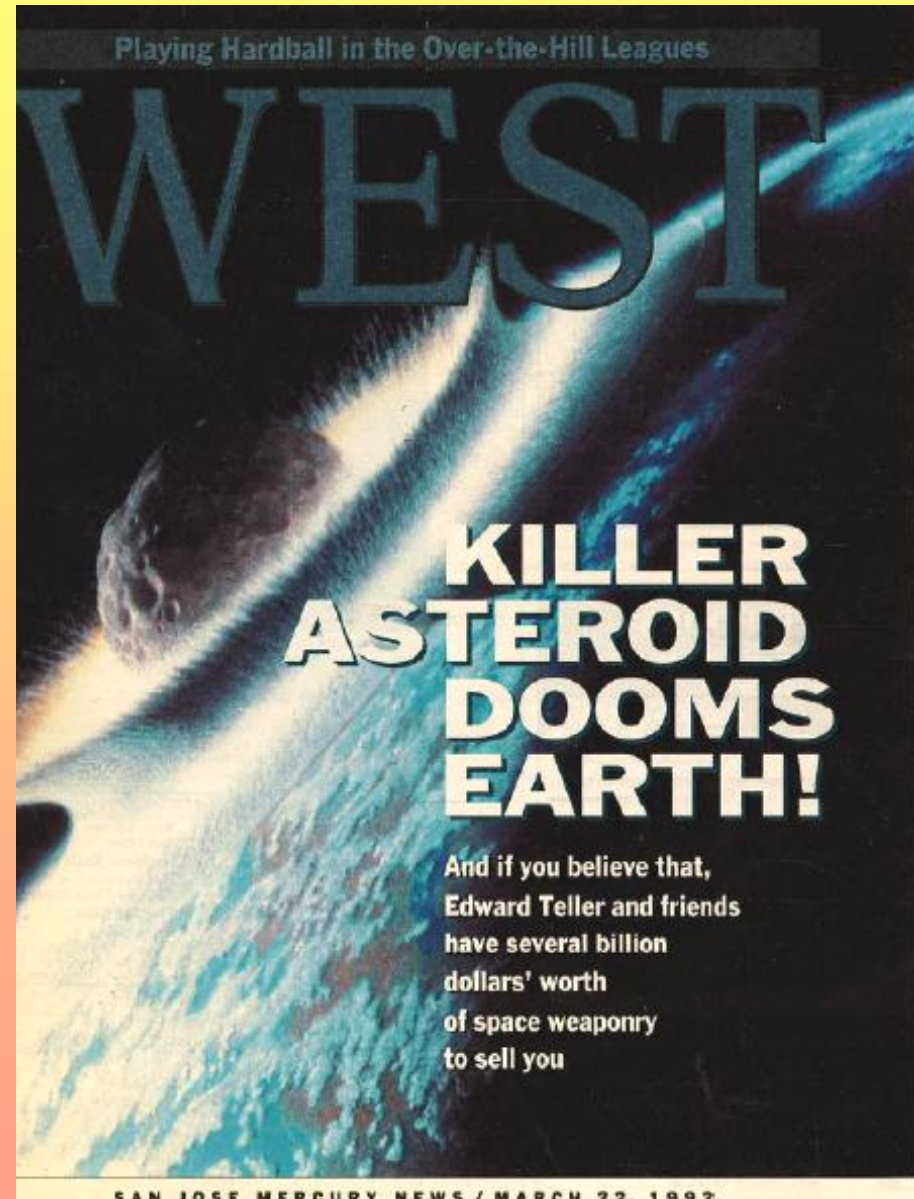
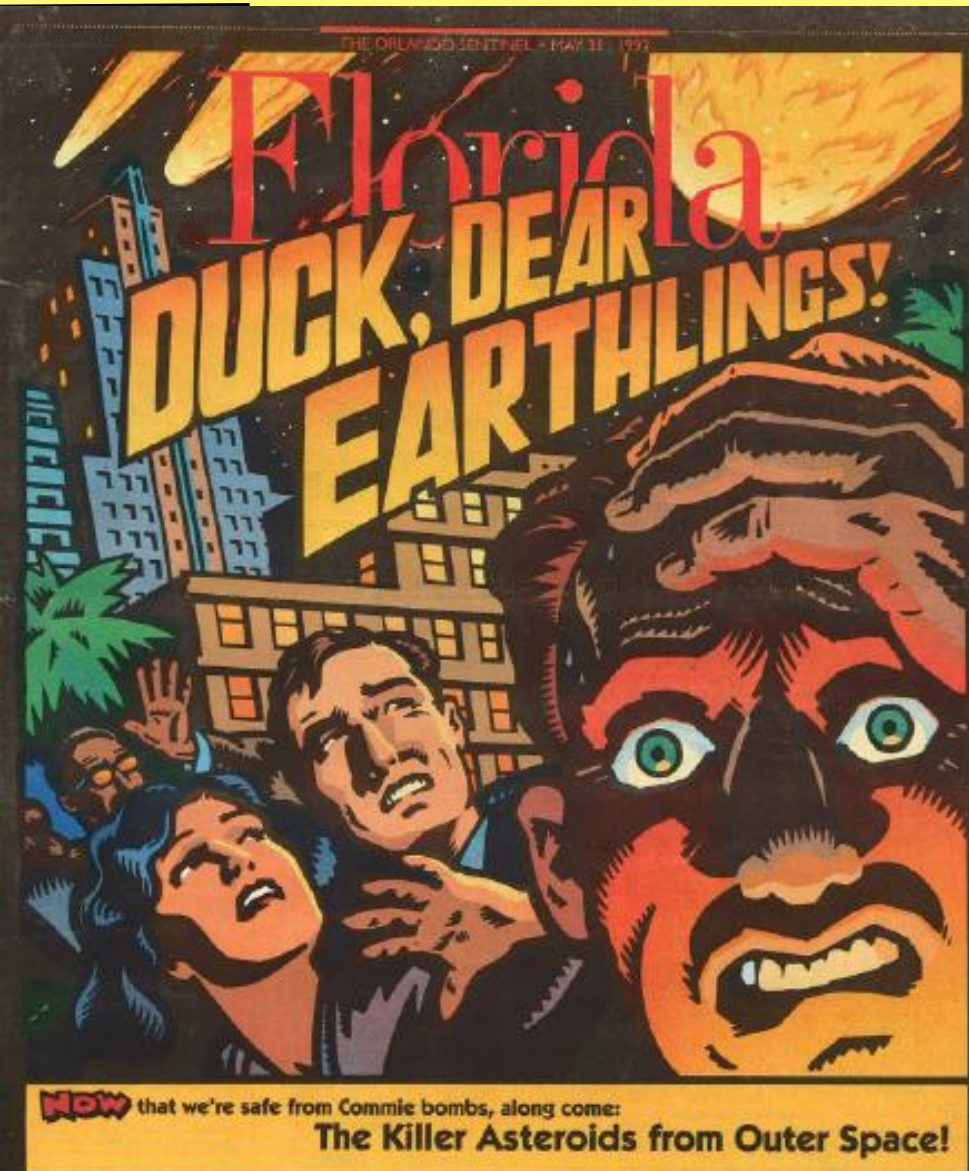
WGBH

NOVA

AAAS  
ADVANCING SCIENCE. SERVING SOCIETY

THE KAVLI FOUNDATION

# Fear-Mongering by the Respectable Press (Orlando Sentinel, San Jose Mercury News)



# The Asteroid Movies



NEW YORK TIMES NATIONAL FRIDAY, MARCH 13, 1998



The first image released by Paramount Pictures to promote its new movie, to be released on May 8, about an asteroid hurtling to Earth. A Disney film, Armageddon, is planned for release on July 1.

## Asteroid, the Films, Heading to Theaters

By BERNARD WEINRAUB

LOS ANGELES, March 12 — The news that an asteroid is expected to pass close to Earth in 2028 hardly caught Hollywood by surprise. Two upcoming films, "Deep Impact" and "Armageddon," bear a striking resemblance to real possibilities.

**A forecast of a catastrophe proves timely.**

in three years. The real-life asteroid is a mile wide, while the one in the film is about seven miles.

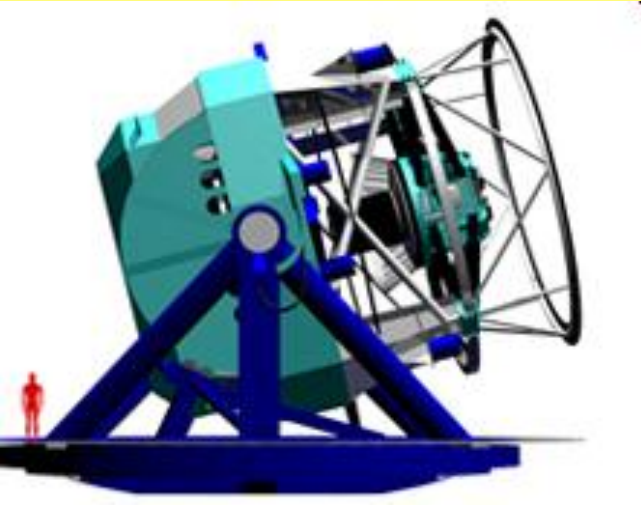
"The reason we wanted to make this movie in the first place," Mr. Zanuck said, "was because of the enormous potential of this actually occurring."

"Deep Impact," a joint produc-

- In 1994, a survey by Paul Slovic showed that ~25% of the public was aware of the potential danger from asteroids
- Awareness climbed dramatically in 1998 when two blockbuster movies were being promoted, coincidentally just as the 1997 XF11 affair was in the headlines
- "Deep Impact" hit the screens two months later. Scientists regarded it as a flawed but inoffensive portrayal of an asteroid impact
- "Armageddon" (opened July 1998) was a totally dreadful movie about Bruce Willis trying to destroy an asteroid "as big as Texas." This movie's grotesquely distorted view of reality has shaped public impressions of NEO defense
- "Armageddon" was nominated for 4 Oscars (including "Best Visual Effects", which actually showed physically absurd attributes of the 'Texas-sized' asteroid)



# Planetary Defense



- **“There’s no controlling the possibility of a meteor strike.”**  
*NY Times* editorial, Dec. 4, 2003.

Of course there is a good possibility of averting disaster: Search for a possible threatening NEO, then send a spacecraft mission to deflect it away from Earth



THE WASHINGTON POST

**SCIENCE**  
 ASTRONOMY

## Shooting Back At Space Rocks?

Seeing Asteroid Threat to Earth,  
 Panels Assess Detection, Defense

By Kathy Sawyer  
 Washington Post Staff Writer

**C**hicken Little is suddenly trendy. Serious astronomers have convinced members of Congress that the sky is bound to fall sooner or later, in the form of a doomsday space rock with Earth's name on it. Leading weapons scientists are offering to nuke any such intruder and save the planet.

This is not tabloid fiction. It is the topic of two technical reports commissioned by Congress to be delivered this week with action plans for asteroid detection and defense.

One report calls for \$50 million in new telescopes to accelerate the hunt for the terminator rock among the maybe 2,000 mountain-sized asteroids whose trajectories cross Earth's path. The second outlines possible responses, including a standing international ground-based armada of 10 missiles tipped with nuclear warheads big enough to blow anything incoming off course or destroy it.

The reports were produced at two workshops that brought together astronomers, weapons-makers and others, convened by NASA at the direction of the House Science, Space and Technology Committee.

Sure, laugh. The dinosaurs ignored the whole thing and look what happened to them.

There is no record of a human ever being killed by a space rock, but many scientists accept the once-revolutionary theory that, some 65 million years ago, an extraterrestrial object wiped out the dinosaurs. The impact of an object about six miles wide on the Yucatan Peninsula, scientists say, exploded with many times the force of the world's entire nuclear arsenal. This blasted enough dust into the upper atmosphere to blot out the sun worldwide for months, affecting plant growth and the food chain.



ILLUSTRATION BY DON DAVID FOR NASA

**The “terminator rock”:** An artist's conception of an asteroid approximately six miles in diameter striking Earth, as seen from 20 miles above impact level.

# NEOs, Politics, and Opinion

Last Wednesday →

A16 z THE NEW YORK TIMES EDITORIAL

MONDAY, APRIL 6, 1992

**The New York Times**

**Killer Asteroids: The Perfect Peril**

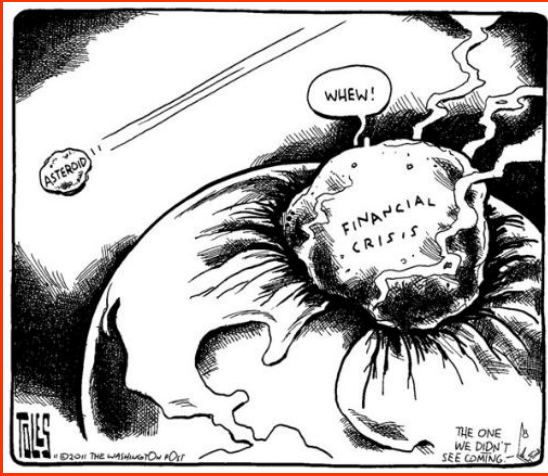
Just when the world thought it could breathe easier about nuclear war, along comes an even more fearsome menace — doomsday asteroids and killer comets that might hurtle into Earth with enough force to wipe out much if not all human life. What was once a science-fiction fantasy is now being treated as a serious threat by astronomers and Government officials.

and would hit with a force greater than 100,000 megatons.

Smaller asteroids, more lethal than a large nuclear weapon, might hit every few centuries, causing severe local damage, most likely in uninhabited areas.

The nation's asteroid astronomers are eager to start tracking this new enemy. The NASA panel

ARTHUR OCHS SULZBERGER JR., Publisher  
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CHICAGO TRIBUNE JUNE 5, 1990

## Asteroid threat is real, Quayle says

WASHINGTON (Reuters)—Vice President Dan Quayle and some astronomers are worried that Americans are too complacent about the possibility of Earth being struck by a giant asteroid like the one blamed by some experts for snuffing out the dinosaurs 65 million years ago.

If the past is truly prologue, they say, an asteroid could come hurtling down at any moment, at any point on the globe.

If it were big enough and landed close enough to a large city, it could kill millions of people on contact and send up clouds of dust that could block out the sun and make the world a cold and life-threatening place for generations, the experts say.

"It would certainly benefit all nations to know when such an event might occur, warn those

who could be affected and maybe some day even affect whether and where such an event might happen," Quayle said in a recent speech to the American Institute of Aeronautics and Astronauts.

Quayle is chairman of the National Space Council, which advises the president on U.S. space policy.

The Aeronautics Institute has been pressing the government to set up a program to identify asteroids that threaten to crash into Earth and look for ways to push them off course.

"Despite the low probability that a life-destroying asteroid impact will occur, the fact is that the probability of such an event is finite and, should it occur, the resulting disaster is likely to be without precedent," the institute said in a report.

While no human has ever been killed by a falling asteroid, at least as far as scientists know, a dog was killed by one in Nakh, Egypt, in 1906.

In March 1989, an asteroid bigger than an aircraft carrier and traveling at 46,000 miles an hour "just missed" the Earth, crossing its orbit just six hours before the planet reached the same point in space.

Jerry Grey, director of science and technology policy for the Aeronautics Institute, said the federal government should try to provide protection from asteroids that scientists call "Earth crossers."

The institute is asking the government to spend up to \$5 million on new telescopes to look for Earth crossers over the next 10 to 15 years.



"I suppose they'll expect a bailout."

WEDNESDAY, MARCH 25, 1992 B1

**THE WALL STREET JOURNAL**

**Never Mind the Peace Dividend,  
The Killer Asteroids Are Coming!**

By BOB DAVIS  
Staff Reporter of THE WALL STREET JOURNAL

WASHINGTON—Talk about Star Wars. The National Aeronautics and Space Administration is about to recommend that the Earth start planning to assemble an arsenal of nuclear missiles to head off an attack by asteroids. NASA astronomers figure that big asteroids smack into the Earth only once every 500,000 years, but say it's never too early to prepare.

"If you did find a [big asteroid], you'd have a danger to the Earth—something capable of killing one billion people," warns David Morrison, a NASA astronomer. Dr. Morrison persuaded Congress to fund two studies of the asteroid peril, which the agency plans to release in a few weeks.

At a meeting in January at Los Alamos National Laboratory in New Mexico, the home of The Bomb, NASA convened a group of weapons scientists to figure out ways to fight asteroids. Their conclusion: Build an armada of 10 ground-based missiles, each equipped with a 100-megaton warhead—bigger than any nuke ever exploded on Earth—and keep them ready for asteroid attack. Then, if astronomers spot the Big One, they can launch nukes and explode them in front of the incoming asteroid millions of miles in space.

The detonations would blow off a few inches of rock and dirt from the asteroid—enough to change its course slightly and save the Earth. "You can impart a more gentle push to the thing" than trying to blast it out of the sky, says Johndale Solem, a physicist at Los Alamos.

Dr. Solem says the Los Alamos group rejected a lot of fanciful ideas before settling on nukes to hunt asteroids. One scientist proposed launching 20,000 spears at a rogue asteroid. Another suggested nudging small asteroids into Earth orbit, and using them to attack bigger asteroids. That plan was called Brilliant Mountains—a big brother to the controversial Star Wars proposal called Brilliant Pebbles.

All this talk distresses Dr. Morrison, who simply wants Earthlings to spend \$50 million to catalog all the one-half-mile wide or larger asteroids and comets that pass near Earth. If one of these asteroids is bound for Earth, it should make a few passes before impact. "You'd have decades of warning," he says.

But that isn't enough for Dr. Solem. He wants to hunt down football-field-sized asteroids, which could level New York City. To combat that threat, you'd need a nuclear armada, a prospect that moved a weapons scientist at Los Alamos to shout: "Nukes forever."



# Asteroid Scares Begin to Diminish...



● **Robert Roy Britt, Space.com, 3 Sept. 2003:**

“A newly discovered asteroid that generated doomsday headlines around the world yesterday morning was, by the end of the day, reduced to innocuous status as additional observations showed it would not hit Earth.

Meanwhile, a whirlwind of media hype has astronomers and asteroid analysts arguing among themselves -- again -- about how they should disseminate information to the public....

The incident was just one in a long series miscues involving astronomers, their public relations efforts, and a media eager to report potential doom....

A handful of similar scares -- about one per year -- have evaporated in similar fashion as professional astronomers go about their business of finding and tracking potentially dangerous asteroids.

There is an increasing sense of sarcasm in the media with each new asteroid scare. Some reporters and editors are getting wise to the long odds -- or perhaps tired of having to report on them -- and doing more than just sensationalizing the data.”

# Serious Journalistic Attempts to Explain NEO Science

ANNALS OF SPACE

## IS THIS THE END?

*It's very unlikely that a major comet will crash into the Earth—but not so unlikely that leading scientists around the world haven't begun to plot ways to make sure it doesn't happen.*

BY TIMOTHY FERRIS

### —DEATH FROM ABOVE

IF the world were to end with what astronomers call "death from above," the first clue might come with the

closer, in orbits that cross Earth's. For nearly thirty years, Marsden has watched them come and go, and has heralded their arrivals like a butler announcing guests at a ball.

civically threaten us, but that is highly unlikely. Marsden goes on to compose the new data into another E-mail telegram.

MINUTES later, Marsden's message

USA TODAY • FRIDAY, MARCH 13, 1988 • 6A

THE NATION

## Asteroid prediction shows 'uncertainty' in astronomy

By Paul Hoyersten  
USA TODAY

Thursday's backpeddling over predictions about an asteroid that will approach Earth 30 years from now points out a basic rule about astronomy.

It is, in many respects, no exact science in which words like "fudge factor" get used.

Scientists who track asteroids started the world Wednesday with projections that a mile-wide asteroid could swing as close as 28,000 miles to the surface of Earth.

Now they are revising that projection upward to a much safer 600,000 miles after new calculations surfaced on Thursday.

The International Astronomical Union's Central Bureau for Astronomical Telegrams, which issued the original alert, serves us a sort of central repository for data on asteroids, comets and small planet-like bodies in the solar system.

The Cambridge, Mass., union also is something of a town crier, spreading the word via e-mail to astronomers around the world when anything unusual is afoot.

When Astronomical Union chief Brian Marsden issued his initial telegram about an asteroid known as 1987 XF11 coming as close as 26,000 miles to Earth in 2028, he used exclamation marks — something the conservative Marsden usually doesn't do, colleagues say.

But he also included a "fudge factor" of his own, adding that the asteroid also could swing as far away from Earth as 500,000 miles. That wide a margin was necessary because the estimate was made on just three months' observations.

Marsden even provided an exact time and date for the event: 1:20 p.m. ET on Thursday, Oct. 26, 2028. And it was to be visible to the eye.

"We were taken by surprise by the media storm," says Astronomical Union astronomer Den Green. "We thought it might be more gradual. We estimated there was an uncertainty in this, so it wasn't like we were misleading anyone."

As a precaution, the Astronomical Union invited astronomers to send in anything they knew about the asteroid and provided a list of years it had been visible from Earth.

That's when Eleanor Helin, an astronomer at NASA's Jet Propulsion Laboratory in Pasadena, Calif., recalled she had some 8-year-old photos of the asteroid she took using the Mount Palomar telescope, northeast of San Diego.

Those photos covered a much larger arc of the asteroid, allowing her colleagues at JPL to replot its path.

"I don't think people read the fine print," says Helin. "With data, it depends on how it's handled. I've taken this all rather sedately in that there's little I can do about it."

For its part, the Astronomical Union has no disagreement with the JPL findings and plans to revise its estimate of the asteroid's approach.

"These things do happen," says asteroid expert Jack Hills of Los Alamos National Laboratory in Albuquerque. "It's still a close approach asteroid but it certainly doesn't stand up and grab your attention the way it did."

► New projections, 1A

Earth

250,000 miles

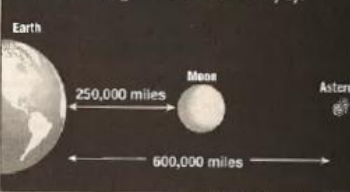
Mars

600,000 miles

Asteroid

### A miss is as good as a mile

New calculations indicate a mile-wide asteroid won't pass any closer than 600,000 miles from Earth in the year 2028. The relative distances between the Earth, the moon and the asteroid during the asteroid's closest fly-by.



By Kevin Rabin and Steve Merritt, USA TODAY

## 600,000 miles away but uncomfortably close to home

By David Colton  
USA TODAY

It's always something. Most of us have finally worked through the Cold War trauma of being Born Under the Bomb. So is a new generation ready to get anxious all over again now that they're Born Under the Asteroid?

attention almost daily," the Rev. Jerry Pulwell said. "Compare that with an asteroid that might make contact with the Earth, and El Niño is nothing."

"Many people are already weary of the idea that the year 2000 has any particular significance," said Ralph Williams, a Biblical scholar at the University of Michigan. "My 13-year-old son is much more likely to pay attention to something like this. If it happened to the dinosaurs,



up on the chart if it's true," said astrologer Linda Black when we contacted her early Thursday morning in California with the then-grim news of impending collision. When we gave her the date again, she breathed a sigh of relief.

"Oh, it's not this Oct. 26," she said with a laugh. "Thank God. I'll still have time to get some things done!"

Black, an astrologer for the Chicago Tribune Syndicate and shifted his focus from UFOs to the Hale-Bopp comet and attached some mystical significance to it," said Craig Branch of the Watchman Fellowship, an anti-cult Christian ministry in Dallas. "The same thing could easily happen again. It will be interesting to see what kind of eschatology (theology of the final days) develops in this case over time."

For those wondering, the Bible does not quite foresee a

THE WASHINGTON POST

## Style Plus

### Why Things Are

# Heads Up!

By Joel Achenbach  
Washington Post Staff Writer

### Why are we suddenly menaced by asteroids from space?

There is a fear industry out there that refuses to shut down. No longer a big market in nuclear terror? Let's try selling the fear of rocks from space.

The timing is awfully suspicious—the Soviet Union becomes defunct and almost within minutes there is talk about Earth-crossing asteroids. Among those discussing this new threat are scientists associated with the Strategic Defense Initiative—instead of shooting down incoming Soviet nukes, they say, we can destroy or divert incoming 'roids.




BY RICHARD THOMPSON FOR THE WASHINGTON POST





# TV, DVD, Web Documentary

- Alternative/visual media
- TV science series (NOVA)
- “Science” TV Channels (e.g. Discovery)
- Network TV specials
- Independent productions
- “Educational” products by planetariums, academia, NASA, etc.
- YouTube briefs; blogs
- Distributed as DVDs, digital downloads

- 
- **Goal: to inform citizens, opinion leaders, and officials about the reality of the impact hazard so that society and individuals can take appropriate action (or not)...but not over-react**
    - neither inflame nor minimize this hazard
    - common media motives: sensationalize, entertain
  - **In past decades, there have been some dysfunctional “scares” based on hype or mistakes**
  - **How to communicate about very bad but very unlikely hazards: such risks are not intuitive, but the NEO hazard exemplifies other important societal hazards**
  - **An important role for the currently diminished numbers of science journalists: be the interface between highly specialized, often inarticulate scientists and the scientifically illiterate public**

