

# Association of Space Explorers

Report to the Scientific & Technical Subcommittee  
of the  
Committee on Peaceful Uses of Outer Space

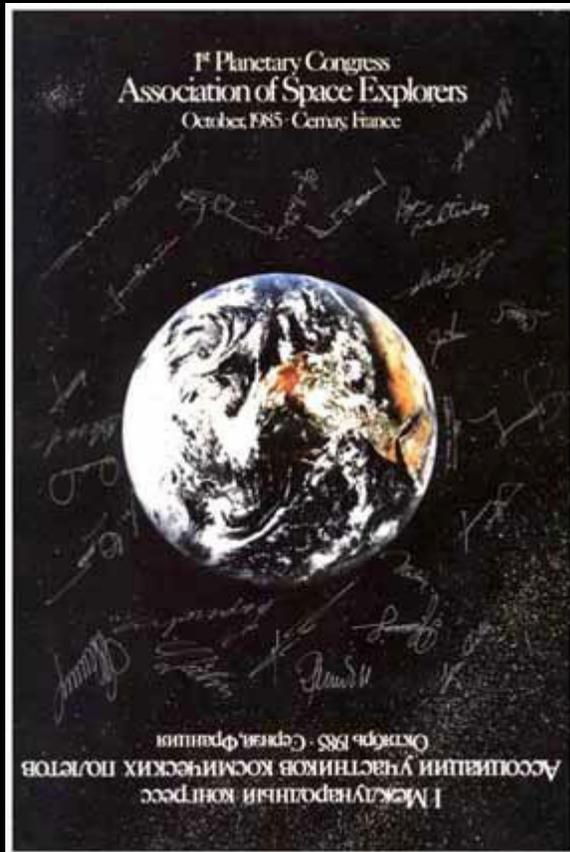
## NEO Deflection: An International Challenge

20 February – 3 March, 2006  
Vienna, Austria



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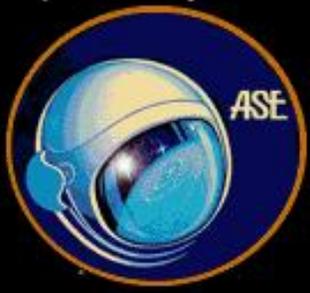
<http://www.space-explorers.org>



A professional organization of over 300 astronauts and cosmonauts from 30 nations.

At our 19<sup>th</sup> Planetary Congress in October 2005 we established a Committee on Near-Earth Objects to encourage international attention to the issue of protecting the Earth from impacts.

An Open Letter to World Leaders calling for action on NEO issues was unanimously adopted and is currently being distributed.



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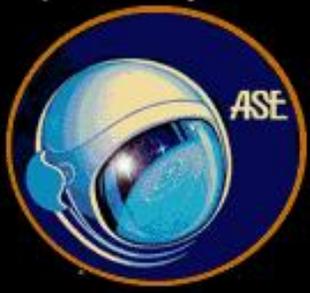
## ASE Open Letter to World Leaders

After reflecting on the devastation caused by natural disasters in 2004 & 2005, we stated..

“..we astronauts and cosmonauts are particularly concerned by a far more threatening natural disaster for which the world is totally unprepared; namely the future impact of a near-Earth object (NEO) with the Earth.”

“..we are aware of the unique fact that these infrequent cosmic collisions are, using advanced space technology, both predictable and preventable.”

“..in our opinion responsible action consists of three components; [early warning], the continued development of [deflection capability], and the cooperative development of international legal and operational policies to facilitate timely and equitable disaster prevention decision-making.”



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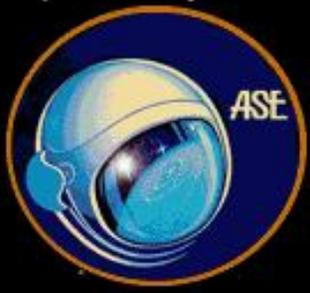
## ASE Open Letter to World Leaders

In closing we said..

“Given the eventuality of such cosmic collisions and the emerging human capability to actually prevent them, the Association of Space Explorers calls on the governments and relevant international organizations of the world, and their respective leaders, to acknowledge this challenge and accept the responsibility for prevention of these most devastating of all natural disasters.”

ASE’s commitment..

“.. the ASE stands ready to support productive national and international responses by providing relevant information, organizing meetings or workshops, and providing expert witnesses.”



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## The Three Components of Protection from NEO Impacts

- ✓ Early Warning
- ✓ Proven Deflection Capability
- ✓ International Decision-making Protocol

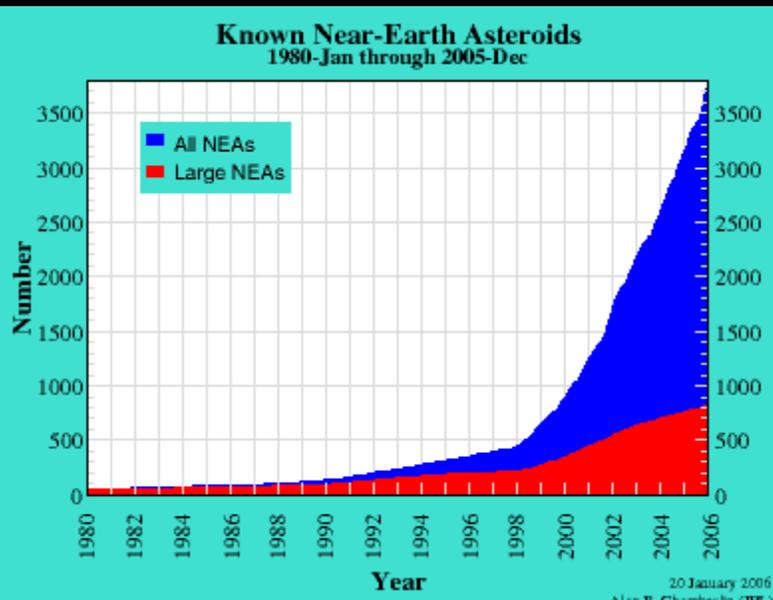
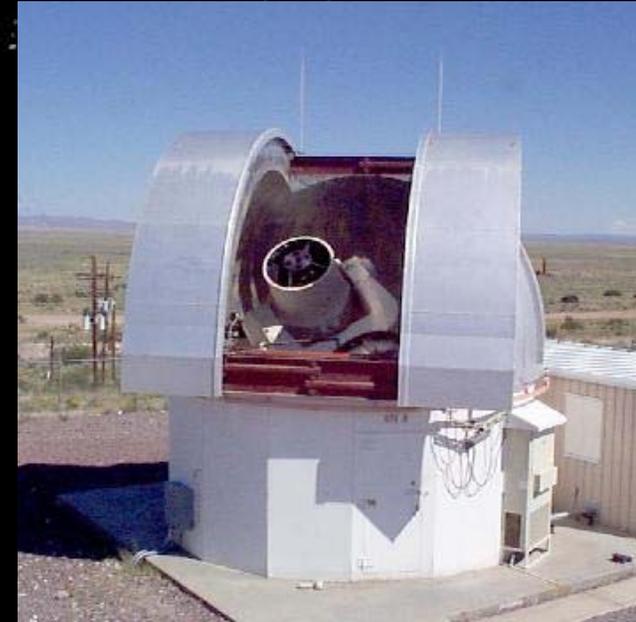


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## Early Warning

### Spaceguard Survey

- ✓ Initial goal (90% of NEOs >1 km) 84% complete (target population = 1100)
- ✓ Revised goal (90% of NEOs > 140 meters) just beginning (target population = 120,000)



## Summary Findings

- ✓ Total NEOs discovered, ~ 4000
- ✓ Total > 1 km, ~ 830
- ✓ Total with non-zero probability of impact within 100 years, ~ 100



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## Early Warning

### Spaceguard 1 & 2

(Comparable Numbers)

2006 2018

Target Population

1,100 120,000

75% completed

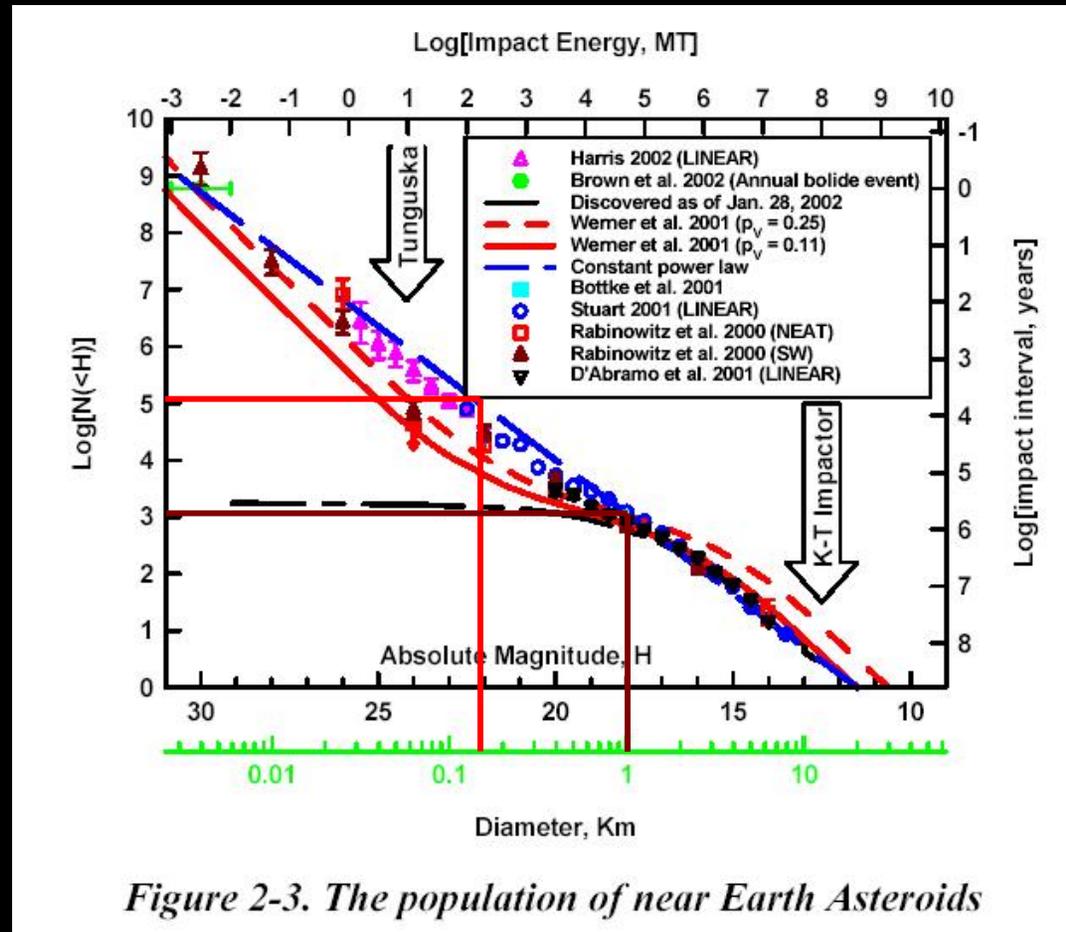
830 90,000

Total Discovered

4,000 435,000

Potential Impactors

100 5 – 10,000(?)





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## Early Warning

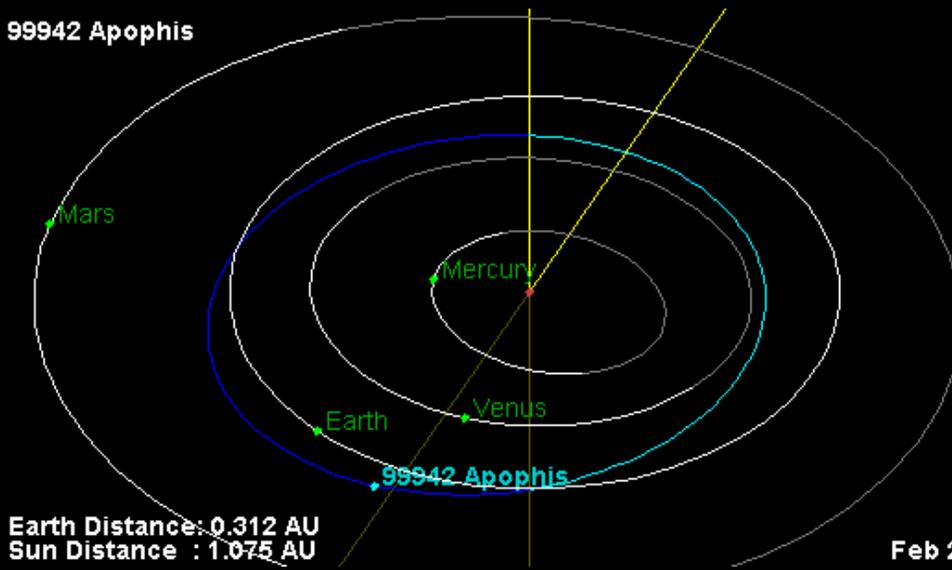
These results were computed on Jan 26, 2006

### 99942 Apophis (2004 MN4) Earth Impact Table

Date	Distance	Width	Sigma Impact	Sigma LOV	Stretch LOV	Impact Probability	Impact Energy	Palermo Scale	Torino Scale
YYYY-MM-DD.DD	(r <sub>Earth</sub> )	(r <sub>Earth</sub> )			(r <sub>Earth</sub> )		(MT)		
2036-04-13.37	0.53	1.32e-03	0.000	1.13087	2.11e+03	1.7e-04	8.73e+02	-1.38	1
2037-04-13.64	0.63	1.22e-03	0.000	-3.81778	2.09e+03	2.0e-07	8.73e+02	-4.31	0
2054-04-13.40	0.62	1.57e-03	0.000	-3.89288	4.52e+04	7.3e-09	8.72e+02	-5.94	0
2062-04-13.22	0.79	0.00e+00	0.000	-3.89575	1.77e+06	2.3e-10	8.72e+02	-7.52	0

## Most Interesting of Current NEOs in Database 99942 Apophis

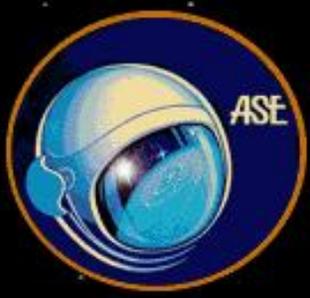
### 99942 Apophis



320 - 400 meters in diameter

Will make a very close pass by Earth in 2029 passing inside the geostationary satellite orbit

Close pass can cause return for impact in 2036 (1 chance in 6000 based on current orbit knowledge)

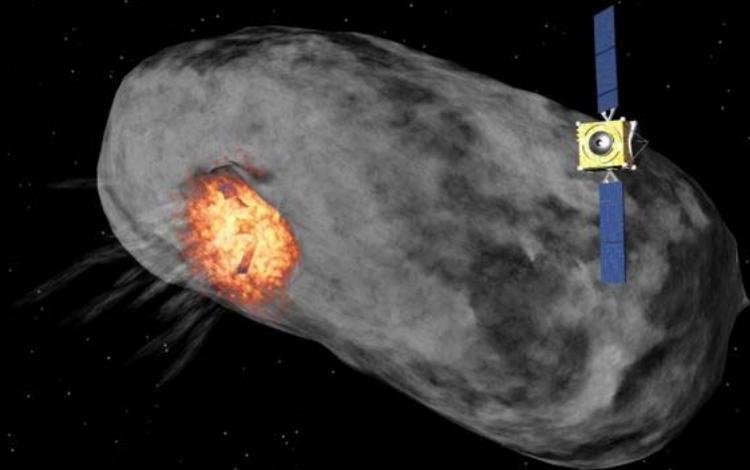


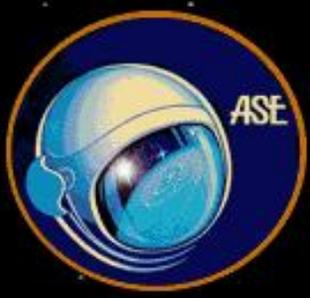
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## Deflection Capability

### Kinetic Impact

- Deep Impact (NASA)  
Successfully impacted Comet Tempel 1 in  
on July 4, 2005
- Don Quijote (ESA, Phase A)  
Proposed to impact target asteroid while  
standoff spacecraft gathers data





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## Deflection Capability

### Gravity Tractor

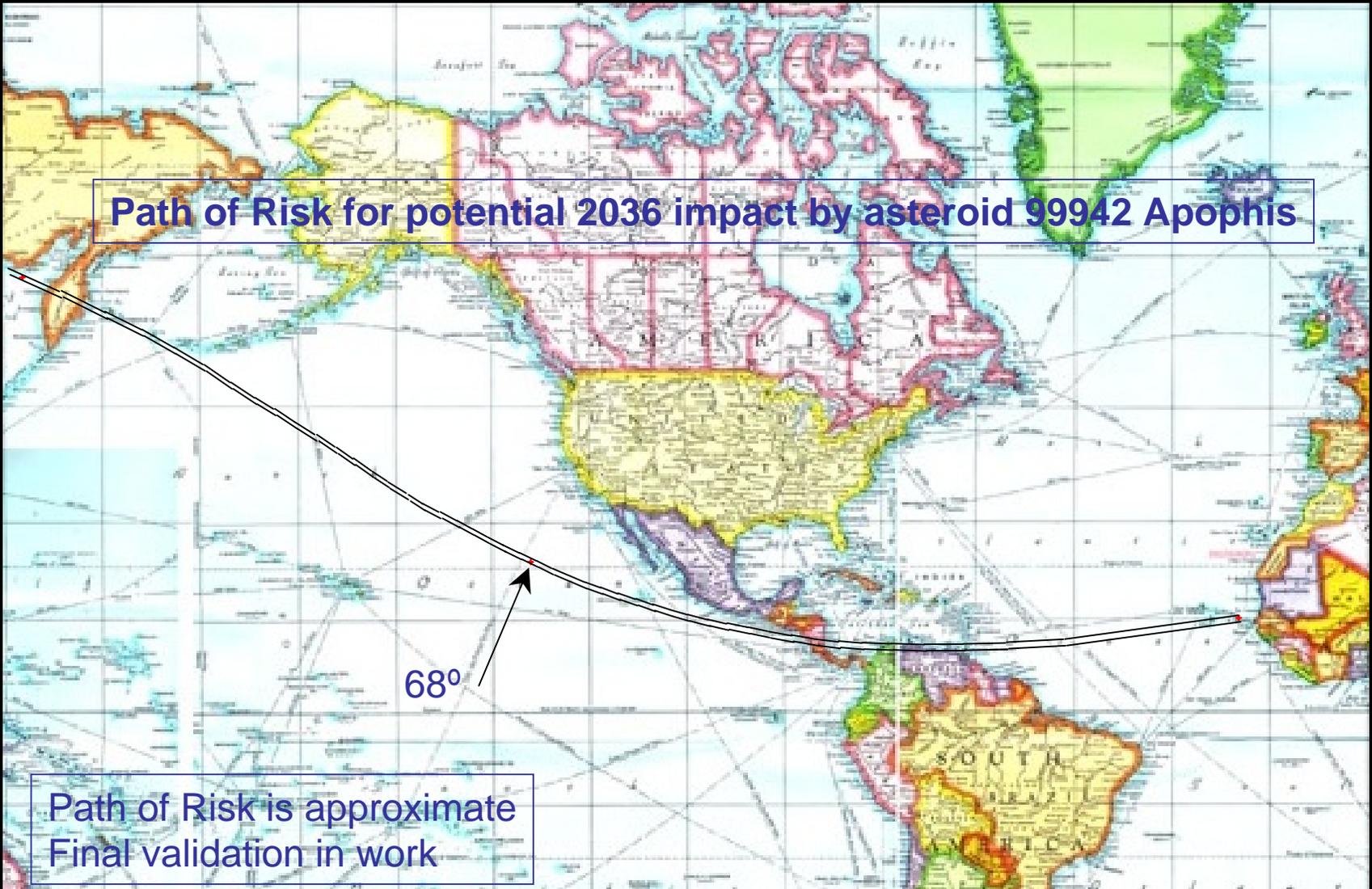
- Proposed by astronauts Ed Lu & Stan Love, B612 Foundation (Nature, 11/2005)
- Pulls the asteroid using mutual gravity as a tow-rope





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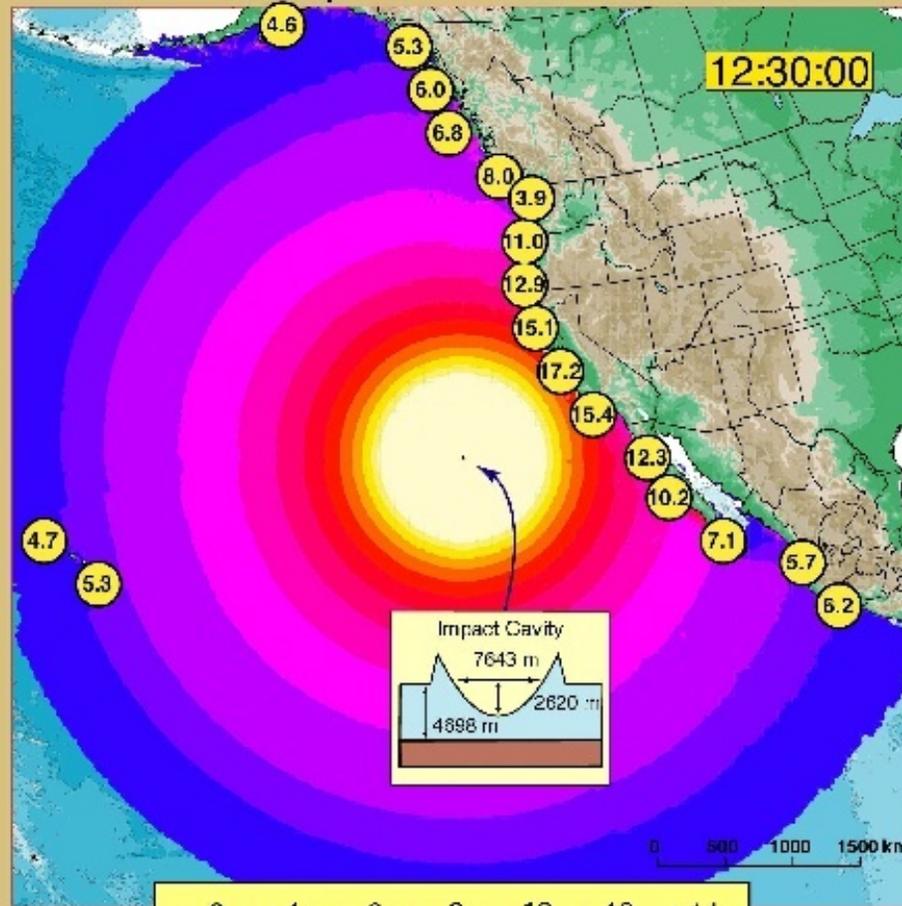
## Decision Context





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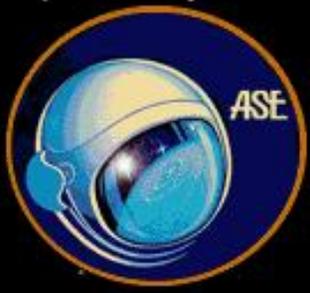
## 2004MN4 Impact Tsunami Simulation



2 4 6 8 10 12 >14  
peak tsunami envelope height (m)

Impactor Dia= 400m  
Velocity= 12.58 km/s  
Energy=  $6.6 \times 10^{18}$  J

Tsunami  
Energy=  $1.0 \times 10^{18}$  J  
Peak Period= 72s



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## Decision-making

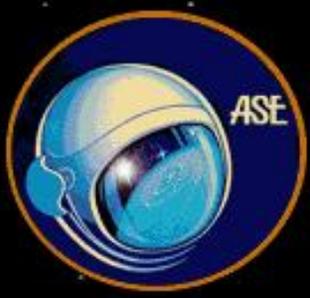
With adequate early warning and a proven deflection technology available everything will be in place... except the decision to act. This is a non-trivial challenge.

In general the people and property of all nations are at risk. NEO impacts are a planet-wide challenge.

In any particular impact case, the people and property of certain specific nations are involved.

Initiating a deflection temporarily increases the risk profile of some nations prior to eliminating the risk for everyone.

There are many decisions to be made in planning and executing a deflection. What are they? Who makes them? Based on what criteria?



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## Decision-making for example..

Issue: If the asteroid is relatively small an evacuation of the local impact zone may be preferable to mounting a deflection mission.

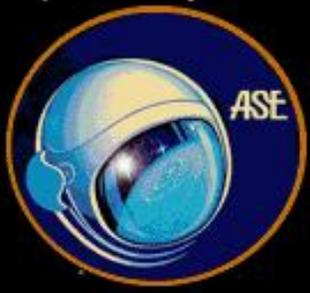
Questions: Who decides? On what basis? Who pays for the evacuation?

Issue: For any anticipated impact the probability of its occurrence will increase gradually.

Questions: At what probability of impact is a deflection planned? By whom? Using what deflection technique? At what probability is a mission launched? Who pays? Who executes the operation?

Issue: Once an asteroid deflection is initiated the original impact point (“act of God”) is shifted across the surface of the Earth (act of humankind) until the deflection is complete.

Questions: In which direction is the impact point to be shifted? Based on what criterion? Who is liable for failure?



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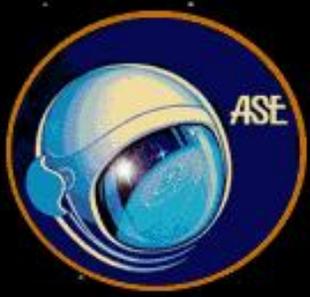
## Decision-making

### Timing..

It is critical that an approved international protocol on asteroid deflection be developed prior to the discovery of a likely impact event.

Once an impact is likely to occur it will have a well known path of risk with very specific nations in jeopardy. At this point competing national interests will dominate the risk trade-offs unless an internationally agreed protocol has already been established.

Since the discovery rate of NEOs will accelerate rapidly in the next few years the immediate development of this NEO deflection protocol is indicated.



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## Conclusion

The Association of Space Explorers believes that the development of an International NEO Deflection Protocol is critical to the protection of life and property from the devastation of a NEO impact.

We further believe that the United Nations is the appropriate international organization which should ultimately sanction such a protocol, and that COPUOS should assume the lead in preparing this instrument.

The ASE is prepared to assist COPUOS in organizing and developing this critical agreement.