NEOShield: une approche globale visant à atténuer le risque d'impact des astéroïdes

M.A. BARUCCI

l'Observatoire de Paris – LESIA

Orleans, 27.5.2014

The NEOShield Consortium

- *"An appropriate team of renowned personalities with an excellent set of relevant skills and experience"* - according to the proposal assessment report
- Access to database of NEO observations; tools and experience relevant to the study of NEO physical properties
- Access to telescopes for NEO characterization
- Hardware and software for impact experiments and their interpretation
- Expertise in investigating different mitigation techniques
- Expertise in relevant space-mission design/ development
- Expertise in impact hazard politics

Participant organisation	Leading personnel	Country
German Aerospace Center (DLR), Berlin *Coordinating partner*	A. W. Harris	Germany
Observatoire de Paris (LESIA and IMCCE)	LESIA: M. A. Barucci, M. Fulchignoni IMCCE: D. Hestroffer, W. Thuillot	France
Centre National de la Recherche Scientifique (Observatoire de la Côte d'Azur)	P. Michel	France
Open University	S. F. Green	UK
Fraunhofer – Ernst-Mach-Institut	F. Schäfer	Germany
Queen's University Belfast	A. Fitzsimmons	UK
Astrium (*supervisory interface for technical work packages*)	N. Saks	Germany France UK
Deimos Space	J. L. Cano	Spain
Carl Sagan Center, SETI Institute	D. Morrison	USA
TsNIIMash (Roscosmos)	S. Meshcheryakov	Russia
University of Surrey	V. Lappas	UK

- Proposal submitted in response to the European Commission's FP7-Space-2011 call - Category: "Prevention of impacts from near-Earth objects (NEOs) on our planet"
- Funds provided by the European Commission: 4.0 million Euro
- Kick-off: January 2012

The OBSPM-LESIA is the leader of two Work Packages (WPs):

WP2. NEO Physical properties
(LESIA, IMCCE, DLR, CNRS, EMI, QUB)

WP9. Global response campaign roadmap
(LESIA, IMCCE, Astrium, Deimos, TsNIIMash, DLR, CSC)

OBSPM-IMCCE:

WP5. Provide orbit evolution calculations

LESIA: M.A. Barucci, M. Fulchignoni, S. Fornasier, D. Perna

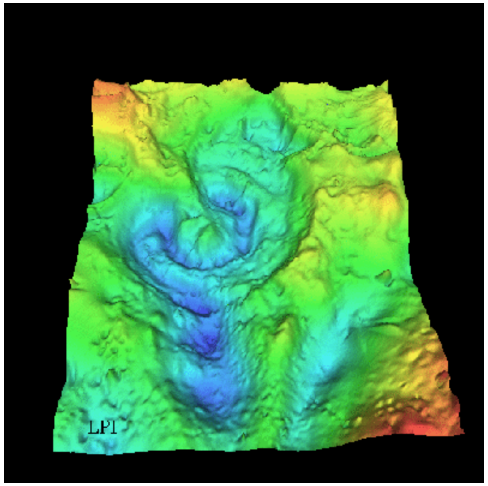
IMCCE: D. Hestroffer, W. Thuillot, M. Birlan, F. Colas, S. Eggl, (D. Bancelin)

Why NEOShield?

Besides being objects of great scientific interest,
Near Earth Objects (NEOs) also represent
a well-founded threat to life on our planet …
["the question is not if, but when, and how big!"]

... nonetheless, up to now there has been no a concerted
international plan on how to deal with the impact threat,
and how to prepare and implement mitigation measures…

... the NEOShield project aims to address these issues!



Why NEOShield?

Altitude of maximum brightness: ~23.3 km

Velocity at peak brightness: ~18.6 km/s

Total impact energy: ~440 kt
(1 kt = 4.184×10^{12} J)

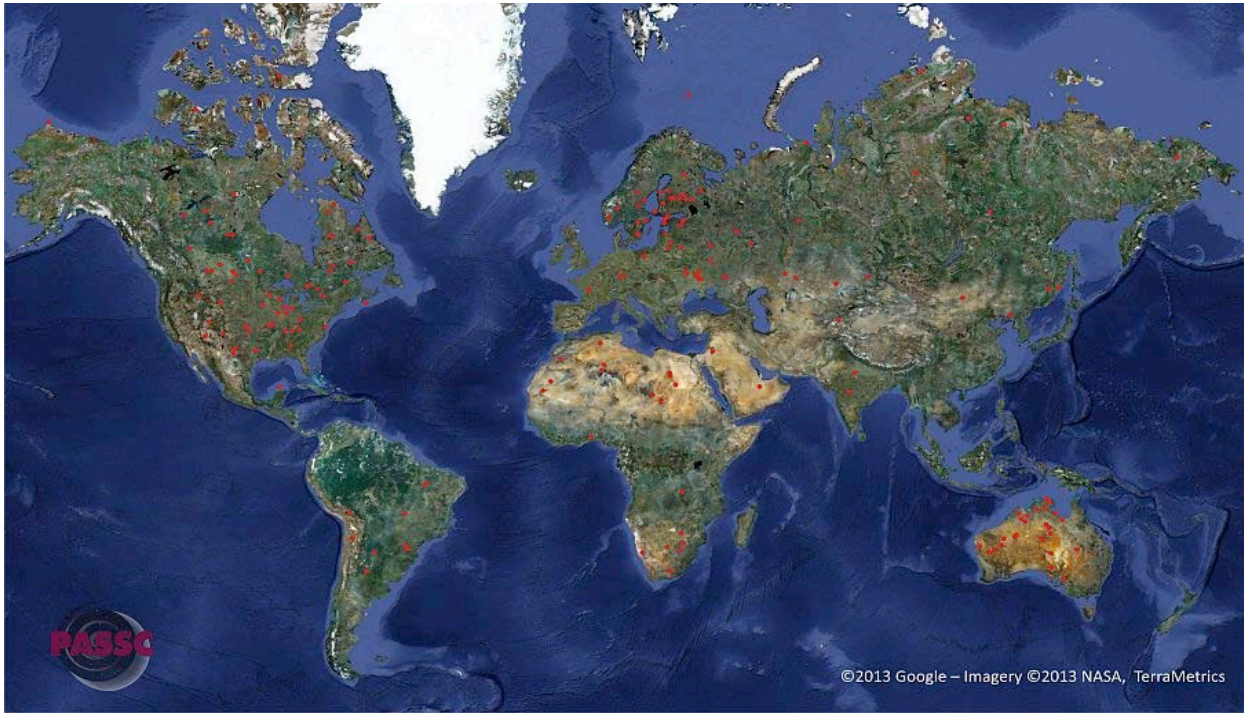
Asteroid diameter: ~18 m

(assuming mean density of LL ordinary chondrites, 3.6 g/cm^3)

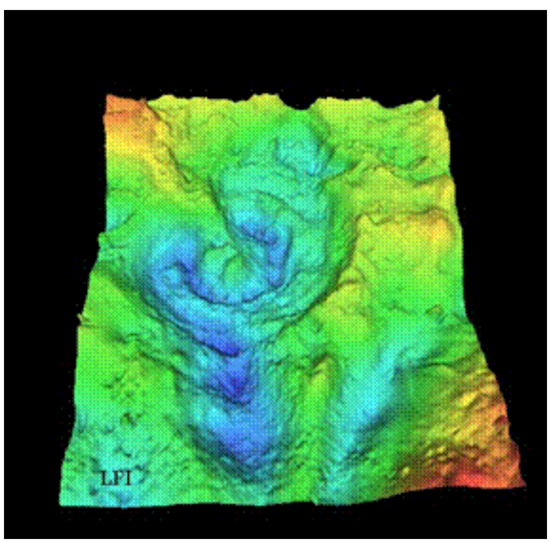
Data from: NASA/JPL

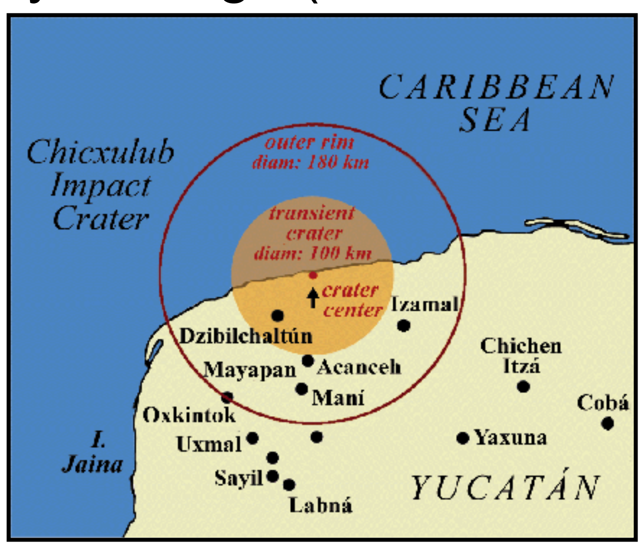
Chelyabinsk, Russia, 15 Feb. 2013

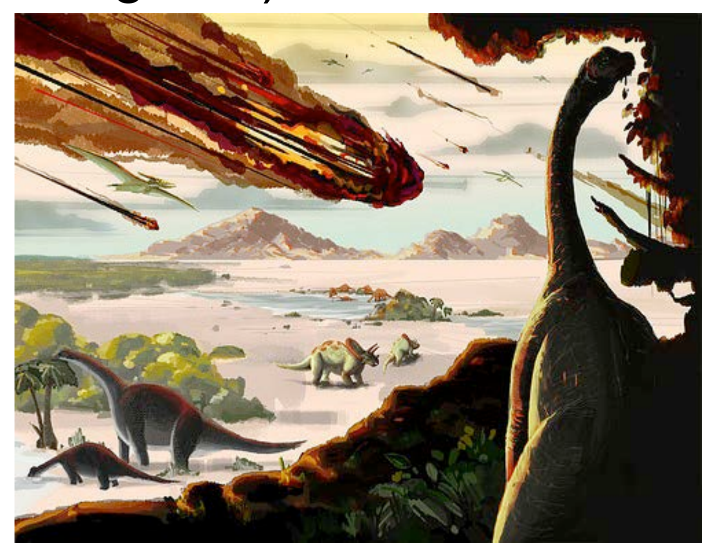
Why NEOShield?



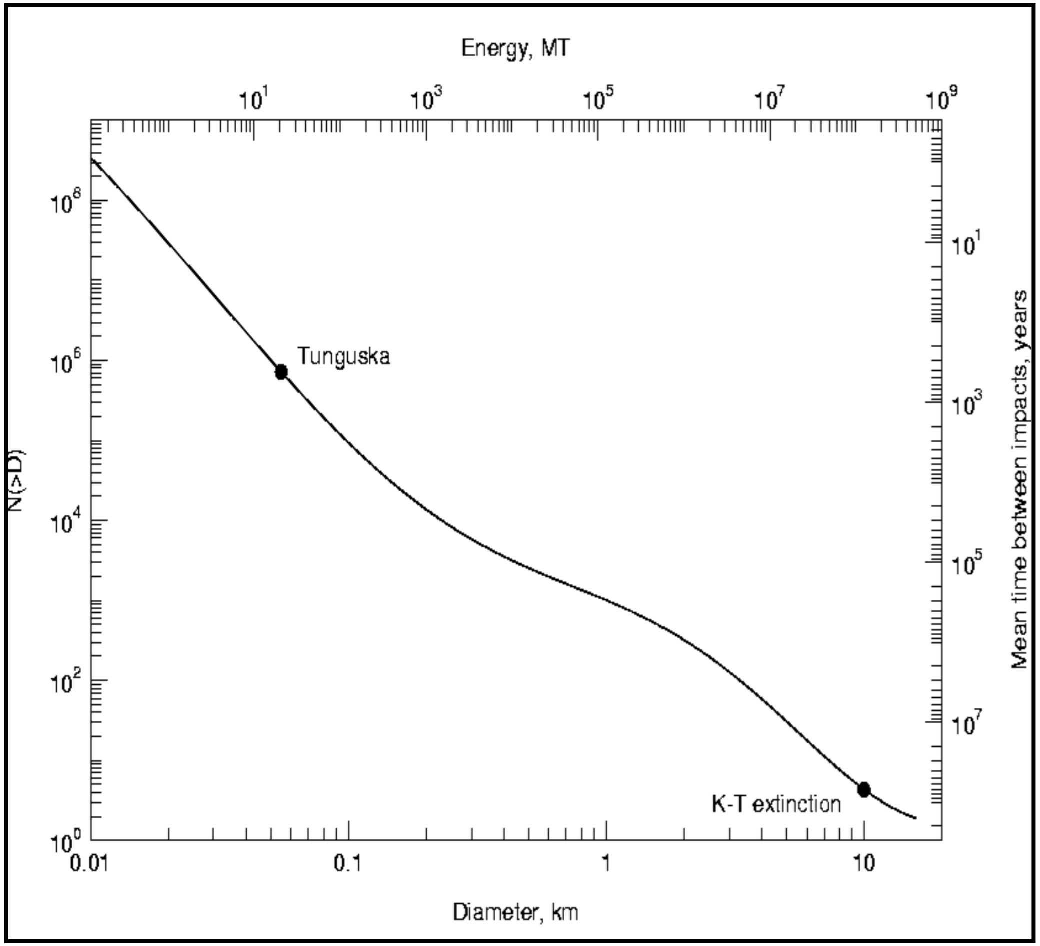
K-T event, ~ 65 million years ago (≈10 km, ≈10^8 megaton)







Why NEOShield?



Event frequency:

20 kiloton (all released in the atmosphere): ~ 1 year

10 megaton: ~ 10^2 years

10^6 megaton: ~ 10^6 years

Why NEOShield?

By Ettore Perozzi

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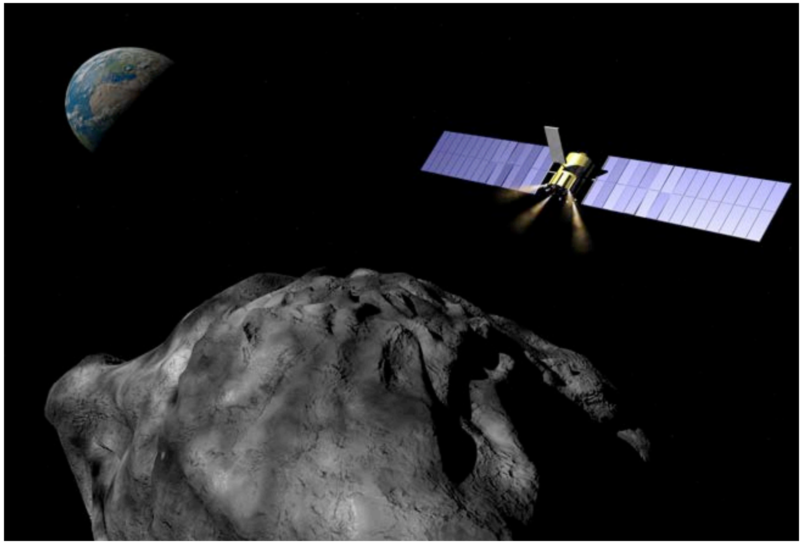
Primary aims of NEOShield

- investigate in detail the three most promising mitigation techniques: kinetic impactor, gravity tractor, blast deflection

- devise feasible demonstration missions

- investigate options for an international strategy for implementation when an actual impact threat arises



Main goals of NEOShield

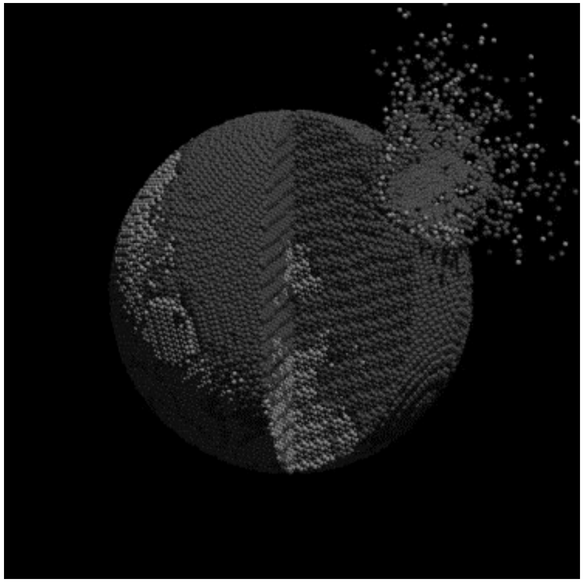
Science

- Analyze physical properties of NEOs from the point of view of mitigation requirements

- Carry out laboratory experiments on high-speed impacts into asteroid surface analogue materials; compare the results with those of numerical simulations to validate numerical models of fragmentation

- Determine requirements, strategy, instrumentation for mitigation precursor reconnaissance (ground-based facilities and space missions)

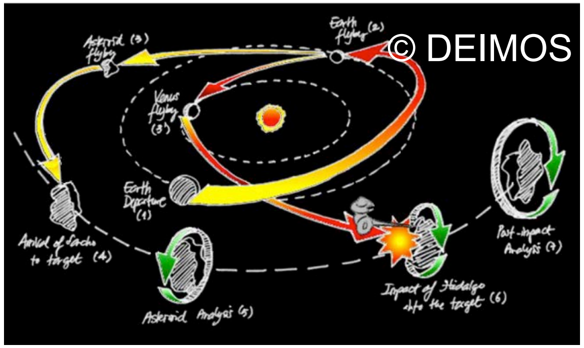
- Identify suitable targets for mitigation demo missions



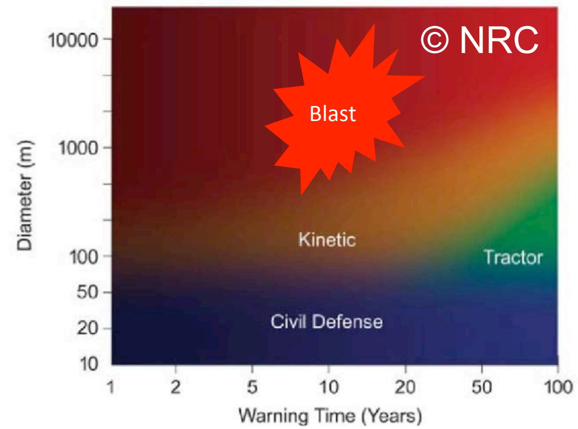
Main goals of NEOShield

Mitigation demonstration missions:

- Develop technologies not ready for implementation in potential mitigation missions (e.g., spacecraft guidance, navigation and control aspects)



- Provide detailed designs of technically and financially realistic missions to demonstrate the applicability and effectiveness of the investigated mitigation techniques

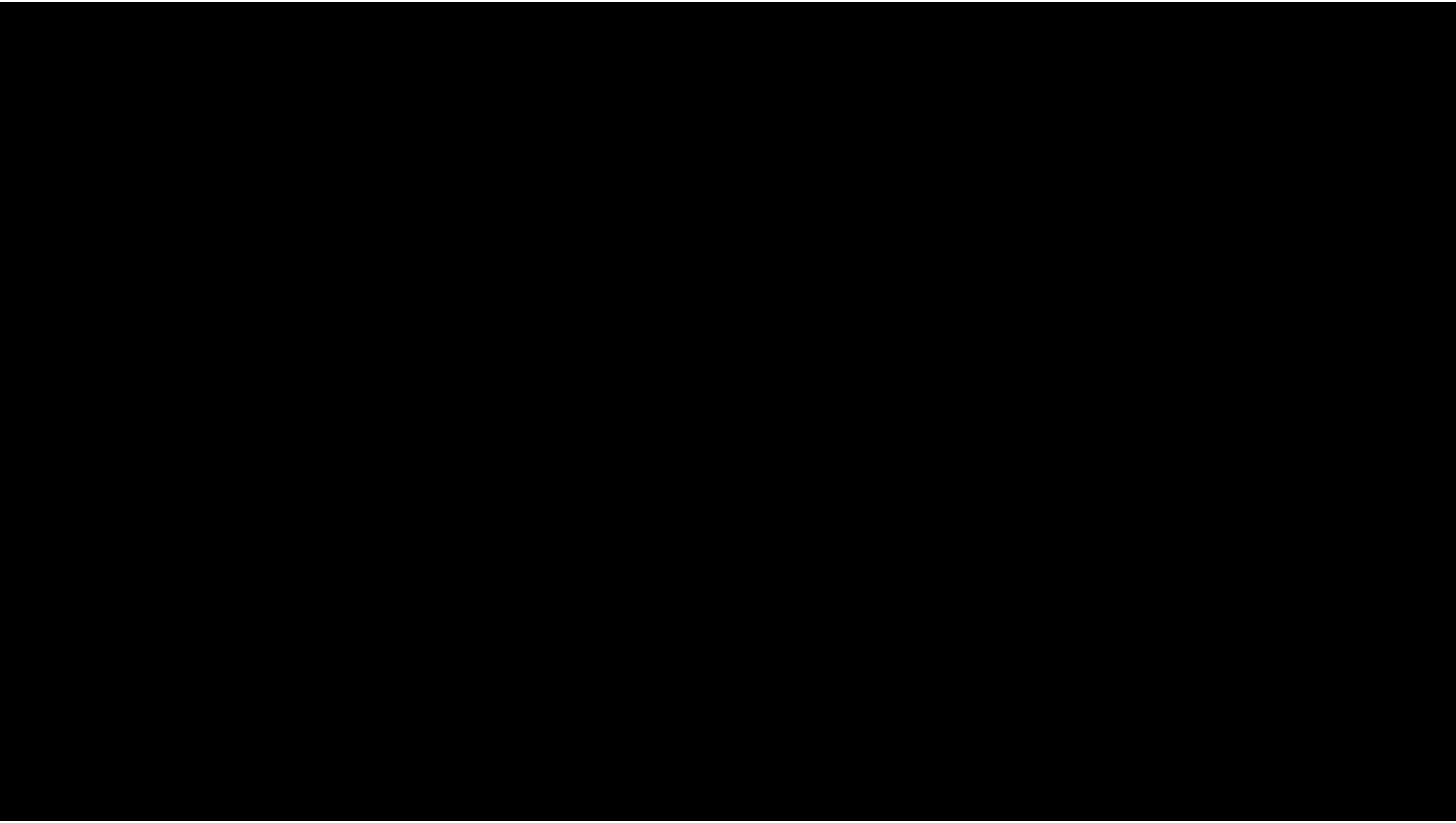


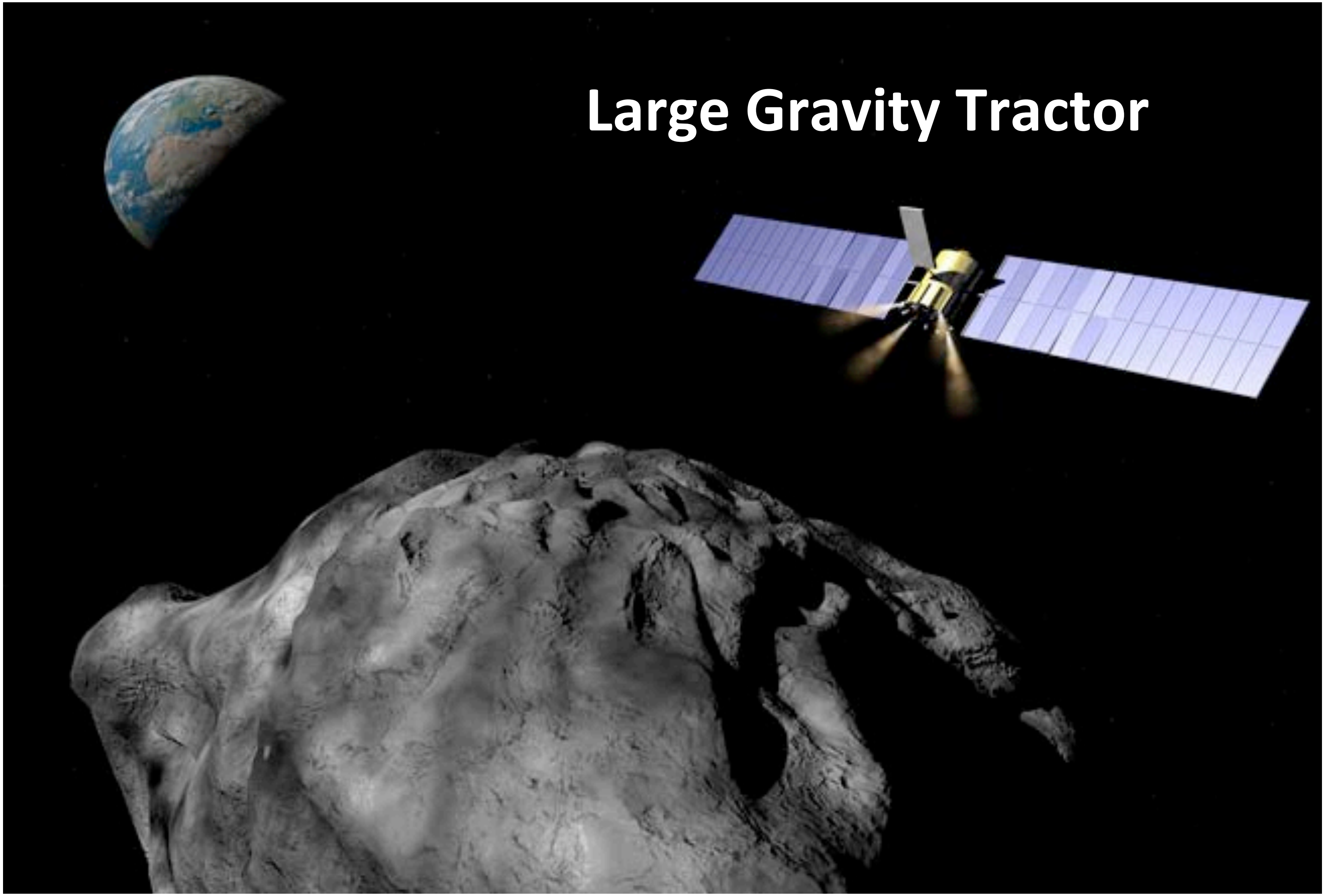
International response:

- Develop a decision-making tool to aid in response planning

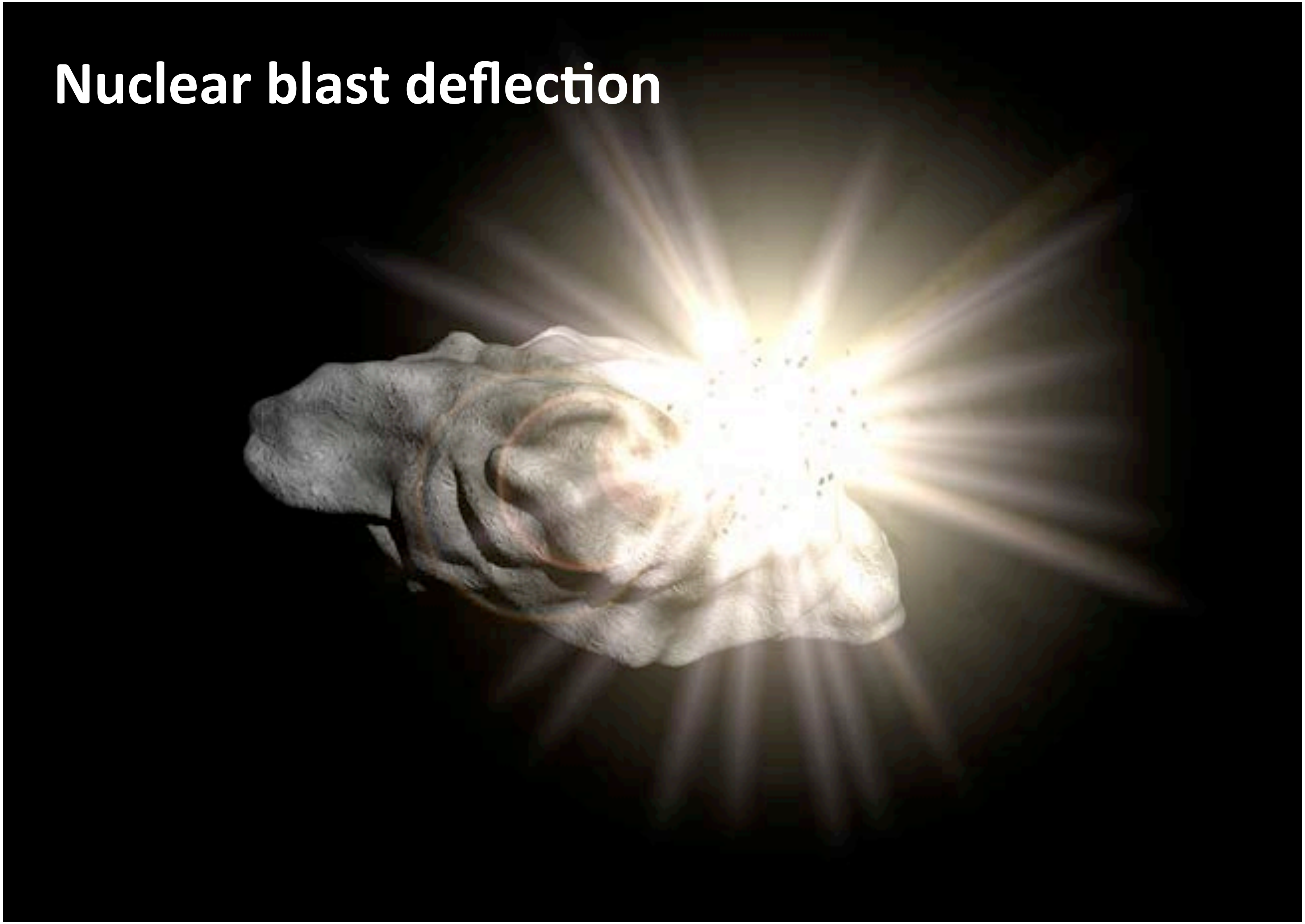
- Develop a global response roadmap in collaboration with partners such as UN (Action Team 14 on NEOs), space agencies (ESA's SSA programme), etc.

Kinetic Impactor





The larger and more massive the spacecraft, the more effective the method. The gravity tractor is also more effective if it hovers close to the asteroid. The major drawback of the large gravity tractor is that there is only a very small force between the spacecraft and the asteroid which means it can take many years to change the asteroid's course enough so the rock misses the Earth. These result in some quite difficult technical challenges such as spacecraft lifetime, launch mass and spacecraft control.



Possibly the most effective - yet controversial - method of deflecting the largest asteroids that could hit our planet. This technique requires the use of a nuclear explosive close to an asteroid, acting just like rocket fuel, pushing the asteroid away from Earth.

Alternative methods:

Moving asteroids with lasers:
There are two broad ideas discussed in papers related to moving asteroids with lasers. Using lasers to boil off material from the asteroid surface can move an asteroid as the gas behaves just like propellant. Also, the light itself can exert a small force, so large enough lasers could potentially move smaller asteroids.

Focusing the Sun's energy:
The use of large mirrors or lenses to concentrate the Sun's energy onto an asteroid using single or multiple spacecraft is an idea that has been discussed in numerous publications.

Changing an asteroid's thermal properties:
The orbit of an asteroid is effected by its thermal properties so it stands to reason that changing the overall thermal properties of an asteroid should result in a change of its orbit. Many ideas have been suggested as to how this can be achieved: from painting an asteroid white, to shading it from the Sun.

In conclusion…

- NEOShield will provide European Commission with the first ever "global approach" mitigation project, including detailed designs of readily feasible demonstration missions

- Development of actual demo missions: an EC-ESA joint strategy is necessary

- Whatever the mitigation technique:
  a careful investigation of the physical properties of the target is essential

- http://www.neoshield.net/

- https://www.facebook.com/NEOShield

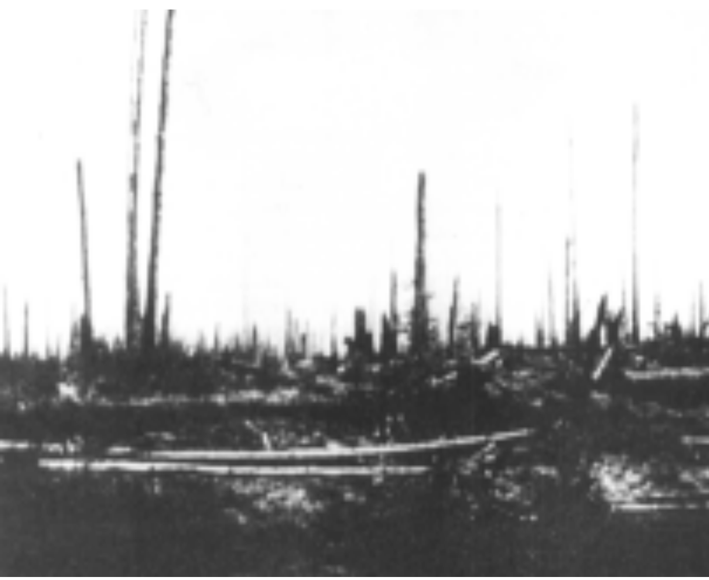
- https://twitter.com/NEOShieldTeam

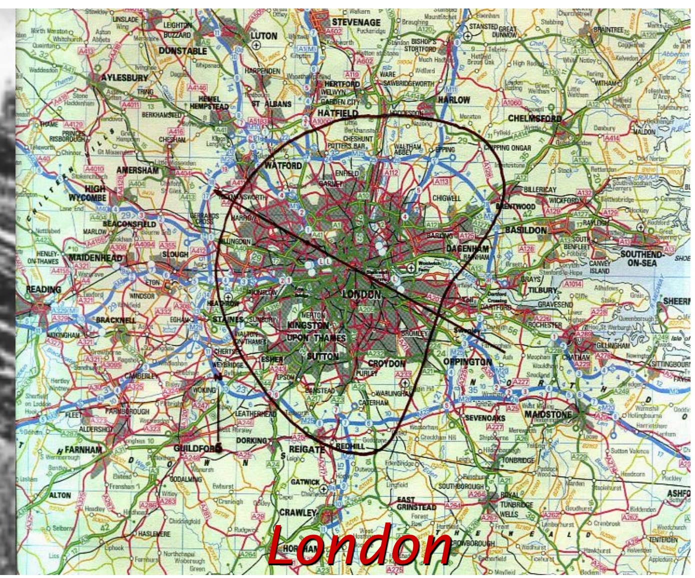
NEOShield 2 - H2020 Protec 2 Call

EXTRA SLIDES

Why NEOShield?

Tunguska, 1908 (~50-100 m, ~10-15 megaton)





Photos from Kulik expedition (1927)

NEOShield Deliverable 2.3

“Instrumentation for mitigation precursor and demo missions ”

Payload	Objectives	Requirements
Radio Science Experiment	Mass, centre of gravity, orbit	Accuracy of ~1% in mass determination
Cameras (Narrow Angle and Wide Angle)	Size, shape, rotational state, topography, surface features	Scale of ~10 cm/pixel. A WAC has a lower priority than a NAC, but could be important to rapidly obtain a global characterization in the case of a limited time to determine the physical properties
Laser Altimeter	Shape, topography, surface properties, position control for gravity tractor	Vertical resolution < 10 cm
V-NIR Spectrometer	Mineralogy	Spectral range: 0.4-4 µm. S/N ratio > 100
Thermal IR Spectrometer and Radiometer	Mineralogy, thermal inertia, temperature distribution	Spectral range: 5-25 µm. S/N ratio > 100. Temperature range: 100-400 K. Temperature resolution: < 1 K
Radar Tomographer	Internal structure, porosity	Multi-channel instrument. Higher frequencies (e.g., 30 Mhz) should allow a spatial resolution of ~ meters for a depth of ~ hundreds of meters below the surface.
Test Projectile	Surface and subsurface properties, hints on internal structure	Scaled to produce “small scale” effects
X-Ray Spectrometer	Elemental composition, abundance of Fe and heavy elements	Detection of Z ≥ 26 elements

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- Based on D2.2
- Study and design appropriate instrumentation for
  i) mitigation precursor missions
  ii) mitigation demo missions
- Determine minimum performance requirements
- Examine the applicability of developed instrumentation
- Investigate necessary modifications to achieve the required performance

SEVENTH FRAMEWORK PROGRAMME

NEOShield Deliverable 2.2

“Report on requirements for mitigation precursor reconnaissance”
(11/2012: First draft; 7/2014: Final study)

- Assessment of the true impact probability through the orbit refinement, including the necessity for a reconnaissance mission.
- Identification of what physical properties are relevant to a particular type of mitigation method.
- Examination of the relevance and accuracy of a variety of observational techniques and data types, and ways in which this crucial information can be best to provide.
- Consideration of a programme of reconnaissance observations, both Earth-based and in situ. Development of a

NEOShield
A Global Approach to Near-Earth Object Impact Threat Mitigation

Contract No:	**FP7-SPACE-2011-282703**	**Project Start:**	**1. January 2012**
Project Coordinator	**DLR**	**Project Duration:**	**41 Months**

WP2 Deliverable 2.2	**D2.2: Report on requirements for mitigation precursor reconnaissance (Initial study).**		
WP Leader	ObsParis-LESIA	Task Leader	ObsParis-LESIA
Due date	30 November 2012		
Delivery date	14 December 2012		
Document Type	Initial report		
Editor (authors)	LESIA / IMCCE / D. Perna, S. Eggl, A. Barucci		
Contributors	D. Bancelin, M. Birlan, S. Fornasier, M. Fulchignoni, D. Hestroffer, W. Thuillot		
Verified by			
Version	1.0		
Dissemination Level			

The NEOShield Consortium consists of:

Deutsches Zentrum für Luft – und Raumfahrt (DLR)	DLR, Project Coordinator	Germany
Observatoire de Paris	OBSPARIS	France
Centre National de la Recherche Scientifique	CNRS	France
The Open University	OU	UK
Fraunhofer Ernst-Mach-Institut	EMI	Germany
Queen's University Belfast	QUB	UK
Astrium GmbH	Astrium-DE	Germany
Astrium Limited	Astrium-UK	UK
Astrium S.A.S.	Astrium-FR	France
Deimos Space	Deimos	Spain
SETI Institute Corporation Carl Sagan Center	CSC	USA
TsNIIMash	TsNIIMash	Russia
University of Surrey	Surrey	UK

Version control / History of Changes

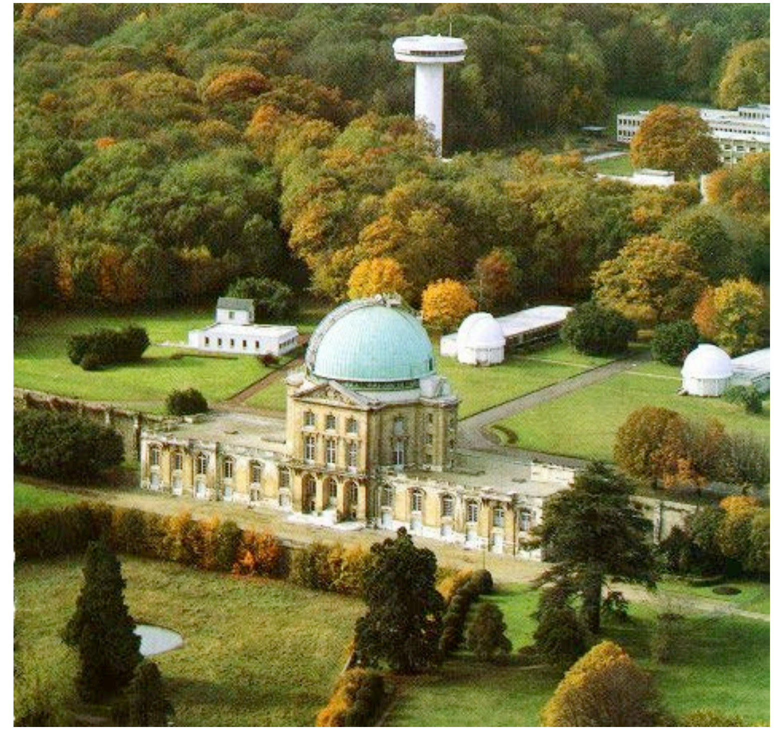
Date	Version	Author	Change description
23.11.12	0.1	D. Perna	First draft
25.11.12	0.2	D. Perna	Sections edited: 4.2, 4.5.1, 5.1, 5.3, 6
14.12.12	1.0	D. Perna	Incorporating comments from Consortium

The role of LESIA within NEOShield

Leader of two Work Packages (WPs):

- **WP2. NEO Physical properties.**

The scientific driver of the project; provides requirements for laboratory experiments, modelling, and reconnaissance of NEO physical properties and designs of scientific instrumentation for mitigation precursor (reconnaissance) missions and mitigation demo missions.



- **WP9. Global response campaign roadmap.**

From a consideration of realistic impact-threat situations, identify the necessary steps for an effective (global) response. The roadmap will consider the necessary international decision-making milestones, practical prerequisites

<u>The role of LESIA within NEOShield</u>

Leader of two Work Packages (WPs):

- **WP2. NEO Physical properties.**

    D2.2: Requirements for mitigation precursor reconnaissance (with IMCCE) (7/2014; First draft due by 11/2012)

    D2.3: Instrumentation designs for mitigation precursor and demo missions (12/2013; First draft due by 06/2013)

- **WP9. Global response campaign roadmap.**

    D9.1: Preliminary roadmap outline (7/2014)

    D9.2: Detailed reconnaissance observations (12/2014)

The “birth” of NEOShield

- Proposal submitted in response to the European Commission's FP7-Space-2011 call for research proposals (deadline: 25th Nov. 2010). Category: “Prevention of impacts from near-Earth objects (NEOs) on our planet”

- After assessment (March 2011), NEOShield topped the list of 6 proposals submitted in the category

- Negotiations with the European Commission were successfully concluded with the signing by the EC of the NEOShield Grant Agreement on 17/11/2011

- Total volume of NEOShield funding: 5.8 million Euro

- Funds provided by the European Commission: 4.0 million Euro

- Kick-off: January 2012