The Status of NEO-related Activities in Germany

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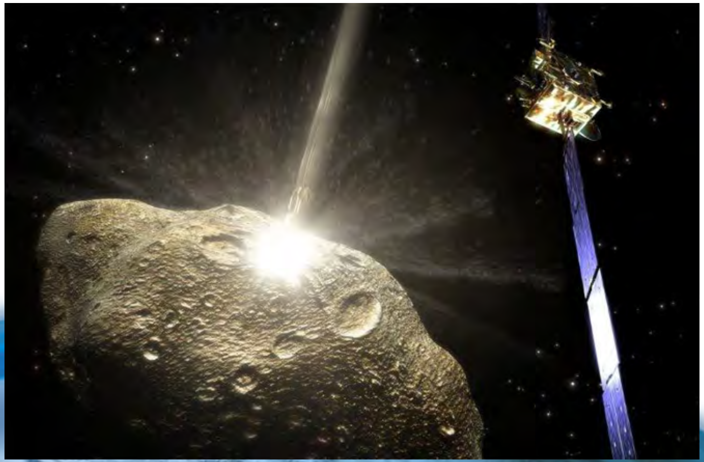
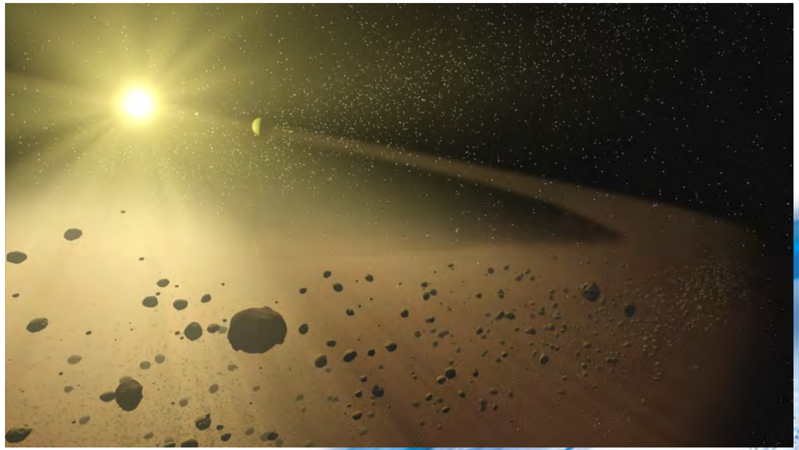
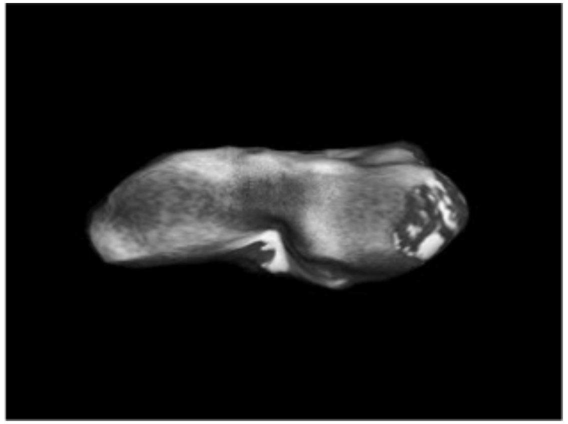
(Including material provided by Jürgen Oberst and Tra-Mi Ho)







Knowledge for Tomorrow

NEOShield (1 & 2)

NEOShield-1, FP7:

- November 2010: Submitted in response to the European Commission's FP7-Space-2011 call for research proposals. Category:
- "Prevention of impacts from near-Earth objects (NEOs) on our planet"
- January 2012 – June 2015.
- Total NEOShield funding = 5.8 million euro (13 partner organisations from 6 nations).
- Coordinator: DLR Institute of Planetary Research (A. Harris)

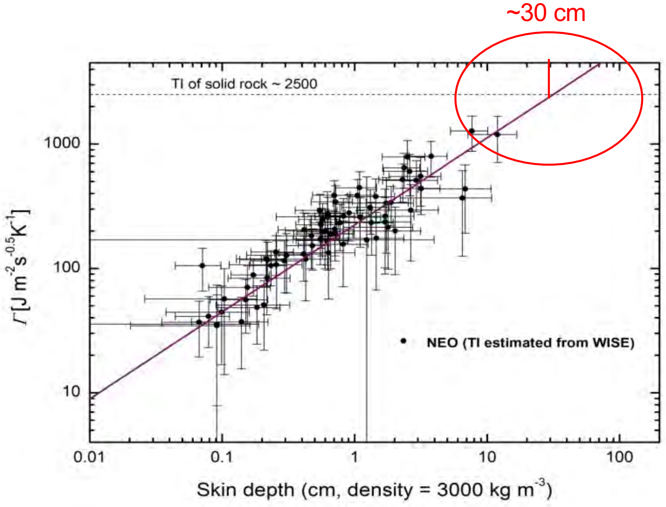
NEOShield-2, Horizon 2020:

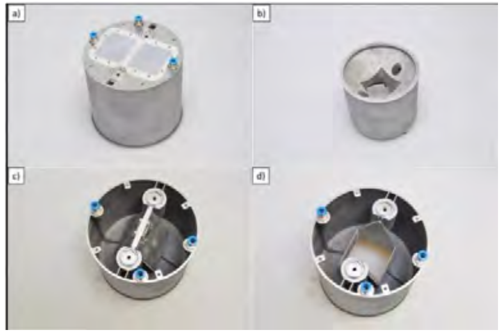
- "Access technologies and characterization for near-Earth objects"
- March 2015 - September 2017.
- Total NEOShield-2 funding ~ 6 million euro (11 partner organisations from 5 nations).
- Coordinator: Airbus D&S, Germany (A. Falke)

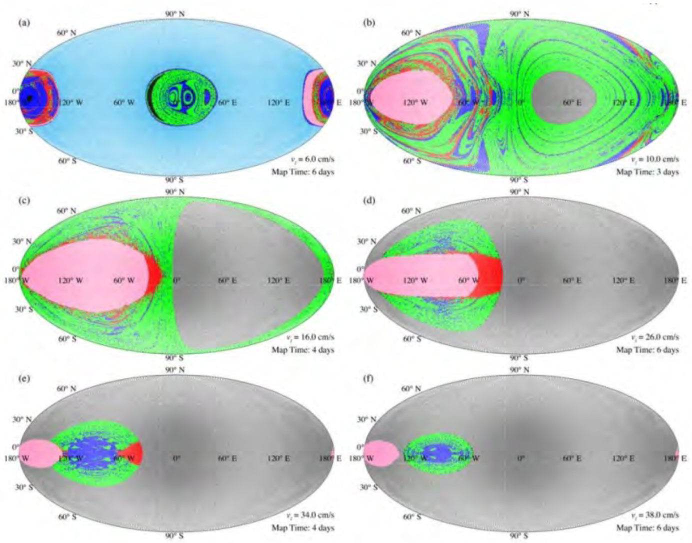
Results from the NEOShield and NEOShield-2 Projects

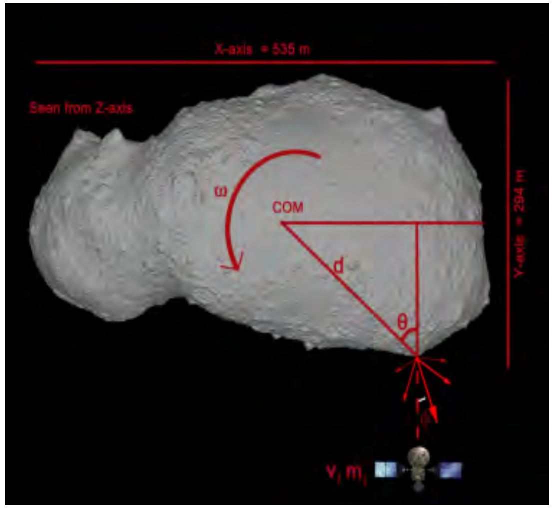
http://www.neoshield.eu/

- Modelling and trade-off studies of NEO deflection methods.
- Detailed studies of feasible space missions to test NEO deflection methods.
- Analyses of observational data on deflection-relevant physical characteristics of NEOs and associated modelling.
- Modelling of impacts on asteroids (kinetic impactor).
- Technical developments in support of in-situ investigations of NEOs.









NEOShield-2: Physical properties of Asteroids

Analysis of observational data

Results obtained	No. NEOs observed	NEOShield-2 partner
Taxonomy via colours	430+	INAF, Italy; IMCCE, Paris, France
Taxonomy via phase functions	11+	INAF, Italy
Taxonomy via spectroscopy	137+	Obs. Paris, France
Spin periods	56	IMCCE, Paris, France

Results obtained	No. asteroids for which data retrieved from archives	NEOShield-2 partner
Astrometry from precovery detections in archival Pan-STARRS images	30	Queen's Univ., Belfast, UK
Sizes, albedos, thermal properties	2000	CNRS, France
Estimated thermal inertia, surface structure	6000	DLR, Germany

www.neoshield.eu

NEOShield-2 | Home | NEOs | Mission | Mitigation Measures | Education | Search

NEOShield-2 Project Executive Summary

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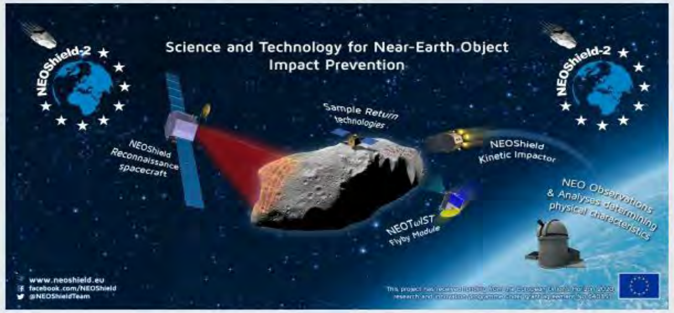
Find here an executive summary of the **first** NEOShield-2 periodic report provided to and accepted by the European Commission.



Contents at a Glance [hide]

Executive Summary

Context & overall objectives

As a result of modern observing techniques thousands of near-Earth objects (NEOs) have been discovered over the past 20 years and the reality of the impact hazard has been laid bare. Even relatively small impactors can cause considerable damage: the asteroid that exploded over the Russian city of Chelyabinsk in February 2013 had a diameter of only 18 m yet produced a blast wave that damaged buildings and caused injuries to some 1500 people [Fig. 1]. The potentially devastating effects of an impact of a large asteroid or comet are now well recognized. Can we protect our civilisation from the next major impact?

In contrast to other natural disasters, such as earthquakes and tsunamis, the impact of an asteroid discovered early enough can be predicted and prevented. Following on from the original NEOShield project (FP7), the objectives of NEOShield-2 included improvement of the targeting accuracy and relative velocity of a kinetic impactor spacecraft to deflect a small asteroid, and development of autonomous spacecraft control systems to facilitate navigation close to a low-gravity, irregularly shaped asteroid. Scientific objectives included astronomical observations of NEOs and the analysis of archival data (radar, infrared, spectroscopy, etc.), complemented by modelling and computer simulations, to improve our understanding of their physical properties and how a NEO would respond to a deflection attempt (for a more detailed Executive Summary including the illustrations see below).

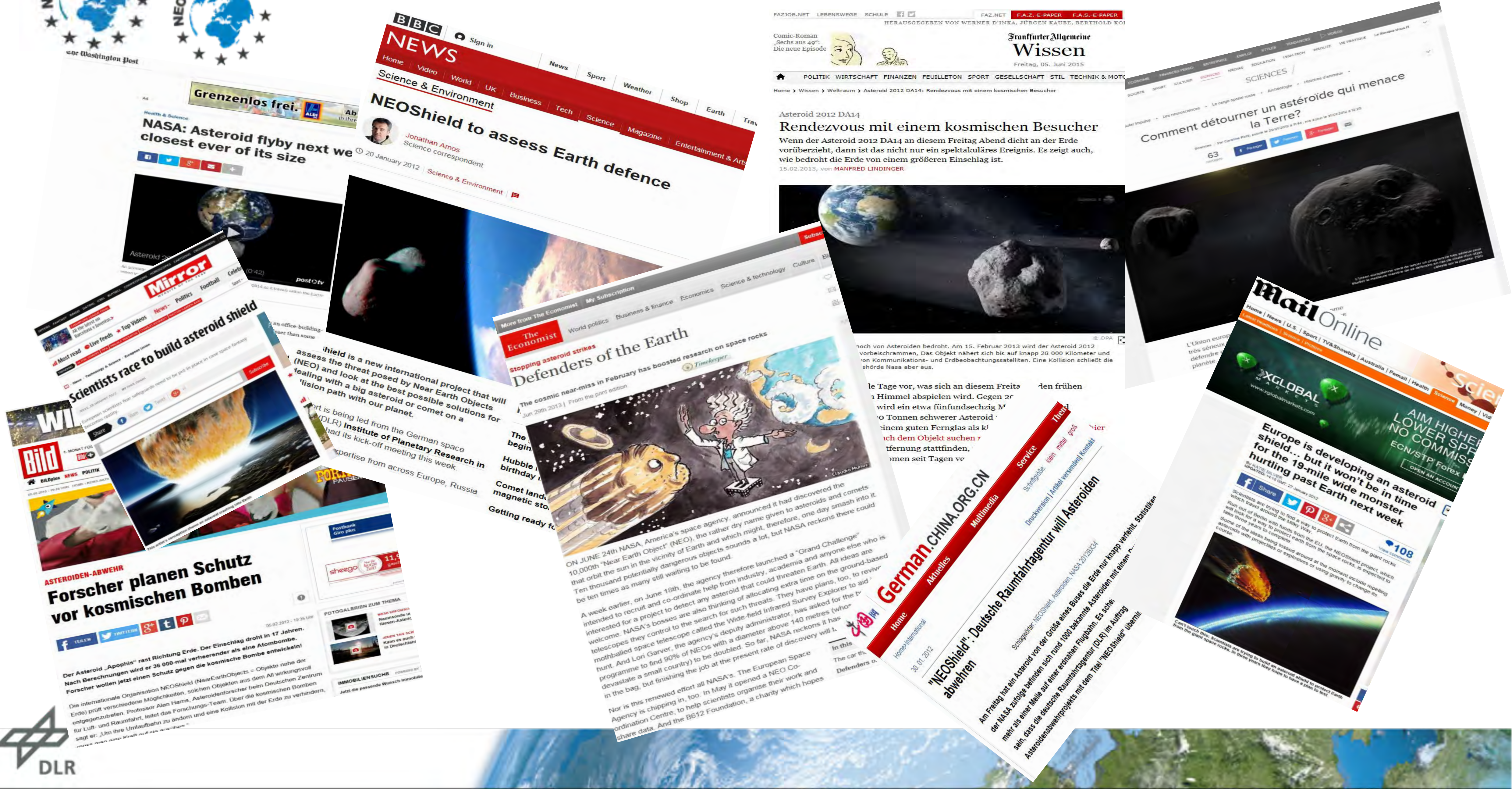
Work performed & main achievements

We have carried out detailed investigations of key technologies vital to the exploration and deflection of NEOs [Fig. 2], including autonomous guidance, navigation, and control systems for a spacecraft in the final approach and proximity phases to an asteroid for the purposes of in-situ science such as surface observations and setting down a lander module, and for a kinetic impactor spacecraft to maximize the targeting accuracy. A harmonized verification approach [Fig. 4] for those technology developments was established leading to an independent validation of all three scenarios to TRL 5-6 by extensive test campaigns. Furthermore, an innovative low-cost kinetic-impactor deflection demonstration concept called NEOTωIST [Fig. 3] has been developed. We have also demonstrated techniques for precise and rapid NEO orbit determination [Fig. 5] and developed mechanisms for the collection of material samples from the surface of a NEO [Fig. 6].

NEOShield – there's no shortage of scientific and technical research results…

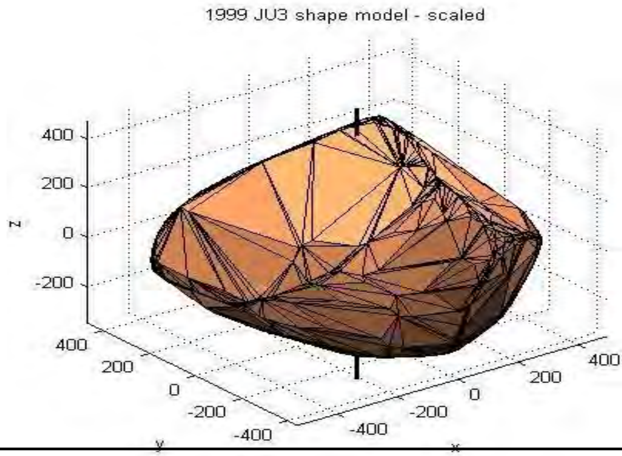
http://www.neoshield.eu/

NEOShield – there's no shortage of media interest…

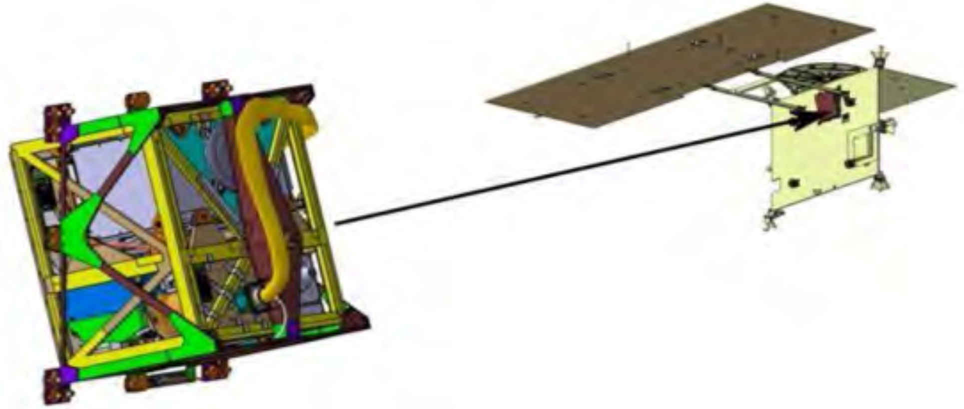


MASCOT onboard Hayabusa 2 (HY2)

- Hayabusa Immediate follow-on Asteroid Sample Return Mission (JAXA/ISAS).
- Target Object: NEA (162173) Ryugu (C-Typ).
- Launch: Dec 2014.
- Arrival + Ops: July 2018 + 18 months.
- Return to Earth: 2020.
- PL: Four orbiter experiments, impactor, sampler, 3 Minerva rovers + MASCOT (DLR/CNES).



Parameters	
Mean volume-equivalent diameter (km)	0.87±0.03
Bulk density (kg/m^3)	1300
Spin period (hrs)	7.63±0.01
Spin axis (J2000), positive pole	λ_ecl = 73.1° β_ecl=-62.3° retrograde rotation Obliquity=151.6°
V_{esc} (m/s)	0.37±0.03
Thermal inertia (global average) (Jm^{-2} s$^{-0.5}$ K^{-1})	Notional: 400
Emissivity	0.9 (assumed)
g (m/s^2)	1.5×10^{-4}
Surface fraction covered with craters	0.4 – 0.9



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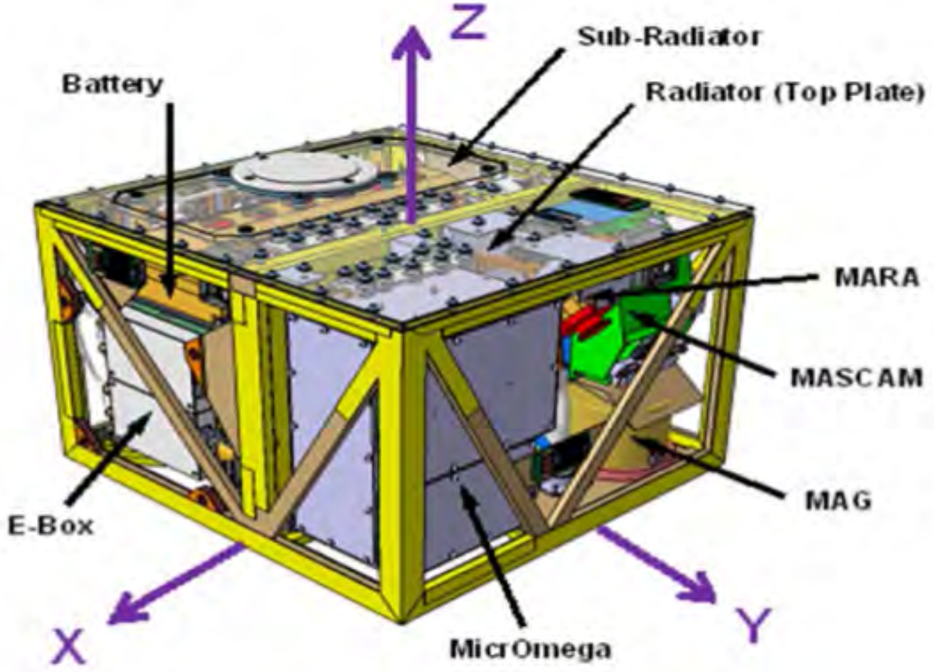
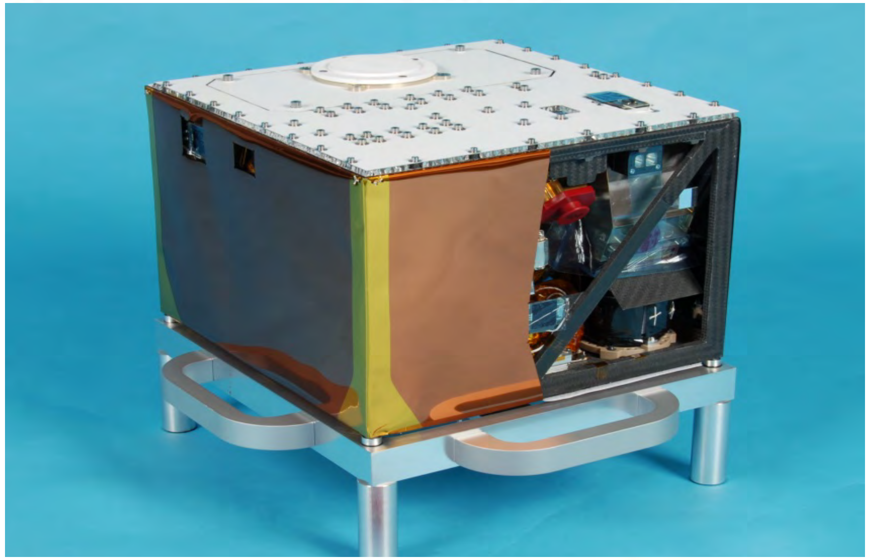
Technische Universität Braunschweig

宇宙航空研究開発機構
Japan Aerospace Exploration Agency

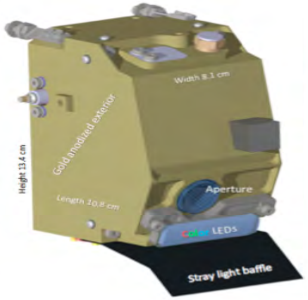
MASCOT

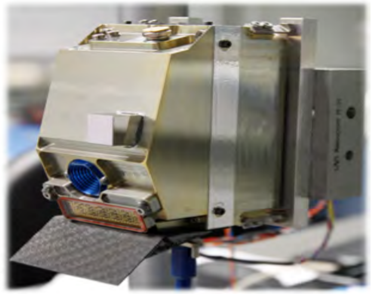
- A small and agile surface science platform carrying a suite of 4 scientific instruments.
- Total mass is ~ 10 kg.
- Total volume is ~ 0.3 x 0.3 x 0.2m³.
- Separation & descent onto the asteroid via free-fall.
- Self righting and relocation ability.
- Current landing window: Oct 2018 (backup window: Feb/May 2019).





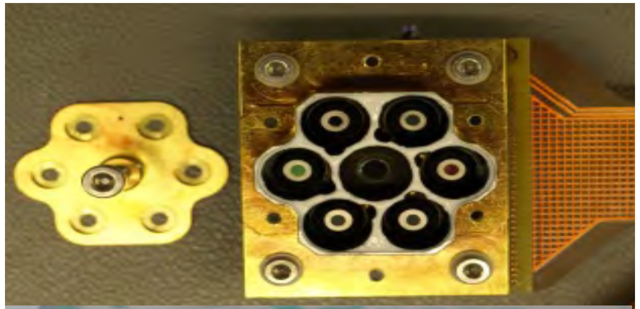
MASCOT Science Payload





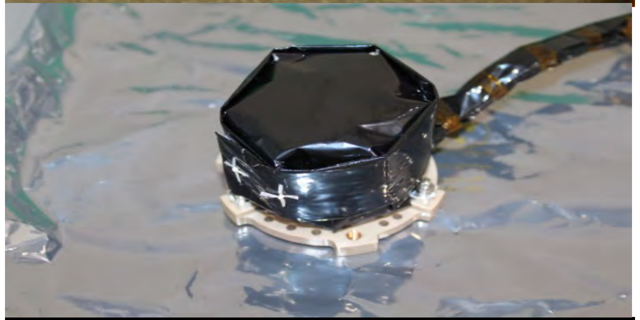
Camera (MasCam)/DLR PF

- *Ground truth* for orbital measurements of the HY2 instruments and the in-situ MSC sensor suite.
- Geological context of the samples.



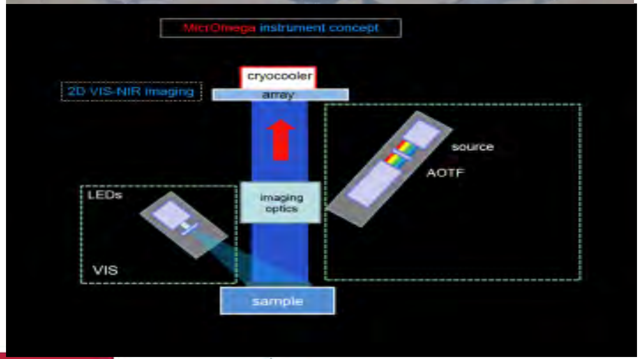
Radiometer (MARA)/DLR PF

- Surface brightness temperature for a full asteroid rotation.
- Surface thermal inertia and spectral slope in the IR.



Magnetometer (MasMag)/TU Braunschweig

- Observe the magnetic field profile during descent and hopping.
- Identification of global and local magnetization of asteroid and reconstruct the coordinate system of the magnetic field vector.

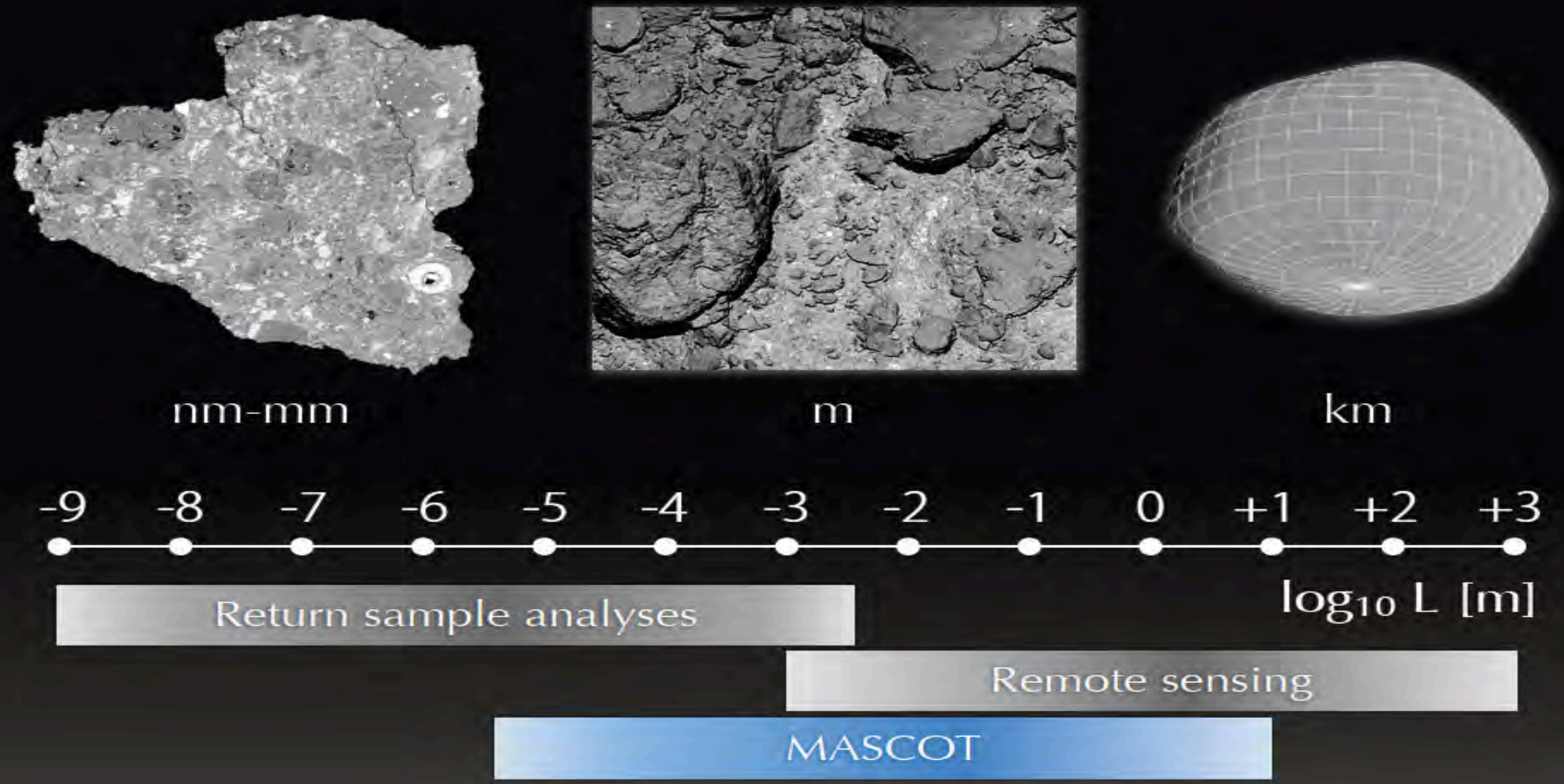


IR Hyper-Spectral Imager (MicrOmega)/IAS Paris

- Composition of the asteroid’s surface, at grain scale in terms of minerals (pristine, altered), ices/frosts, organics.
- Microscopic structure of the soil, and the relation between the various phases of distinct compositions.

MASCOT
DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center
cnes CENTRE NATIONAL D'ÉTUDES SPATIALES
IAS Orsay
Technische Universität Braunschweig
JAXA 宇宙航空研究開発機構 Japan Aerospace Exploration Agency

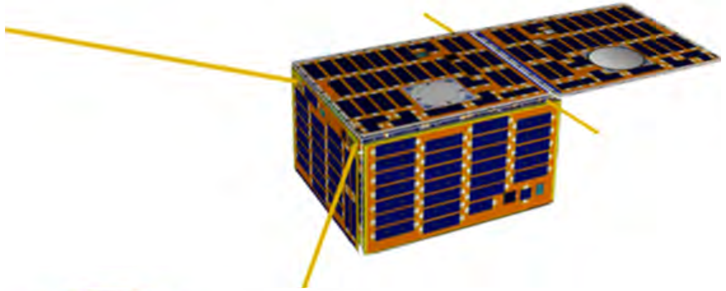
MASCOT will serve as ground truth tie point between sample science (10^{-3}-10^{-6}m) & remote sensing sciences (10^{3} – 10^{-3}m)



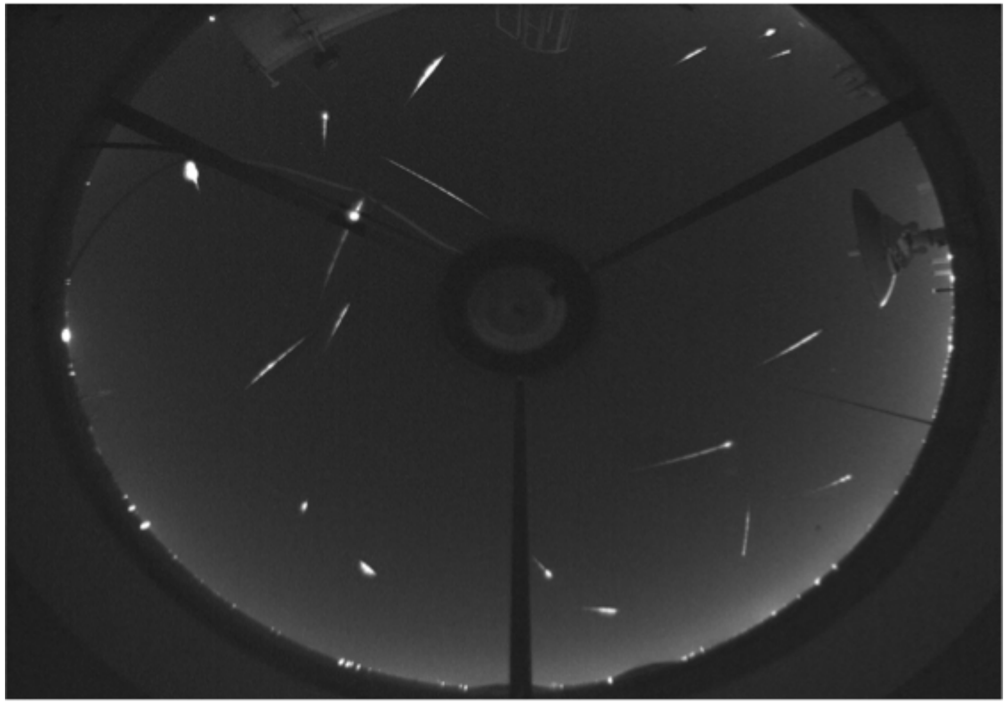
MASCOT: Conclusions/Outlook

- The MASCOT concept is agile, lightweight and flexible. ⇒ It is applicable for various future exploration missions of low gravity bodies.

- The MASCOT lander is part of future missions studies such as
  - AIM (ESA): Asteroid Impact Deflection Mission
  - MMX (JAXA): Mars Moons Explorer Mission.



Feuerkugelnetz = Fireball Network



Background

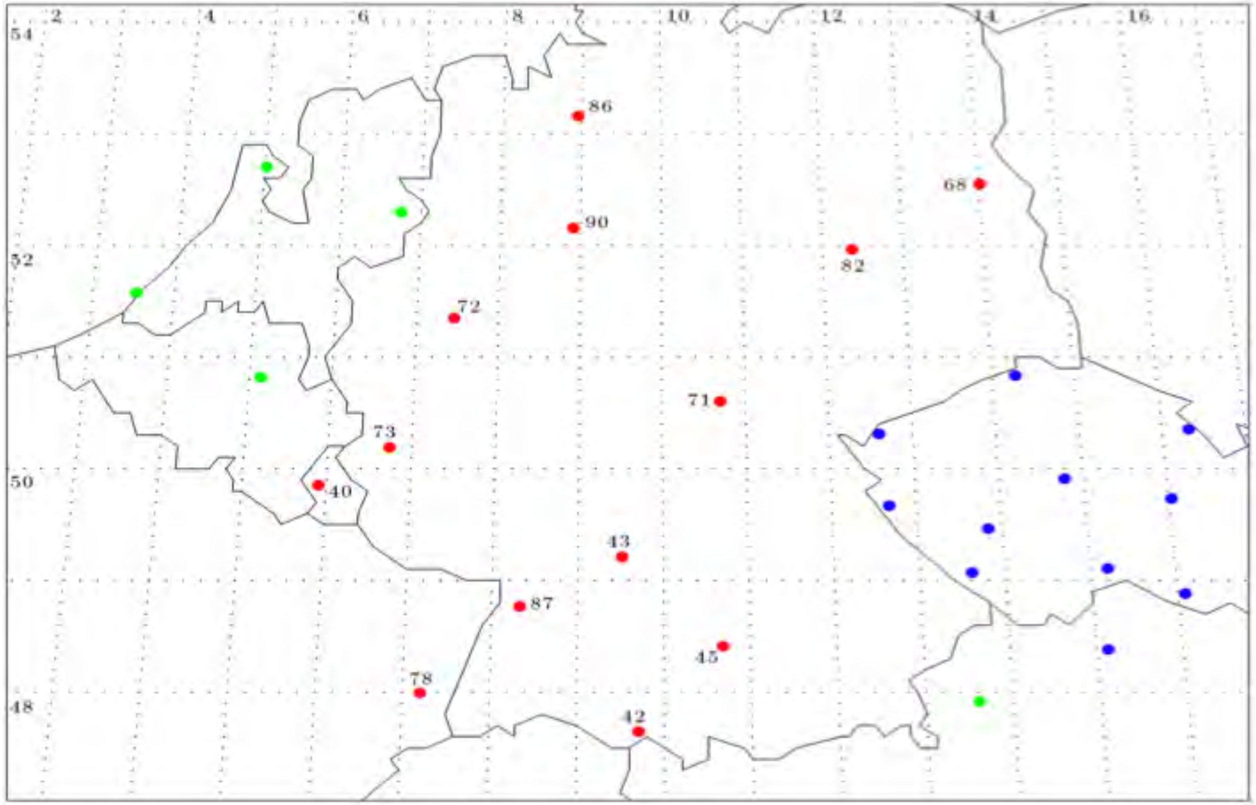
- Earth is bombarded by several 10,000 t of meteoroids every year.
- Spatial/temporal distribution of meteoroids is complex; small meteoroids travel in swarms and streams.
- Public very interested in meteor events!

Science Goals

- Study spatial/temporal mass/frequency distribution of the meteoroid flux.
- Track large fireballs and enable meteorite recoveries.
- Contribute to public awareness of space environment.

Fireball Observations

- Early network established in the 60s, Max Planck-Institute für Kernphysik, Heidelberg
- Today there are 25 cameras stationed in Germany, Czech Republic, Belgium, Luxembourg and Austria.
- One long exposure per night. The camera looks into a convex mirror, or is fitted with a fisheye lens, to provide a view of the entire sky.
- A propellor shutter rotates at 12.5 Hz in front of the camera to aid the analysis of meteor tracks.
- Some 50 meteors per year with V brighter than -6 are detected.



Activities in Berlin

- Development of digital meteor camera prototypes.
- Software development for event detection, trajectory reconstruction, orbit determination, photometric solution.
- Joint activity with TU Berlin.
- Test campaigns of the prototypes.
- Provision of an E-mail address for event reporting (feuerkugel@dlr.de).

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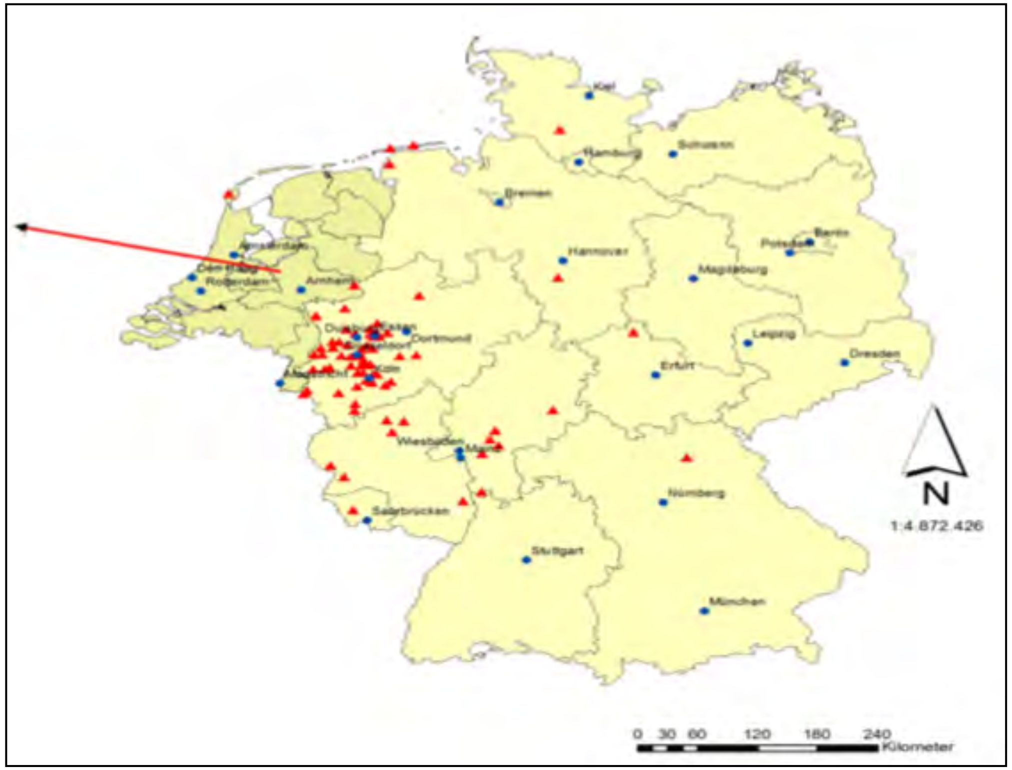

Eyewitness reports received on feuerkugel@dlr.de for a large meteor event on 21. September 2017

Future perspectives DLR, Berlin

- The impact hazard is mentioned in the DLR's latest strategy document:

  DLR-Strategie 2030: "Investigations of planets, asteroids and comets in our Solar System, including improvements in our understanding of the potential danger from impacts of [NEOs] on the Earth."

  - Nice words but no money!

- We're hoping for further financial support from the EU's Horizon 2020 research programme (earliest September 2018).