Space Mission Planning Advisory Group

Open Forum

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ESA

(Chair of SMPAG)

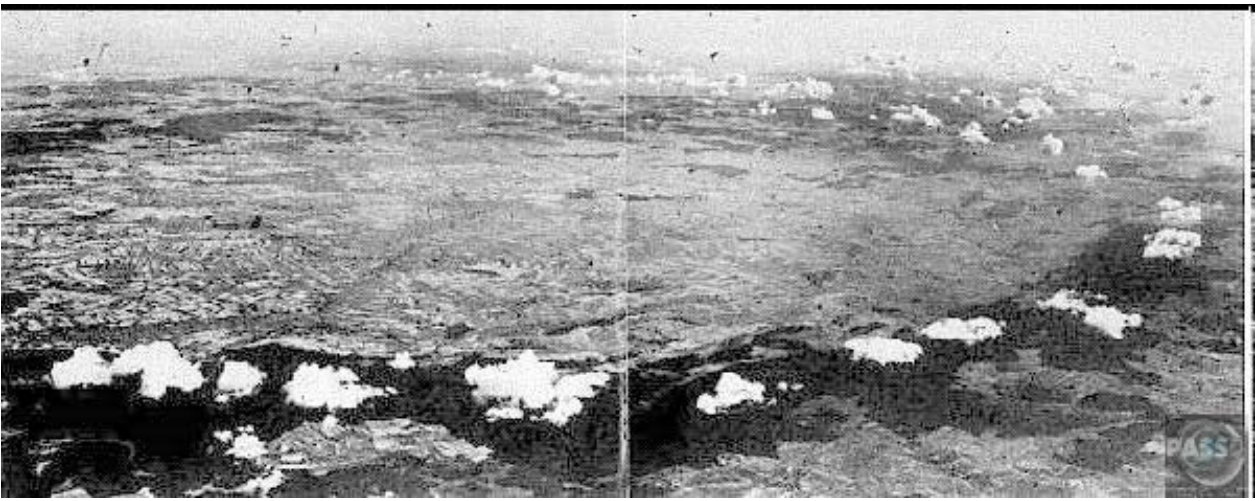
18 February 2016

SMPAG purpose and membership

The purpose of the SMPAG is to prepare for an international response to a NEO impact threat through the exchange of information, development of options for collaborative research and mission opportunities and NEO threat mitigation planning activities.

Membership is open to all national space agencies or governmental or inter-governmental entities that coordinate and fund space activities and are capable of contribution to or carrying out a space based NEO mitigation campaign.

Impact crater



Nördlinger Ries

25 km, 15 Mio Jahre

Meteor Crater in Arizona

1.2 km, 50 000 Jahre

Chelyabinsk impact event

Video from dashboard camera (from N. Artemieva)

Chelyabinsk Event

Effects on ground

NEO mitigation in case of a real threat
Slide 1 / 2

Two basic classes of impact scenarios:

1. Asteroid on direct collision course with Earth

a) Object is not discovered >> bad luck

b) Object is detected days or weeks before impact

- **Object is likely rather small (< 100 m)**
- **Effects are local (but severe damage is possible)**
- **Impact time and ground corridor are known**
- **Uncertainties of effects remain until actual impact**
- **Time for warnings / evacuations**

NEO mitigation in case of a real threat
Slide 2 / 2

2. Object is discovered years or decades before a potential impact.

- **The object can be big or small**
- **Impact effects can be local or global**
- **Only an impact probability can be calculated long in advance but no certainty**
- **There is time for further studies of the object**
- **Impact time and ground corridor (usually thin (100-200 km) but long (half around Earth)) are known**
- **Deflection via space mission is in principle possible**

The sooner the easier!

A velocity change of 3 cm / s moves the NEO position by 14000 km in 15 years!

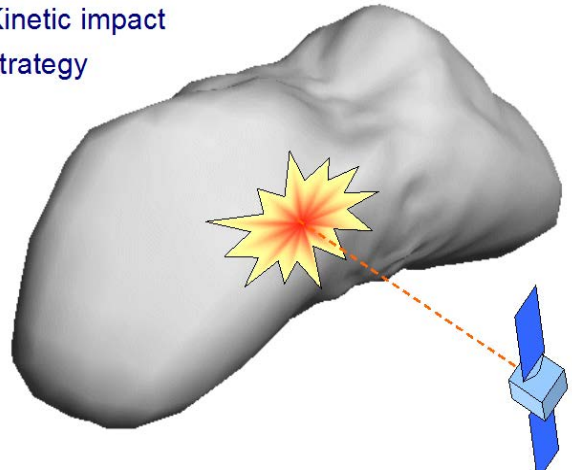
Possible NEO deflection strategies
(Illustrationen von L. Cano, Deimos)

Explosive strategy

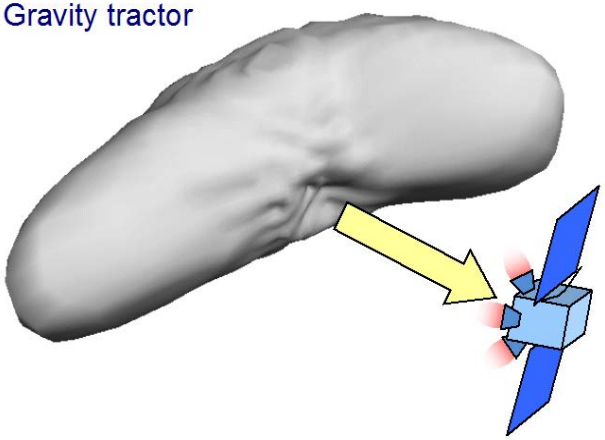
(stand-off)

Kinetic impact

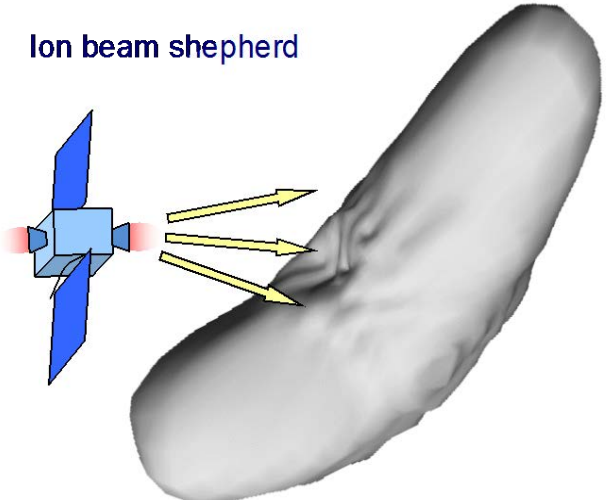
strategy



Gravity tractor

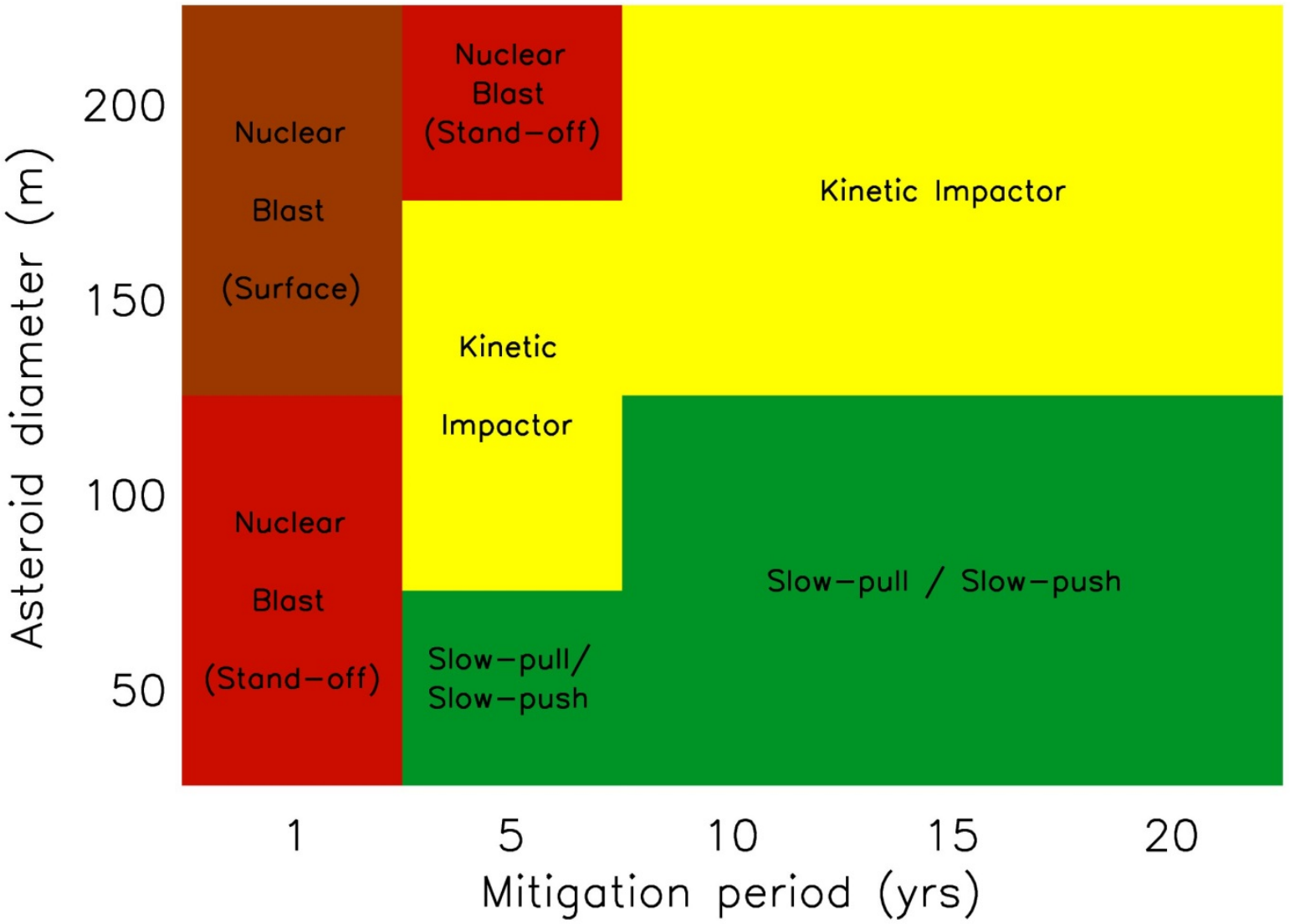


Ion beam shepherd



NEO Deflection options

(from Drube et al.)



SMPAG Membership
(Status 16 February 2016)

Official members with nominated delegations:

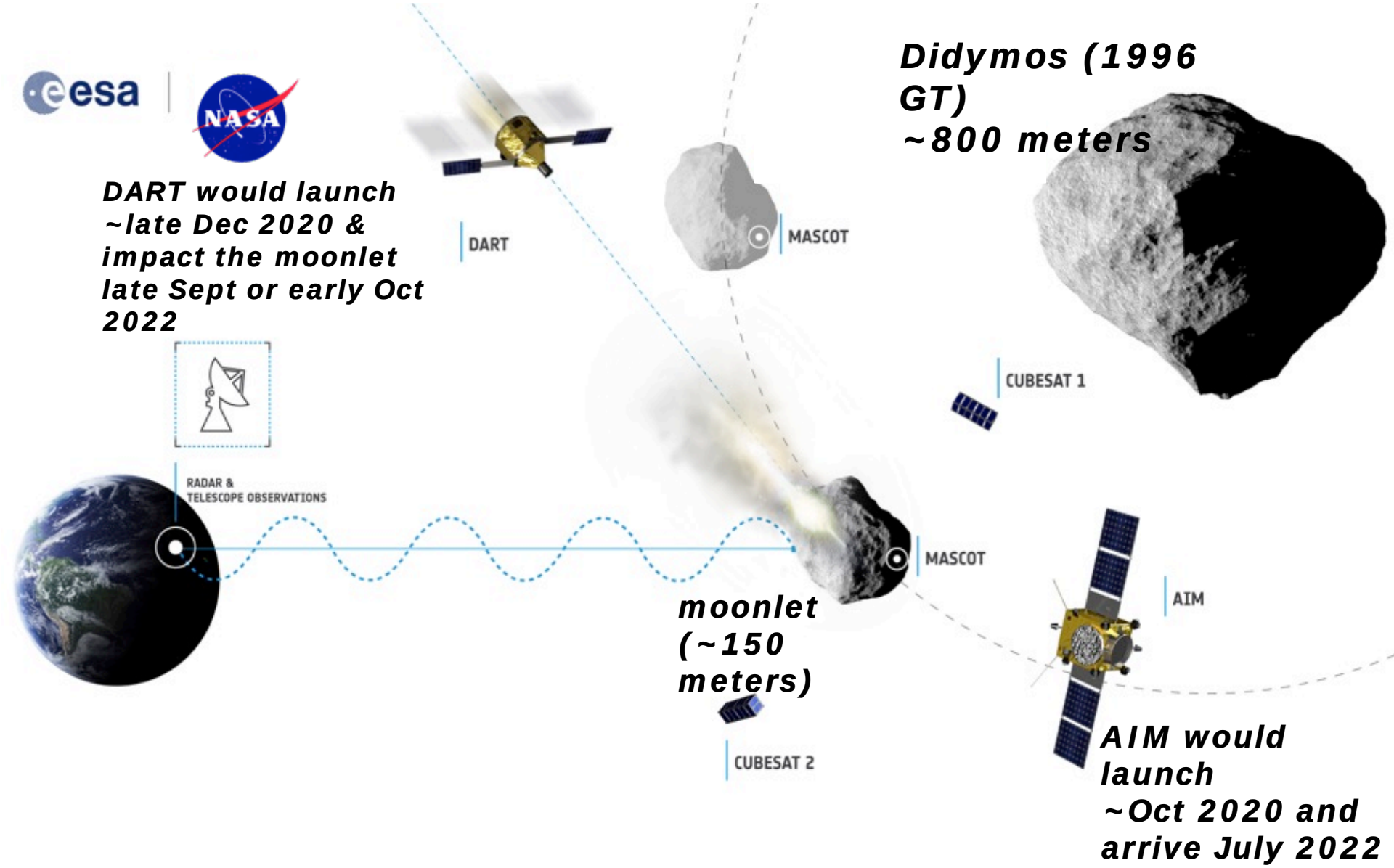
AEM (Mexico)
ASI (Italy)
Belspo (Belgium)
CNES (France)
DLR (Germany)
IAWN (ex officio)
ISA (Israel)
JAXA (Japan)
ESA
NASA (USA)
ROSA (Romania)
ROSCOSMOS (Russian Federation)
SSAU (Ukraine)
SUPARCO (Pakistan)
UKSA (UK)
KASI (South Korea)

Intention of Membership indicated:

CSA (Canada)
China

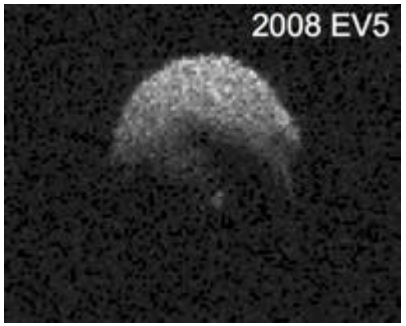
Observers: ASE, IAA, IAU, UNOOSA

AIDA: Joint ESA-NASA Study Effort

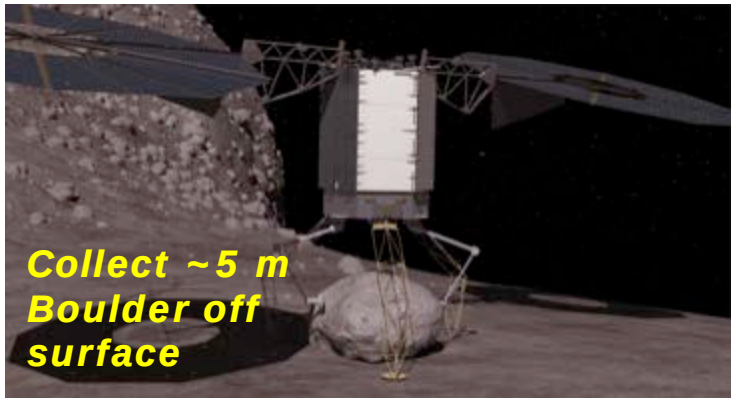


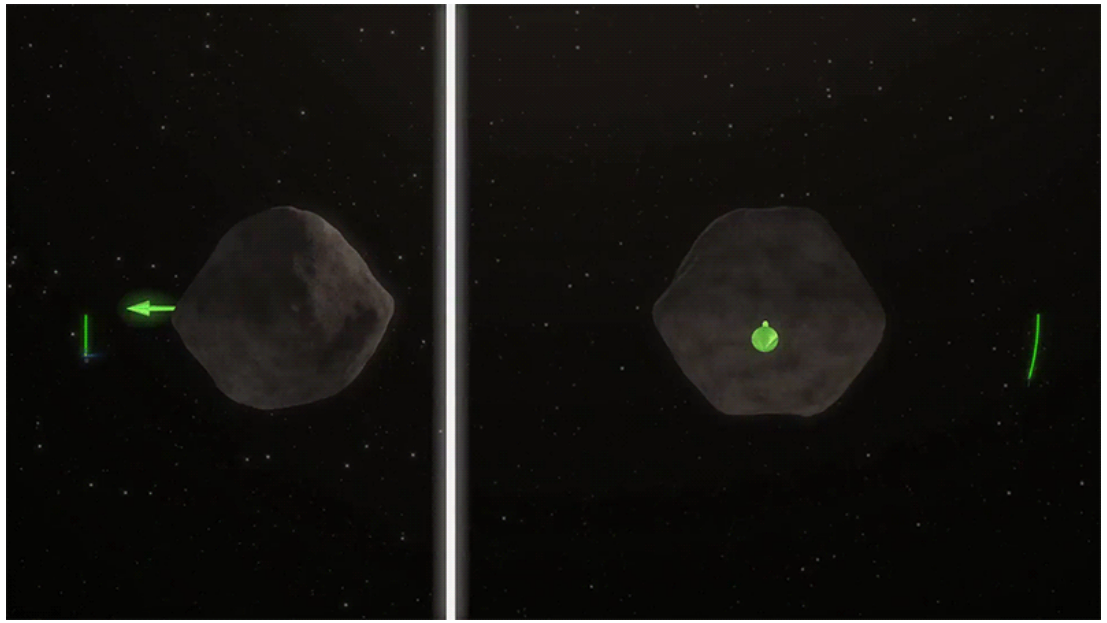
Asteroid Redirect Mission (ARM) Study

- *Launch in Dec 2020*
- *Current target for ARM is 2008 EV_5*
- *Arrive ~2023*
- *Demonstrate the gravity tractor technique*



Radar image of the near-Earth asteroid 2008 EV_5 [from Arecibo, 23 Dec 2008] hints of large boulders on surface.



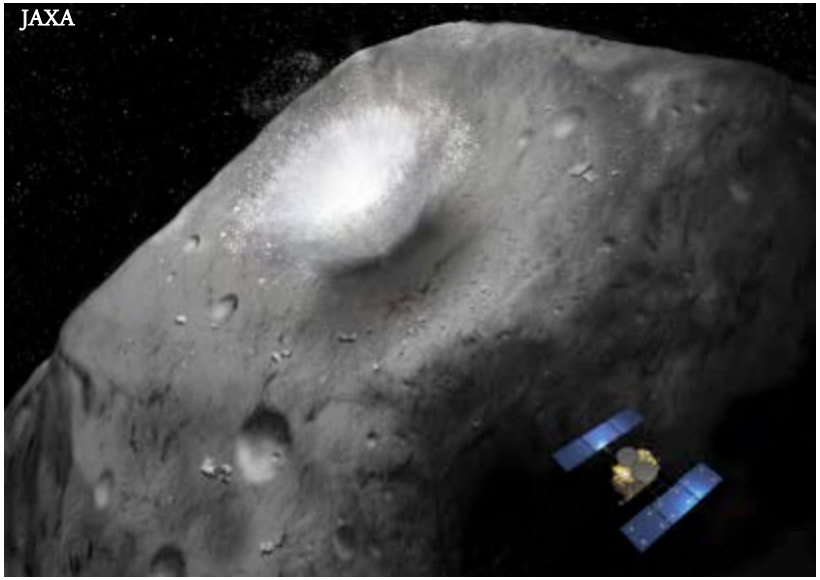


Rosetta mission to Comet 67P C.-G.

(Image: ESA)

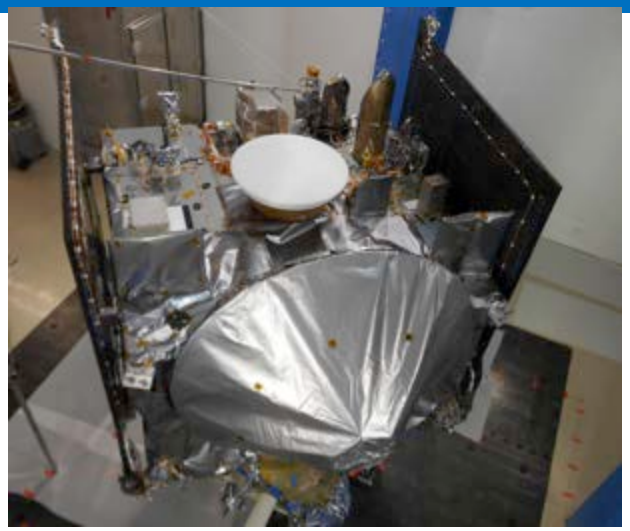
Hayabusa 2: JAXA mission

Launched on 3 Dec 2014, *Hayabusa 2* is a new technology, science-driven mission to mature deep space round-trip exploration. As with *Rosetta*, missions to small bodies have planetary defense implications.

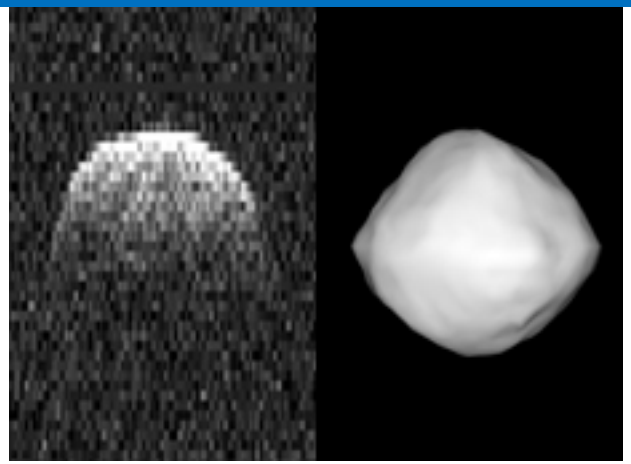


- ***Hayabusa 2* arrives at the asteroid Ryugu (1999 JU_3) ~July 2018.**
- **Cratering experiment in 2019 (not a deflection attempt; science test)**
- **Return to Earth in 2020**

OSIRIS-REx: NASA Mission



***OSIRIS-REx* spacecraft during assembly & integration at Kennedy Space Center**



Radar image and derived shape model of the near-Earth asteroid Bennu


Bonus Slides

Examples of available information on NEOs
(Status 16 Feb 2016; Data from NEODyS)

5 NEOs with highest impact risk during next 60 years

NEO	Relative velocity [km/s]	NEO size [m]	Date	Impact probability
2000SG344	11.3	46	13 Sep 2072	1/1900
Apophis	12.6	375	12 Apr 2068	1/532000
2009JF1	26.4	16	06 May 2022	1/4500
1994WR12	14.9	140	24 Nov 2072	1/65000
2006QV89	12.3	37	09 Sep 2019	1/12000

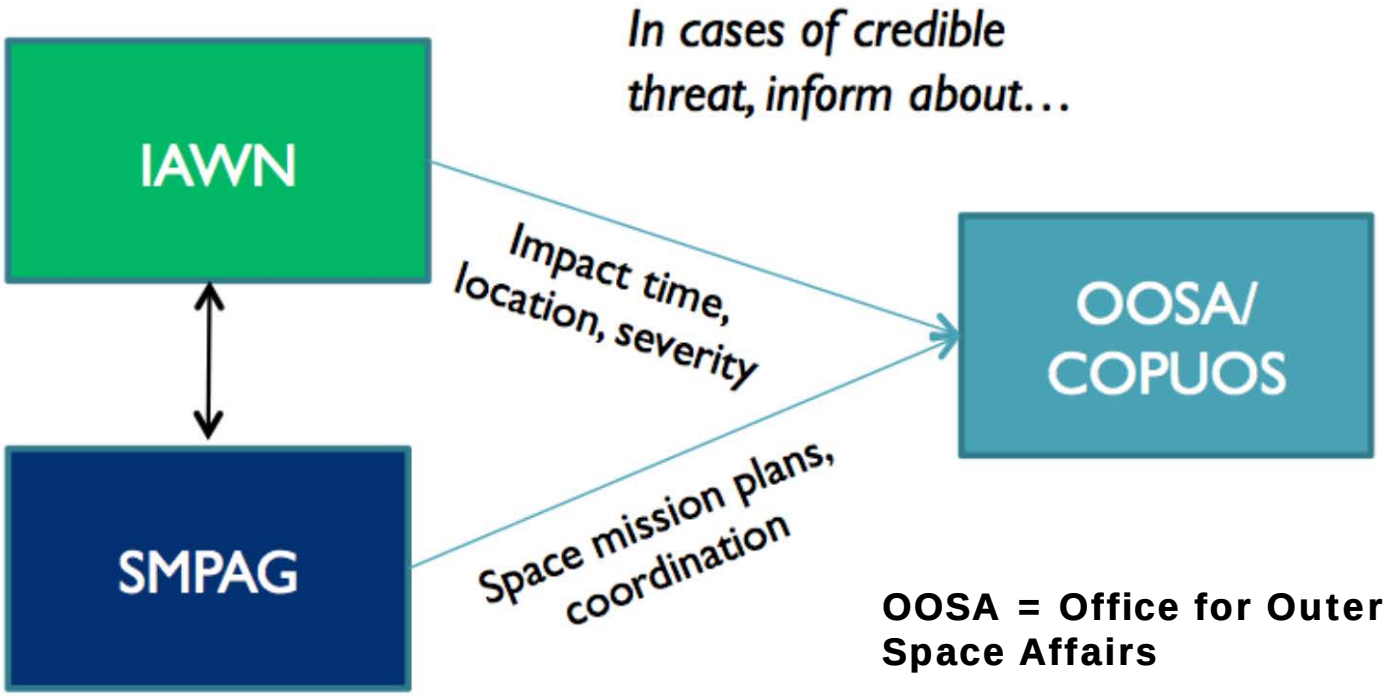
NEO impacts: frequency and effects

- **Asteroids (and Comets) hit Earth with very high velocities.**
- **typical: 10 - 20 km/s, 20 times faster than a gun bullet!**

NEO diameter	Impact energy [Megatons TNT] (1g TNT ≡ 4184 J)	Typical interval [Years]	Effect
1 m	0.00008	0.05	Fireball, Meteorites could reach ground
3 m	0.002	0.5	Bright fireball, Sudan Event, Meteorites reach ground
10 m	0.08	5	Big fireball, fear, shock wave, 5-fold energy of Hiroshima bomb
40 m	5	300	Tunguska explosion or crater
140 m	220	10,000	Regional destruction, Tsunami
500 m	10,000	200,000	Europe-wide destruction
1 km	80,000	700,000	Millions dead, global effects
10 km	80 million	100 million	End of human civilisation

International coordination

IAWN = International Asteroid Warning Network



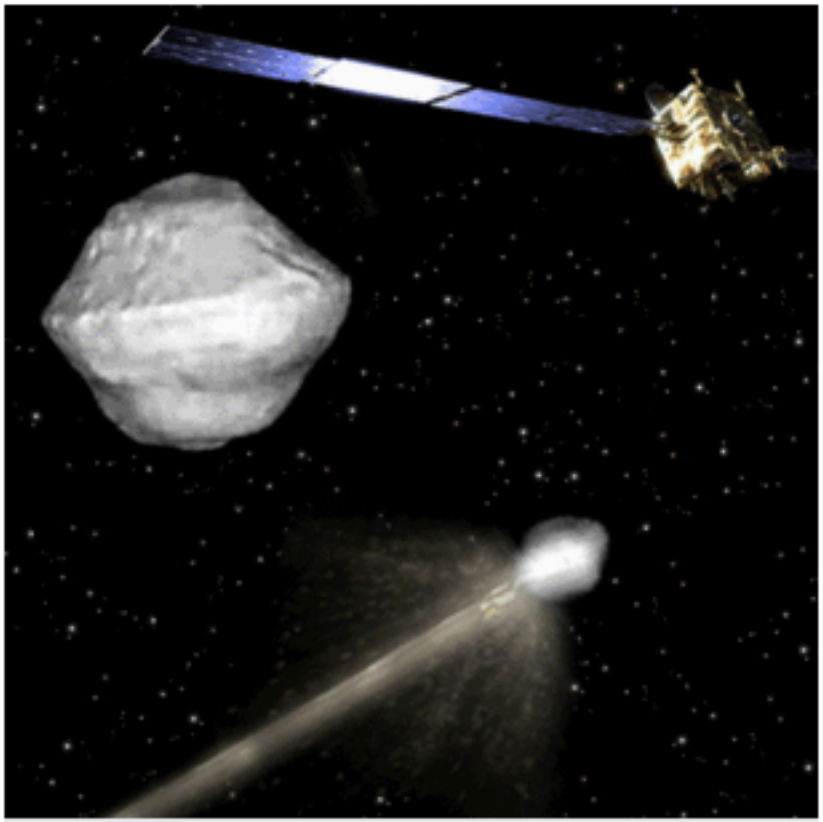
SMPAG = Space Missions Planning Advisory Group

OOSA = Office for Outer Space Affairs

COPUOS = Committee for Peaceful Uses of Outer Space (of the United Nations)

Asteroid mission studies

ASTEROID IMPACT & DEFLECTION ASSESSMENT (AIDA) STUDY



AIDA mission concept

AIDA = DART + AIM

DART: NASA; impact the secondary of asteroid Didymos

AIM: ESA; to observe the system

Financing is still pending

Launch of AIM: Oct 2020 for arrival in Aug 2022 and DART impact in Oct 2022

SMPAG formation and status

The SMPAG was officially established in February 2014

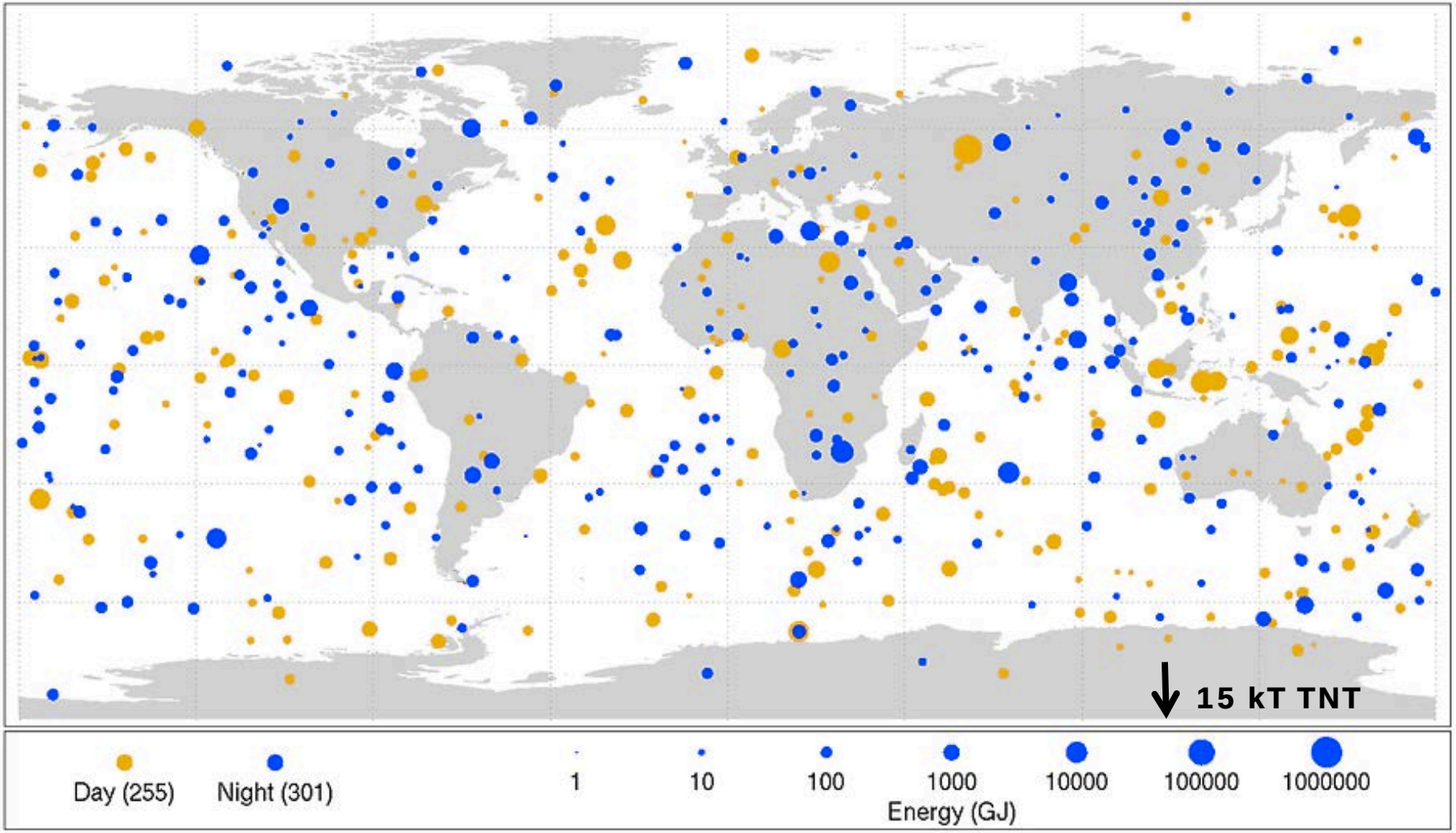
SMPAG Terms of References were finalized in June 2014

SMPAG has established a work plan in November 2015 which is a living document

SMPAG works in close coordination with IAWN

Bolide Events 1994–2013

(Small Asteroids that Disintegrated in Earth's Atmosphere)



SMPAG work plan

A list of 11 activities has been identified by SMPAG:

- **Criteria and thresholds for impact threat response actions. (Lead: NASA)**
- **Mitigation Mission Types and technologies to be considered (Lead: UKSA)**
- **Mapping of threat scenarios to mission types (Lead: ESA)**
- **Reference missions for different NEO threat scenarios (Lead: ASI)**
- **A plan for SMPAG action in case of a credible threat (Lead: NASA/IAA)**

SMPAG work plan, cont.

- Communication guidelines in case of a credible threat (Lead: NASA)
- Produce a ‘road map’ for future work on planetary defense (Lead: DLR)
- Consequences, including failure, of NEO mitigation space missions (Lead: TBD)
- Criteria for deflection targeting (Lead: TBD)
- Study the nuclear device option (Lead TBD)
- Toolbox for a characterization payload (Lead: CNES)

Threshold criteria

Crater with 14-m diameter formed by impact from space in 2007 in Carancas, Peru.

Chelyabinsk impact event (20-m size NEO)

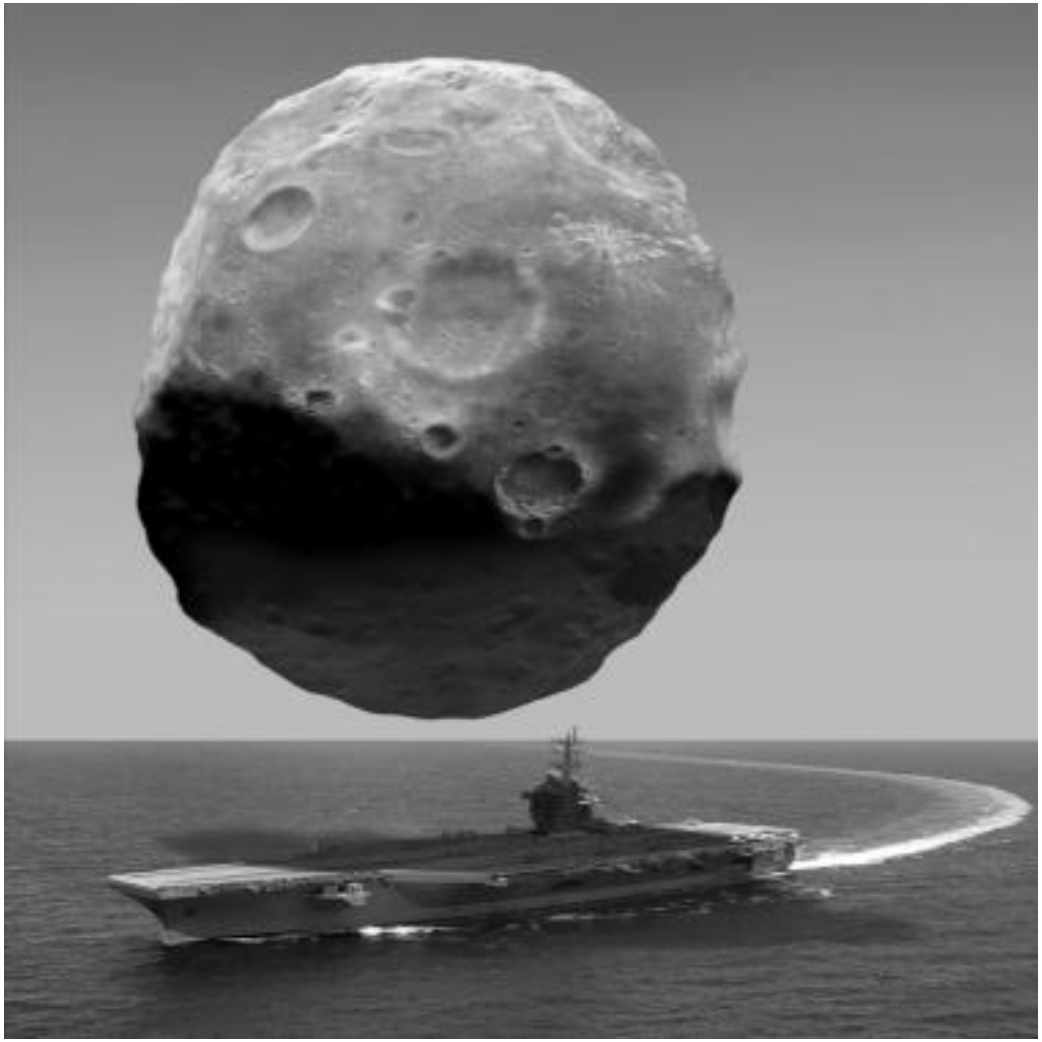
Comparison of sizes

Asteroid 2005 YU 55

Diameter ≈ 300 m

Passed within Lunar distance in November 2011.

(rom SWF Report 2012, illustration by Michael Carrol)



NEO deflection

The kinetic impactor is the most advanced method

Illustration:
ESA