EXERCISE EXERCISE EXERCISE

Hypothetical Asteroid Impact Exercise

Panel 1a: Notification of asteroid impact threat and early preparedness

Point of Contact: Terik Daly
terik.daly@jhuapl.edu

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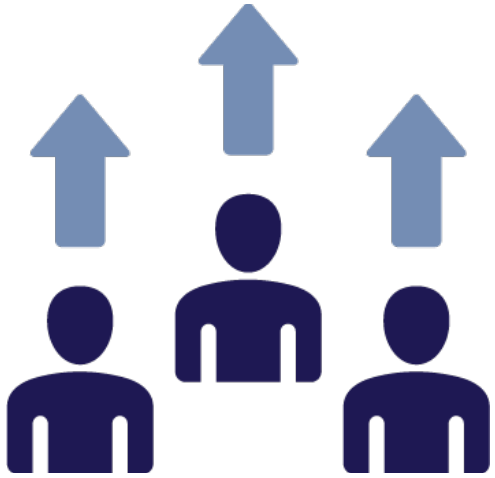
Panel Objectives



Awareness Raising

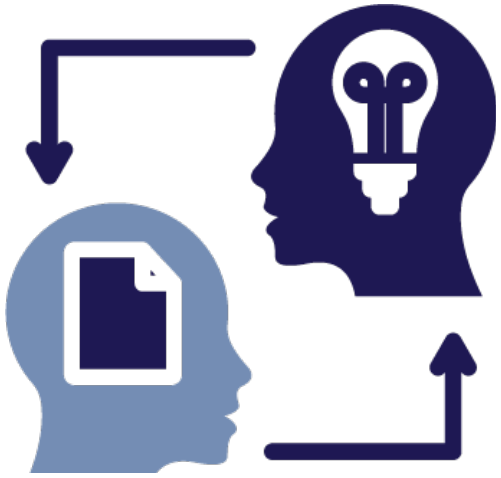
Raise awareness about the nature of asteroid threats and challenges related to preparing for an effective international response

International Views

Hear international viewpoints about asteroid impact threats and potential ways of responding to them

Decision Making

Discuss ways of communicating with decision makers about a potential asteroid impact and options for responding to it



Perception

Expand perspectives of planetary defense specialists about how non-specialists perceive asteroid impact threats

Meet the Presenters

Kelly Fast

NASA Headquarters & International Asteroid Warning Network

Davide Farnocchia

NASA JPL Center for Near-Earth Object Studies

Lorien Wheeler

NASA Ames Asteroid Threat Assessment Project

Detlef Koschny

Technical University of Munich & Space Mission Planning Advisory Group on behalf of ESA

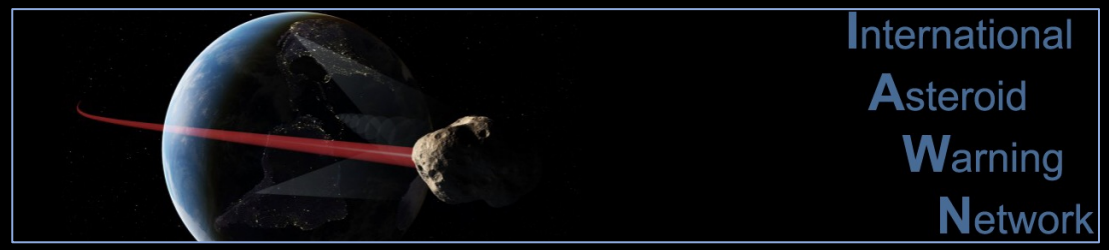
It is 1 August 2024.

It is 1 August 2024.

INTERNATIONAL ASTEROID WARNING NETWORK (IAWN)

POTENTIAL ASTEROID IMPACT NOTIFICATION – HYPOTHETICAL SIMULATION

Date: August 1, 2024
From: International Asteroid Warning Network (IAWN)
Point of Contact: IAWN Coordinating Officer for the IAWN Steering Committee [email]
To: Chair, Space Mission Planning Advisory Group (SMPAG);
United Nations Office of Outer Space Affairs
Title: Potential for Impact of Near-Earth Asteroid 2024 PDC25



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Simulated Impact Threat Scenario

Notification by the International Asteroid Warning Network (IAWN)

Kelly Fast, NASA
IAWN Coordinating Officer

9th IAA Planetary Defense Conference

Scenario date: 1 August 2024

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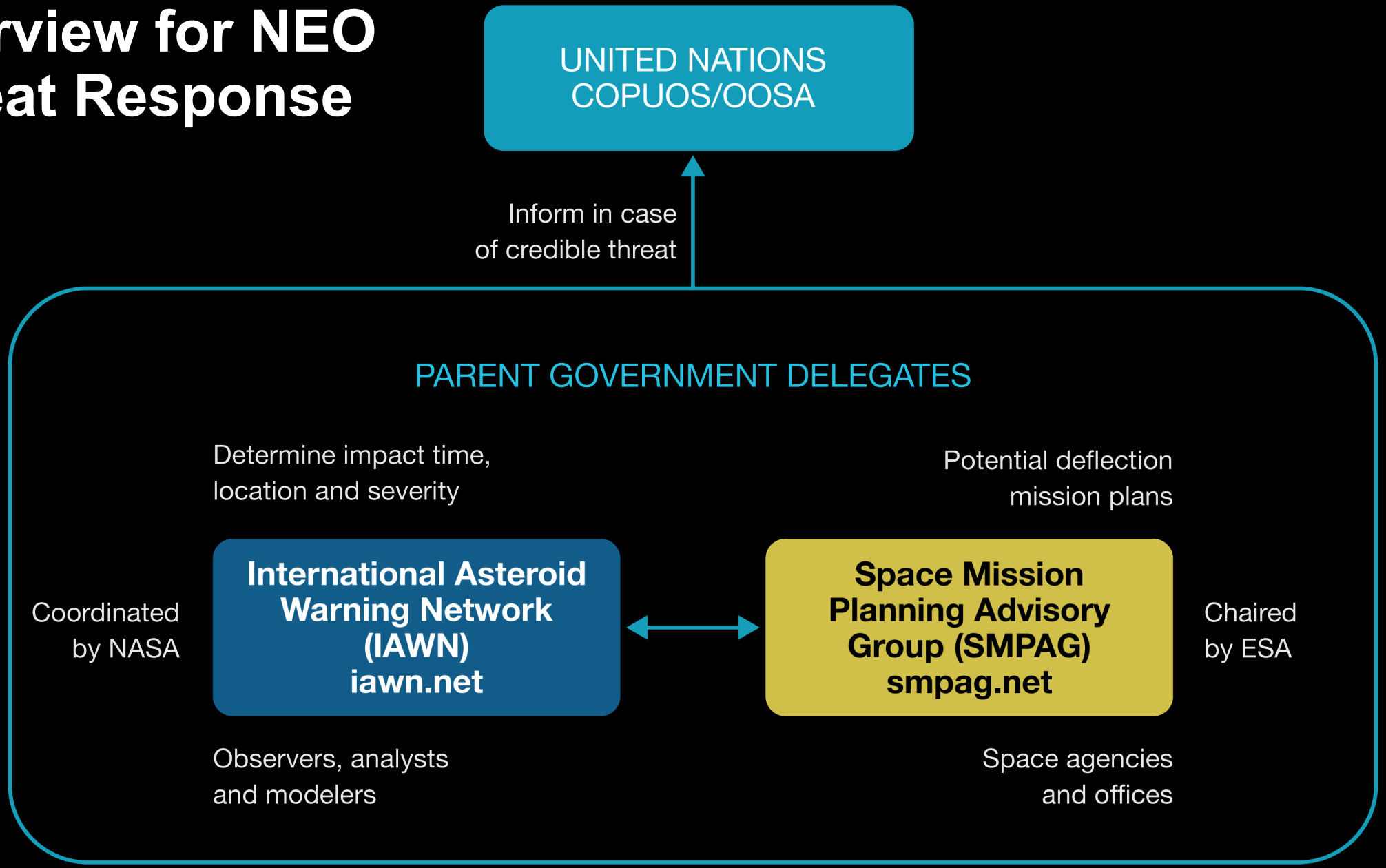
https://iawn.net/

The International Asteroid Warning Network (IAWN)

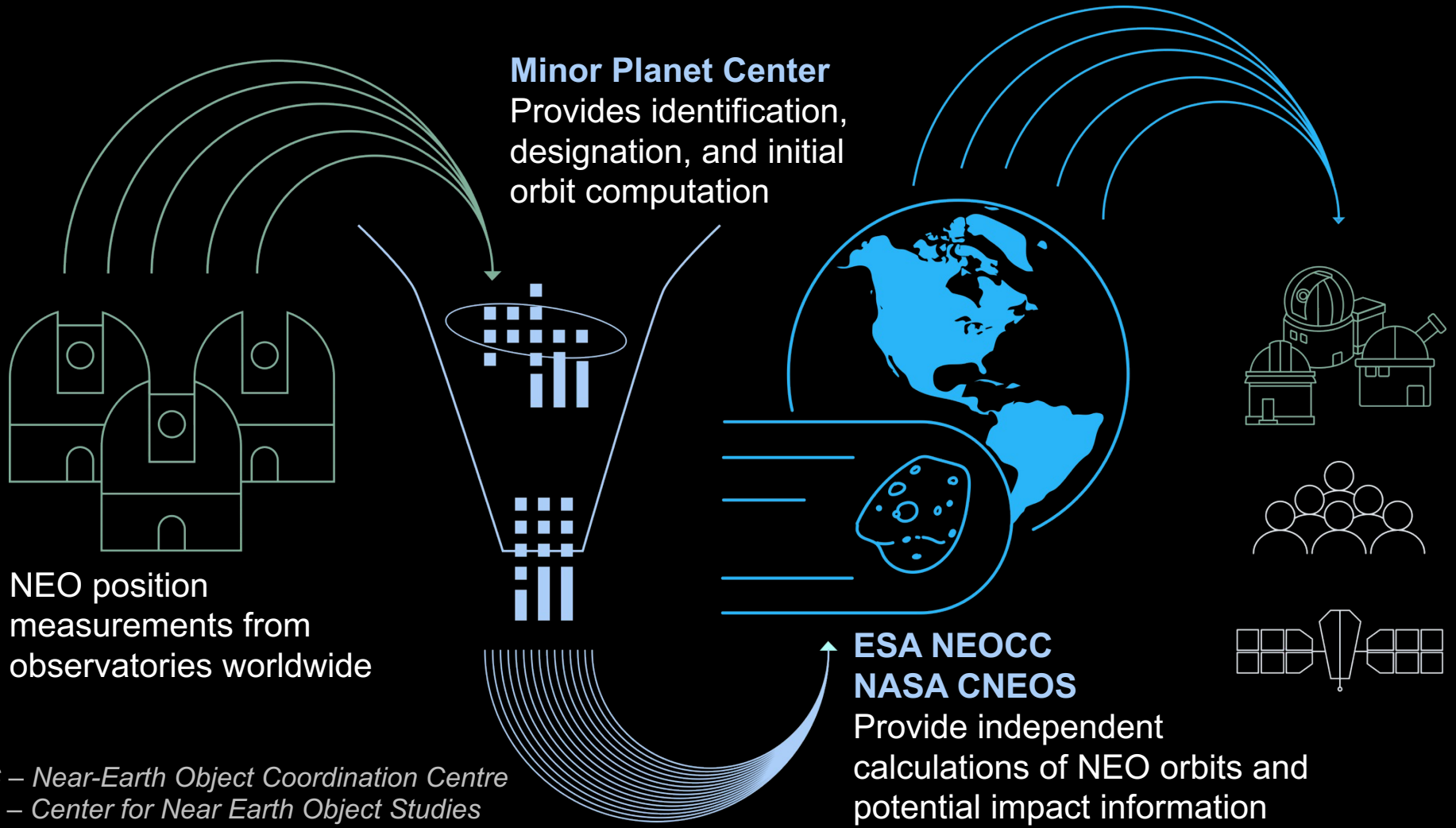
- A worldwide collaboration recommended by the United Nations to detect, track, and physically characterize near-Earth objects
- Signatories include scientific institutions, observatories, and independent astronomers involved in asteroid observations, orbit computation, and modeling
- IAWN's goal is to provide the most accurate and up-to-date information available on the impact potential and effects

Currently 69 signatories from over 28 countries

Overview for NEO Threat Response



NEO Observations to Impact Predictions



Minor Planet Center
Provides identification, designation, and initial orbit computation

NEO position measurements from observatories worldwide

ESA NEOCC
NASA CNEOS
Provide independent calculations of NEO orbits and potential impact information

Information made available to the public and to support follow-on observations by Earth-based and space-based facilities

NEOCC – Near-Earth Object Coordination Centre
CNEOS – Center for Near Earth Object Studies

International Asteroid Warning Network

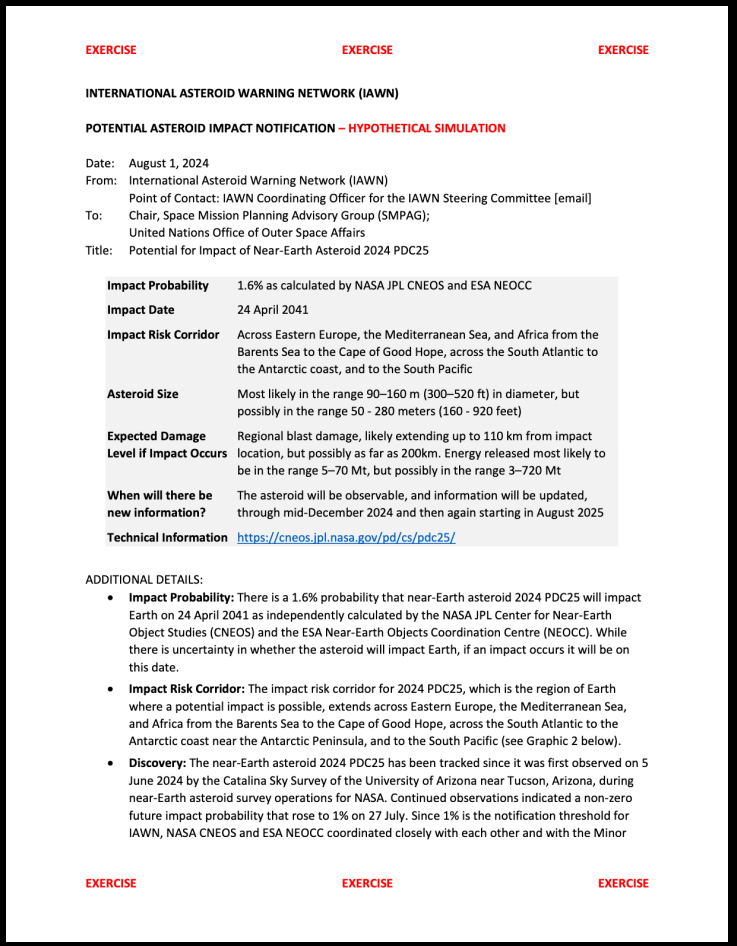
IAWN Notification

IAWN shall warn of predicted impacts exceeding a probability of **1%** for all objects characterized to be greater than **10 meters** in size* and notify:

- Chair, Space Mission Planning Advisory Group (SMPAG)
- United Nations Office for Outer Space Affairs (UNOOSA)
  - UNOOSA will notify UN Member States

IAWN signatories will also notify and work with their own governments according to their own national policies, as applicable.

** Roughly equivalent to an absolute magnitude of 28 if only brightness data can be collected*



EXERCISE EXERCISE EXERCISE

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Date: August 1, 2024
From: International Asteroid Warning Network (IAWN)
Point of Contact: IAWN Coordinating Officer for the IAWN Steering Committee [email]
To: Chair, Space Mission Planning Advisory Group (SMPAG);
United Nations Office of Outer Space Affairs
Title: Potential for Impact of Near-Earth Asteroid 2024 PDC25

Impact Probability	1.6% as calculated by NASA JPL CNEOS and ESA NEOCC
Impact Date	24 April 2041
Impact Risk Corridor	Across Eastern Europe, the Mediterranean Sea, and Africa from the Barents Sea to the Cape of Good Hope, across the South Atlantic to the Antarctic coast, and to the South Pacific
Asteroid Size	Most likely in the range 90–160 m (300–520 ft) in diameter, but possibly in the range 50 - 280 meters (160 - 920 feet)
Expected Damage Level if Impact Occurs	Regional blast damage, likely extending up to 110 km from impact location, but possibly as far as 200km. Energy released most likely to be in the range 5–70 Mt, but possibly in the range 3–720 Mt
When will there be new information?	The asteroid will be observable, and information will be updated, through mid-December 2024 and then again starting in August 2025
Technical Information	https://cneos.jpl.nasa.gov/pd/cs/pdc25/

ADDITIONAL DETAILS:

- **Impact Probability:** There is a 1.6% probability that near-Earth asteroid 2024 PDC25 will impact Earth on 24 April 2041 as independently calculated by the NASA JPL Center for Near-Earth Object Studies (CNEOS) and the ESA Near-Earth Objects Coordination Centre (NEOCC). While there is uncertainty in whether the asteroid will impact Earth, if an impact occurs it will be on this date.
- **Impact Risk Corridor:** The impact risk corridor for 2024 PDC25, which is the region of Earth where a potential impact is possible, extends across Eastern Europe, the Mediterranean Sea, and Africa from the Barents Sea to the Cape of Good Hope, across the South Atlantic to the Antarctic coast near the Antarctic Peninsula, and to the South Pacific (see Graphic 2 below).
- **Discovery:** The near-Earth asteroid 2024 PDC25 has been tracked since it was first observed on 5 June 2024 by the Catalina Sky Survey of the University of Arizona near Tucson, Arizona, during near-Earth asteroid survey operations for NASA. Continued observations indicated a non-zero future impact probability that rose to 1% on 27 July. Since 1% is the notification threshold for IAWN, NASA CNEOS and ESA NEOCC coordinated closely with each other and with the Minor

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IAWN Notification: Key Points

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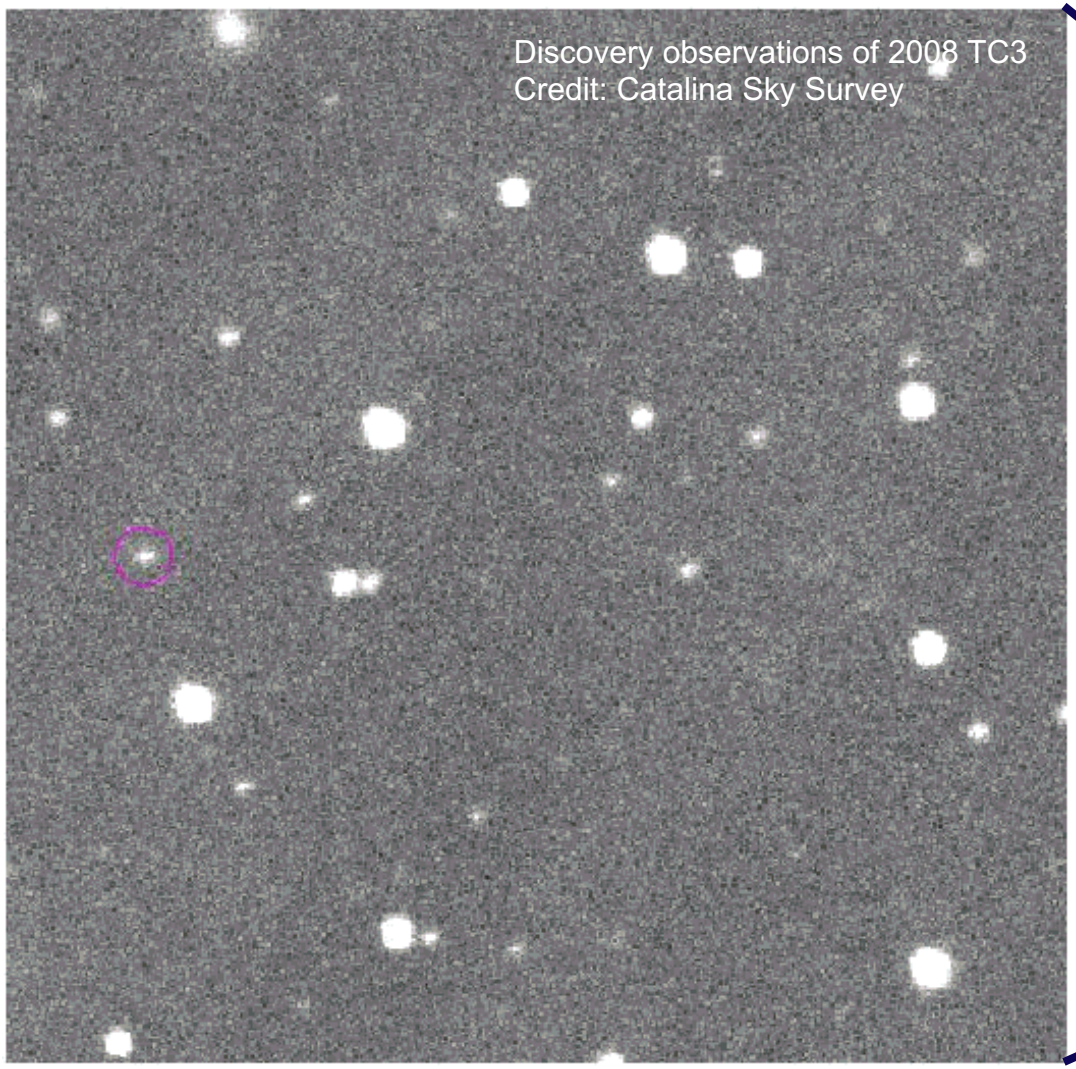
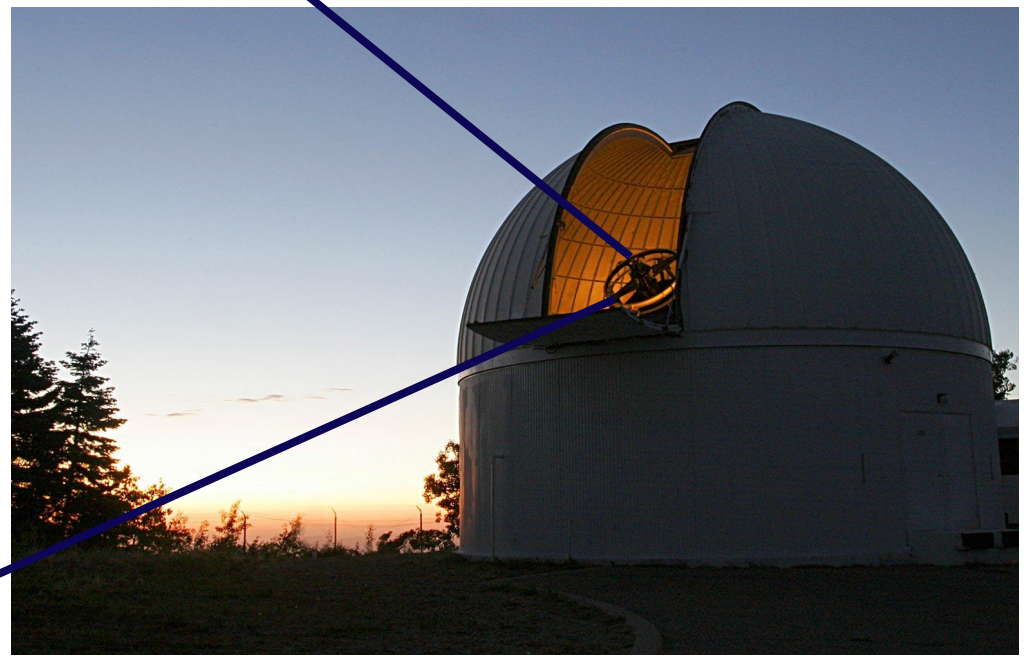
Current Knowledge from Telescopic Observations

Davide Farnocchia
Center for Near-Earth Object Studies
NASA Jet Propulsion Laboratory, California Institute of Technology

Discovery of asteroid 2024 PDC25



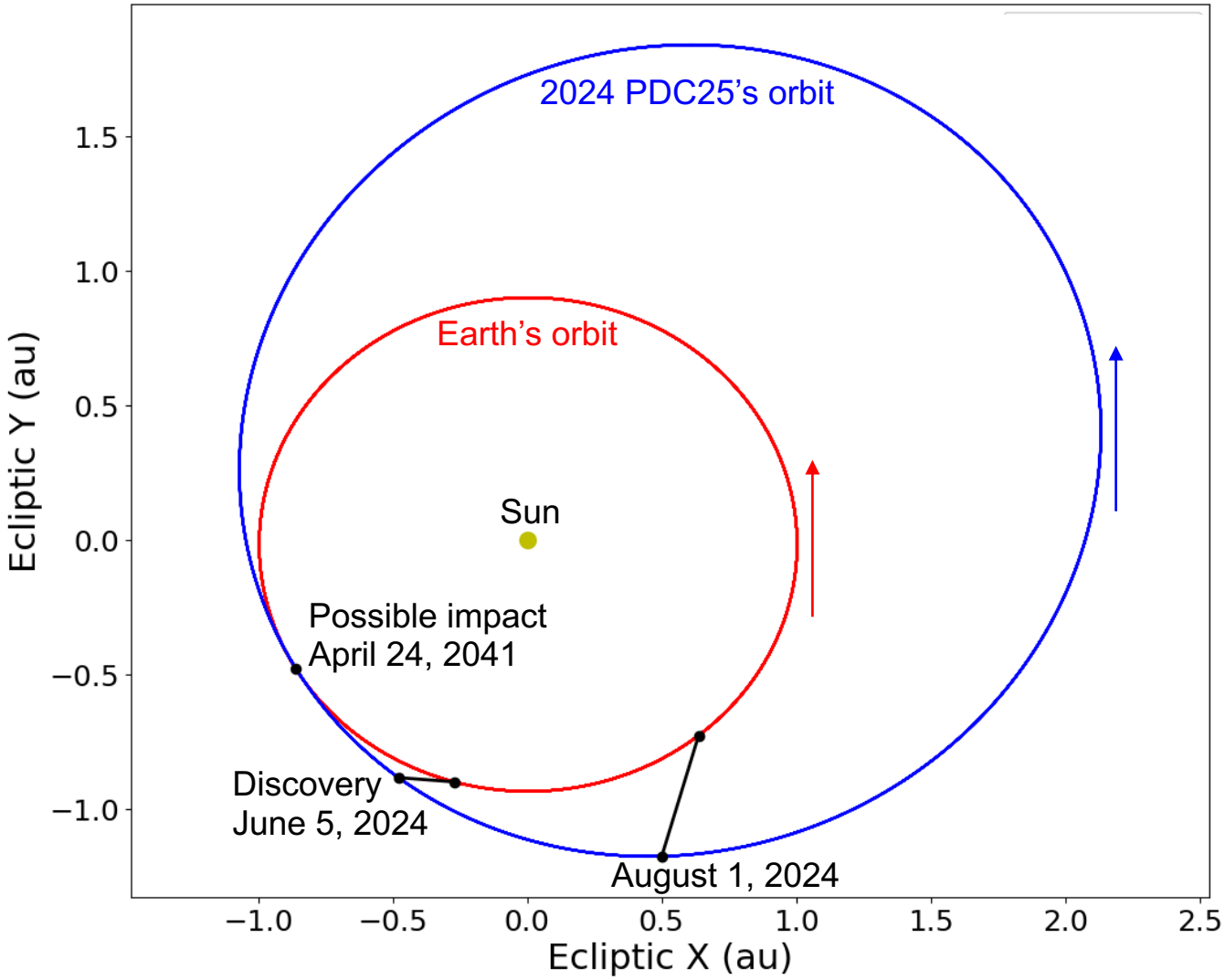
- Asteroid 2024 PDC25 was discovered on June 5, 2024 by the NASA-funded Catalina Sky Survey.
- Announced by the Minor Planet Center on June 7, 2024.



Orbit and tracking of asteroid 2024 PDC25

- 2024 PDC25 is on 1.0 au × 2.3 au orbit, with an inclination of 11° and an orbit period of 2.1 years.
- 2024 PDC25 has been tracked by optical telescopes since discovery. It will be observable until mid-December 2024 and again starting in August 2025.

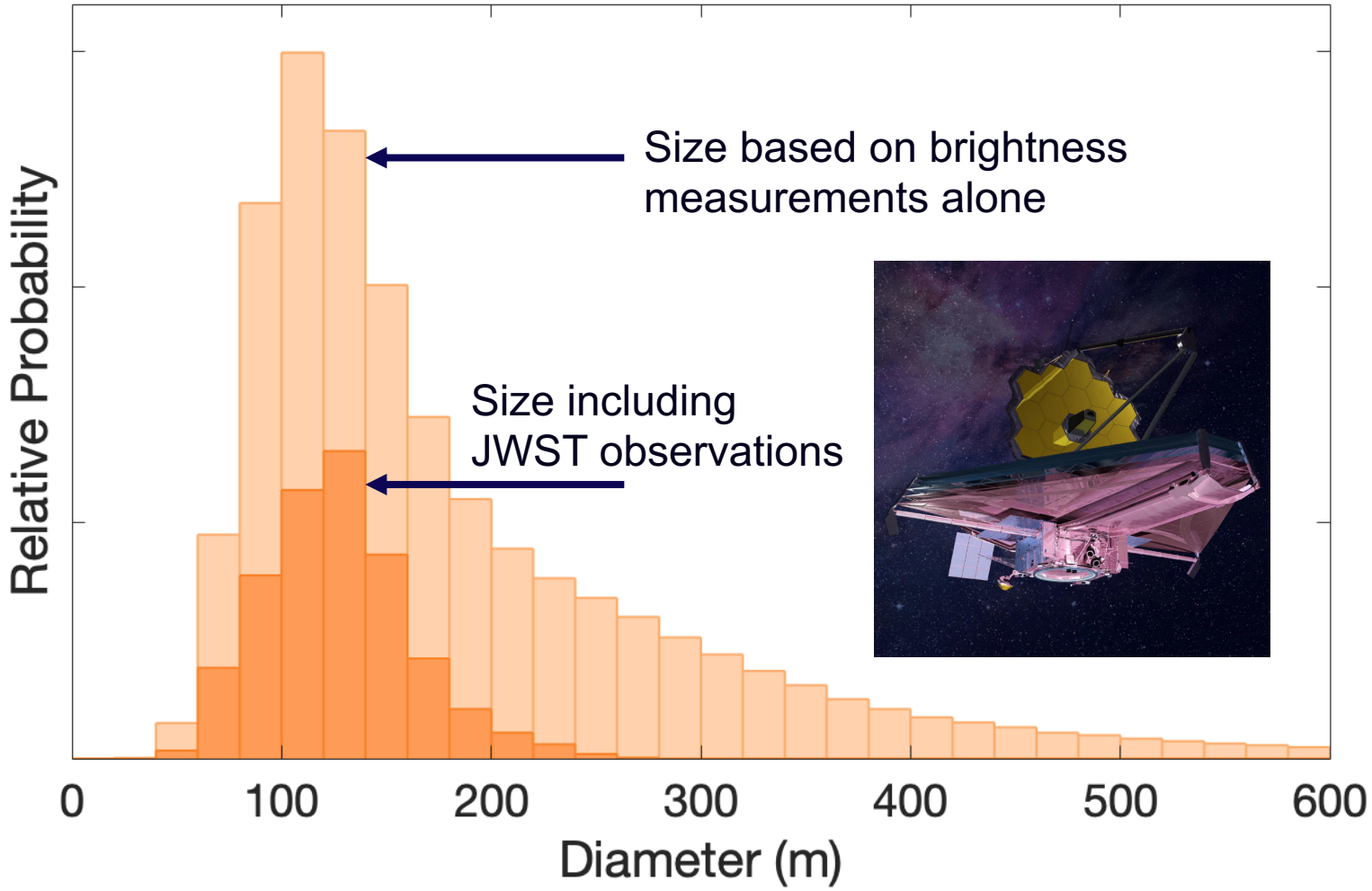
Radar observations are not possible until 2041.



Physical properties of asteroid 2024 PDC25

Spectral and infrared observations from the James Webb Space Telescope provide key constraints

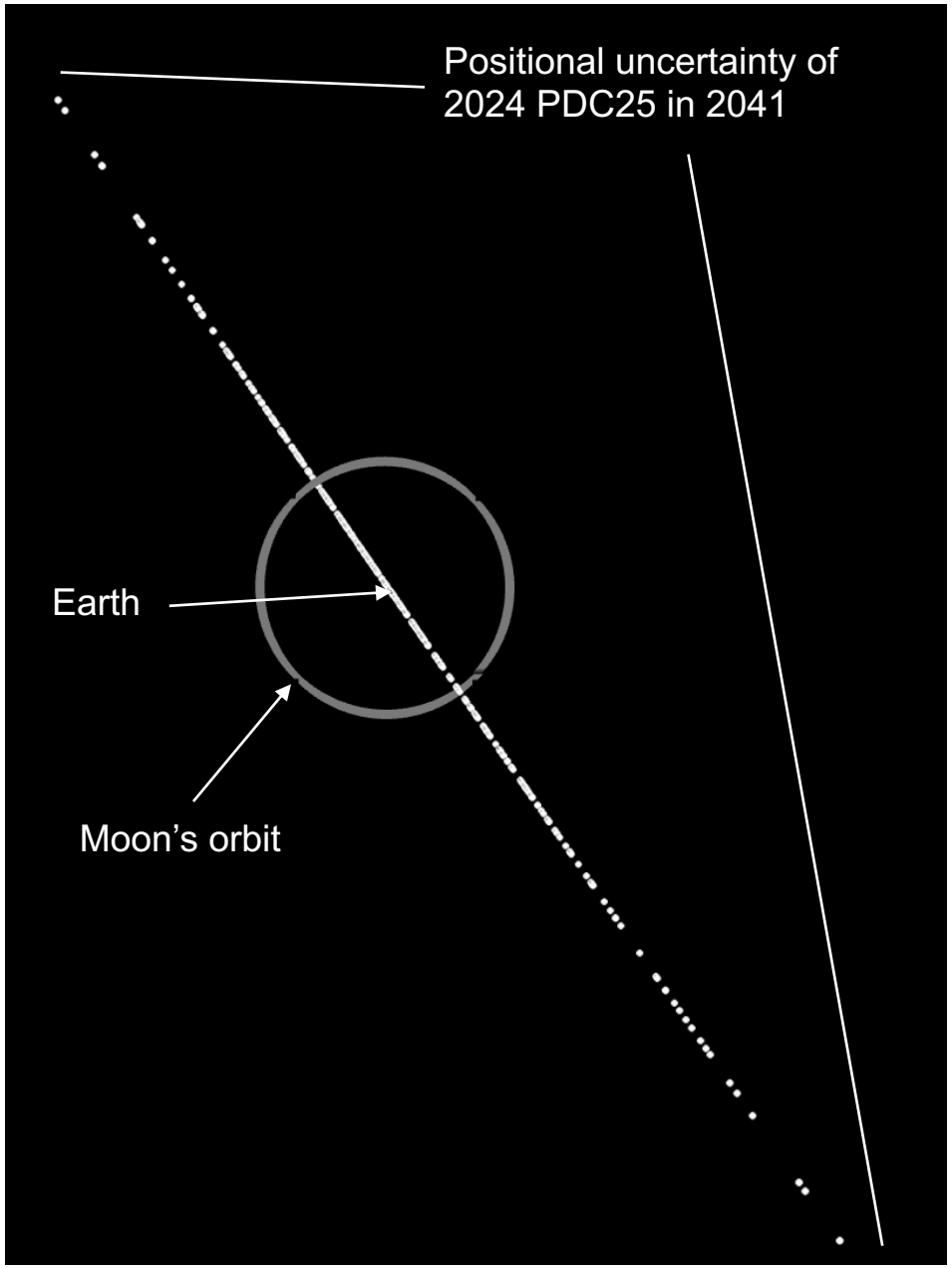
- 2024 PDC25 is an S-type (stony) asteroid.
- Diameter most likely between 90–160 m, but possibly in the range 50–280 m.
- Impact energy most likely to be in the range 5–70 Mt, but possibly in the range 3–720 Mt.



Potential impact of 2024 PDC25

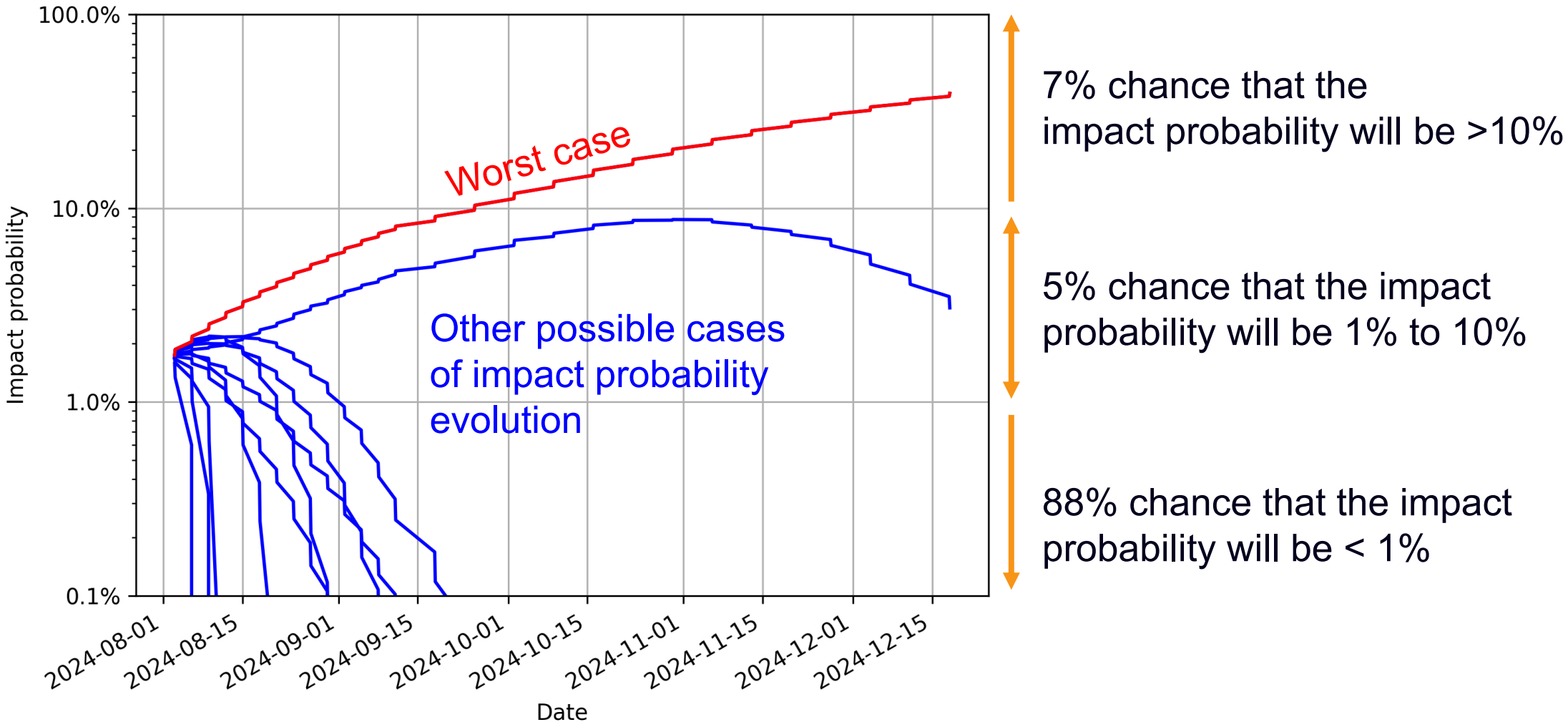
Currently, 1.6% probability of Earth impact in April 2041

- 2024 PDC25 will make a close approach to Earth in April 2041, and there is a 1.6% probability of impact.
- Based on the current orbit uncertainty, the position of 2024 PDC25 in 2041 can only be predicted to within ±1.7 million km (4.3 lunar distances).
- Based on asteroid population estimates, objects of the size of 2024 PDC25 impact the Earth every 35,000 years or so, on average.
- On the Torino Impact Hazard Scale (0 to 10), this potential impact currently has a rating of 3. Only Apophis in 2004 reached a higher level on the Torino Scale.
- As the asteroid is tracked over the coming months, the position uncertainty in 2041 will shrink, and the impact probability will change.



Expected evolution of asteroid impact probability

Impact probability will evolve as asteroid observations continue until mid-December 2024

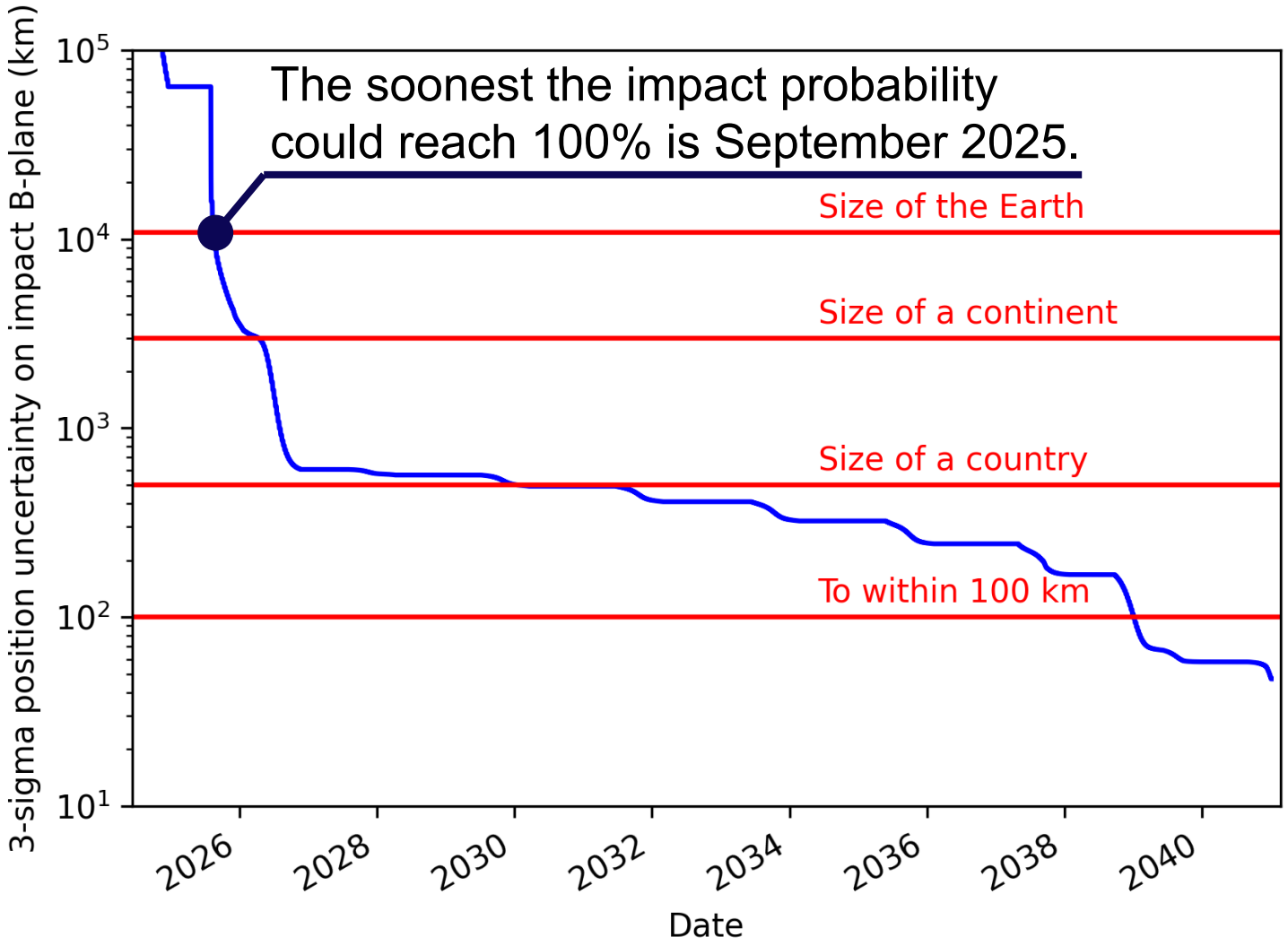


Expected evolution of asteroid location knowledge

From Earth-based observations

- If 2024 PDC25 is on an impact trajectory, we cannot yet predict the impact location.
- We can predict the accuracy of the impact location knowledge.
- Without a space mission, we won't know the impact location to within 100 km until 2039.

A reconnaissance mission would enable us to accurately predict the impact location much earlier.



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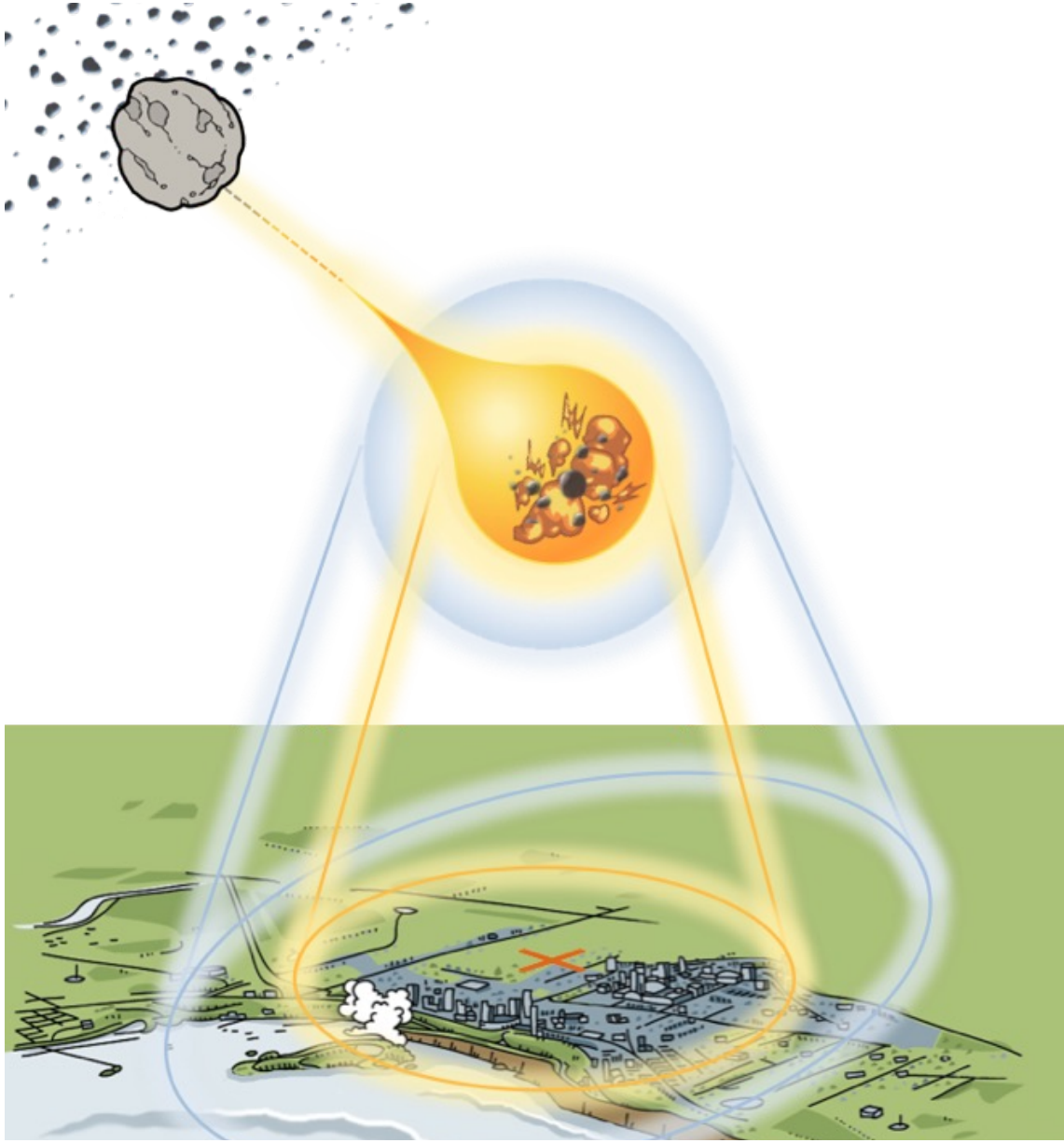
Impact Risk Assessment

Lorien Wheeler
Asteroid Threat Assessment Project
NASA Ames Research Center



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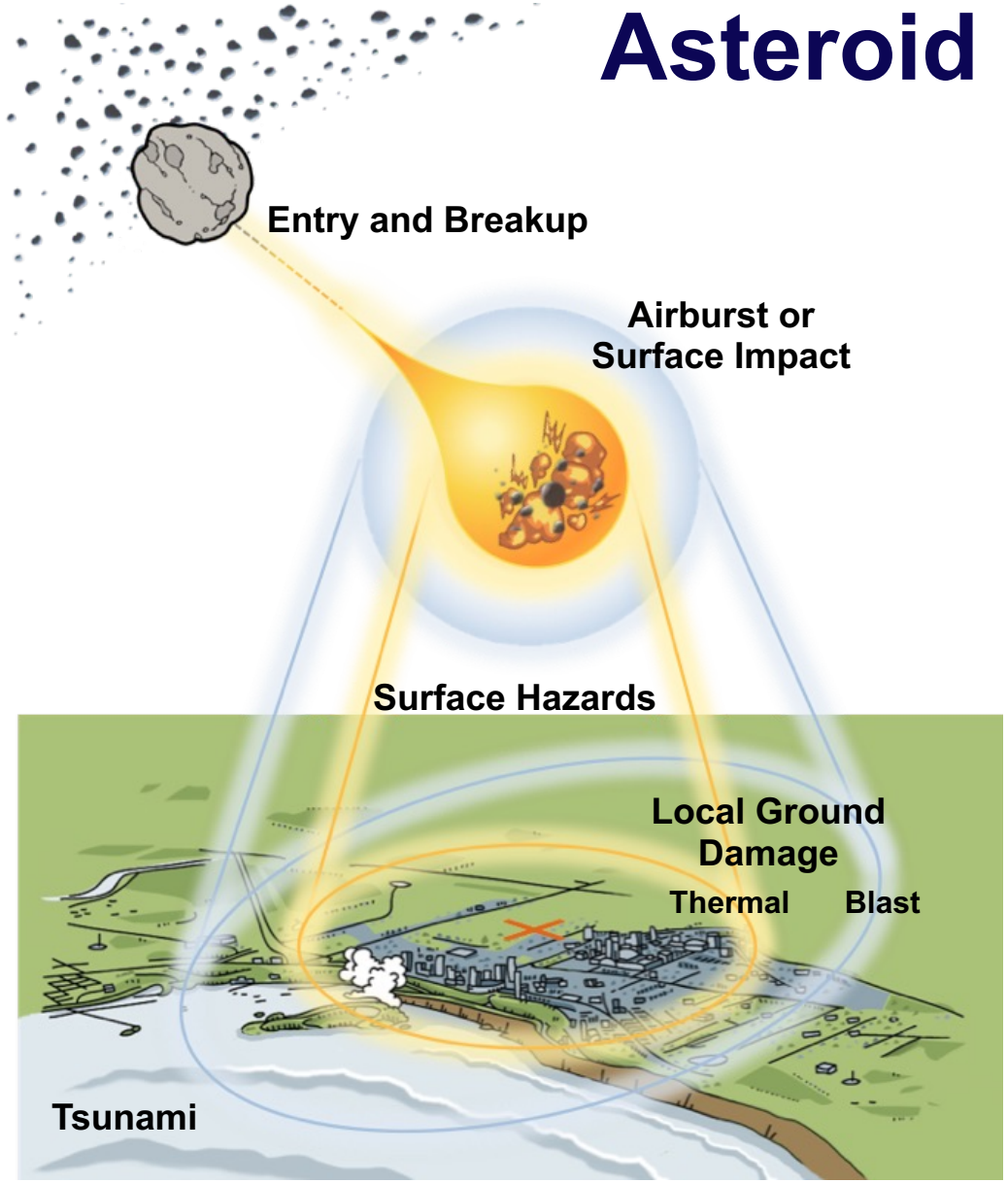
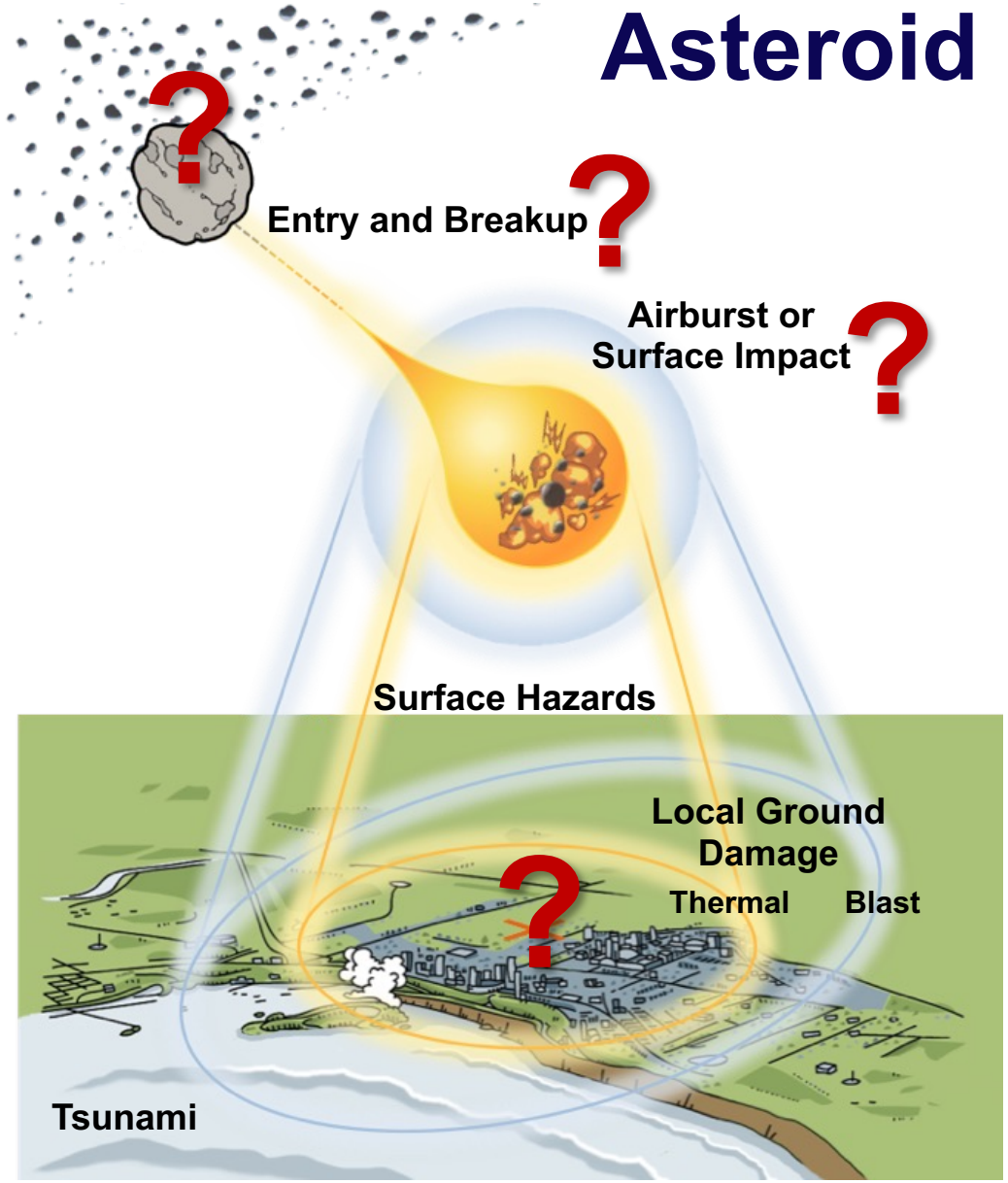
Asteroid Impact Hazards



- Asteroids can cause damage by exploding in the atmosphere or by impacting Earth's surface
- Potential hazards include destructive blast waves, thermal fireballs, or tsunamis
- Damage depends on asteroid properties, atmospheric entry, and impact location

Asteroid Impact Hazards

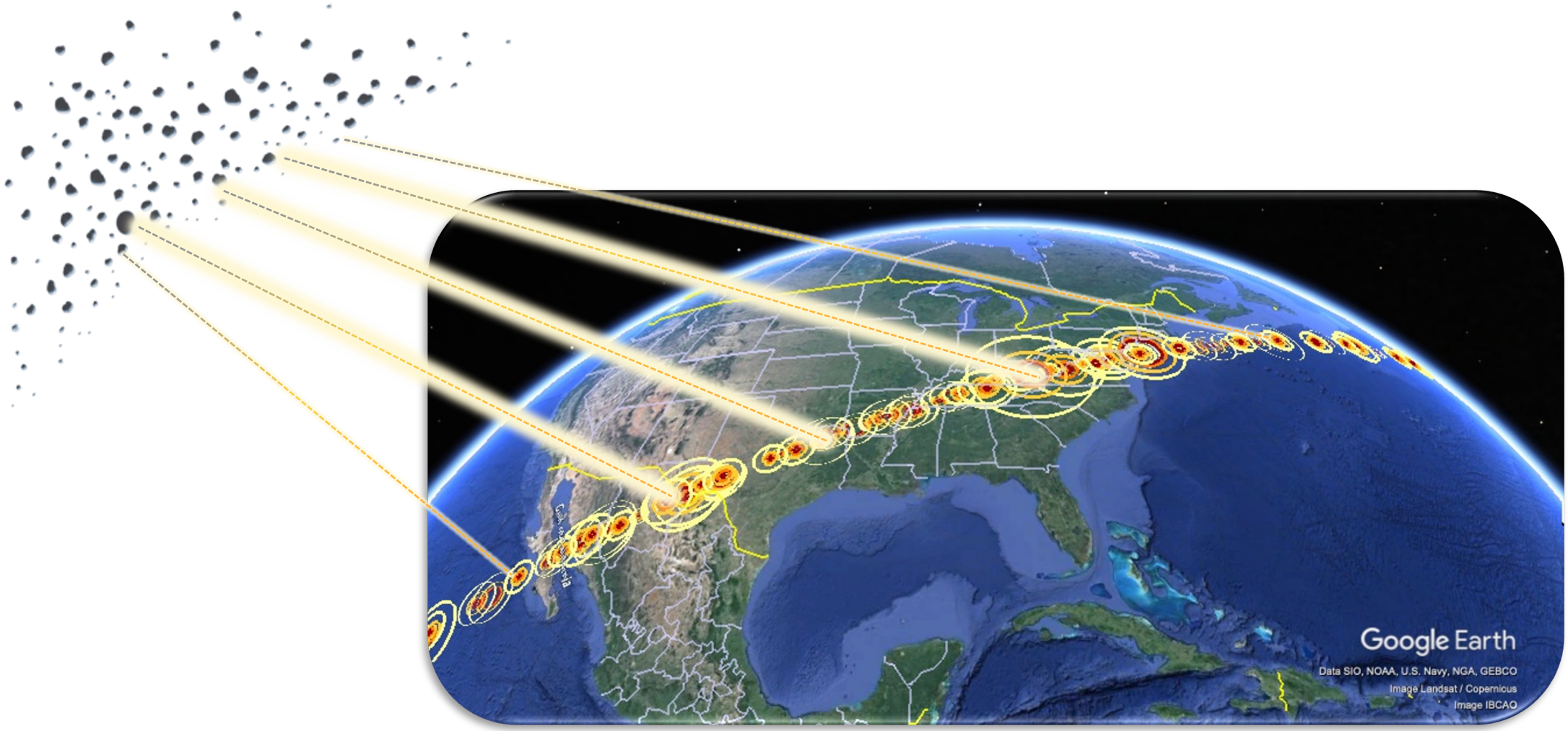


- Asteroids can cause damage by exploding in the atmosphere or by impacting Earth's surface
- Potential hazards include destructive blast waves, thermal fireballs, or tsunamis
- Damage depends on asteroid properties, atmospheric entry, and impact location

Properties and impact location of asteroid 2024 PDC25 are uncertain, so the potential damage is highly uncertain

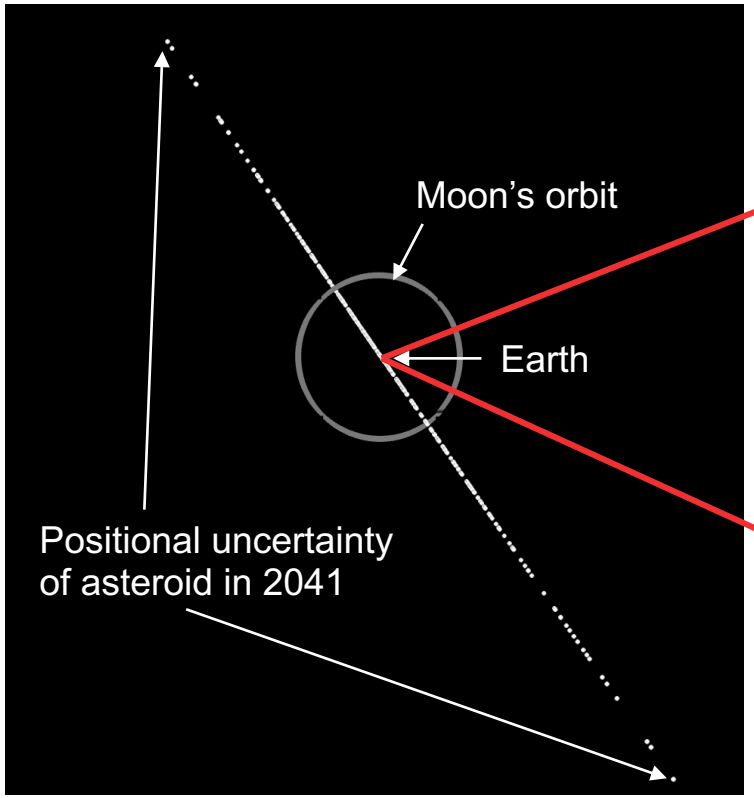
Impact Risk Assessment

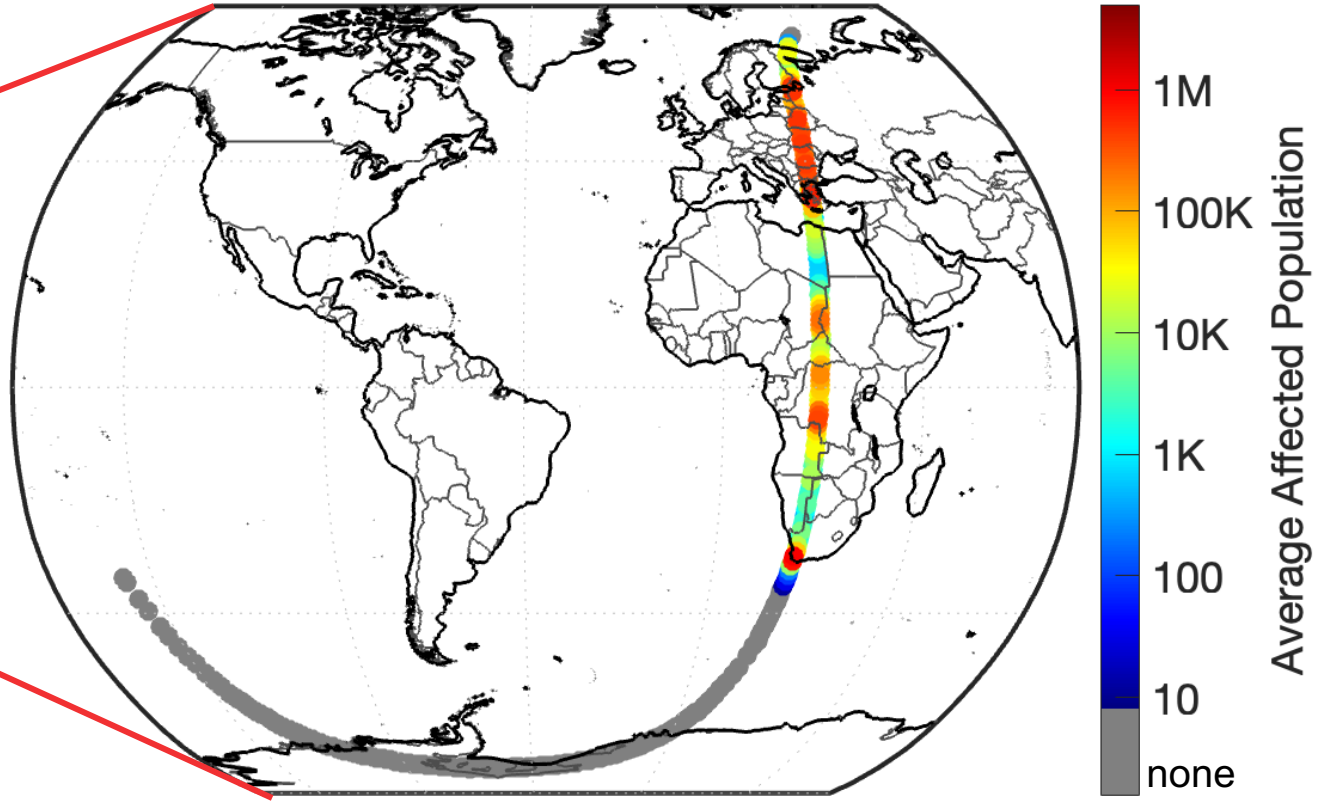
Models millions of cases to evaluate range & likelihood of potential damage, given uncertainties



What are the damage risks if the asteroid 2024 PDC25 hits Earth?

August 2024: 1.6% chance of Earth impact by an asteroid 50–280 m in diameter with 3–720 Mt of energy



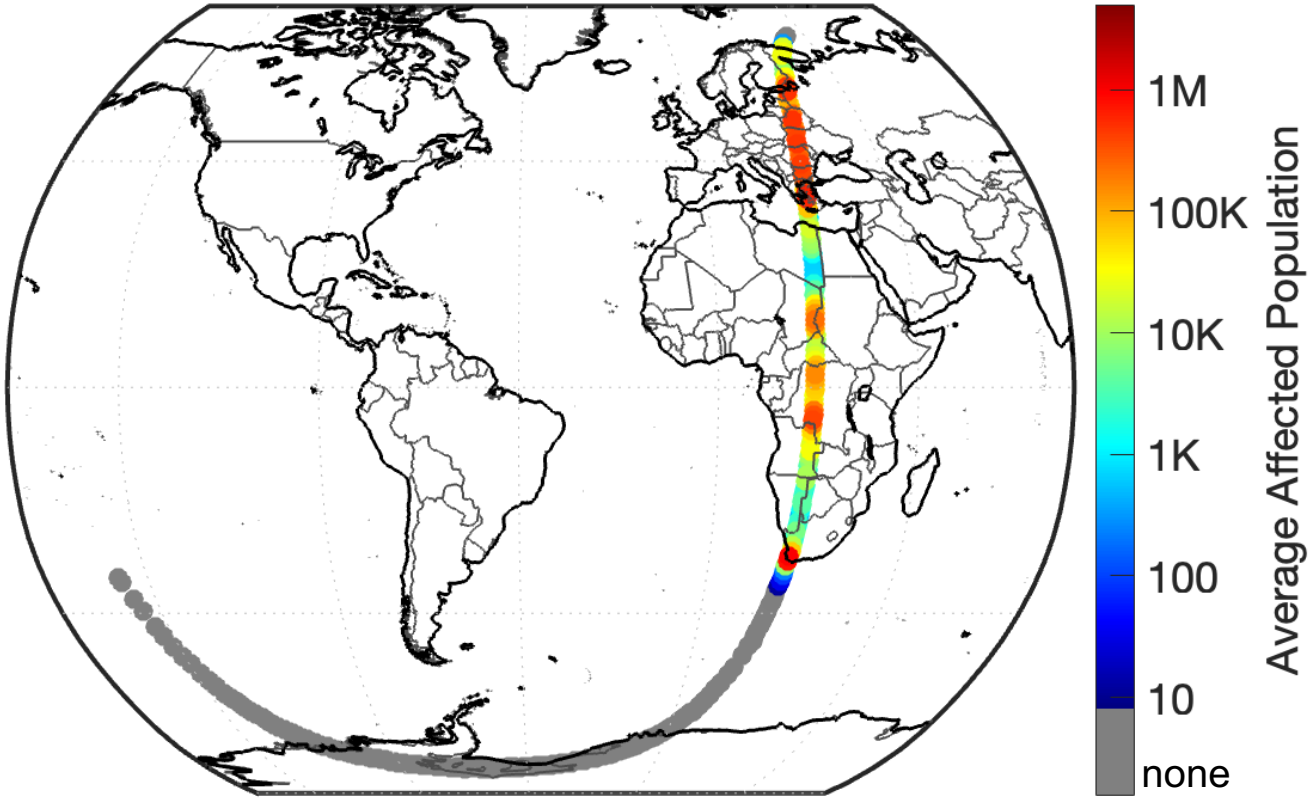


If Earth impact occurs, there is a ~50/50 chance of damage to populated areas

Impact Hazard Summary

August 2024: 1.6% chance of Earth impact by an asteroid 50–280 m in diameter with 3–720 Mt of energy

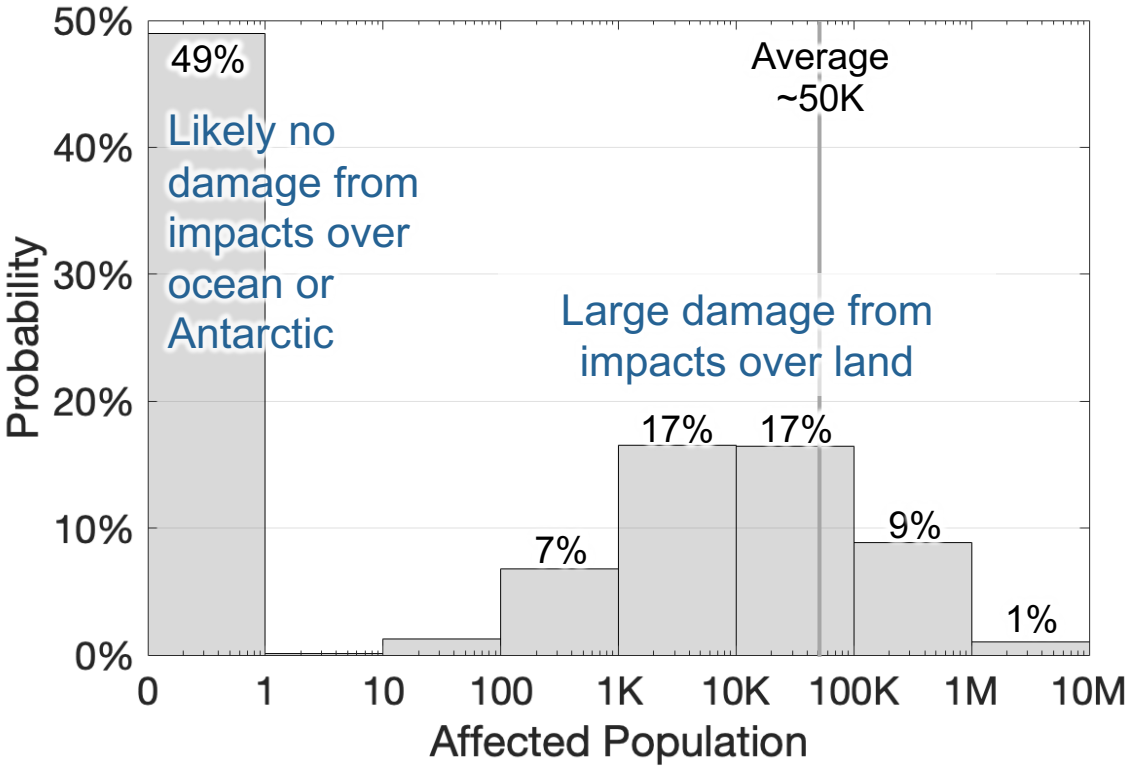
- Primary hazard is a **destructive blast wave** from a high-energy, low-altitude airburst
- Blast damage could span multiple cities or larger provinces, potentially affecting **thousands to millions of people**
- **Significant tsunami are unlikely**, but the largest impacts near coasts could cause inundation damage



If Earth impact occurs, there is a ~50/50 chance of damage to populated areas

Affected Population Risks

Damage probabilities *if Earth impact occurs;* Earth impact probability is currently 1.6%



Likelihood of the impact affecting at least this many people if Earth impact occurs

0	>1K	>10K	>100K	>1M
49%	**43%**	**26%**	**10%**	**1%**

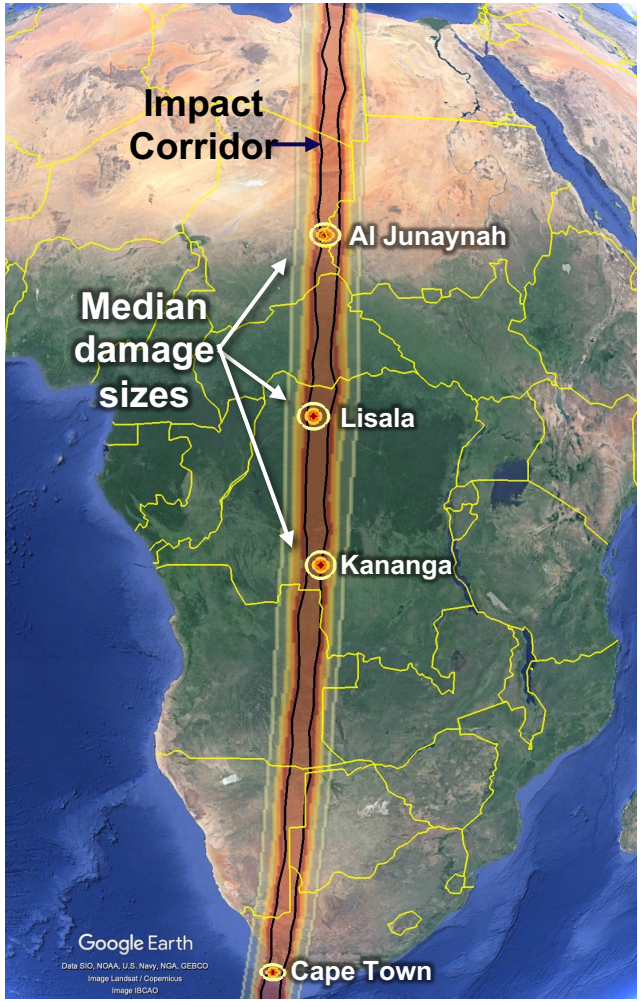
Impacts over land would likely affect 1K–100K people, potentially up to ~5M people

~50K people affected on average

If Earth impact occurs, chances of no damage or large damage are both likely

Ground Damage Risk Swath

Regions potentially at risk to ground damage given ranges of damage sizes and locations



Damage Level	Description
Serious	Windows shatter, some structure damage
Severe	Widespread structure damage
Critical	Residential structures collapse
Unsurvivable	Devastation, structures flattened or burned

Areas potentially at risk to blast damage span a ~500-km-wide swath from South Africa to the Barents Sea, crossing Africa, the Mediterranean, and Eastern Europe

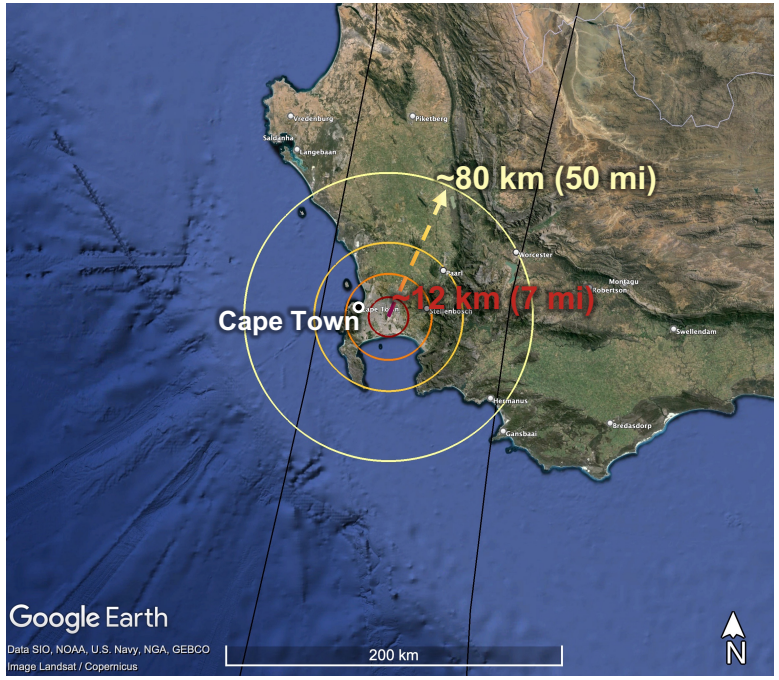
- Damage risk swath shows extent of regions *potentially* at risk to ground damage, given ranges of potential damage locations and sizes
- Black border shows range of potential airburst/impact locations
- Rings show median damage sizes at sample locations

Potential Ground Damage Sizes & Severities

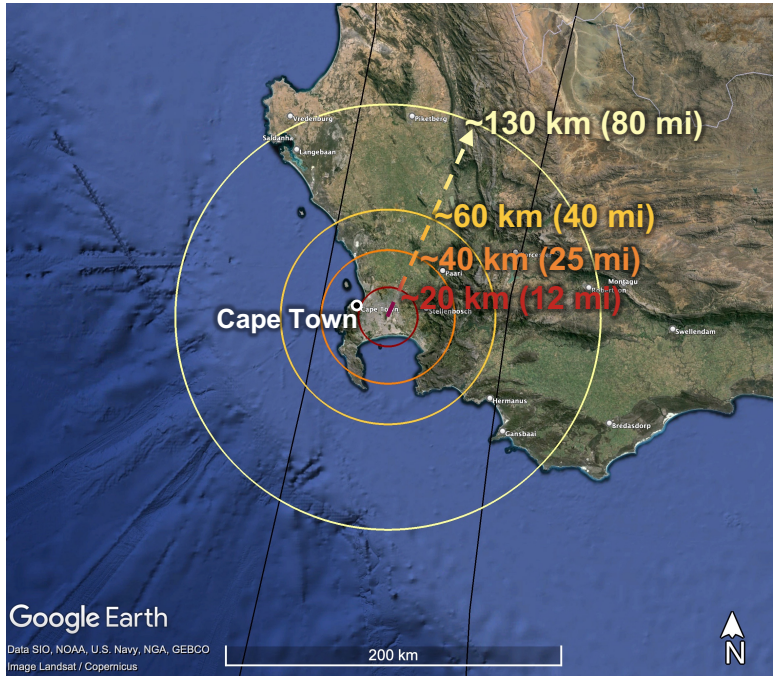
Example over Cape Town, South Africa

Likely damage sizes could span multiple metropolitan areas or counties

Large damage sizes could span multiple provinces or states



Median (50th%) Damage



Large (95th%) Damage

Damage severities could reach **unsurvivable** levels near the blast, extending to larger areas of **structural damage, fires, and shattered windows**

Damage Level	Description
Serious	Windows shatter, some structure damage
Severe	Widespread structure damage
Critical	Residential structures collapse
Unsurvivable	Devastation, structures flattened or burned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SOUTH AFRICA
IAA
INTERNATIONAL ACADEMY OF ASTRONAUTICS
2025

It is now October 2024.
16.5 years until potential impact

Potential impact
24 April 2041

IAWN
notification
1 August 2024

It is now October 2024.
16.5 years until potential impact

IAWN
notification
1 August 2024

Potential impact
24 April 2041

EXERCISE EXERCISE EXERCISE

August 2024
IAWN issues notification about potential impactor

August to October 2024
Delegates of the UN-endorsed Space Mission Planning Advisory Group (SMPAG) meet virtually on a recurring basis to assess space mission options

10 & 11 October 2024
SMPAG meets in Milan, Italy

29 October 2024
SMPAG shares recommendations

The impact probability is now 18%. There is an 82% chance the probability of Earth impact will be >1% when observations end in December.

EXERCISE EXERCISE EXERCISE

Recommendations for Space Mission Options

Detlef Koschny
Chair, Space Mission Planning Advisory Group
(SMPAG)

9th IAA Planetary Defense Conference

Scenario date: 29 October 2024

Space Mission Planning Advisory Group

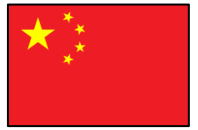
SMPAG

Endorsed by the UN Committee on the Peaceful Uses of Outer Space in 2013


FFG
(Austria)


BELSPO
(Belgium)


CSA
(Canada)


CNSA
(China)


Czech Republic

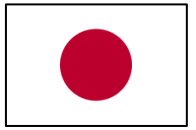

ESA


CNES
(France)


DLR
(Germany)


ISA
(Israel)


ASI
(Italy)


JAXA
(Japan)


KASI
(Korea)


AEM
(Mexico)

+ Observer or ex-officio status: ASE, COSPAR, ESO, IAA, IAU, IAWN, SWF, UNOOSA


SUPARCO
(Pakistan)


ROSA
(Romania)


ROSCOSMOS
(Russia)


SSAU
(Ukraine)


UK Space Agency
(UK)


NASA
(USA)

SMPAG members as of January 2024

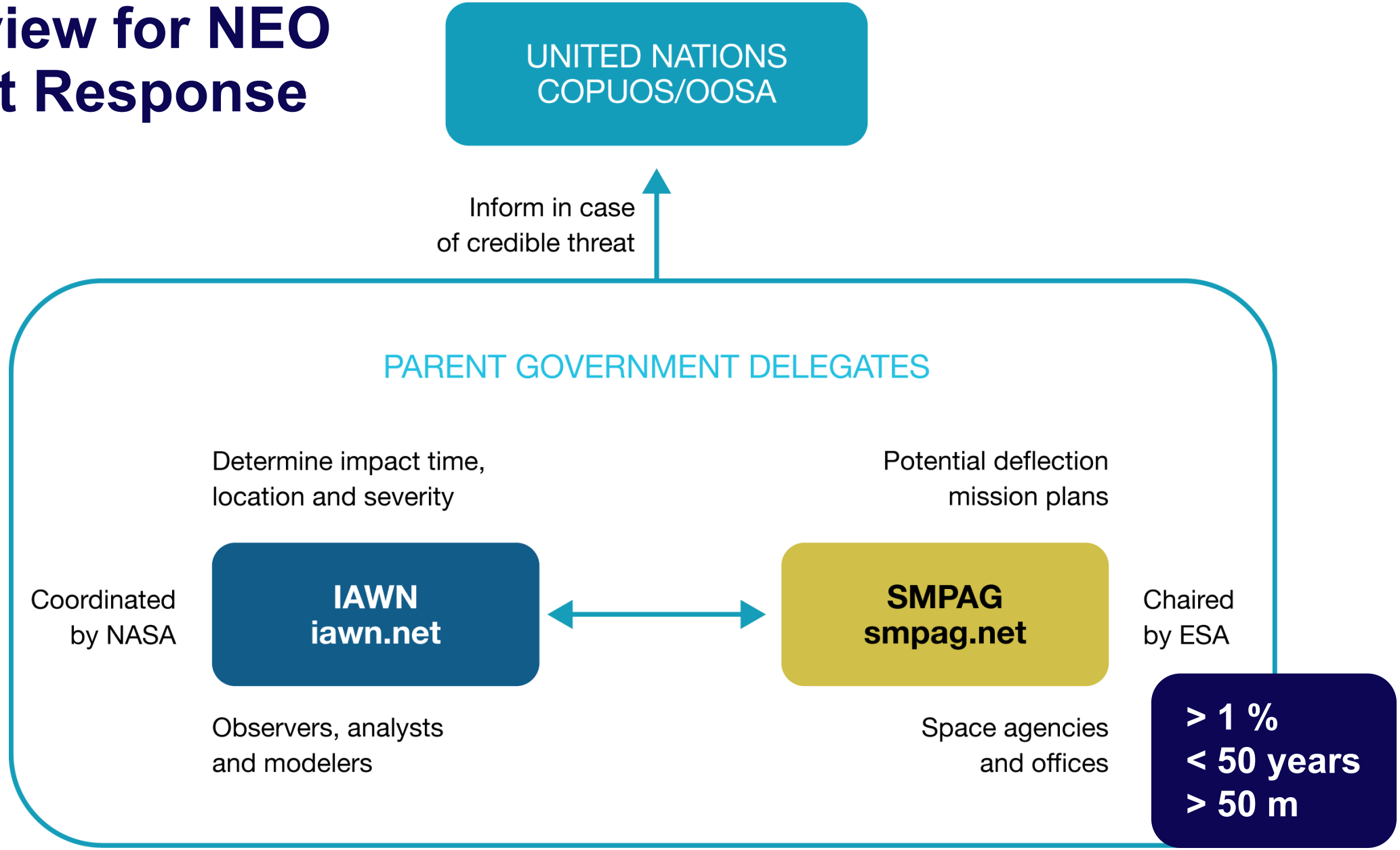
Excerpts from Terms of Reference

SMPAG

*"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."*

Reference: SMPAG Terms of Reference, https://www.cosmos.esa.int/web/smpag/terms_of_reference_v2

Overview for NEO Threat Response



MISSION OPTIONS TIMELINE

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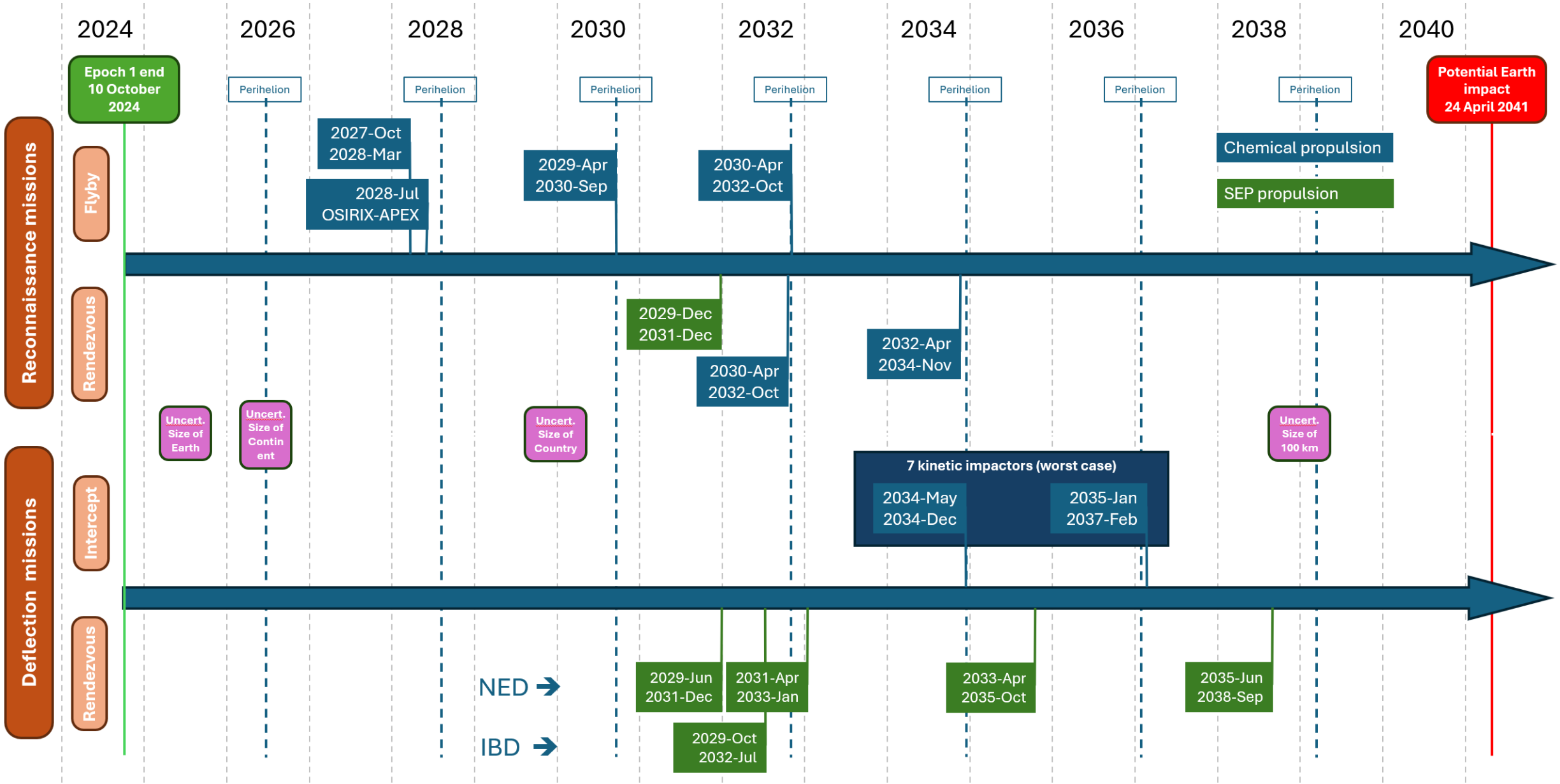

EXERCISE EXERCISE EXERCISE

Five SMPAG Recommendations

1 

Start, as soon as possible, the initial design phases (phases A/B) of a fast flyby reconnaissance mission.

2 

Consider re-tasking an already flying spacecraft to perform an early reconnaissance of the target asteroid.

3 

Start, as soon as possible, the initial design phases (phases A/B) of a solar electric propulsion (SEP) rendezvous reconnaissance mission, independently of the implementation of a flyby reconnaissance mission.

4 

Start, as soon as possible, the initial design phases (phases A/B) of in-space mitigation missions, based on the following concepts, including the risk assessment on each option: kinetic impactor (KI) and ion beam deflection (IBD).

5 

Perform detailed simulations assessing the possibility to disrupt an asteroid by an impulse transfer. The work should be done by several SMPAG delegations independently.


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IAA
INTERNATIONAL ACADEMY OF ASTRONAUTICS
2025

It is October 2024
16.5 years until potential impact; 18% chance of impact

Potential impact
24 April 2041

Affected people among Earth-impacting scenarios

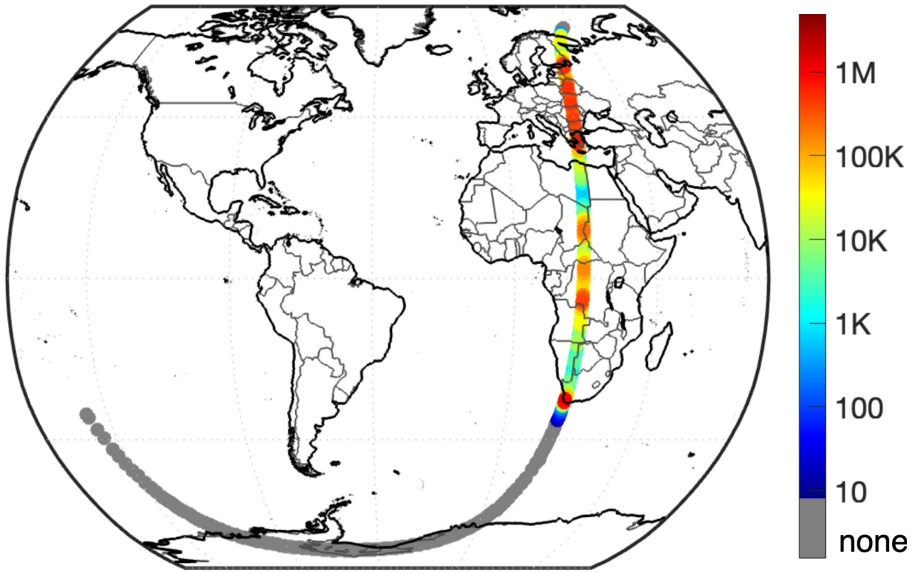
0	>1K	>10K	>100K	>1M
49%	43%	26%	10%	1%

Possible asteroid sizes (m)

50 — **Most likely size: 90–160** — 280

Rocky composition

Avg. affected population along potential impact regions



SMPAG Recommendations

- Flyby Recon
- Retask for Recon
- Rendezvous Recon
- In-Space Mitigation
- Disruption Modeling

Participant Discussion

What did you learn during the panel?

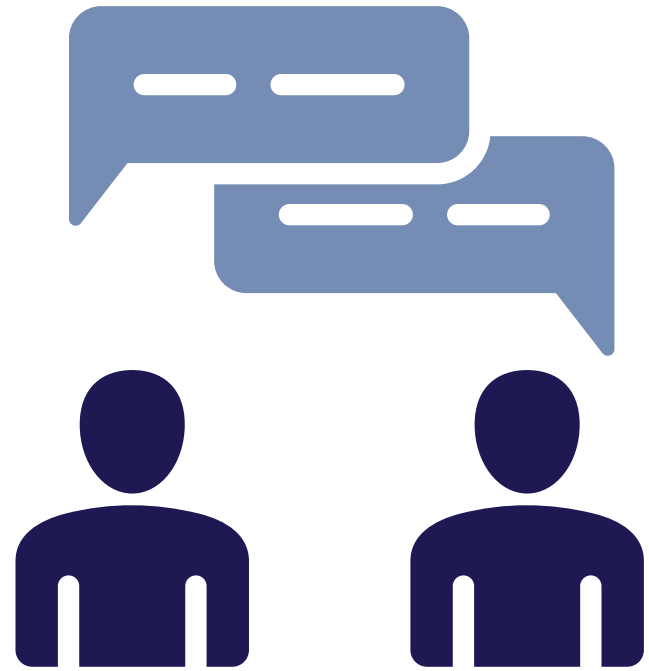
What in the panelists' comments aligned with your expectations? What surprised you?

Did your perspective on planetary defense change in any way after listening to the panelists? If so, how?

What are the implications of the panelists' comments for your own work?

What concrete actions could be taken to make progress on the issues raised by the panelists?

If you could ask the panelists to elaborate on one specific point, what would it be?



Share Your Perspectives

Which recommendation about asteroid reconnaissance would you advocate that your government prioritize, given the current level of risk?

a) Fast flyby reconnaissance mission

b) Re-tasking already flying spacecraft for reconnaissance

c) Rendezvous reconnaissance mission

Which recommendation related to Earth impact prevention would you advocate that your government prioritize, given the current level of risk?

a) Initial design phases of in-space mitigation missions

b) Detailed simulations assessing the possibility of asteroid disruption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