Session Decision to Act - Oral Presentations (8)
Friday April 30th, 2021, Noon-1.30pm CET

Mr. Luciano Vaz Ferreira
PhD Student at University of Reading
Liability waivers and planetary defense missions: the Good Samaritan principle

Mr. Krzysztof Niewęgłowski
PhD Candidate at Maria Curie Skłodowska University in Lublin
Obligation to participate in planetary defense action as part of international jus cogens

Dr. Anne-Sophie Martin
Postdoctoral Research Fellow at Sapienza University of Rome
Reacting to Near-Earth Object Impact: Exceptional Circomstances Justifying Non-Compliance with International law

Mr. Avishai Melamed
Incoming Graduate Student at Cornell University
Planetary Defense as Entrepreneurial Politics: The Case for Policy Optimization

Dr. Alissa J. Haddaji
Lecturer on Law - Space Law, Policy And Ethics at Harvard University
Understanding the social-anthropological aspects of an asteroid impact threat response from transdisciplinary lessons learned in natural disaster management

Prof. Aaron Boley
Associate Professor at UBC
Precautionary Planetary Defence: Pre-emptive Deflections and Exercising Restraint

Dr. Detlef Koschny
Acting Head, Planetary Defence Office at ESA
ESA's Activities in Planetary Defence

Dr. Gerhard Drolshagen
Senior Expert at University Oldenburg
Scope, objectives and first results of the Space Mission Planning Advisory Group

Session Decision to Act - Posters (5)
Friday, April, 30th, 2021

Mr. Petr Bohacek
Policy Fellow
Charles University
Effective or inclusive decision-making? Normative and empirical analysis of the governance trade-offs in Planetary Defense

Mr. Joel Marks
University of New Haven
What Is Planetary Defense? From Research to Implementation

Mr. Hannes Mayer
Project Assistant
Competence Centre for Space Law at Karl-Franzens-University Graz
Planetary defence - timeline of key developments

Mr. Ryan Puleo
The George Washington University
The Future rôle for the United States in Planetary Defense

Ms. Elisa Simó Soler
PhD Student
Faculty of Law, University of Valencia
Saving humanity democratically? From impact refugees to deterritorialized States: deeping the extreme legal and policy cases.

7th IAA Planetary Defense Conference
26-30 April 2021, Online Event
Hosted by UNOOSA in collaboration with ESA

LIABILITY WAIVERS AND PLANETARY DEFENSE MISSIONS: THE GOOD SAMARITAN PRINCIPLE

Luciano Vaz Ferreira
University of Reading (U.K.)

What if a planetary defense mission goes wrong?

- Error in orbit correction or fragmentation causing modification or multiplication of the impact site

- Direct damage caused by spacecraft from the planetary mission

What are the international legal consequences?

- The International Law imposes payment of compensation to the ‘victim State’ for damages caused by space objects in almost any circumstances

- Is it fair for a planetary defense mission?

- **Research question:** explore alternatives to the current international liability regime applied to planetary defense missions, offering options that could contemplate liability waivers

Concept of Liability in International Law

- Different from **Responsibility:** internationally wrongful acts, violations to International Law (e.g. NED)
- **Liability:** Injurious consequences arising out of acts not prohibited by International Law (e.g. space launching and other planetary defense alternatives)
- Obligation to prevent harm and eliminate or mitigate damages
- Sources: International customs, 1967 Outer Space Treaty, 1972 Space Liability Convention (SLC)

Types of Liability in International Law

- **Fault-based Liability:** intentional or a negligent act
- **Strict-liability:** Risky activities. Compensation even if there is compliance with standards of care
- **Absolute Liability:** more rigorous than strict liability, restricted exoneration clauses (GOLDIE, 1965)

Space Liability Convention (SLC)

Launching State Concept in the Space Liability Convention

- States which launches or procures the launching
- State whose territory or facility a space object is launched

Types of Liability in the Space Liability Convention

- **Absolute Liability:** damages caused on Earth and aircraft flying
- **Fault-Based Liability:** other space objects (e.g. satellites)

Issues for Planetary Defense Missions in the SLC

- Absolute liability seems unfair for planetary defense missions
- No standards of care for fault-based liability
- No liability exoneration based on force majeure, necessity, or distress (FOSTER, 1972; KERREST & THRO, 2017)
- Disproportionate liability for all participants (‘procures the launching’ vagueness)

Alternatives to Liability Exoneration and Waivers for Planetary Defense Missions

- Inspiration on “Good Samaritan Principle” in domestic law: legal protection to those who help injured, sick or in danger person

How?

- Article V of SLC “apportioning agreements” for planetary defense missions. ISS Agreement experience.
- New treaty on planetary defense or a SLC Ammendment
- United Nations Security Council Resolution

Thank you!

Questions?

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7TH IAA PLANETARY DEFENSE CONFERENCE
26 – 30 APRIL 2021

Vienna, Austria

Obligation to participate in planetary defense action as part of international jus cogens

Krzysztof Niewęgłowski

PhD student at Maria Curie Skłodowska University in Lublin, Poland

Legislation Expert at Research Bureau of Polish Parliament

Obligation to participate in planetary defense action as part of international jus cogens

Krzysztof Niewęgłowski

NEO collision threat as threat to international peace and security

Threat of asteroid collision with global consequences can be considered as threat to international peace and security. It implies, that provisions of UN Charter could be applied in order to prevent a global catastrophe.

UN Security Councils' primary responsibility is to maitain international peace and security.
UN Members are obligated to accept and carry out the decisions of the Security Council

Obligation to participate in planetary defense action as part of international jus cogens

Krzysztof Niewęgłowski

The concept of *jus cogens* in international public law

Article 53 of Vienna Convention on Law of Treaties – introduction of *Jus Cogens* into the international legal order

Jus cogens is a norm:
1) of universal international law;
2) accepted and recognized by the international community of states as a whole;
3) norm from which no derogation is permitted;
4) norm that can be changed only by a subsequent norm of general international law of the same character.

Obligation to participate in planetary defense action as part of international jus cogens

Krzysztof Niewęgłowski

The concept of *jus cogens* in international public law

The identification of *jus cogens* norms is made on the basis of three criteria. The **sociological criterion** is met if the norm is accepted and recognized as peremptory by the international community of states as a whole. The **normative criterion** consists in the prohibition of derogation. The **axiological criterion** concerns the values cited above that underlie the contemporary international community. Only the combined fulfillment of these three criteria allows for the recognition of an international legal norm as an *jus cogens* norm.

THERE IS NO CATALOGUE OF JUS COGENS NORMS

Obligation to participate in planetary defense action as part of international jus cogens

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Obligation to participate in planetary defense action as part of international jus cogens

Krzysztof Niewęgłowski

UN Charter provisions as legal source of obligations to participate in planetary defense

Article 1
The Purposes of the United Nations are:

1. To maintain international peace and security, and to that end: to take effective collective measures for the prevention and removal of threats to the peace (…)
(…)
3. To achieve international co-operation in solving international problems of an economic, social, cultural, or humanitarian character (…)

Obligation to participate in planetary defense action as part of international jus cogens

Krzysztof Niewęgłowski

UN Charter provisions as legal source of obligations to participate in planetary defense

Article 2

The Organization and its Members, in pursuit of the Purposes stated in Article 1, shall act in accordance with the following Principles.

(…)

2. All Members, in order to ensure to all of them the rights and benefits resulting from membership, shall fulfill in good faith the obligations assumed by them in accordance with the present Charter.

(…)

5. All Members shall give the United Nations every assistance in any action it takes in accordance with the present Charter, and shall refrain from giving assistance to any state against which the United Nations is taking preventive or enforcement action.

(…)

6. The Organization shall ensure that states which are not Members of the United Nations act in accordance with these Principles so far as may be necessary for the maintenance of international peace and security.

Obligation to participate in planetary defense action as part of international jus cogens

Krzysztof Niewęgłowski

Role of Security Council in Planetary Defense

Article 24
The Security Council primary responsibility is the maintenance of international peace and security and States agree that in carrying out its duties under this responsibility the Security Council acts on their behalf.

Article 25
The Members of the United Nations agree to accept and carry out the decisions of the Security Council.

Article 39
The Security Council determinates the existence of any threat to the peace and makes recommendations or decides what measures shall be taken to maintain or restore international peace and security.

Obligation to participate in planetary defense action as part of international jus cogens

Krzysztof Niewęgłowski

Role of Security Council in Planetary Defense

Article 41
The Security Council decides what measures not involving the use of armed force to employ.

Article 42
If measures not involving the use of armed force are inadequate, it can take action by air, sea, or land forces as may be necessary

Article 43
All Members of the United Nations, in order to contribute to the maintenance of international peace and security make aviable to the Security Council armed forces, assistance, and facilities

Obligation to participate in planetary defense action as part of international jus cogens

Krzysztof Niewęgłowski

Role of Security Council in Planetary Defense

Article 48
All members of the United Nations or some of tchem have to take action required to carry out the decisions of the Security Council

Article 49
The Members of the United Nations shall join in affording mutual assistance in carrying out the measures decided upon by the Security Council.

Obligation to participate in planetary defense action as part of international jus cogens

Krzysztof Niewęgłowski

Are these obligations to be considered as *jus cogens?*

YES

- They meet all the criterions for identification of *jus cogens* (sociological, normative and axiological)
- Article 1 and 2 of UN Charter were shown as example of *jus cogens* during drafting VCLT
- They are connected to values protected by other, recognised *jus cogens* norms

NO

- UN Charter contains provisions of specific nature (art. 103)
- *Jus cogens* main effect is focused on valitity of treaties
- Beside Vienna Conference, there is no proof of *jus cogens* character of mentioned UN Charter obligations

Obligation to participate in planetary defense action as part of international jus cogens

Krzysztof Niewęgłowski

Conclusions

Are States obligated to participate in global planetary defense action?

YES
(if the Security Council takes an action)

Is an obligation to participate in planetary defense action an international *jus cogens?*

There is no definite answer, because this obligation is strictly bound to the UN Charter

Thank you for your attention

Krzysztof Niewęgłowski

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Reacting to Near-Earth Object Impact

Exceptional Circumstances Justifying Non-Compliance with International Law

Anne-Sophie Martin

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Introduction

- NEO => less predictable and pose much greater harm than falling space debris
- Impossible to control outer space/deep space and to monitor all potential asteroid and comet threats
- States' right and obligation to protect its territory and its population, but no obligation under international law to assist other States
- Duty of non-intervention in internal affairs of other States

NEO Threat – Relevant Space Law Provisions

- Article III of the Outer Space Treaty => space activities carried on in accordance with international law
- Article VI of the Outer Space Treaty. States responsibility for national activities which apply also to private entities involving in planetary defense missions
- Article VII of the OST => liability in case of damage

NEO Threat – Relevant Space Law Provisions

- Article IX of the Outer Space Treaty => due regard to the corresponding interests of all other States parties and mutual assistance
- Article X of the Outer Space Treaty => international cooperation and observing the flight of space objects. Relevant also for NEO trajectory?
- Article XI of the Outer Space Treaty => information and data sharing about space objects. Relevant also for NEO trajectory?
- Principle X of the UN Principles on Remote Sensing (1986)

NEO Threat – International Law

- Application of *'precautionary principle'*
- Principle 18 of Rio Declaration (1992) => notification of any natural disasters
- Article 9 of the International Law Commission (ILC) in its *Articles on the protection of persons in the event of disasters* => "obligation on States to take the necessary and appropriate measures to prevent harm from impending disasters".

NEO Threat –Violation of International Law

- Violation of an international obligation in case of a planetary defense mission => States' international responsibility

- 2001 Articles on Responsibility of States for Internationally Wrongful Acts (ARSIWA) and Article 2 (definition of an internationally wrongful act)

React to NEO threat – States' Responsibility under IL

- Obligation to cease the wrongful conduct and to assure non-reiteration (Art. 29, 30 ARSIWA)
- Make reparation (Art. 31 and 34-37 ARSIWA)

React to NEO threat – Circumstances Justifying Non-Compliance with IL

- Circumstances where the wrongfulness is excluded in the use of a planetary defense method
  - Consent
  - Distress
  - Necessity

React to NEO threat – CONSENT (art.20 ARSIWA)

- Within the limits of the consent and only in relation to the States (maybe all States) that have given their consent
- Third States, which have not consented to the planetary defense mission => wrongfulness not excluded
- A possibility => UN General Assembly/Security Council resolution reflecting broad consent to a specific planetary defense mission (on a case-by-case basis)

React to NEO threat – Distress (art. 24 ARSIWA)

- Lives of persons threatened by the possible impact of a NEO
- Planetary defense method justified if there is “no other reasonable way” of saving lives
- Must not endanger the population and put the territory of other States at risk

React to NEO threat – Necessity (Art.25 ARSIWA)

- Interest threatened by a grave and imminent peril;
- Objectively and clearly established, not just speculated;
- Action undertaken as the only way to safeguard the interest;
- Gabčíkovo-Nagymaros Project (Hungary/Slovakia), Judgment, ICJ. Reports 1997, p. 7, para. 51.

React to NEO threat – In Practice

- Changes in orbit trajectory, rotational dynamics may avoid the potential impact without that other measures are necessary to conduct;
- Technological development (using optical and radio telescope) will also allow to anticipate NEO threat, and to obtain accurate data;
- Acknowledgement of previously unknown facts, or by reconsidering existing facts.

React to NEO Threat – In Practice

- Difficulty to undertake a comprehensive evaluation if the specific conditions for invoking circumstances precluding wrongfulness are present;
- As soon as the invoked circumstance of threat ceases to exist, State obliged to return to lawful conduct (Art. 27 Lit. (a) ARSIWA);
- Exception: if a State intentionally alters the course of the object towards the territory of another State to protect its own interests => responsibility under international law.

Dispute Settlement – Peaceful Means

- Mediation, negotiation;
- Arbitration (Permanent Court of Arbitration – PCA Outer Space Rules);
- Judicial settlement of disputes by the International Court of Justice (Art. 33 UN Charter);
- Security Council or General Assembly (Art. 35 UN Charter) => recommending appropriate procedures.

Conclusion

- Any planetary defense action affecting the territory and population under the jurisdiction of another State would be contrary to international law, unless the action is justified by a circumstance precluding wrongfulness or authorized by a resolution of the UN Security Council (with time-limited and under specific circumstances);

- A duty of States under international law to mitigate disasters related to a NEO impact and to inform about a potential NEO impact threat;

- Guidelines/Code of Conduct containing the following relevant principles should be implemented and widely distributed (governments, space agencies, industries): international cooperation (role of the UNGA and UNSC), obligations under international law, duty to inform, exceptions to comply with international law and dispute settlement mechanisms.


Thank you!
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Planetary Defense as Entrepreneurial Politics

PDC 2021

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Executive Summary

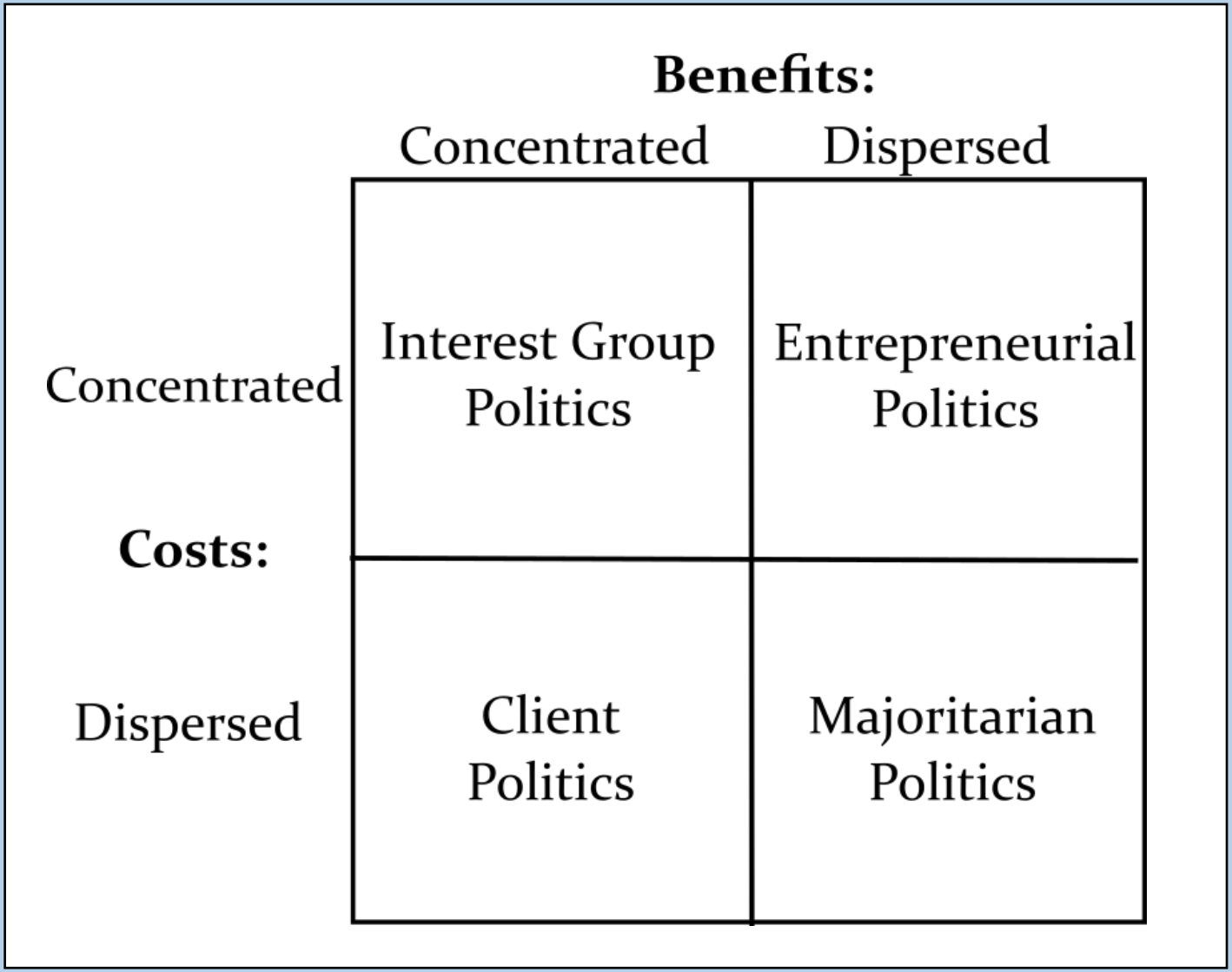
- **Opportunity**: Investments into effective planetary defense readiness.
- **Obstacles**:
  - **Natural**: Low likelihood/High consequence NEO hazard
  - **Political**: Limitations of the majoritarian[1] policy approach.
- **Solutions:** Consideration of non-technical factors necessary to attain greater political viability.
  - **Constituency-building:** Concentrating planetary defense benefits as to raise policy support.
  - **Coalition-building:** Alternatively, disperse costs to assuage budget-minded opposition.
- **Consideration**:
  - Transitional stage of Entrepreneurial Politics

1. Cameron 2017

Efficient Planetary Defense

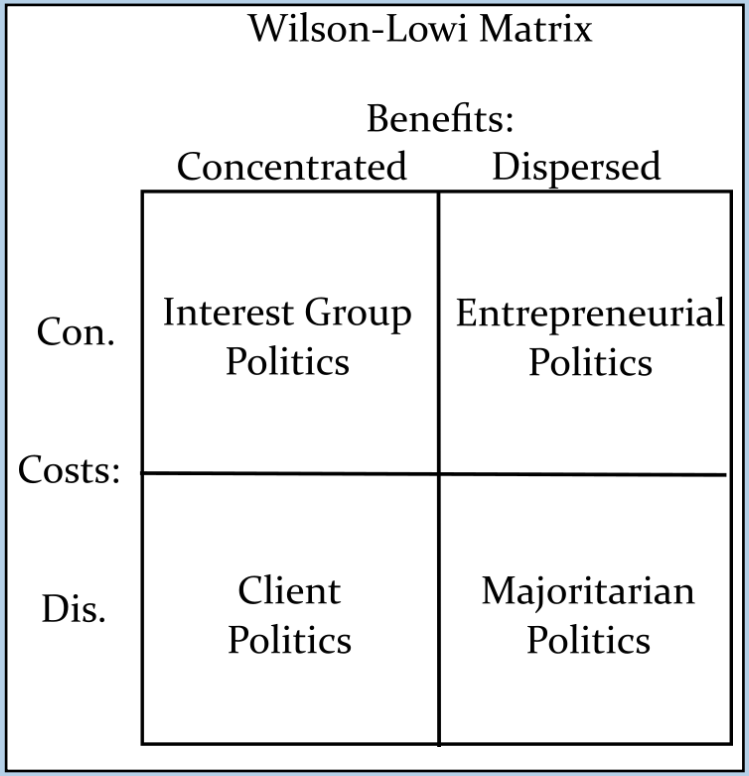
- **Assets**
  - Advanced Warning
  - Adaptable Mitigation Capabilities and Contingencies
- **Opportunities for Improvement**
  - Procedural/Methodological Refinement
  - A Routine Service

The Wilson-Lowi Matrix

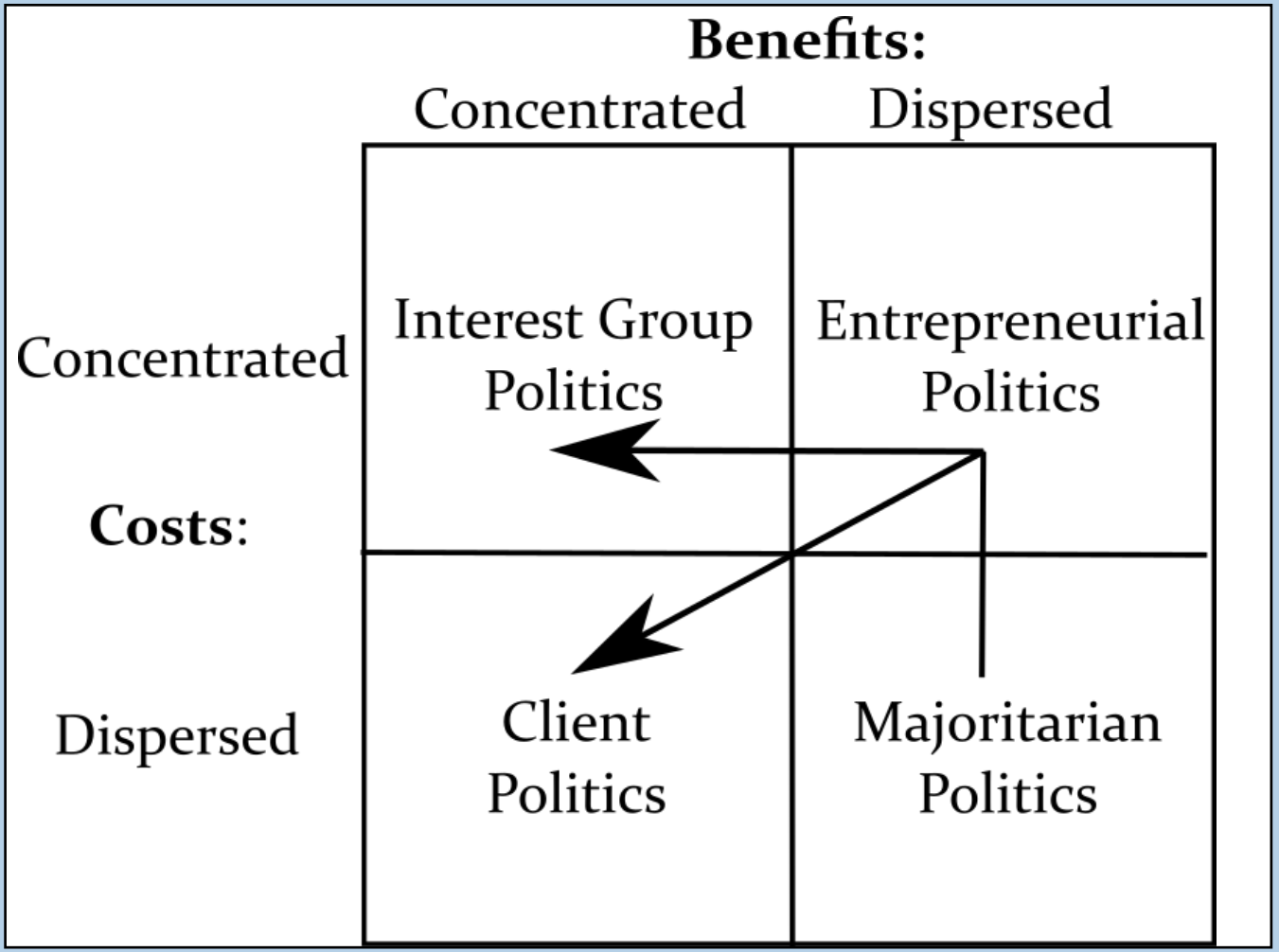


The Obstacle to Effectiveness: Entrepreneurial Policy

- **An imperfect cost-benefit balance:**
  - **Concentrated Costs**
    - Incentivizes Organized Fiscal Opposition
  - **Dispersed Benefits**
    - Non-excludable benefit causes "free riders" Problem
    - Disincentivizes Investment
    - Limited Advocacy, No "Planetary Defense Lobby"
    - Constricts Organization, No "Future Meteor Targets Association"

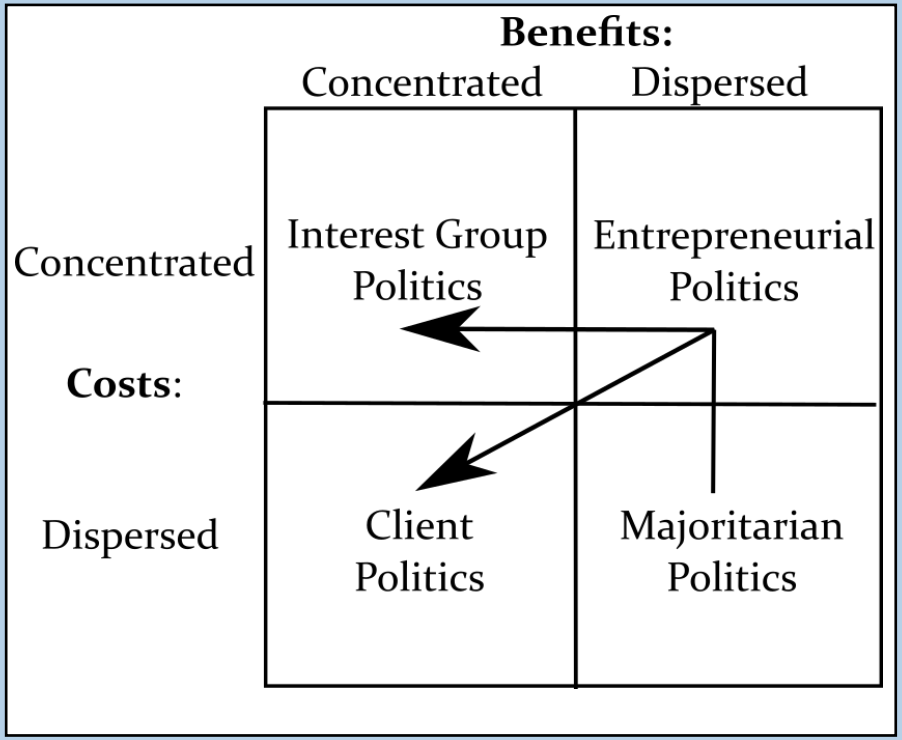


Tools for Optimization: Creating a Constituency



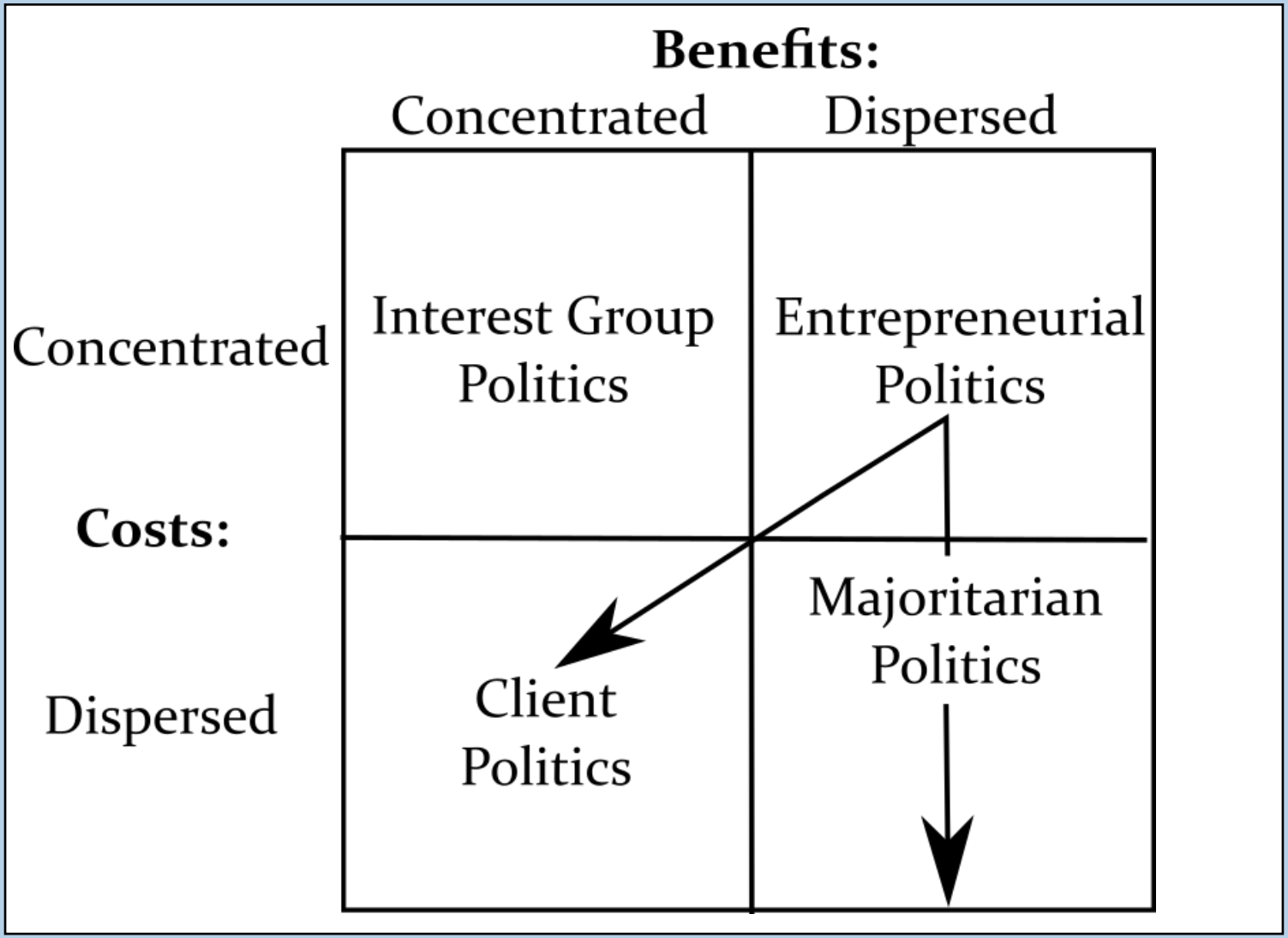
Tools for Optimization: Creating a Constituency

- **Concentrating Benefits**
  - **Returns on Investment**
    - Expanding Markets [2] [3]
    - Space Industry
      - Lifter Manufacture
  - **Supporting Parallel Opportunities**
    - Linking R&D Projects
      - Energy Collection
      - Asteroid Mining
      - Space Vehicle Development
    - Supporting State Priorities
      - Satellite replacement
      - Facilitating increased space activities
- **Increasing Organization**



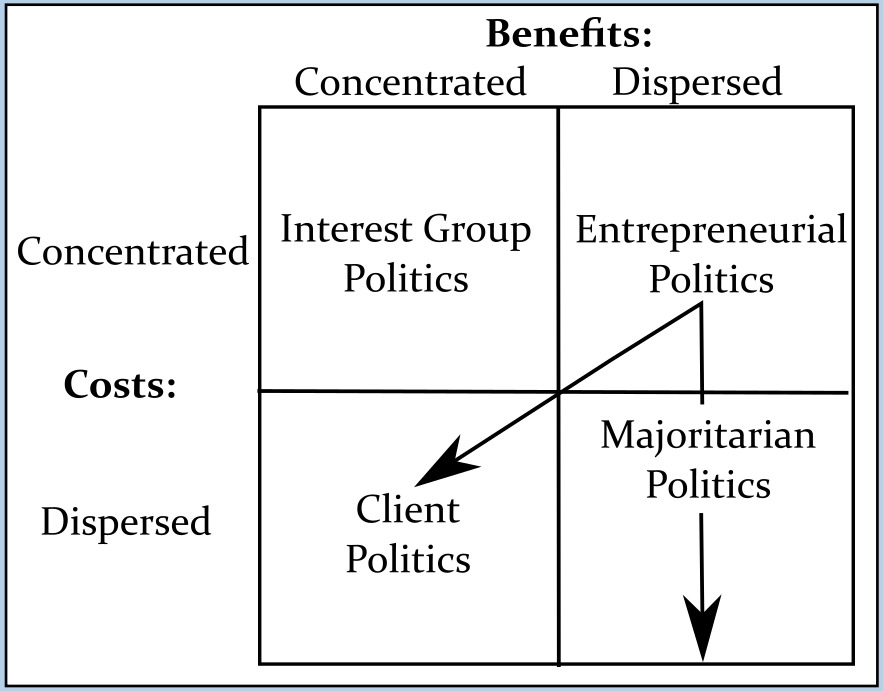
2. George 2019
3. M. Stanley 2017

Tools for Optimization: Distributing Costs



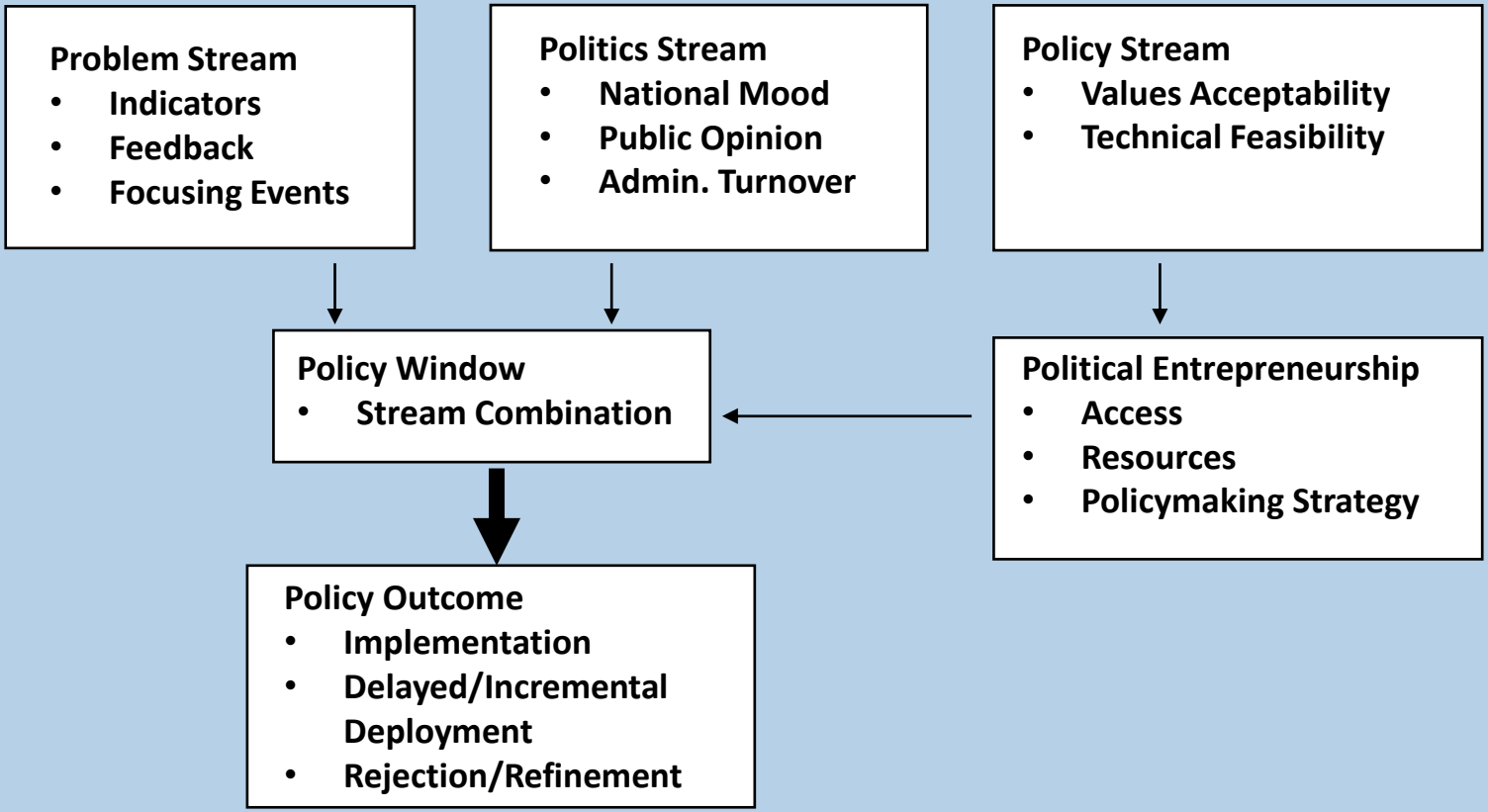
Tools for Optimization: Distributing Costs

- **Deepening Majoritarian Politics**
  - Multilateral Planetary Defense
    - International Cost-Sharing
    - Incremental Improvement
- **Reaching Client Politics**
  - Organizing Support and Dispersed Costs = Optimal Advocacy



Tools for Optimization: Crafting Entrepreneurial Policy

- **Further Lessons from Public Policy**
  - Multiple-Streams Framework



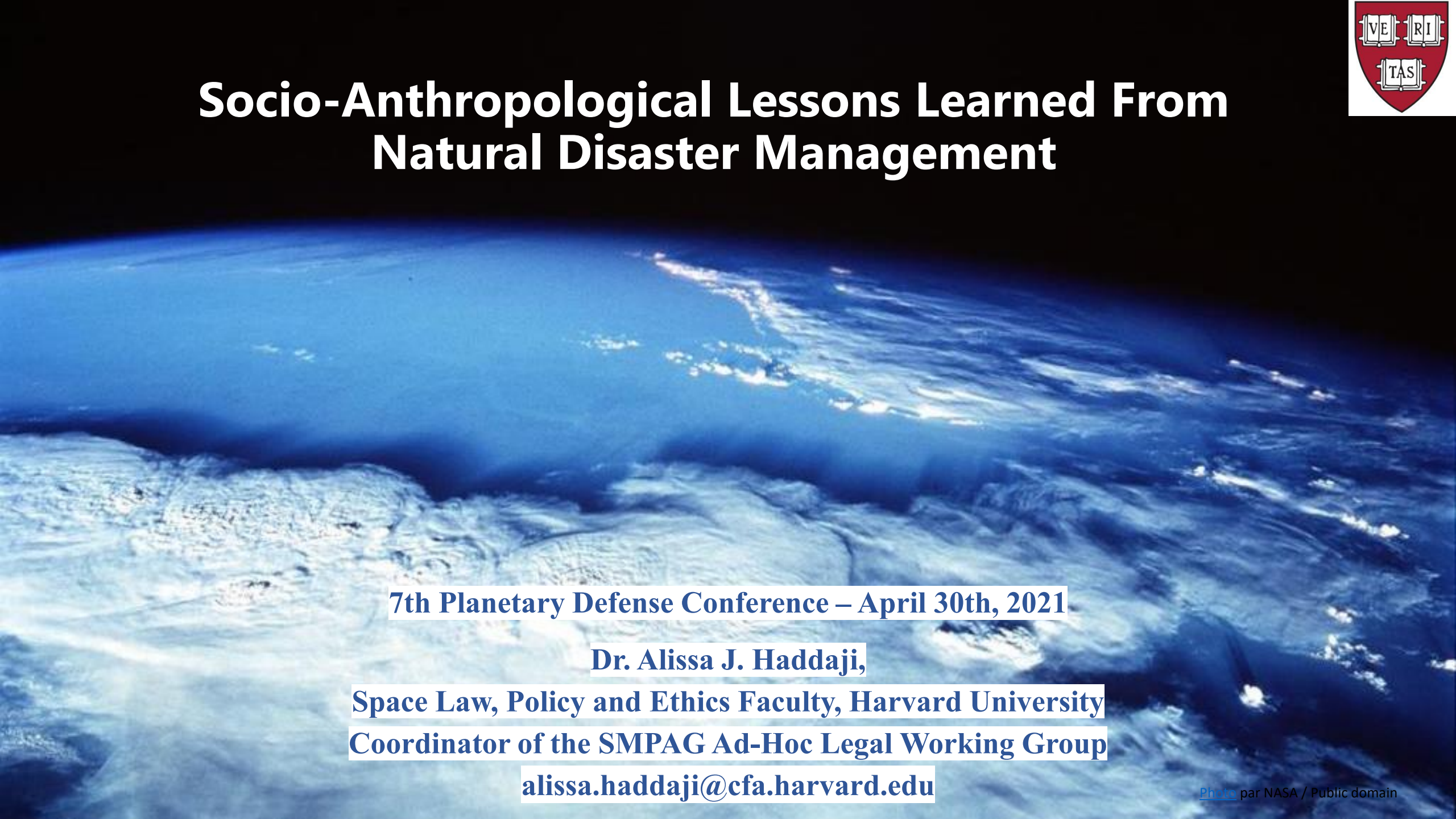
Summary

- **Moving from the majoritarian status quo**
  - Effective entrepreneurship can help achieve efficient planetary defense.

References

- [1] Cameron, Charles. “Assessing the Lay of the Land: The Interest Group Matrix.” *The Political Analysis Toolkit*, Tokyo, 2016, pp. 16, 20-21 (Working Paper).
- [2] George, Kelly Whealan. "The economic impacts of the commercial space industry." *Space Policy* 47 (2019): 181-186.
- [3] M. Stanley. "Space: investing in the final frontier." *2018-11-07. https://www. morganstanley. com/ideas/investing-in-space* (2019).

Socio-Anthropological Lessons Learned From Natural Disaster Management



7th Planetary Defense Conference – April 30th, 2021

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Introduction

- **Anthropology:** From the Greek words *ánthrōpos* (ἄνθρωπος, "**human**") and *lógos* (λόγος, "**study**")

- Socio-anthropology enables the **analysis of local cultural knowledge.** In the context of Planetary Defense, it aims to **contextualize and understand better the populations that may be impacted.**

- A disaster will **disrupt a pre-established social order** that one **must get acquainted** with it to **better assist it**.

Structure

- I. Examples of Social Challenges
- II. Socio-anthropological Lessons Learned from Natural Disaster Management Literature

I. Examples of Social Challenges

Different Priorities

- **Social inequalities** induce the probability that some social categories **will suffer more significant damage than others**.
- On most occasions, **severe socio-economic problems** will be perceived as **more important than a natural threat**. The risk of an asteroid colliding with Earth **may seem quite abstract** and **not of immediate importance** to populations facing **life-threatening struggles** such as **famines, war, economic hardship** or lack of health care coverage.

Resistance to Displacement

- As anthropologist Boscoboinik has explained, despite seismic shocks or tsunami warnings, **human communities** over the ages **have consistently avoided being displaced**. This can be explained by a **cultural attachment to their land**, or a **fatalistic belief** that it is "their fate" to be killed by the disaster in question.
- **Economic reasons** can also play an important part in their refusal to be displaced. Indeed, they **may not have anywhere else to go** and/or **may not have the economic resources necessary to leave.** Decision makers dealing with asteroid threat management will therefore have to consider that **some populations will decide to remain in the zone of impact.**

Mass Death Management

- An asteroid impact would entail a **collective trauma** where "*the living sleep along the dead*": with mass graves, cities eradicated, saturated cemeteries, etc.
- Local populations can be deeply disturbed by **the lack of cultural care during mass burials.**
- During a natural disaster, populations can perceive **death rituals as necessary to try to make sense and somehow "normalize" the disaster.** A **disregard for death rituals** can deeply disturb sets of population and **enhance their traumas**.

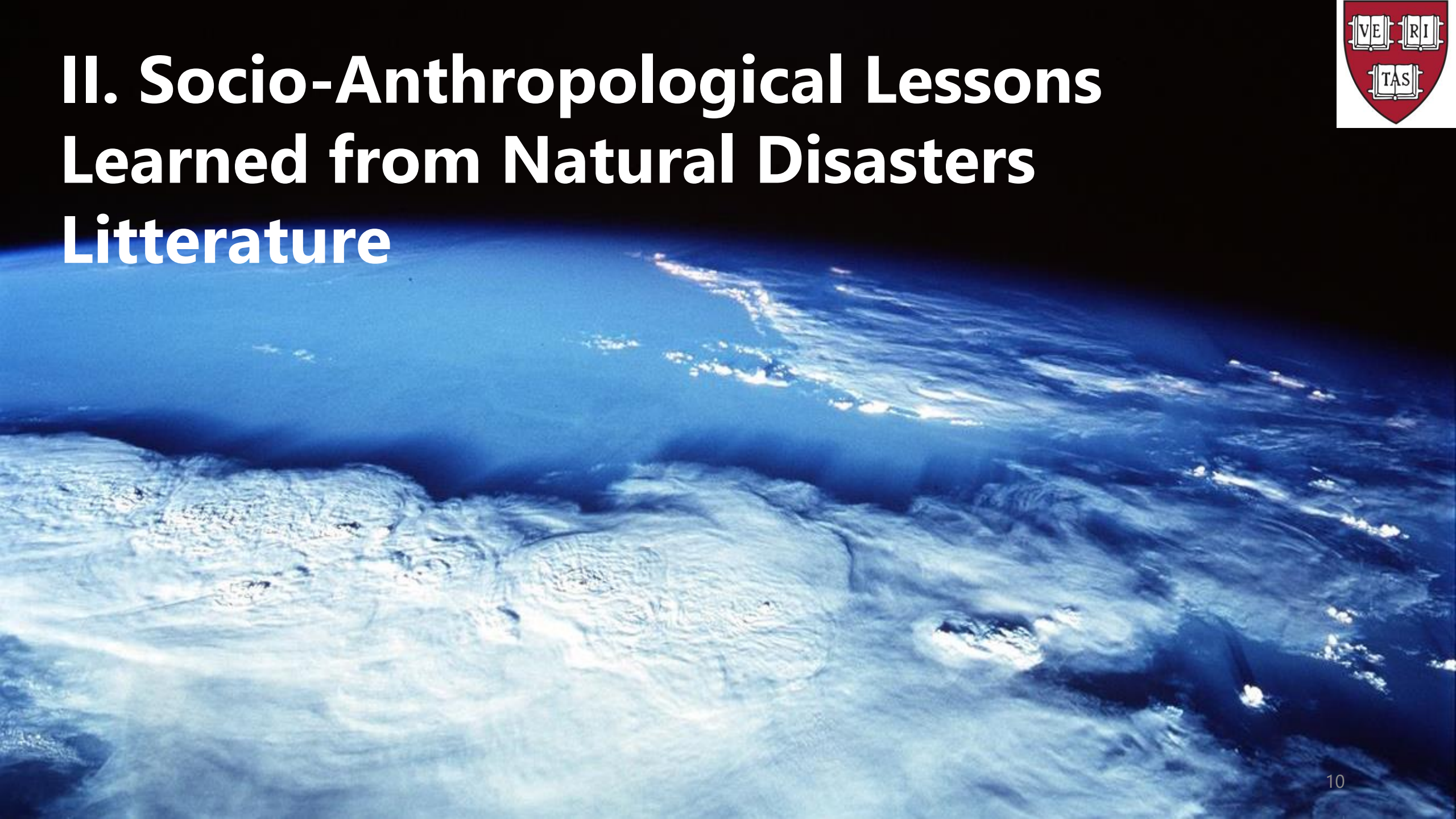
Losing Faith

- An **asteroid impact may deprive some people of their faith**. Such was the case after the earthquake that shook Lisbon, Portugal, in 1755, killing in an instant a hundred thousand people. Philosophers from all over western Europe came then to **challenge the concept of divine justice**, the existence of God itself and precipitated the belief of a "**secular catastrophe**" .

Loss of World Heritage

- An asteroid impact may result in great **cultural loss** which previous disasters may inform the Planetary Defense community on. **The fire of Alexandria's library**, is considered a common example of cultural loss. Built in 334 BC, the library burnt in 48 BC and, with it, **the largest collection of classical antiquity and Egyptian literature** estimated to more than **100,000 pieces of literature.**

II. Socio-Anthropological Lessons Learned from Natural Disasters Litterature



3 Attitudes When Facing a Disaster

Anthropologist Douglas identified three main attitudes towards a disaster: **optimism**, **pessimism** and **fatalism:**

- An **optimistic** attitude: To consider that the asteroid is actually going to **miss the Earth** or that a **mitigation mission will be successful**,
- A **pessimistic** attitude: May result in **mass panic** and **attempts to evacuate the zone** of potential impact,
- A **fatalistic** approach: People believing that it is **their fate to die from the asteroid impact**. The latter could be explained by religious and/or spiritual beliefs that this impact is an "act" of God and/or of the Universe and is consequently **not meant to be prevented**.

These three attitudes will entail radically different reactions and will thus impact risk management.

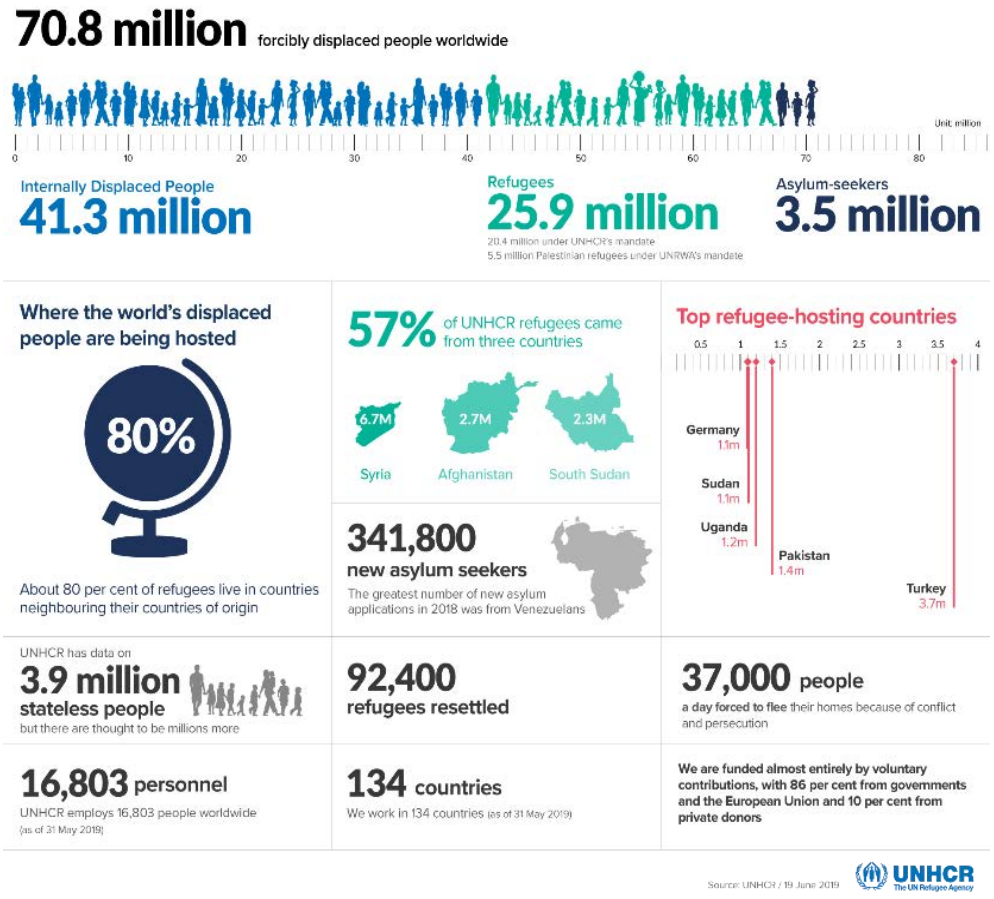
Learning From The Past

- If a large asteroid impacted the Earth, it would not be the first time the world would face a mass extinction. Such information can be found in **pandemics literature**. For instance, during the four years of the **1347-1351** pandemic, **20% to 60%** of the western world population - depending on sources in a context with few statistics - was **killed** by **the Black Plague**. In other circumstances, entire cities were erased due to a natural disaster. Such was the case of the eruption of **Vesuvius that destroyed Pompeii in 79 AD**.
- These events are so rare that **the means to fight them and adapt to them** tend to **fade over the centuries**. That timescale **defies generational memory** and is one of the challenges facing Planetary Defense.

Learning from better-known natural disasters

- Learn from similarly **rare recurring deadly events through decades/centuries**, such as **volcanic eruptions**, **earthquakes** and **tsunamis** (Fukushima, 2011: costliest natural disaster in human history, estimated at **$235 billion**. More than 470,000 people were ordered to leave their homes and about 174,000 were still displaced in March 2016)

- Learn from data on **population displacement**: The United Nations Refugee Agency estimated that out of the 70.8 million people forcibly displaced worldwide, **80% live in countries neighboring their countries of origin**.



Building « bottom-up » systems

- In order to be efficient and resilient, **any intervention** would need to be **locally rooted**. Top/down-only systems should be avoided as they are eventually **poorly adapted to local needs** or do not know or take into consideration **local practices**.
- Detailed **knowledge** of **international relations** and **local regimes** are also important to set up **cross-border space risk management systems**.

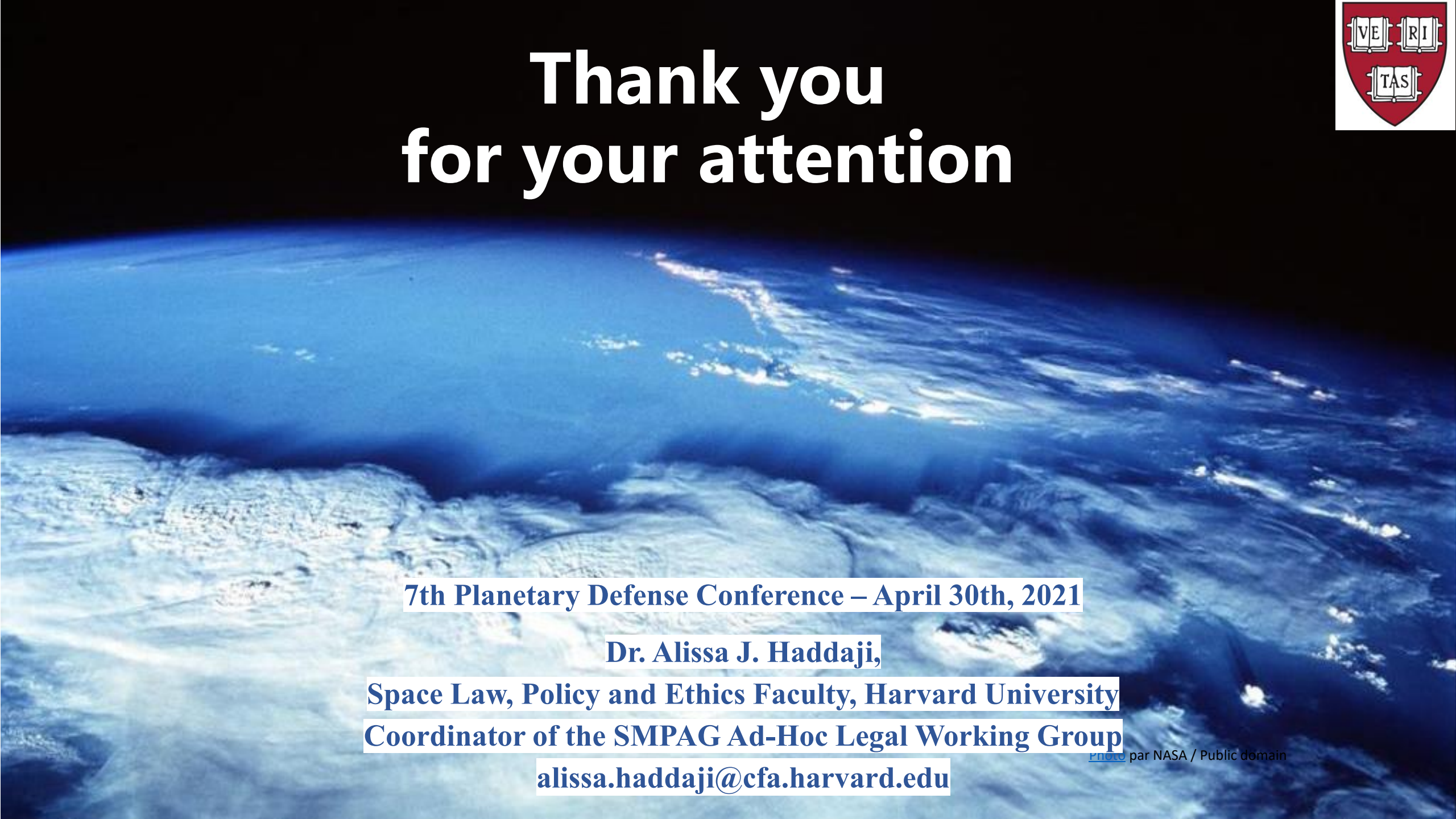
Helping population cope with a « *cata-strophein* »

- Taleb defines a **Black Swan** as a **low probability, unpredictable event** which, should it occur, **would have exceptionally far-reaching consequences**. Such catastrophes can create a mental blocking of unwanted perceptions called **scotomization**. Anthropologists Susanna Hoffman and Anthony Oliver-Smith explain that this can be interpreted as "**comprehension denial**". **Educating populations** on the topic of Planetary Defense could help **prevent this mental shock**.

Conclusions

- **Natural disaster management literature** teaches us that **risk perception will vary depending on the local population observed.**
- I share James's and Friedman's recommendation to **invite anthropologists, psychologists, economists and religious experts** in the design phase of crisis management planning and would extend it to **future Planetary Defense conferences** and similar venues.
- **Goal:** to build joint academic research projects to reflect on and **plan the most adequate ways to interact with populations under a potential asteroid impact threat.**

Thank you for your attention



7th Planetary Defense Conference – April 30th, 2021

Dr. Alissa J. Haddaji,
Space Law, Policy and Ethics Faculty, Harvard University
Coordinator of the SMPAG Ad-Hoc Legal Working Group
alissa.haddaji@cfa.harvard.edu

Precautionary Planetary Defence

Aaron Boley and Michael Byers

Outer Space Institute

University of British Columbia

7th IAA Planetary Defense Conference – PDC 2021
26-30 April 2021, Vienna, Austria

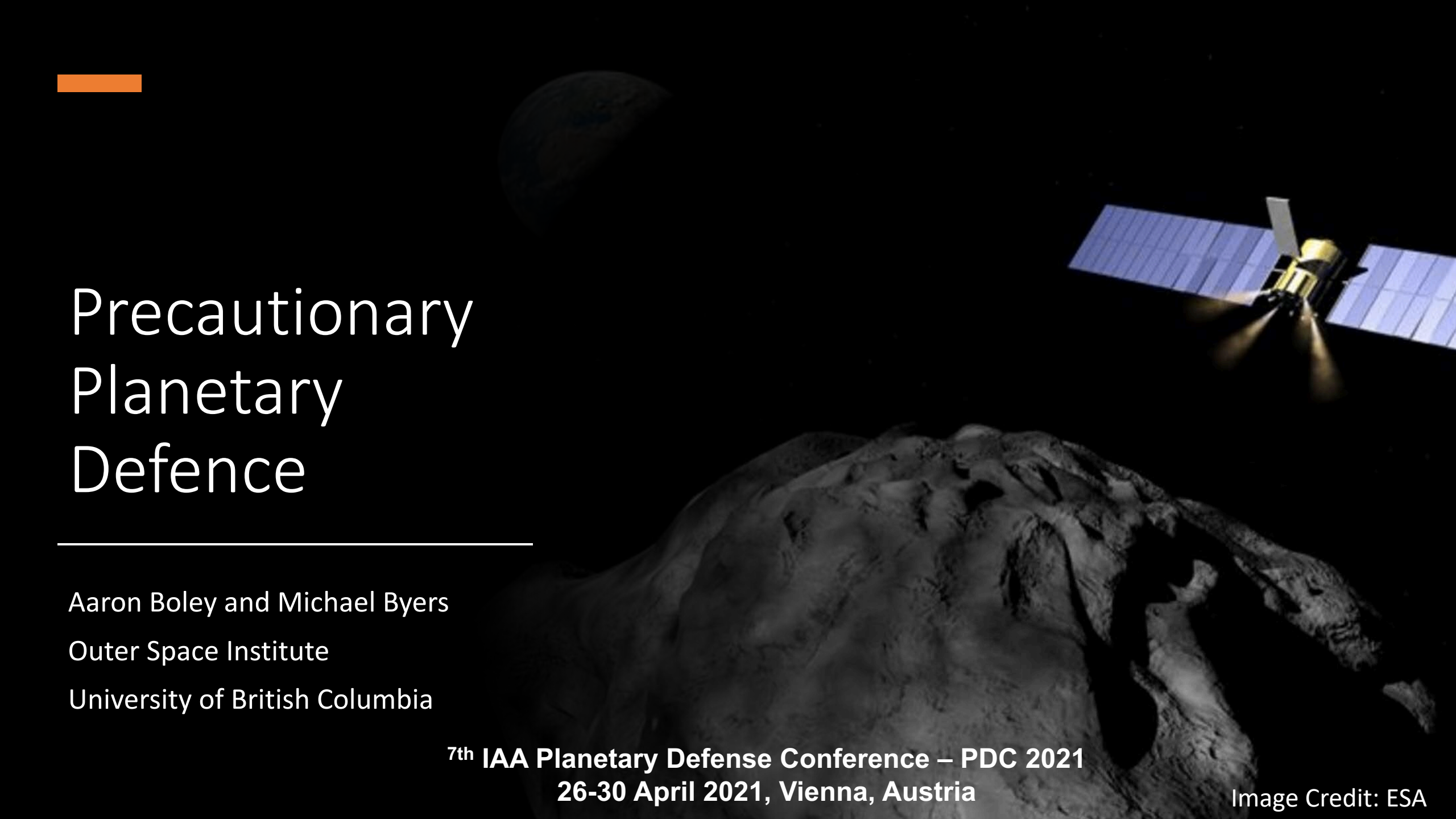
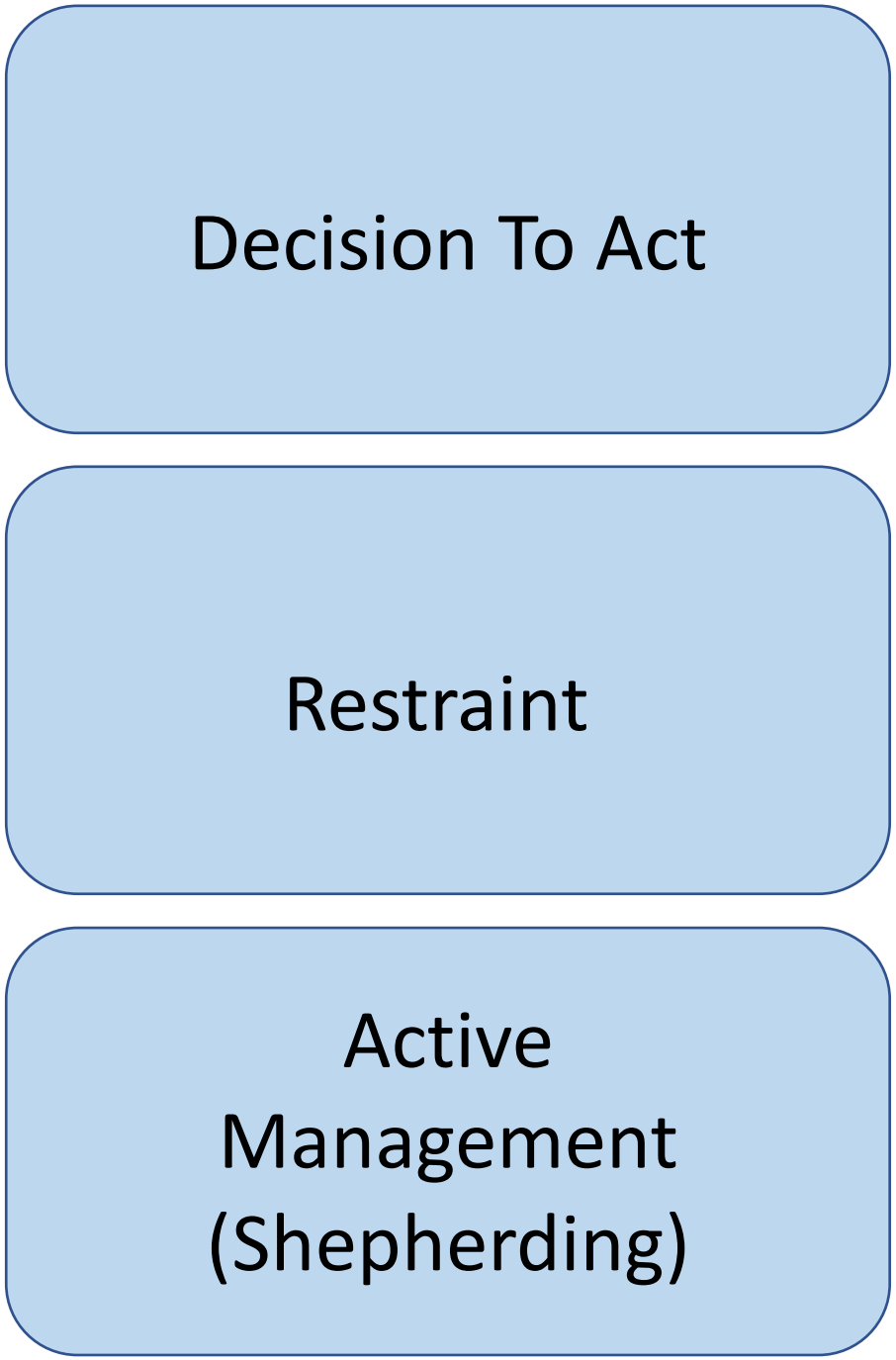


Image Credit: ESA



Decision-making scenarios often involve determining whether, when, and how to respond to a high-probability impactor

There are further considerations.

- When should we choose to limit visits to an asteroid?
- When should we be proactive (moving asteroids to safer harbours)?

Showing Restraint

- Let’s use Apophis as an instructive example
  - Dangerous in size
  - Multiple keyhole complexes
  - Up until March 2021 [1], accessibility of keyholes was of concern due to uncertainty
  - Huge interest in the asteroid from scientists and the public

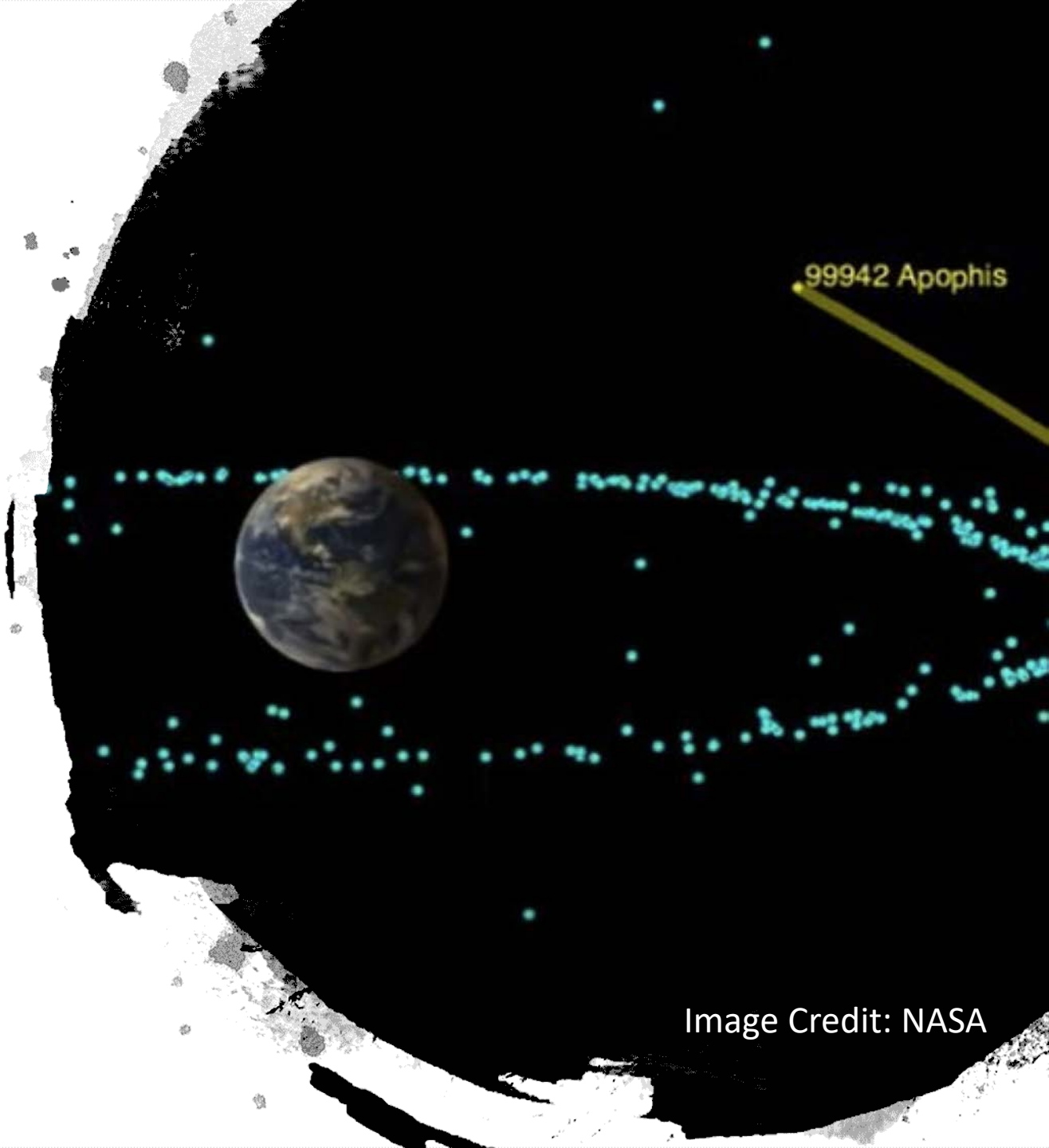
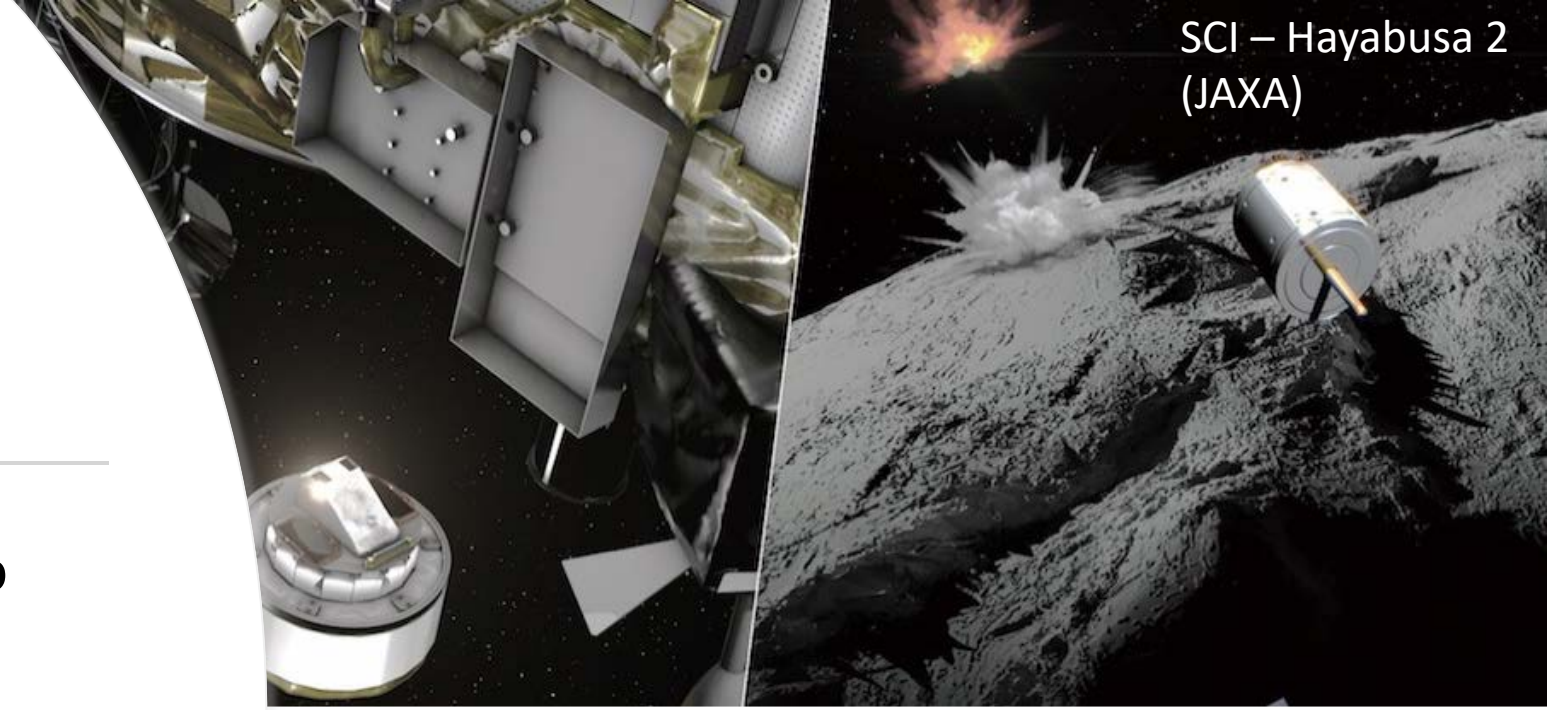


Image Credit: NASA

[1] CNEOS press release

What to do when everyone wants to go?

- Multiple state actors may wish to visit a high-value asteroid (e.g., Apophis)
- Non-state actors might get involved with their own plans
- Deep space traffic management
- Outcomes include low-probability, high-consequence mission failures



See also discussion in Chesley and Farnocchia 2021

Why might non-state actors become involved?

- Test or demonstrate technology
- Generate Publicity
- Play Hero
- *Something that we've not thought of*
- Eventually, asteroid mining will be a consideration

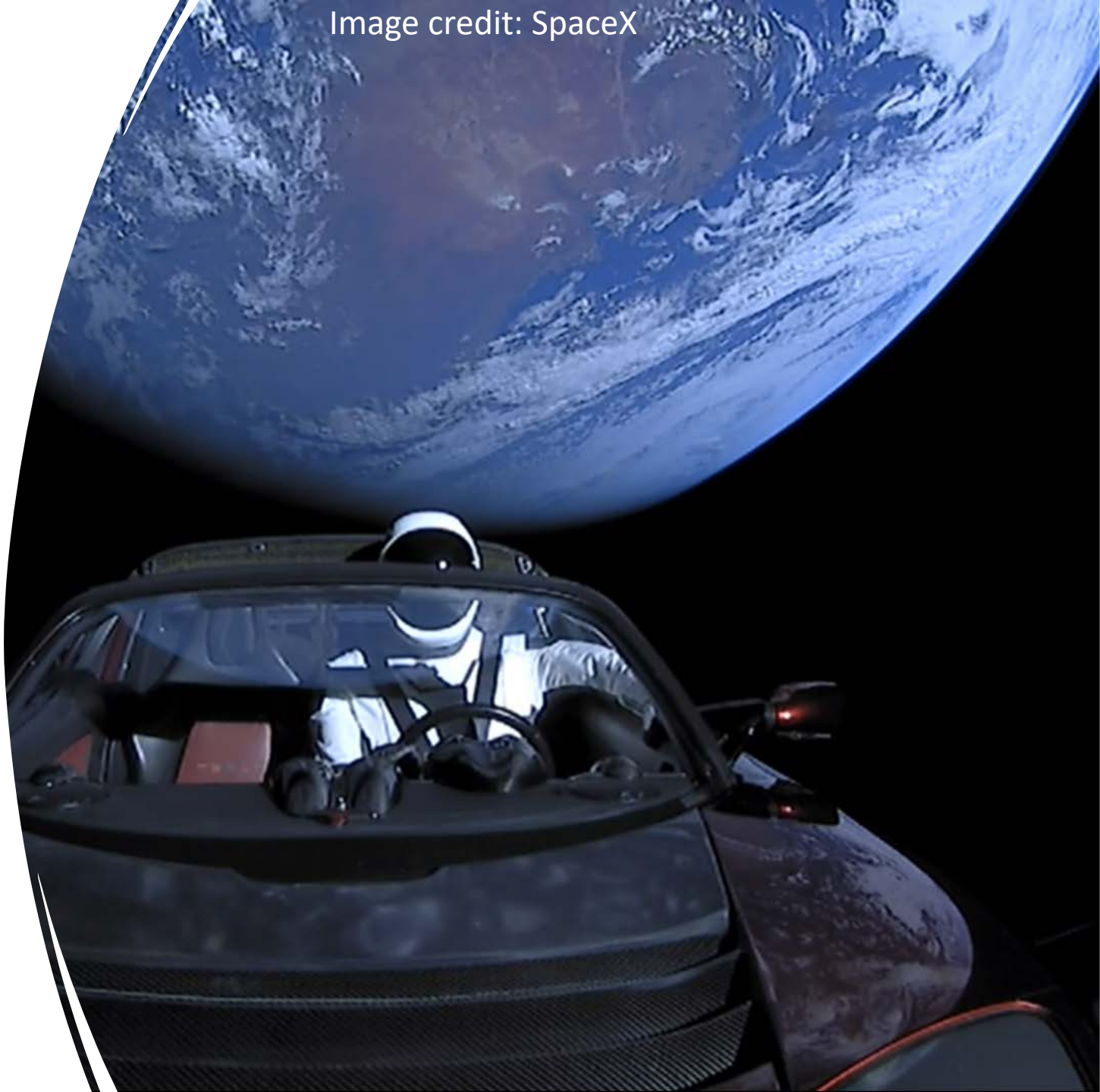


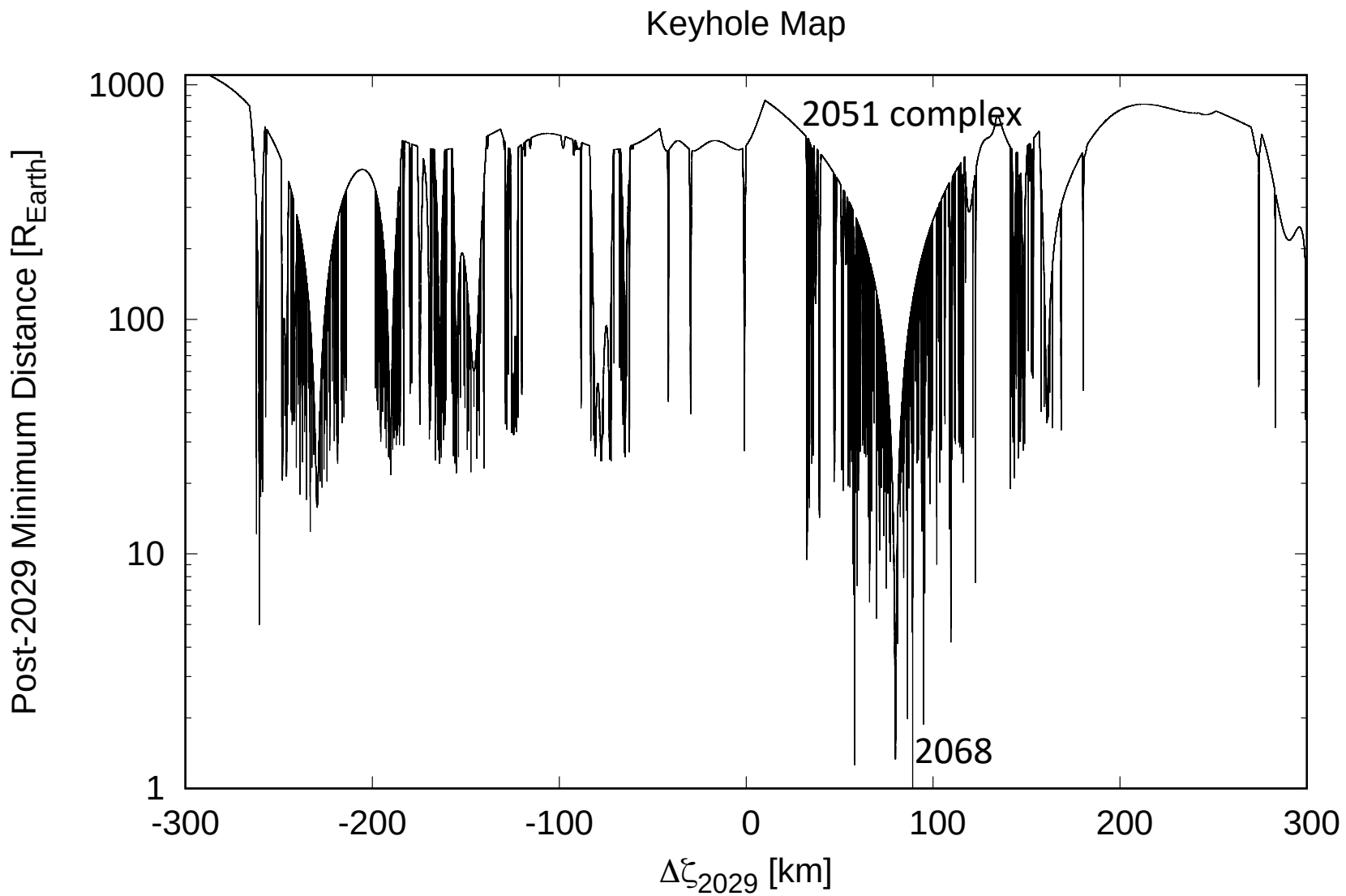
Image credit: SpaceX

Showing Restraint

To what degree should activities be limited?

Do we apply the precautionary principle, and if so, how?

Hypothetically, imagine a situation in which Apophis's uncertainty still overlapped the 2051 complex.



If restraint is warranted, who decides?

- What about SMPAG?
  - Advisory only. Seeks to develop cooperative activities
- The launching state has authority for granting launch licenses
- Provided past levels of cooperation are maintained, SMPAG provides framework for planetary defence decision making, but:
    - Growing worries about breakdown in cooperation [1] and militarization of cis-lunar space [2]

[1] Boley & Byers (2020), Science. [2] Hitchens (2021), Breaking Defense

Image credit: DARPA

But don’t forget we have highly capable non-state actors

- SpaceX and Starship, SpaceIL (Beresheet), NASA mining contracts for the Moon [1]
- Varying national regulation, not directly involved with SMPAG

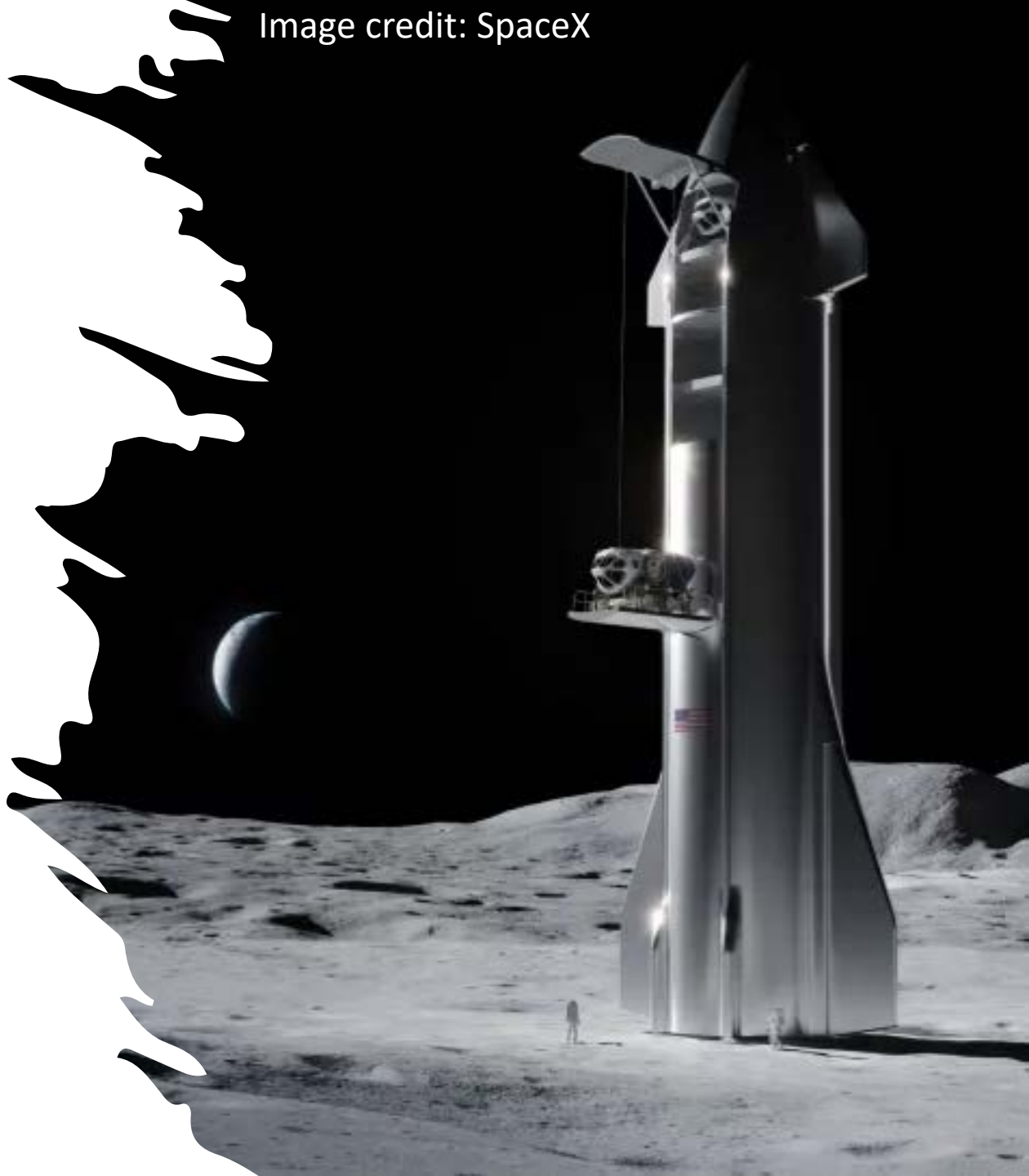


Image credit: SpaceX

[1] NASA, Press Release, 3 December 2020

UN Security Council Role

- Security council resolution possible, but heavy-handed approach to a solvable problem
- Resolutions must be supported by nine of the 15 members
  - No vetoes by any of the five permanent members (China, Russia, US, UK, France)
- But preparatory resolution could be very useful
  - E.g., requiring any state planning or licensing a mission to an asteroid to consult with SMPAG

Image credit: Shannon Stapleton/Reuters

Active Management

- Maybe a given asteroid has an uncomfortably large collision probability well into the future
- Maybe an asteroid is in an OK spot, but it could be better
- Safe harbour [1] or Safest Accessible Harbour

Object Designation	Year Range	Potential Impacts	Impact Probability (cumulative)
29075 (1950 DA)	2880-2880	1	1.2e-4
101955 Bennu (1999 RQ36)	2175-2199	78	3.7e-4
(2000 SG344)	2069-2113	101	2.6e-3
(2009 JF1)	2022-2022	1	2.6e-4
(2007 FT3)	2024-2116	164	1.4e-6
(2008 JL3)	2027-2119	27	1.6e-4
(2021 EU)	2024-2056	3	4.6e-5
(2010 RF12)	2095-2119	59	4.7e-2
(2005 QK76)	2030-2107	9	6.8e-5
(2005 ED224)	2023-2064	5	2.6e-6
(1994 GK)	2051-2067	5	6.9e-5
(2008 UB7)	2048-2100	31	3.5e-5

Screen capture of CNEOS Sentry

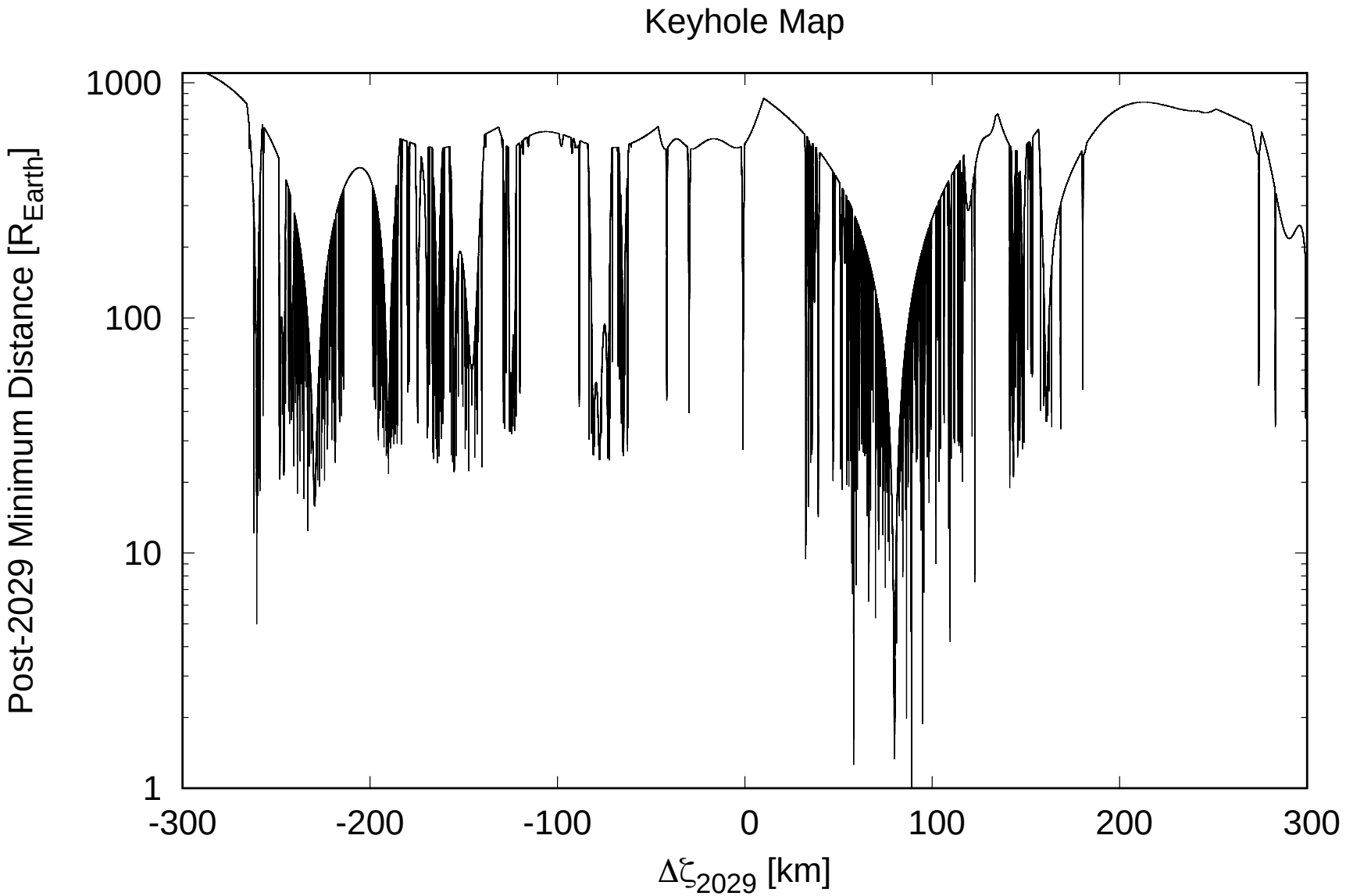
[1] Yeomans et al. 2009, PDC2009

Active Management

As a thought experiment, if we had the means, would we try to make Apophis safer?

Is any non-impact trajectory good enough?

Can we compare the relative safety of harbours? (E.g., is the cusp better than the nominal position in this plot?)



Conflict between restraint and active management

A strict approach to the precautionary principle might suggest that no active management should be done

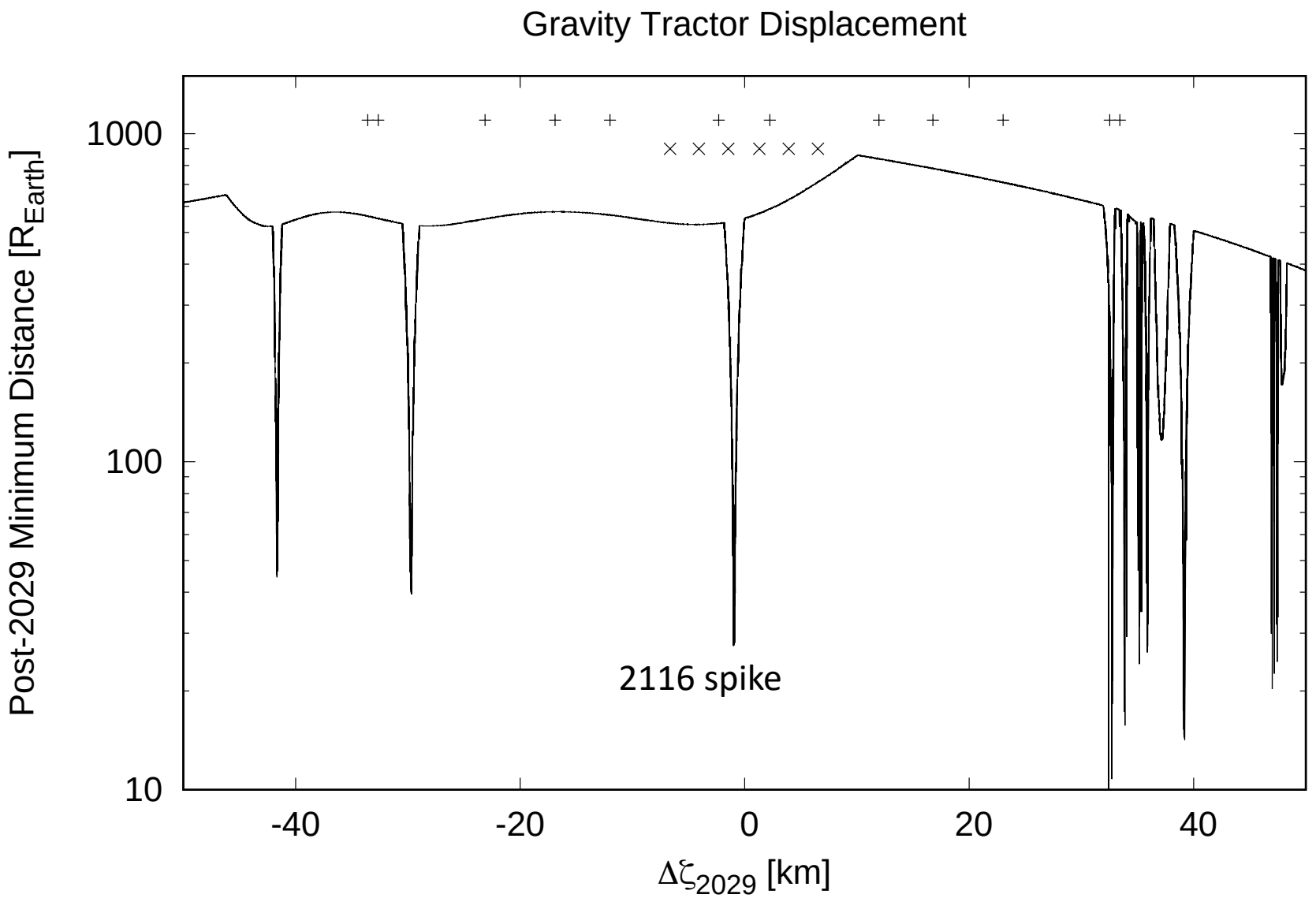
Arguably, at a minimum, we need tractoring practice so that we have options (or can respond to an emergency)

A fully reusable gravity tractor might not be far away

How hard would it be to tractor Apophis to a different harbour (as a thought experiment)?

Crosses (x) are 10^{-12} m s^{-2} for 2026-2027, 2027-2028, and 2028-2029

Plusses (+) are 10^{-11} m s^{-2} for 6 months starting in either April or October (2026, 2027, 2028)



See also Yeomans et al. 2009, PDC2009, Figure 5

ESA's activities in Planetary Defence

D. Koschny and the ESA Planetary Defence Team

PDC 2021

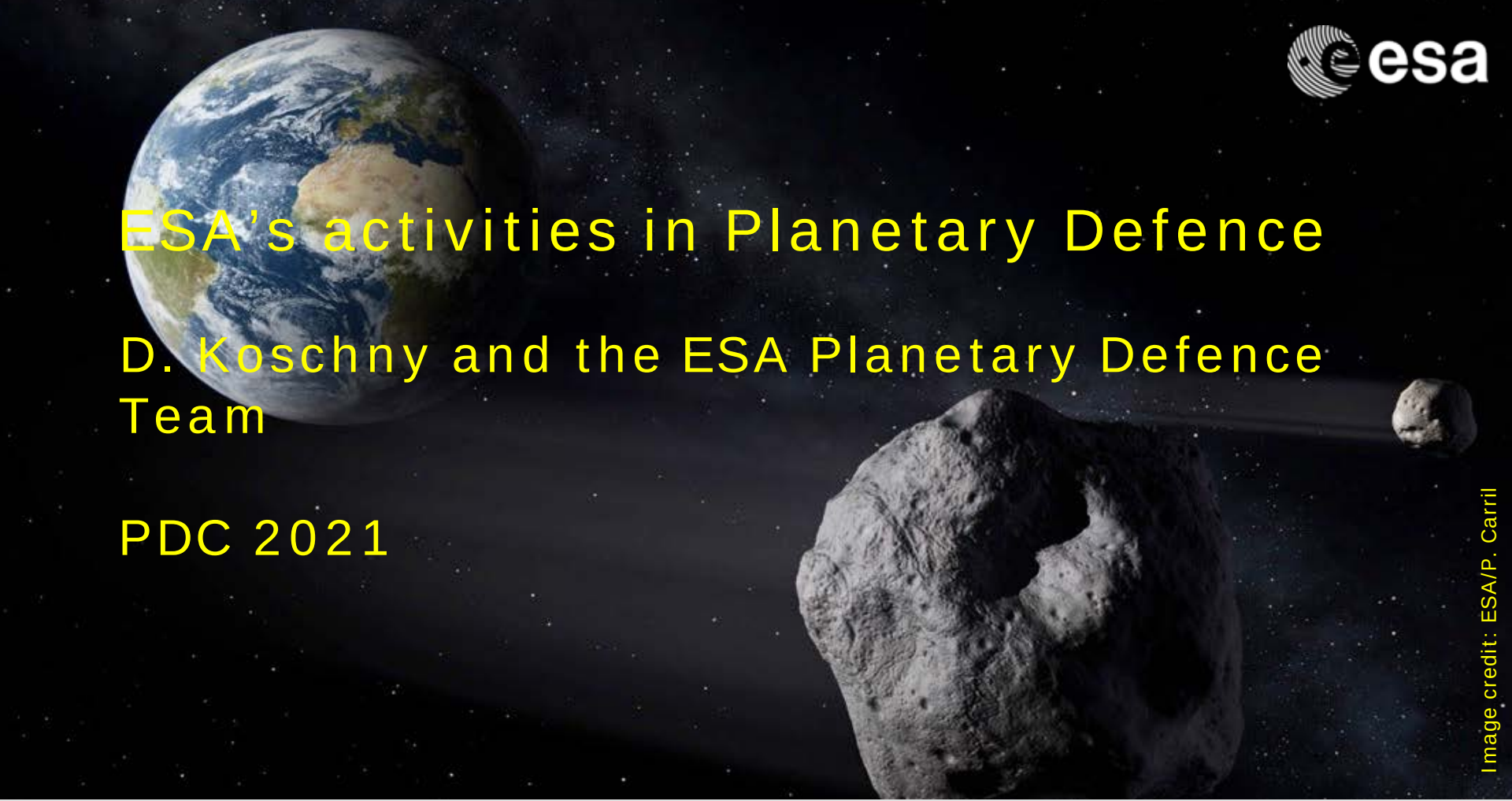


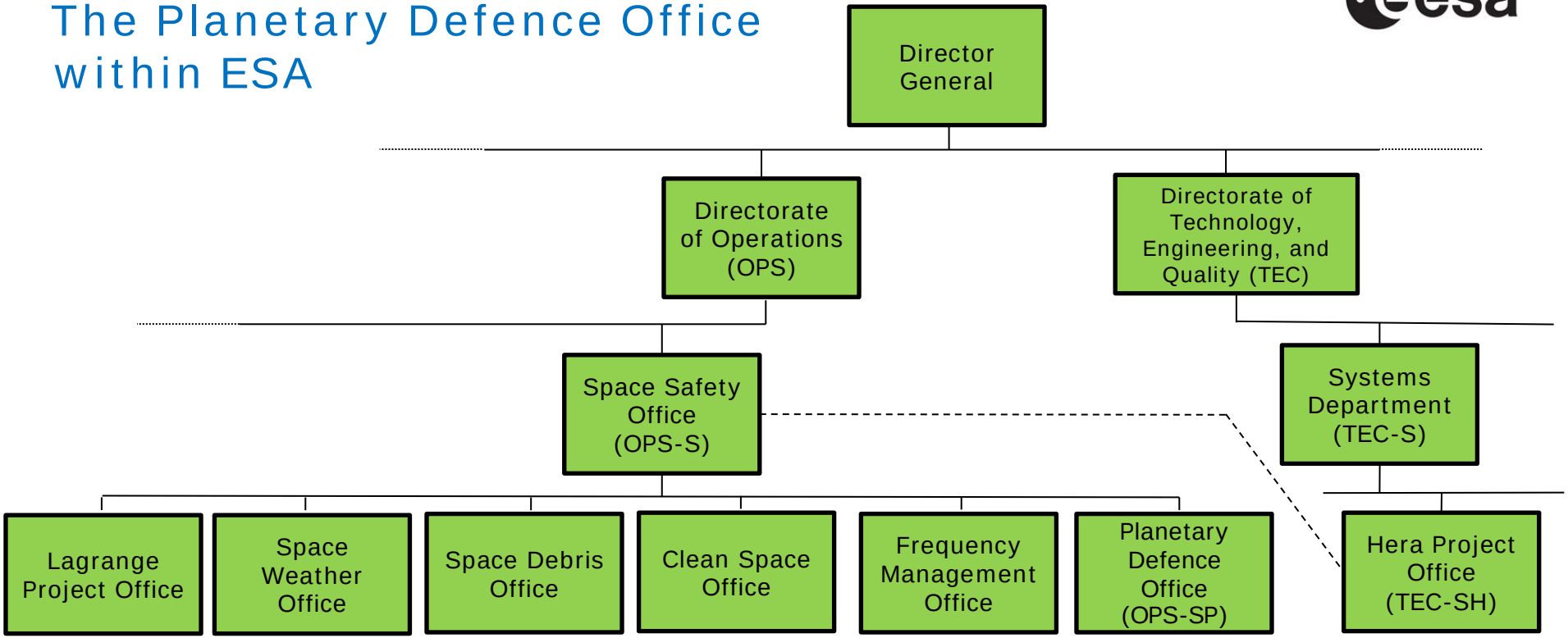
Image credit: ESA/P. Carril

Our ‘mission statement’

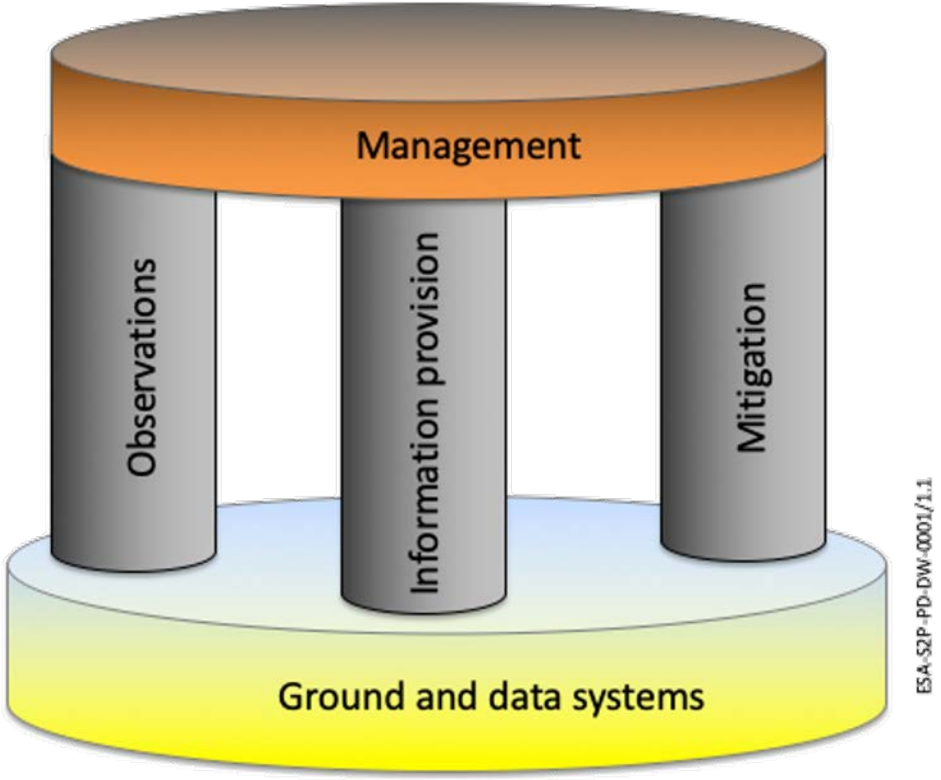
“The goal of Space Safety is [] the protection of our planet, humanity and assets in space and on Earth from dangers originating in Space” (PB-SSA 2018(24))

- To be aware of situation of natural objects in space
- To predict possible impacts and their consequences and inform relevant parties
- To prepare for risk mitigation, by technological developments and on political level

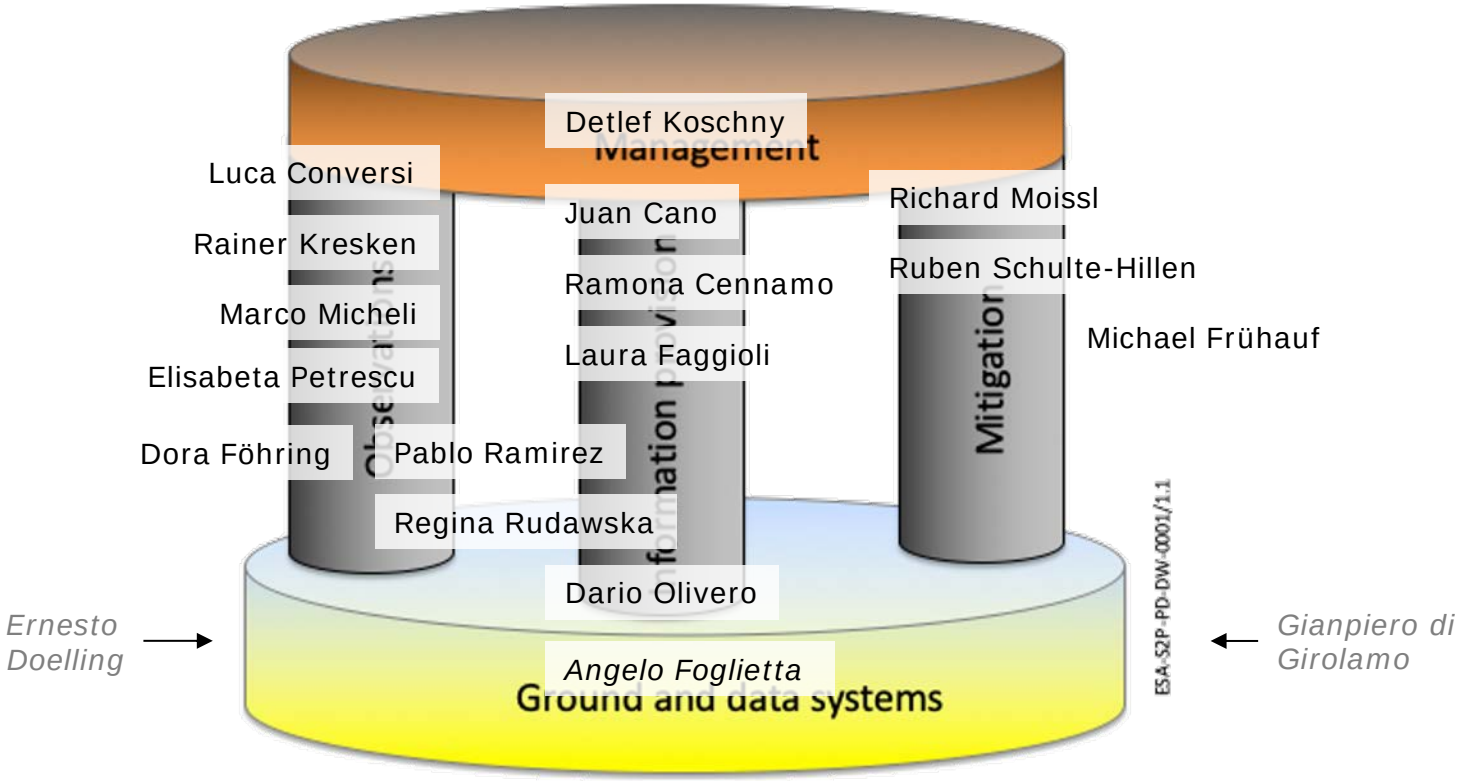
The Planetary Defence Office within ESA



The setup of the Planetary Defence Office



ESA's Planetary Defence team



The NEO Coordination Centre

- The ‘instantiation’ of the Planetary Defence team – a building at ESA’s location ESRIN in Frascati close to Rome, Italy. About half of our team is located there. Computing h/w in separate building.

Images: ESA/NEOCC

Observations

Some of the observatories we work with

Observations

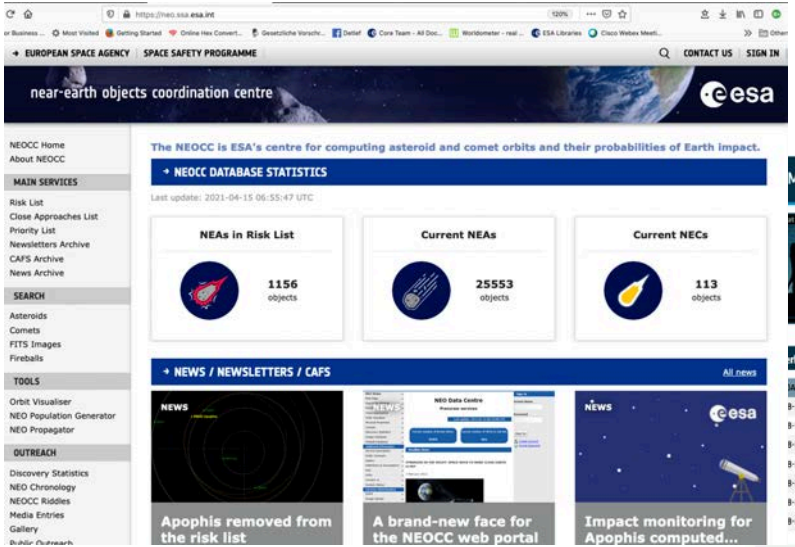
- Conversi et al. ‘ESA’s NEO Coordination Centre observational network’
- Micheli et al. ‘Recent observational highlights from ESA’s NEO Coordnation Centre’
- Perozzi et al. ‘An efficient deployment strategy for the first ESA Flyeye NEO survey telescope’
- Rudawska et al. ‘FITS image archive at ESA’s NEO Coordination Centre’

Also check out:

- Zolnowski et al. ‘6ROADS – Highly precise optical observations of NEO, fast-moving satellites and Space Debris from a worldwide telescope network

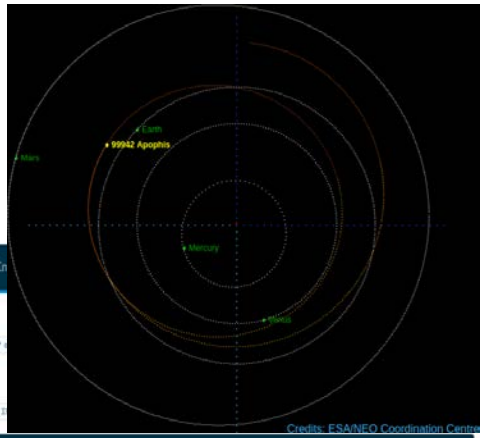
Information provision

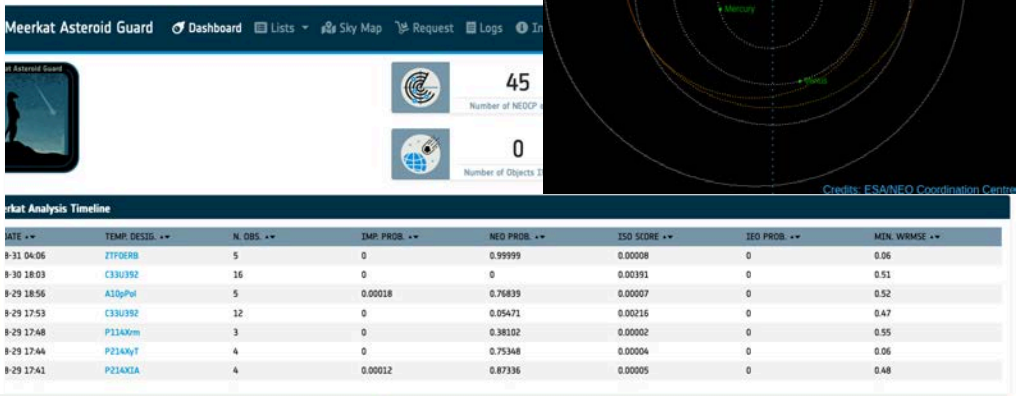
Information distribution via web portal – risk list, orbits, physical properties, Close-Encounter Fact Sheets….

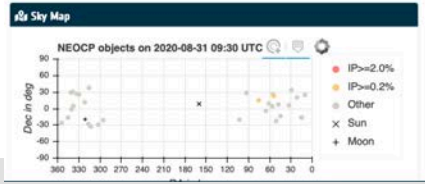


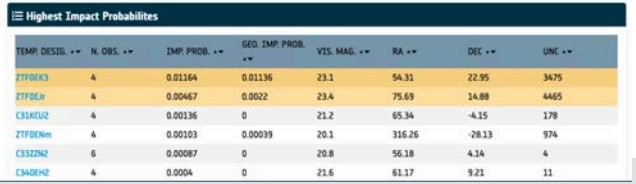
Orbit Determination and Impact Monitoring software

Many tools and scripts, notification systems…









Information provision

- Cano et al. ‘Evaluation fo an NEO close approach frequency index for public/media release purposes’
- Cano et al. ‘Recent evolutions in ESA’s NEO Coordination Centre information system
- Di Girolamo et al. ‘ESA’s planetary defence NEO Coordination Centre DevOps model-based operations’
- Frühauf et al. ‘Meerkat Asteroid Guard imminent impactor warning service of the European Space Agency’

Also check out:

- Bernardi et al. ‘New NEODyS tools for the EU-funded NEOROCKS project’

Mitigation

space situational awareness

→ NEAR-EARTH OBJECTS

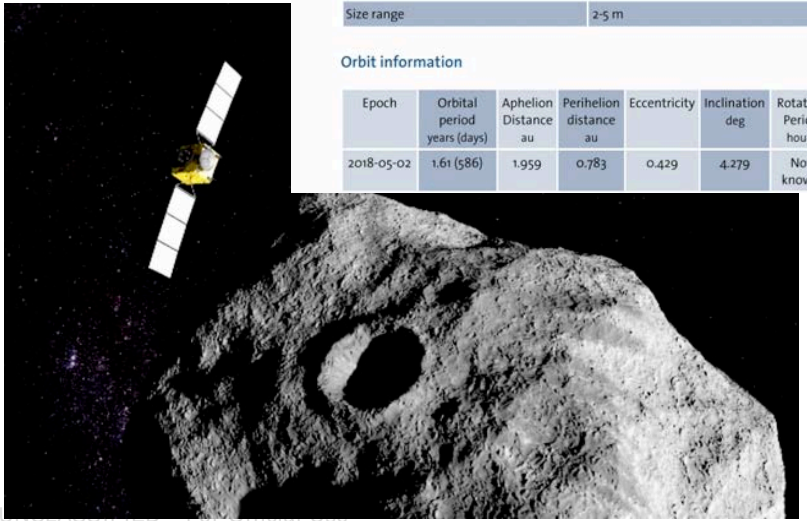
Close approach fact sheet for asteroid 2018 LA

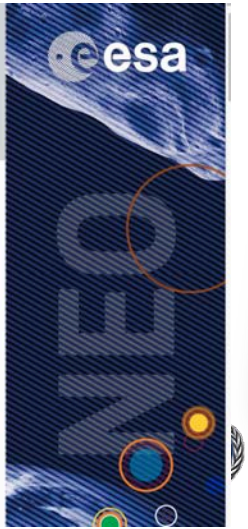
A small asteroid impacted the Earth on 02 June 2018.

Impact date	2018-06-02
Impact time	~16:45 UTC
Minimum distance from Earth surface	The object impacted the Earth
Fly-by speed	17.0 km/s
Size range	2-5 m

Orbit information

Epoch	Orbital period years (days)	Aphelion Distance au	Perihelion distance au	Eccentricity	Inclination deg	Rotation Period hours
2018-05-02	1.61 (586)	1.959	0.783	0.429	4.279	Not known





The medium-sized asteroid 2012TC4 had a close approach with the Earth on 12 October 2017. The minimum distance was outside the geostationary ring. This is a special-interest event.

Flyby information:
Flyby date: 2017-10-12
Closest approach time: 05:41 UTC +/- 0 s
Flyby distance from Earth surface: 43832 km +/- 1 km
Flyby speed: 7.26 km/s
Size range: 13.0 m to 30.0 m
Discovery date: 2012-10-04
Discovery site: Haleakala

Orbit information:
The flyby caused a change in the orbit elements.
Date before and after flyby: Before = 2017-09-12, after = 2017-22-12
Orbital periods in years/days: Before = 0.005/1.67, after= 0.006/2.06
Aphelion distances in au: Before = 1.878, after = 2.275
Perihelion distances in au: Before = 0.934, after = 0.965
Eccentricities: Before = 0.336, after = 2017-22-12
Inclinations in deg: Before = 0.857, after = 0.536

Mitigation Information:
No mitigation actions required for this object.
Days since closest approach: -1203
Cumulative impact probability: 0
Composition (Taxonomic type): Unknown
Rotation period in hours: 0.204

Other information:
Peak brightness magnitude: 12.7
Date of previous encounter: 2012-20-12
Date of next encounter: 2050-10-19
Encounter peculiarities: An international observation campaign devoted to the very close flyby of 2012TC4 had been organised.

United Nations COPUOS/OOSA

Inform in case of credible threat

Parent Government Delegates

Determine impact time, location and severity

Potential deflection mission plans

International Asteroid Warning Network (IAWN) — P_i >1% / S > 50m — Space Missions Planning Advisory Group (SMPAG)

Observers, analysts, modelers...

Space Agencies and Offices

And there is an international context

Mitigation

- Drolshagen et al. ‘Scope, objectives and first results of the Space Mission Planning Advisory Group (SMPAG)’
- … and we are preparing our ‘Close Approaches Fact Sheet’ and the ‘Automated Impact and Close Approach Message’ as part of the exercise
- And of course look at all the Hera talks


esa
Image credit: ESA/P. Carril

Scope, objectives and first results of the Space Mission Planning Advisory Group (SMPAG)

Gerhard Drolshagen[1], Romana Kofler[2] and Detlef Koschny[3,4]

[1] *University Oldenburg,*

[2] *UN Office for Outer Space Affairs (UNOOSA),*

[3] *ESA/ESTEC and* [4] *LRT / TU Munich*

PDC 2021, 30-Apr-2021, Session 11

SMPAG background

- The United Nations formed the Action Team 14 to address NEO mitigation issues.
- They recommended the formation of 2 groups: IAWN and SMPAG.
- The formation of SMPAG was endorsed by the UN in 2013.
- SMPAG was officially established in 2014.

- 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.

SMPAG background

- SMPAG is an international technical/scientific group with some political ´touch´
- SMPAG is an advisory group. It should present options for NEO mitigation missions to decision makers but has no decision power itself
- Membership is open to national Space Agencies or other governmental or inter-governmental space entities who can contribute to Planetary Defense space missions
- SMPAG works by consensus
- All costs (e.g. for studies, simulations and meetings) has to be covered by its members

SMPAG Membership and Set-up
(Status 26 April 2021)

- At present SMPAG has 19 official members and 6 permanent observers.

- ESA is presently Chair of SMPAG
- UNOOSA is the Secretariat to SMPAG

- SMPAG has established a workplan comprising 11 items

- SMPAG typically meets twice per year

- SMPAG reports annually to the STSC of UNCOPUOS

SMPAG Membership
(Status 26 Apr 2021)

Official members with nominated delegations:

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

Permanent Observers: ASE, IAA, IAU, UNOOSA, ESO, COSPAR

SMPAG work plan

A list of 11 initial activities has been identified by SMPAG. These activities and their status are described in a workplan.

This workplan is a living document. Activities could be modified, added or combined.

2 examples of workplan activities:

- Criteria and thresholds for impact threat response actions.
  - This task was addressed jointly with the International Asteroid Warning Network (IAWN) and is completed (see next slide)
- Study the nuclear device option
  - As this is a politically sensitive issue it was agreed to collect publicly available reports and articles on the subject

IAWN/SMPAG Thresholds

- Issue warnings if object
  - has an impact probability > 1%
  - is > ca 10 m in diameter
- Prepare for civil protection measures if object
  - has an impact probability > 10% within 20 years
  - is > ca 20 m in diameter
- Start to assess space mission options if object
  - has an impact probability > 1% within 50 years
  - is > ca 50 m in diameter

SMPAG achievements and status

- Recommendations were issued to:
  - Perform a demonstration of an asteroid deflection mission (DART/HERA, now ongoing)
  - Perform small-class high-velocity flyby missions to small bodies like Comet Interceptor of ESA or DESTINY+ of JAXA (both are in preparation)

- A joint SMPAG/IAWN/UNOOSA brochure was produced (ST/SPACE/73) available at unoosa.org
- Several presentations and publications on IAWN/SMPAG were made

- See smpag.net for reports and most presentations given at SMPAG meetings

SMPAG achievements and status, cont.

- An ad-hoc working group on legal issues (SMPAG Legal WG) was officially established during the 7th SMPAG meeting in Oct 2016
- The Legal WG made a major effort to review and assess existing space laws relevant for planetary defence
- A Report of the Legal WG entitled ´Planetary Defence, Legal Overview and Assessment´ has been produced and delivered to SMPAG.
- It is available at smpag.net.

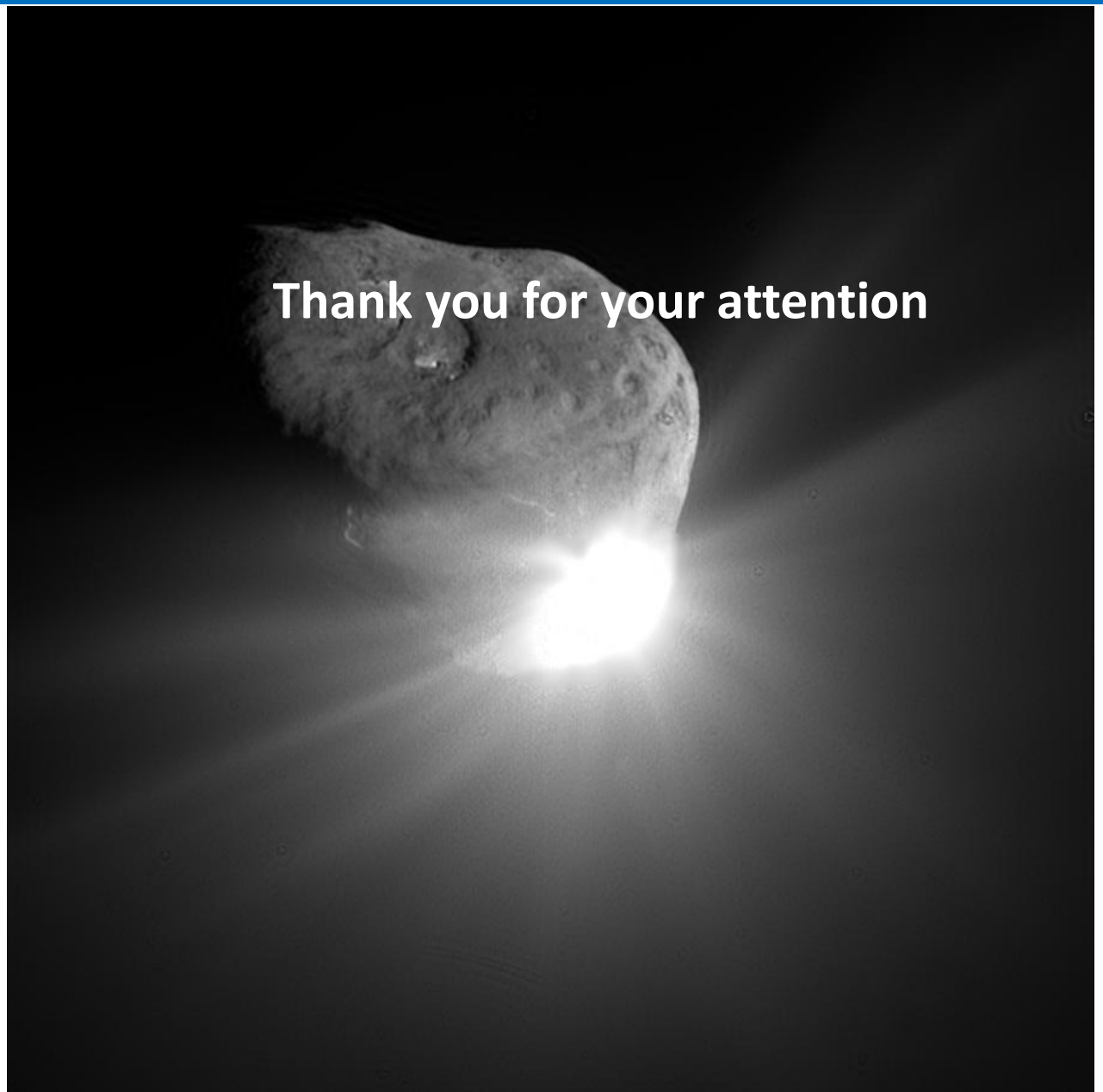
SMPAG Exercise

- It is discussed to perform SMPAG exercises
- These would assess space mission options for a threatening objects with the aim to e.g.:
  - Practice and test the working procedure of SMPAG
  - Assess the status of available knowledge and tools for Planetary Defense missions
  - Practice the coordination and flow of information between participants
  - Prepare an output format of the assessment results and advise for decision makers
  - As a realistic case a virtual impactor from an existing object in the risk list could be used for the exercise
- A preparatory workshop is planned during this summer to assess the effort, feasibility, requirements, format, etc**... for** such an exercise.

SMPAG Overview

Deep Impact Mission
Comet Tempel 1
Impact in 2005

Image: NASA



7th IAA Planetary Defense Conference

26-30 April 2021, Online Event

Hosted by UNOOSA in collaboration with ESA

Q&A

Session 11 – The Decision to Act

Break

Up next: Session 12 – Public Education & Communication