Pursuant to the General Assembly resolutions 70/82 of 9 December 2015 and 71/90 of 6 December 2016, in which the Assembly notes with satisfaction the establishment of and work carried out by the International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG) to implement the recommendations for an international response to the near-Earth object impact threat, endorsed by the Committee on the Peaceful Uses of Outer Space (COPUOS)[1]; and pursuant to the Committee noting that should a credible threat of impact be discovered by the IAWN, available information would be provided by IAWN and disseminated to all Member States through the Office for Outer Space Affairs (A/79/20, para. 135), the following information and recommendations are provided for an international response to the asteroid "2024 PDC25" impact threat.

1. On 1 August 2024, IAWN issued a notification on a potential impact probability of Near-Earth Asteroid "2024 PDC25", as enclosed to this document in Annex I, informing SMPAG and UNOOSA that 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.

2. IAWN issued a notification in accordance with criteria and thresholds for impact response actions, as contained in A/AC.105/C.1/2017/CRP.25 that was before the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space. The threshold for issuing warnings of possible impact effects is a probability of impact greater than 1 % and a rough size estimated to be greater than 10 meters (33 feet). IAWN is a worldwide collaboration of asteroid observers and modelers that was recommended by the United Nations, see https://iawn.net.

ADDITIONAL DETAILS (as contained in Annex I):

- **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 Object 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.
- **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's NEOCC coordinated closely with each other and with the Minor Planet Center and the worldwide network of observatories in the IAWN on technical and observational confirmation before issuing this notification.
- **Future Observability and Updated Information:** Further observations will reduce the uncertainty in the asteroid's trajectory and impact probability. The asteroid will be observable through mid-December 2024, when it will then become unobservable from Earth until August

[1] Official Records of the General Assembly, Sixty-eighth Session, Supplement No. 20 (A/68/20), para. 144; and A/AC.105/1038, para. 198, and annex III.

2025 through mid-November 2026. The asteroid will be quite faint and will likely require large (2-meter and larger) telescopes.

- **Asteroid size:** Most likely in the range 90–160 meters (300–520 feet) in diameter, but could be in the range 50–280 meters (160–920 feet) in size. The size range was estimated using infrared data from the James Webb Space Telescope (JWST) since it was able to point in the asteroid's direction. The size cannot be estimated with further precision without deep space radar observations or without imagery from a spacecraft that can closely approach the asteroid. The asteroid is too distant for radar observations and will not come within range until 2041.
- **Technical information:** The latest technical information concerning this and any future IAWN notifications about asteroid "2024 PDC25" is made available by IAWN to the worldwide community at https://cneos.jpl.nasa.gov/pd/cs/pdc25/.

4. On 10 October, IAWN issued an update based upon collection of additional worldwide observations on Near-Earth Asteroid 2024 PDC25 that increased the impact probability to 14 % on 24 April 2041.

5. The Space Mission Planning Advisory Group (SMPAG) currently comprises 18 space agencies and governmental or inter-governmental entities that, as per its Terms of Reference, to coordinate and fund space activities and are capable of contributing to or carrying out a space-based NEO mitigation campaign. In response to the notification, SMPAG undertook activities in accordance with criteria 3 of proposed criteria and thresholds for impact response actions, which states that SMPAG should start mission option(s) planning when warned of a possible impact:

- Predicted to be within 50 years,
- Probability is assessed to be greater than 1 per cent, and
- Object is characterized to be greater than 50 meters in size, or roughly equivalent to absolute magnitude of 26 if only brightness data can be collected.

6. SMPAG, based on the currently available information about hypothetical impact of asteroid "2024 PDC25", in terms of mission scenario planning, advises to[2]:

I. Start, as soon as possible, the initial design phases (so-called phases A/B) of a **fast flyby reconnaissance mission.** The effort of such a mission would be comparable to sending a spacecraft the size of the recently flown first impact deflection technology demonstration mission (DART). Multiple missions should be launched for redundancy reasons. The fast flyby reconnaissance mission is important for narrowing down the uncertainties in the asteroid size and mass in order to plan for an effective deflection as early as possible.

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

[2] In this hypothetical asteroid impact exercise for asteroid "2024 PDC25", the following SMPAG members participated so far: AEM, ASI, CNES, CNSA, CZ, DLR, ESA, FFG, ISA, NASA, UKSA, and observers: IAWN, COSPAR, SWF, UNOOSA.

III. Start, as soon as possible, the initial design phases (phases A/B) of a solar electric propulsion **rendezvous reconnaissance mission**, independently of the implementation of **an earlier flyby reconnaissance mission.** Such a rendezvous mission could reach the asteroid about a year earlier compared to chemical propulsion options. This reconnaissance mission will refine the information about the asteroid even further to ensure that mission response to deflect this asteroid is proportionate and adequate. The effort of such a mission would be comparable to sending a spacecraft the size of the recently launched reconnaissance mission Hera. Multiple missions should be launched for redundancy reasons.

IV. 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 (deflection and disruption missions): These are missions where a spacecraft impacts the asteroid. This will either result in a deflection or, if enough energy is imparted, a complete disruption into pieces small enough to not be dangerous. The DART mission (Double-Asteroid Redirection Test) has demonstrated the kinetic impactor deflection mission; a mission to disrupt the object still needs demonstration[3].

- Ion beam deflection: Ion beam thrusters (solar-electric propulsion) appropriately mounted on a spacecraft are used to slowly push the asteroid away. While the propulsion technology exists this deflection concept still needs demonstration.

Decisions about continuance of deflection/disruption mission developments should be dependent on flyby reconnaissance results to reduce uncertainties. However, delaying the launch of an ion beam deflection mission until after 2029 may significantly reduce the viability of non-nuclear explosive device deflection options. SMPAG notes that, due to international treaty obligations, an NED-option should only be analysed and considered for approval as last resort if no other non-nuclear device options are determined to be adequately viable to deflect or robustly disrupt the asteroid.

The list of technical options may not be exhaustive i.e. the laser ablation method may be considered as additional option in the future.

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

7. Within the initial study phase, SMPAG also looked at the payload and spacecraft designs for the required missions and produced instrument priorities. SMPAG noted that currently available technologies will suffice for the proposed reconnaissance missions. For the in-space mitigation missions, only the kinetic impactor deflection has been demonstrated so far. For the other deflection concepts, more technology developments will be needed.

8. SMPAG noted that cost estimates are expected to be made by space agencies as part of their mission design to inform future decisions. SMPAG further noted that there would be lost opportunity costs if no action is taken for a fast flyby reconnaissance mission, as per recommendation I above. The earlier a deflection is performed, the smaller the needed energy, i.e. smaller/fewer launchers and spacecraft would be needed.

9. Related to communication, SMPAG encourages its members to communicate on SMPAG activities contained in this document for potential response to the impact threat with their respective audiences.

10. The SMPAG Legal Working Group, established in 2016 by SMPAG, as per its Terms of Reference, is tasked to (i) describe the existing legal context, in particular international law, relevant to the work of SMPAG; (ii) identify, formulate and prioritize relevant legal questions and issues requiring clarification; (iii) where necessary, suggesting possible ways forward to deal with legal questions and

[3] More detailed explanations of these concepts are given in the annex about terminology.

issues; and (iv) provide legal advice to SMPAG, as required. The SMPAG Legal Working Group has been tasked by SMPAG to provide assessment of legal-related questions for the exercise scenario.

11. Detailed technical information produced by participating SMPAG members for this hypothetical asteroid impact response is contained in Annex II.

12. The present document serves as initial information. SMPAG continues to work on the exercise impact scenario and further information will be provided as it becomes available.

13. This information would be disseminated to the United Nations Members States by the Office for Outer Space Affairs, as the secretariat to SMPAG, and in accordance with the mandate of the annual General Assembly resolution on international cooperation in the peaceful uses of outer space that reiterates the importance of information-sharing in discovering, monitoring and physically characterizing potentially hazardous near-Earth objects to ensure that all countries, in particular developing countries with limited capacity for predicting and mitigating a near-Earth object impact, are aware of potential threats, emphasizes the need for capacity-building for effective emergency response and disaster management in the event of a near-Earth object impact, and notes with satisfaction the work carried out by the International Asteroid Warning Network and the Space Mission Planning Advisory Group to strengthen international cooperation to mitigate the potential threat posed by near-Earth objects, with the support of the Office, serving as the permanent secretariat of the Advisory Group (78/20, para. 14).

Annex I: Notification by IAWN, 1 August 2024

See separate file "IAWN_notification_epoch_1_2024-08-01.pdf".

Annex II: Further technical information by SMPAG as of 11 October 2024

(a) Timeline for launch opportunities

See separate file "Mission_options_timeline_2024-10-10.pdf"

(b) Brain charts for different mission options

See separate file "Notional_recommendations_charts_v4_2024-10-11.pdf"

(c) Payload options

See separate file "Payload_options_2024-10-11.pdf"

Annex III: Terminology

Flyby mission: A space mission that flies by its target. This allows to observe the target for only a short period of time, but would provide first observations of the object. They are quicker to implement than rendezvous missions as the spacecraft does not need to match its arrival speed with the orbit velocity of the target.

In-space mitigation mission: A space mission which will mitigate the threat of an asteroid on an impact course with our planet. These can be deflection missions or disruption missions. A deflection mission would alter the object's velocity, thus changing its arrival time at the Earth's orbit. If the deflection is large enough, it will miss the Earth. A disruption mission will disrupt the object. It is important that the disruption is 'robust', i.e. the remaining pieces are small enough to not pose any threat to our planet anymore, even if they stay on the same course as the initial object. The relative velocity between the fragments of the disrupted asteroid needs to be large enough to extensively reduce gravitational reaggregation. It should be noted that this technology has not yet been demonstrated and has rather high risks.

Ion beam deflection: A spacecraft designed to rendezvous with the asteroid and hit its surface with the ions expelled by solar electric powered ion thrusters on the spacecraft, very similar to solar electric propulsion systems. The instantaneous force is very small but accumulates over a long period of time to gradually deflect the asteroid's course away from the Earth. Ion thrusters now have significant space flight heritage, but the ion beam deflection technique itself requires further technology development, particularly in the precise control and continuous proximity operations involved, which have not yet been demonstrated in flight.

Kinetic impactor: A spacecraft designed to strike the asteroid and near-instantaneously deflect the asteroid's course away from an Earth impact, or designed to be massive enough to robustly disrupt the asteroid, breaking it up into small and widely dispersed fragments that no longer pose a risk to the surface of Earth. The kinetic impactor deflection technique was demonstrated by NASA's Double Asteroid Redirection Test (DART) mission in 2022.

Near-Earth Asteroid: A small body in the solar system, typically composed of rock or iron, coming closer than 1.3 au to the Sun. 1 au is an 'astronomical unit', the average distance between the Earth and the Sun.

Nuclear Explosive Device: Use of a nuclear device to detonate at an effective distance above the asteroid surface to super-heat a layer and cause enough blow off to near-instantaneously deflect the asteroid's course away from an Earth impact, or detonate very close or on the surface to cause a robust disruption of the asteroid into pieces small enough to disintegrate in Earth's atmosphere. The relative velocity between the fragments of the disrupted asteroid needs to be large enough to extensively reduce gravitational reaggregation. It should be noted that this technology has not yet been demonstrated and has rather high risks. Due to international treaty obligations, this option would only be considered for approval if no other non-nuclear device options are determined to be adequately viable to deflect or robustly disrupt the asteroid..

Reconnaissance mission: A space mission which will provide basic observations of the target object. The obtained information would be less than that of a full rendezvous characterisation mission. Typically, a flyby mission could allow basic reconnaissance, rather than a detailed characterisation of the object.

Rendezvous mission: A space mission that goes to the target object and stays in proximity with the object for a period of time of months to years, typically orbiting the object. Rendezvous missions require more orbit change energy and greater technical design than a flyby mission, as they will have to match their velocity to that of the target object upon arrival and maintain positioning with it.