SMPAG Action Item 5.1: Recommended Criteria & Thresholds for Action for Potential NEO Impact Threat

Report

The International Asteroid Warning Network (IAWN) is an international group of organizations involved in detecting, tracking, and characterizing NEOs. IAWN was organized in response to a United Nations (UN) recommendation and operates independently of the UN. IAWN's primary focus is the discovery of potentially hazardous NEOs (asteroids and comets) and the identification of those objects requiring action. IAWN is intended to function as an internationally recognized clearinghouse for the receipt, acknowledgement, and processing of all NEO observations, and as a global portal for accurate and validated information on the NEO population. There may be occasions in which IAWN will issue an alert for predicted impact events depending on the estimated size of the object and the time before impact. For celestial objects 10 to 20 meters in size on an impact trajectory to the Earth, a spaceflight mission to mitigate the impact will not be mounted. For larger celestial bodies (i.e., 50 meters in size and larger), criterion #3, described below, notifies the Space Mission Planning Advisory Group (SMPAG).

Background

There have been several historical cases that involved potentially hazardous NEOs. These include:

- 2004 MN_4, [99942 Apophis], was discovered June 2004. In December 2004 this asteroid was 2 on the Torino impact risk scale (possible impacts in 2029 and 2036). By 2006, 2029 impact risk was eliminated. By 2013, 2036 impact risk was eliminated.

- Asteroid 2011 AG_5, discovered June 2011. A chance of Earth impact in 2040 was predicted in September 2011. The asteroid was recovered in October 2012, and by December 2012, the risk of impact in 2040 was eliminated.

- Asteroid 2007 VK_{184}, discovered November 2007. Based on observations from November 2007 to January 2008, this object was rated 1 on the Torino impact risk scale. The object was recovered in March 2014, and subsequent observations eliminated the impact risk.

- The coincidental occurrences on 15 February 2013 of the Chelyabinsk asteroid impact event and the close approach of asteroid 2012 DA_{14}.

NEO messaging cannot be completely standardized. Messages are scenario-dependent and each scenario is unique. It is essential that the information provided by the different

IAWN member organizations should be consistent. The checklist and content below is to be included in warning messages, as needed and available.

- ☐ Asteroid name/designation.
- ☐ Asteroid characteristics – size (metric and standard), brightness/albedo, etc.
- ☐ Observational history.
- ☐ Who discovered the asteroid and why the observation could be made.
- ☐ Prediction of asteroid trajectory including closest distance from the surface of the Earth as well as date and time of close approach.
- ☐ A colloquial/non-statistical qualifier of impact risk
- ☐ Hazard to space assets (if any)
- ☐ Future observations (including radar observations).
- ☐ Will amateur observers be able to see the object?
- ☐ Consistent terms of measurement (i.e., "size" rather than "diameter" of object, brightness/albedo of object, etc.
- ☐ Authoritative source(s) for more information.

Below is an example of how warning message might appear that covers the minimum details in such a warning message.

```
A small asteroid, provisionally designated 2017 XYZ) was discovered on
31 Nov 2017 by Pan-STARRS located atop Halekakala (Maui), Hawaii and
reported to the Minor Planet Center.  Additional follow-up observations
by the Catalina Sky Survey, the University of Hawaii 2.2-meter, and the
Large Altazimuth Telescope (BTA-6) 6-meter telescopes have confirmed
the orbit of 2017 XYZ.

Subsequent planetary radar observations at Goldstone, showed that
asteroid 2017 XYZ is approximately 120 meters in size.  Future bi-
static observations may indicate a shape for the asteroid.  Additional
future observations are planned with NASA's Infrared Telescope Facility
to ascertain the composition of this asteroid.

Based on current calculations, the asteroid currently has a 4%
probability of impact will be on 31 Sep 2028 in the Eastern Pacific
Ocean near the southern coast of California at 13:13 UTC.
```

Future observations are planned with the planetary radar systems located in Goldstone and Arecibo on 1 April 2018. Further radar observations will precisely determine the orbit of 2017 XYZ.

The International Asteroid Warning Network (IAWN) has informed the Space Mission Planning Advisory Group (SMPAG), currently chaired by the European Space Agency. SMPAG has begun the process to examine and advise on possible mission planning options to mitigate the possible impact event in 2028.

IAWN is the informational clearinghouse for sharing the most current information on the potential hazards posed by asteroids. More information may be found at:

http://www.iawn.net

The latest developments by SMPAG and the mitigation efforts for 2017 XYZ are located at:

https://www.cosmos.esa.int/web/smpag

The above message template is subject to change depending on the unique nature of a potential/possible/probable asteroid impact scenario. The current IAWN *ex officio* member [to SMPAG] will report to the SMPAG chair and members when threshold criteria #3 occurs.

The accepted criteria for warning of a pending impact event (dependent on predicted probability and size) were agreed to and accepted by SMPAG at the 8th SMPAG meeting in Vienna, Austria on 1 February 2017 [and revisited by SMPAG membership at the 9th SMPAG gathering on 11 October 2017 in Toulouse, France].

1) **IAWN shall warn of predicted impacts exceeding a probability of 1% for all objects characterized to be greater than 10 meters in size, or roughly equivalent to absolute magnitude of 28 if only brightness data can be collected.**

   Rationale: Impact probabilities greater than 1 per cent are rare yet warrant awareness of possible effects. Most objects greater than 10 meters in size could have some effects (air blast and pieces) that could reach the Earth's surface. IAWN is compelled to warn populations if bodies will have effects that reach the ground. Setting threshold at 1 per cent is a compromise between not being overly alarmist and not warning too late for necessary action to be initiated. It is a probability figure that individuals and governments can comprehend. An alert such as this demonstrates that the IAWN is functioning. Further, it ensures the flow of communications from IAWN to the public and the United Nations.

2) **Terrestrial preparedness planning should begin when warned of a possible impact:**

   - **Predicted to be within 20 years,**
   - **Probability of impact is assessed to be greater than 10%, and**
   - **Object is characterized to be greater than 20 meters in size, or roughly equivalent to absolute magnitude of 27 if only brightness data can be collected.**

   Rationale: Effective terrestrial preparedness involves determination of the "risk corridor" for impact of an object. This is made possible with the increased 10% impact probabilities within 20 years, which is not too long to begin planning, especially in cases for larger objects. This provides population centres on the Earth information to begin plans for emergency preparedness if needed. The surprising effects of the Chelyabinsk event in 2013 from an object ~18 meters in size led to the establishment of a relatively low limit (20 meters) in this threshold criteria.

3) **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%, and**
   - **Object is characterized to be greater than 50 meters in size, or roughly equivalent to absolute magnitude of 26 (this magnitude presumes a possible albedo of 3%; i.e., a dark object) if only brightness data can be collected**

Rationale*: Several decades warning, if available, provides sufficient lead time to mount in-space characterization missions to enable more effective mitigation techniques. If more than 1 per cent probability of impact by a 50-meter sized object is assessed, IAWN will inform SMPAG immediately following verification of the orbit. Part of a characterization mission plan would likely be to deploy a radio transponder with the object to enable more precise tracking of the orbit.*

These thresholds are intended to be simple and easy to understand. The use of integer H values (absolute magnitude), is a compromise as there is not an immediate estimate on the real size with only visible wavelength data from a detection. Hence, H=28 corresponds to 10 meters; H=27 is 20 meters. For objects ~50 meters in size, the intent here is to be somewhat conservative for a significant impact threat, IAWN and SMPAG members agreed to stipulate H=26. (Further, it should be pointed out that NEOWISE is seeing a significant peak in the NEO population between 0.02 and 0.05 albedo.)