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# A Simulated Asteroid Impact Over The Swiss–German Border

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**Introduction**

In Nov 2014, ESA has performed a workshop with representatives of two European emergency response agencies, namely those from Switzerland and Germany, to simulate a possible asteroid impact threat. This activity was part of the work of ESA's near-Earth object (NEO) segment in the Space Situational Awareness (SSA) programme. It can also be seen as part of the activities of ESA's involvement in the UN-sanctioned International Asteroid Warning Network (IAWN).

**Participants**

The following agencies/organizations were represented at the workshop:

- Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (BBK), Germany.
- Bundesamt für Bevölkerungsschutz, Nationale Alarmzentrale, Switzerland.
- German Space Situational Awareness Center (GSSAC).
- ESA member country delegates or representatives.
- ESA's SSA programme, the coordination office of the director for Human Spaceflight and Operations.
- The EC-funded NEOShield project was invited as observer.

**Workshop goal and programme**

The main goal of the workshop was to use the scenario as a discussion baseline to see what kind of information would need to be made available by ESA and how emergency response bodies would react. The workshop aimed at understanding the problem and providing input for the definition of future procedures and information flow in case of a real threatening impact event.

The workshop took place over 1.5 days. After a general introduction into the topic to bring everybody on the same grounds, a potential impact scenario was presented.

The (truly existing) Near-Earth Asteroid 2014QN266 was used as starting point for the exercise. ESA’s Optical Ground Station, a 1-m telescope on Tenerife, discovered it in August 2014. The object is about 24 m in size (thus slightly bigger than the Chelyabinsk object with 19 m size). Within this scenario, its orbit was slightly modified so that it would impact Earth near the Swiss-German boarder on 13 March 2027. The exercise started with the assumed re-discovery of the object 30 days before impact and an impact probability of 20 %. A total of 5 key points in time (30 days, 26 days, 5 days, 3 days, 1 hour after) were discussed in sessions of about 1.5 hours duration. At these key points in time the assumed impact probability was increasing to 100 % and the uncertainty of impact location and energy release was reduced (but it never completely vanished). Eventually the NEO broke up and hit the surface in the area around lake Constance.

At each point the following questions were addressed:

- Is any information needed at this point?
- Which information would be required by the emergency response agencies.
- How would this information be used.
- What would be expected from ESA at each step.
- Whom should ESA give the information.
- How will the public respond.

An emphasis was given on providing an estimate of the uncertainties of the provided information. An example: Just after the discovery, 30 days before impact, the only information is the position of the object and a rough magnitude estimate. Size depends on the unknown albedo, and the mass on both the unknown size and the unknown material properties. The resulting mass estimate can therefore be uncertain by orders of magnitude.

In the case discussed at the workshop, the following key measurement milestones relative to the time of impact $T_0$ were assumed:

$T_0$ - 30 days: Recovery of the object, only astrometric (positional) observations available.

$T_0$ - 26 days: Extensive follow-up with a large number of astrometric measurements. This leads to a much better orbit prediction.

$T_0$ - 10 days: The object has become bright enough to allow spectroscopic observations. These allow determining the spectral class and giving some constraints on albedo and composition, reducing the uncertainties for size and mass.

$T_0$ - 5 days: More spectral and astrometric observations, leading to refinements mainly in the orbit prediction.

$T_0$ - 3 days: Radar observations become possible, constraining the size very well. The radar signal properties show in our simulated case a metallic object, constraining the composition.

The assumed available information including uncertainties is shown in Table 1. Note that the goal of this scenario was to test response strategies, not to model the evolution of the physical properties in high detail.

**Results**

At each time step the workshop participants had about 2 hours to discuss the presented information. At the end of the workshop, a summary discussion took place. The following conclusions can be found in the workshop summary.

(1) The emergency response organizations from Switzerland and Germany have all the basic capabilities and procedures in place to deal with a potential impact threat.

(2) Timely and reliable information on the potential impact probability, location and severity is most important. The information should include the uncertainties of impact probabilities and locations. It is of special importance to know when the impact is certain.

(3) The national emergency response organizations would like to be informed already at low probabilities and also in case of impact locations outside of their own country. They will decide internally at what risk level they will take actions.

(4) In case of a real impact threat local authorities and the general population will be informed early and continuously (daily) to build up trust in the provided information. This continuous provision of updated information has to be assured.

(5) ESA was requested to provide information not just on the impact time and location but also on expected damage on ground. This should include a distinction of areas of severity, e.g. areas where a shock wave can be felt or where broken windows, fallen trees, collapse of power lines, collapse of buildings, etc., are expected. Damage should be estimated outside of the impact corridor ellipse as well. Development of an operational tool for the prediction of impact effects had already been recommended previously within an SSA study (SN-VII) on impact effects and ESA plans to initiate such an activity as soon as funding becomes available.

(6) The data dissemination and communication procedures, including contact points, still need to be defined, both, within ESA and between ESA and the national entities.

**Summary and outlook**

This paper reports the main results from a workshop between ESA and national emergency response agencies to discuss a simulated asteroid impact threat. The workshop was a success and allowed refining an 'information plan' which describes the way ESA should distribution impact threat-related information. A follow-up workshop with members of all ESA SSA member countries is foreseen for 2015. The main goal of this future workshop will be to test and finalize the information plan.

*Table 1: Assumed knowledge of the asteroid properties at each time step discussed in the workshop. Note that the velocity was assumed to be 12.5 km/s and its value did not change during the simulation.*

| Time to impact | Impact probability | Uncertainty ellipse | Size | Mass | Impact energy | Assumed possible effects |
|---|---|---|---|---|---|---|
| 30 days | 20 % | 30000 km x 500 km | 12 m – 38 m | 900 t – 200000 t | $1.6 \cdot 10^{16}$ J – $7 \cdot 10^{17}$ J | Airburst in atmosphere – 1 km crater |
| 26 days | 60 % | 2000 km x 200 km | 12 m – 38 m | 900 t – 200000 t | $1.6 \cdot 10^{16}$ J – $7 \cdot 10^{17}$ J | Airburst in atmosphere – 1 km crater |
| 10 days | 100 % | 1000 km x 100 km | 17 m – 38 m | 7800 t – 87000 t | $6.1 \cdot 10^{14}$ J – $6.9 \cdot 10^{15}$ J | Airburst in atmosphere (Tunguska-like) – Several impact craters 10s – 100s of m in diameter |
| 5 days | 100 % | 400 km x 80 km | 17 m – 38 m | 7800 t – 87000 t | $6.1 \cdot 10^{14}$ J – $6.9 \cdot 10^{15}$ J | Airburst in atmosphere (Tunguska-like) – Several impact craters 10s – 100s of m in diameter |
| 3 days | 100 % | 150 km x 30 km | 17 m | 18330 t | $1.4 \cdot 10^{15}$ J | Bright fireball, shockwaves comparable to Chelyabinsk. Possibly one large crater 100 m diameter, resulting shock- and heat waves - or several smaller craters |
| 0 days | The fictive object broke into three main objects. One 5-m object reached the ground and produced a 30 m crater close to Friedrichshafen/Germany; a 3-m object fell into Lake Constance and produced some minor flooding in the shore areas; an 8-m object hit the center of St. Gallen in Switzerland, destroying buildings up to 1 km away. | | | | | |