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Statuts 08 Oct 2017

Consequences, Including Failure, of NEO Mitigation Space Missions

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NOTE: This is an "extended outline". The task is broken up into individual items. These items are described at a rather high level. The extended outline is supposed to serve as the basis of a discussion.

There is considerable overlap with other tasks: These areas of overlap will be stubbed off with references to other Work Plan tasks in the final document. The non-overlapping items will have to be developed in more detail.

1. Introduction

1.1 Background

An important aspect of the proposed task is the analysis of possible failure scenarios. These possible failure scenarios are numerous, among them management and interface problems during the planning phase, launch failures and the dangers associated with them (especially when considering nuclear payloads), communication problems during the cruise phase and target acquisition problems.

A potentially very serious problem is the non-availability of critical items within the required time frame. The task will have to identify such failure points and explore the possibility of building a store of spare parts to be immediately available.
Even if the mission develops according to plan, there is still no guarantee of success. The momentum imparted on the target might not be sufficient; destruction, for example using the nuclear option, might not be complete enough; deflection might even be counterproductive in the sense that the impact location might change from a relatively unpopulated area to an area of high population density with little chance of timely evacuation.

2. Desirable Outcome

The desirable outcome of a mitigation mission ideally is to turn the threat into a non-event. An object which has successfully been deflected will safely pass by the planet. Only a very few people will be able to even observe it.

2.1 Re-imbursement of cost

In the most ideal case the hazard will be averted. A considerable amount of money and resources will have been spent to make this possible. Those nations and organizations which funded this effort will conceivably want to recover the investment.

2.2 Strengthening of the international community

A successful mitigation mission will go a long way towards demonstrating the usefulness of international collaboration

2.3 Appreciation of rational thinking

If the application of science and technology, through a successful mitigation mission, succeeds in saving the planet and along with it the human species from destruction, one should assume that people will drop irrational believes and preconceived notions. But then, who knows....

3. Possible alternative Outcomes/Failures

The alternative outcomes (incomplete mitigation) do not differ from possible impact scenarios except in one important aspect: the incomplete mitigation action might alter the nature of the impact and the impact location in such a way that there is very little lead time for preparing the situation on the ground to cope with the changed scenario.

3.1 Planning failures

Even though groups like SMPAG and similar groups at different space agencies are trying to diligently plan for different mitigation scenarios, the planning process might fall short. A major reason is that quite often the threat is not being taken seriously. As a consequence the planning effort does not get the required attention and the required funding. It is thus important to strongly convey the problem to all stakeholders.

in particular, the space agencies will have to deviate from the way the planning process is carried out under normal circumstances. This effort to accelerate the planning process because of the obvious time constraints might lead to serious planning problems, with a corresponding increase of risk.

3.2 Implementation failures

If a threat is identified with sufficient lead time development of a plan and the implementation will be possible. If, however, the threat materializes on short notice there is every reason to expect that even with very good planning the implementation of the plan will be less than optimal.

In order to save time shortcuts will have to be made. Testing, for instance, might be reduced to a minimum. History shows that when this was done with other space missions, usually because of schedule constraints and resource issues, serious problems were the result (e.g. HST spherical aberration).

3.3 Operational failures

Spacecraft do fail. In addition to the usual failures there might be additional failure possibilities due to the fact that a mitigation mission is most likely a one-of-a-kind mission. While time pressure might be a great motivator, the need to get things done on a fast track might be the cause of serious omissions.

3.4 Interface problems

There will be the need of international collaboration, probably on a scale which has not been attempted before. Interacting organizational entities are prone to synchronization and communication problems. This will be even more serious as events will force the collaboration of entities which have never collaborated before, and which have totally different operational paradigms.

3.5 Insufficient deflection

Unless the lead time is long enough to allow a pathfinder mission to the object, we will know very little about the mass, the structure and the composition of any particular threatening object. The deflection might thus be inadequate, possibly resulting in just shifting the impact location.

3.6 Undesirable impact locations

An impact which happens without any human intervention is quite literally a force majeure. As soon as there is human intervention, like the unsuccessful attempt to deflect the object, we have to expect that serious problems will surface.

3.7 Water impact

Saving Greenland at the expense of an impact in the Atlantic Ocean, which causes a sizable tsunami in Western Europe and along the Eastern Seaboard of the US is not a good tradeoff.

3.8 Airburst

TBD

4. The issue of responsibility/liability

As soon as there is interference with the trajectory (deflection) or with the structure of an object (impactor, explosion) the event will no longer be considered force majeure. This means that the issue of responsibility and liability will be raised.

According to Art VI OST, States Parties to the treaty bear international responsibility for their national activities in outer space.

A planetary defence operation does constitute such an activity. The state carrying out such an activity bears international responsibility for said undertaking.

If the operation were a multinational effort, Art VI OST would apply as well.
In this case, the responsibility is borne by the states involved and the intergovernmental agency that may be concerned. It is rather unlikely that a planetary defence operation would be carried out by a non-governmental entity.

It is, however, not clear how responsibility is to be attributed if an operation is carried out by a supra-national entity such as the European Union. Such a case does not fall under Art. VI sentence 3 OST.

An asteroid or other NEO is a natural occurrence. It can therefore hardly be considered a space object, especially as it is not being launched into outer space and for this very reason cannot be attributed to a launching state.

No state ever launched or attempted to launch this object nor was it "designed" to be launched into outer space. It just happened to be there. In this particular case, we are dealing with indirect damage – be it on Earth or in space. The proof of causation is rather difficult. Not every damage emanating from a space object happens locally and immediately.

A spacecraft equipped with a nuclear explosive device or a kinetic impactor or even a gravitational tractor may have set the events in motion that led to the damage. The actual damage may only appear sometime after the successful intercept of the asteroid. In order to trigger liability, the damage must be a result of the initial event caused by the planetary defence undertaking, even if subsequent or indirect. There are

several legal notions such as damage that is foreseeable but not too remote, which are used to determine whether damage caused indirectly is included within the scope of the initial event.

If any planetary defence mission – destruction, deflection or redirection of an asteroid – leads to a damage, this may lead to the state (or states or international organization) carrying out the mission being held liable for those damages under Art VII OST.

The Ad-Hoc Working Group on Space Law of the SMPAG will have to look into the matter. This is a serious matter, which can lead to international disputes.

More TBD

5. Post-impact scenarios

5.1 Minor impact at well determined location

Given sufficient lead time an impact at a well determined location can be mitigated by using procedures which are similar to those used to evacuate large population groups in case of a hurricane. Even though the impact location might be devastated the infrastructure in the surrounding areas will still be functioning. The different national emergency systems will be able to cope with such an event quite efficiently.

5.2 Minor impact at unknown/surprising location

The situation is different if the exact impact location cannot be determined with sufficient accuracy to allow a meaningful evacuation. The threat might also materialize so fast that evacuation is not any more possible. The loss of life will be larger, but the national emergency services will be able to cope with the situation

5.3 Multiple minor impacts

Depending on the internal structure of the object there might be multiple impacts of smaller bodies, either because the object breaks up due to differential gravitational forces, or because to attempt to deflect the body resulted in a breakup.

5.4 Major impact on land

TBD

5.5 Major impact in the ocean

TBD

6. Strategic planning

6.1 Launch vehicles

Even in the case of sufficient lead time the procurement of a suitable heavy lift launcher might be rather difficult. Allowing for a launch failure we probably have to consider the need for more than one launch vehicle. The consequence of these considerations probably is that we need a minimum of two heavy lift launchers available for immediate mitigation action on standby.

6.2 Deflector payloads

Similar considerations apply to the deflector/mitigation payloads. It is unreasonable to expect that in a rapidly evolving scenario it will be possible to specify, design and build the required deflection payload. The logical consequence is that we sould aim for the availability of various mitigation payloads, such that a mission can be launched on rather short notice.

6.3 Redundant communications infrastructure

We have come to take the instant availability of fast communication for granted. In a post-impact scenario this might not be the case any longer.

6.4 Consumables: fuel, power, food, medical

Consumables in the impact area will be in short supply. Plans for a suitable system of moving resources into an affected area will have to be developed.

More TBD

6.5 Transportation

TBD

6.6 Information

The public will have a strong urge to follow the progress of a mitigation mission. There is the danger, however, that facts will be distorted or amplified out of proportion. An

information system which prevents this, and which provides accurate and reliable information, will be required.

6.7 Education

Asteroid impact mitigation suffers from the fact that impacts fortunately do not occur very often. As a result people become complacent. The population of the planet needs to be educated on all aspects of the asteroid threat.

Education is also required for local governments and the respective emergency management systems. Current emergency plans always assume a restricted area (hurricane, flooding). Governments need to be made aware of the fact that the potential threat might extend across a whole country., or, in fact, across a whole continent.

6.8 International Coordination

As the consequences of a failed mitigation mission will probably affect several counries to varying degrees it is important to establish, ahead of time, a framework of international collaboration and coordination.

7. Consequential hazards in case of a mitigation mission failure

7.1 CBRN hazards

Nuclear power plants are being operated by many countries. A failed mitigation mission is the kind of threat that these facilities were not designed for. This could lead to Fukushima-type events. This also extends to industry dealing with hazardous chemical and biological material.

7.2 Physiological hazards

TBS

7.3 Natural hazards

TBS

7.4 Social hazards

The breakdown of the social fabric of a country has the potential to cause civil unrest.

More TBS

8. Civil protection

8.1 Emergency governance

A sizable impact has the potential of destabilizing, or even of destroying, the local governance structure. While large countries with sufficient resources will be able to cope, there is the danger that an impact in a politically less stable region will give rise to unrest and even civil strife. A suitable plan for emergency governance should be developed.

8.2 Medical services/triage

A major impact will cause severe loss of life and will produce a large number of injuries. Hospitals near the impact area might not be functioning any longer. Military type mobile medical services are probably the best way to cope with this. Suitable plans should be developed.

8.3 Critical infrastructure

Emergency plans to set up the most critical infrastructure (medical, food, water) must be developed. The same is true for communication and transportation.

9. Government and Law

9.1 Need for international agreements

The international agreements which are required to implement must include provisions for handling failed missions

9.2 Prevention of opportunistic political action

In a post-impact scenario which neutralizes the security forces of a country, adjacent countries, or in fact hegemonic superpowers might be tempted to use the occasion to change the political realities in a region.

9.3 Emergency administration

In case the administrative infrastructure of a sizable region is disabled there should be a default procedure to execute the required administrative procedures.

9.4 Law enforcement

Even at far less dramatic events, like during the aftermath of a hurricane, we see widespread lawlessness, usually confined to looting and break-ins. In a severe post-impact scenario this might be considerably amplified, as resources become scarce. Plans for a suitable system of emergency law enforcement are probably required.

10. Priorities

11. Communications and Interfaces

TBD

Appendix

a. Acronyms and Abbreviations

CBRN
NEO
SMPAG
TBD
TBS