

SMPAG Task 5.8 "Consequences, including failure ..."

- Task Leader: G. Drolshagen ESA/University Oldenburg
- Country/agency in charge: Austria/FFG (Austrian Space Agency), S. Mayer
- Coordinator: R. Albrecht, Austrian Space Forum (ASF)
- SMPAG collaborators: Italy, UK, CZ

Input received from:

- H. Böck, Atominstitut Technical University Vienna
- P. Bohacek, AMO Research Center
- P. Boyce, American Astronomical Society
- G. Drolshagen, ESA/U. Oldenburg
- O. Hainaut, ESO
- Ch. Köberl, U. Vienna, NHM Vienna
- H. Mayer, U. Graz
- S. Mayer, FFG
- B. Müller, U. Vienna
- L. Nagel, U. Vienna
- N. Renner, Stabstelle für Grosschadensereignisse, Wien
- A. Stadler-Wallig, Stabstelle für Grosschadensereignisse, Wien



Status update

Task 5.8 "Consequences, Including Failure, of a NEO Mitigation Space Mission

An interim report was produced for the fall meeting 2018 in Knoxville. The initial approach was considered too detailed in several areas, while being incomplete in others.

To better define the scope of the report there was a topical workshop at the NHM in Vienna in February 2019. There were 20 participants, SMPAG members and exerts.

A list of requirements was produced. More requirements were added following the Planetary Defense Conference 2019. The list was circulated for comments.

The requirements were grouped and mapped into the structure of the report. As several requirements are often dealt with in more than one section there is a certain amount of duplication.

An update was prepared for the fall meeting 2019 at ESO

A snapshot as of mid-January was submitted to Gerhard Drolshagen, to Stephan Mayer and to several "friends of task 5.8" for review and comments

For the last two weeks I have been concentrating on the economic aspects



Requirements Matrix

Requirements as identified during the Splinter Meeting and during PDC 2019, grouped into the sections of the report.

Note: subsections are denoted as .x, because the subsection numbering will change as there are shifts and additions.

1.0 Introduction

- Discuss cost of mitigation actions against cost of possible damage 1.x
- Assume object size larger than 50 meters 1.x
- How will people react during the different stages? 1.x, 2.x
- even though impact probability might be low, the number of casualties can be high 1.x
- Find out existing UN mechanisms 1.x
- will embargoes work? 1.x, 2.x
- ESA has information plan 1.x, 3.x
- Is there a NASA report on possible impact effects in the US? 1.x, 6.x
- A report on impact effects to be done by the Berlin Museum of Natural History for ESA 1.x
- Consider time to impact 1.x
- consider time scales 1.x, 2.x, 3.x
- consider "false warning" 1.x, 2.x,



Requirements section 1, cont'd

- The introduction should have a review of possibilities
- Describe the differences between other natural disasters (hurricanes) and asteroid impacts 1.x, 2.x

1.x

- where to keep? (nuclear?) 1.x, 2.x, 3.x - EMPs from nuclear options negligible 1.x - impacts can cause EMPs 1.x, 6.x - substantiate the need for an international response 1.x, 2.x, 3.x - use careful language: suggest, recommend, advise 1.x, 2.x - Resources 1.x, 2.x, 3.x - Priorities: include in next decadal survey 1.x - Disruption of financial system 1.x, 2.x, 6.x 1.x, 2.x, 5.x, 7.x - Rapid mission development - Incomplete mitigation 1.x, 5.x - CTBTO 1.x, 7.x
- Cooperation with emergency services 1.x, 2.x, 7.x



2.0 Mitigation Scenario

- Consider communication aspects 2.x
- It is important to monitor the deflection 2.x
- Assume impact probability = 1, IAWN has issued a level 3 alert 2.x
- How will people react during the different stages? 1.x, 2.x
- Consider different levels of communication: public, media, government-to-government 2.x, 3.x
- will embargoes work? 1.x, 2.x
- important: transparency, danger of speculation/rumors 2.x, 3,x
- How to communicate the nuclear option? 2.x,3.x
- What to do with the spacecraft in case it turns out the mission would not have been necessary 2.x, 5.x
- What to do with a nuclear payload in such a case? 2.x, 5.x
- consider cost-effectiveness of different possible missions 2.x, 3.x
- Identify organisational interfaces 2.x, 5.x
- consider time scales 1.x, 2.x, 3.x
- consider "false warning" 1.x, 2.x,
- consider standoff explosion/nuclear 2.x, 5.x
- Assess asteroid fragmentation 2.x, 5.x



Requirements section 2 cont'd

- Describe the differences between other natural disasters and asteroid impacts 1.x, 2.x
- Redundancy. Should different agencies /different countries work independently? 2.x, 4.x

2.x

 Payload to be designed ahead of time 	2.x, 3.x, 5.x	
- Needs to be updated to reflect evolving technology	2.x, 3.x, 5.x	
where to keep? (nuclear?)	1.x, 2.x, 3.x	
- substantiate the need for an international response	1.x, 2.x, 3.x	
 use careful language: suggest, recommend, advise 	1.x, 2.x	
- Resources	1.x, 2.x, 3.x	
 Problems predicting impact location 	2.x, 6.x	
- Disruption of financial system	1.x, 2.x, 6.x	
- Rapid mission development	1.x, 2.x, 5.x, 7.x	
- Communication: consider the effect of incomplete mitigation on other countries		

- Cooperation with emergency services 1.x, 2.x, 7.x
- Evacuation problems: traffic, lodging, food 2.x, 3.x, 7.x
- Evacuation problems: elderly, handicapped, hospitals 2.x, 3.x, 7.x
- Effects on the Internet 2.x, 6.x, 7.x



Requirements section 3.0 Pre-Event Consequences

 Discuss impact corridor vs. impact location 	3.x
 option to do nothing has to be retained, even after launch 	3.x
- Consider different levels of communication: public, media, gove	ernment-to-government 2.x, 3.x
 important: transparency, danger of speculation/rumors 	2.x, 3,x
- ESA has information plan	1.x, 3.x
- How to communicate the nuclear option?	2.x,3.x
- consider cost-effectiveness of different possible missions	2.x, 3.x
- consider time scales	1.x, 2.x, 3.x
 Reference DLR technology roadmap 	3.x
- consider impactor vs nuclear	3.x, 5.x
 Payload to be designed ahead of time 	2.x, 3.x, 5.x
 Needs to be updated to reflect evolving technology 	2.x, 3.x, 5.x
where to keep? (nuclear?)	1.x, 2.x, 3.x
 substantiate the need for an international response 	1.x, 2.x, 3.x
- Resources	1.x, 2.x, 3.x
 Evacuation problems: traffic, lodging, food 	2.x, 3.x, 7.x
 Evacuation problems: elderly, handicapped, hospitals 	2.x, 3.x, 7.x
- Health and medical services	3.x, 6.x, 7.x



Requirements 4.0 Consequences of a Successful Mission

- positive effects: science, int'l collaboration, funding, UN 4.0
- Redundancy. Should different agencies /different countries work independently? 2.x, 4.x

Requirements 5.0 Failure Scenarios

- List possible failures and probabilities

5.x

- What to do with the spacecraft if it turns out the mission would not have been necessary 2.x, 5.x

- What to do with a nuclear payload in such a case?	2.x, 5.x
- Identify organisational interfaces	2.x, 5.x
 consider standoff explosion/nuclear 	2.x, 5.x
- consider impactor vs nuclear	3.x, 5.x
- Assess asteroid fragmentation	2.x, 5.x
 Payload to be designed ahead of time 	2.x, 3.x, 5.x
- Needs to be updated to reflect evolving technology	2.x, 3.x, 5.x
- Rapid mission development	1.x, 2.x, 5.x, 7.x
- Incomplete mitigation	1.x, 5.x



Requirements section 6.0 Consequences of a Failed Mission

- Mass panic 6.0
- Is there a NASA report on possible impact effects in the US? 1.x, 6.x
- Radiation hazard from nuclear power plants 6.x
- asteroid itself might be radioactive because of (solar)irradiation 6.x
- impacts can cause EMPs 1.x, 6.x
- Problems predicting impact location 2.x, 6.x
- Disruption of financial system 1.x, 2.x, 6.x
- Effects on transportation infrastructure 6.x
- Effects on agriculture 6.0
- Water impact 6.x
- Health and medical services 3.x, 6.x, 7.x
- Effects on the Internet 2.x, 6.x, 7.x



Requirements section 7.0 Strategic Planning

- Should different agencies /different countries work independently? 2.x, 4.x

- Rapid mission development	1.x, 2.x, 5.x, 7.x
- Recon mission(s)	7.x
- Combination recon plus nuclear	7.x
- Redundancy	7.x
- Begin work on kinetic impactor	7.x
- CTBTO	1.x, 7.x
 Cooperation with emergency services 	1.x, 2.x, 7.x
 Evacuation problems: traffic, lodging, food 	2.x, 3.x, 7.x
- Evacuation problems: elderly, handicapped, hospitals	2.x, 3.x, 7.x
- Health and medical services	3.x, 6.x, 7.x
- Effects on the Internet	2.x, 6.x, 7.x

Appendix

- Glossary
- Literature, references
- Web resources
- Case studies
- Identify detailed technical issues for future task items



Consequences for the economy

- During the PDC 2019 Exercise we "lost" New York City and Wall Street. This obviously has consequences for the economy
- It turned out to be impossible to get the the opinion of a professional economist. I tried the Vienna Business University, the economics editor of the largest circulation newspaper in Austria, und the retired Head of a leading German economy research institute
- The issue is so undefined that people are unwilling to say anything
- Read several books on world economy (i.a. Greenspan, Lewis, Sinn, Sarrazin). We live on thin ice!
- Found a relevant paper with numbers: Mohamed Dore, Brock University, Toronto, Canada. "The Economic Consequences due to Asteroid and Comet Impacts". In: "Asteroid Impacts on Human Society" Springer 2007. However: it assumes that an asteroid strikes by surprise. Deals with post-impact consequences only.
- The post-impact consequences are very much like the consequences of an earthquake, the eruption of a volcano, or a Tsunami, except that the distribution and the type of the damage will be different

- There is a major difference for the pre-encounter consequences, especially in the case of the possible impact of a large object, which might be detected years ahead of time and for which the impact probability increases and the impact location is uncertain during this time. Additional uncertainty will be introduced by a mitigation mission which might only be partially successful, but which will change the impact location in unforeseen ways.



Dore addresses 6 scenarios:

- 1. Damage up to 5 billion \$, fatalities up to hundreds, 10**4 injured. Local infrastructure damaged. Example; 1989 San Francisco earthquake. Recovery: months. Can be handled by one country

- 2. 5 - 20 billion damages, 10**4 killed, 10**5 injured/homeless. Local infrastructure destroyed. Example: 1995 Kobe earthquake. Recovery: years. Can be handled by countries

- 3. Several 100 billion in damages, loss of a major city (San Diego). 10**5 fatalities, 10**6 injured, 10**6 homeless. Loss of regional infrastructure. Loss of regional governance. Recovery: many years. Requires international collaboration.

- 4. damage in the trillions, 10**6 fatalities. (New York City; PDC 2019!). Major loss of infrastructure, cascading effects., domestically and internationally. Recovery: decades. Requires global collaboration

- 5. Loss of a whole country. Depending on the country this might be a serious blow to the global economy (Switzerland, UK). For a developing nation this means financial default, with all consequences to the creditor nations/institutions. Recovery: many decades. Requires global collaboration

- 6. Global catastrophe. All bets are off



The mechanisms of the economy and the **pre-event** uncertainties

- For a working economy the following elements are required (but not necessarily sufficient)

Production units:

Will they continue to be available? How long? Will the work force be available? How long? Will maintenance work be performed? Will spare parts be delivered?

Customer-producer communication

Will there be customers? Will communication channels be available? How reliable will they be? Will the road/rail infrastructure be available?

Payment system

Most payments are electronic. Will the system remain available? Will the currency remain stable? Serious devaluation will have consequences for the value of the currency reserves world wide. Cryptocurrencies? Barter? Taxation? Developing countries? Corruption? Black markets?

Banking system

How reliable will it be? Will there be a shortage of cash? Will people still accept computer payments? Availability of loans?

Investor confidence

All investments in or near the impact corridor will slow down or stop. Insurance? Hedging? Predatory buying? Short selling? Fake news? Rumors?



Mechanisms, cont'd.

Markets (stocks, commodities, real estate)

real estate prices in or near the impact corridor will fall. Mortgages will default. People might sell off assets and buy durable goods. Stocks will fall commodities will spike. Futures contracts and other derivatives will behave erratically. Trading might have to be stopped.

Legal system, rule of law, enforcement

Will the system continue to work? How long? Will law enforcement agents be available? Can fraud, embezzlement, loan defaults, etc. be prosecuted? Will there be looting, vandalism?

Central bank, federal reserve

Will the currency remain stable? Will the national authorities be able to support the currency? (Fiat money is not backed by commodities, but only by the confidence in the financial construct).

All tied together by IT

Problem: since the economy is multi-factorial there is no set of conditions which guarantees stability



Example: 9/11 Lost Wall Street for a few days

Uncertainty: for about one week it was not clear whether and where the attacks might continue.

The Federal Reserve added \$100 billion in liquidity **per day**, during the three days following the attack, to help avert a financial crisis and to stabilize the Dollar

Gold prices spiked 30% in London trading. Oil prices also spiked upwards. Gas prices in the United States also briefly shot up, though the spike in prices lasted only about one week.

Currency trading continued, with the US Dollar falling sharply.

The next day, European stock markets fell sharply, including declines of 4.6% in Spain, 8.5% in Germany and 5.7% on the London Stock Exchange.

Stocks in the Latin American markets also plunged, with a 9.2% drop in Brazil, 5.2% drop in Argentina, and 5.6% decline in Mexico, before trading was halted.

Total cost is hard to estimate- Department of Homeland Security was installed, extensive security measures were implemented, "war on terror" was started, Irak was invaded. Total cost until now as high as \$10 trillion.



Example: SARS, Corona Virus

These are examples of threat situations in large but limited areas, for which the magnitude of the threat and the final results were/are not definitively predictable. There is no physical destruction, but there are impacts on productivity, infrastructure, medical system, law enforcement, food supply.

SARS 2002-2003: estimated cost **40-50 billion US\$.** Source: Jong-Wha Lee and Warwick J. McKibbin "Estimating the global economic costs of SARS" in: Learning from SARS Workshop. The National Academic Press, Washington, DC https://www.ncbi.nlm.nih.gov/books/NBK92473/

Corona Virus: Even if the virus outbreak turns out be comparable to SARS, its global economic effects are likely to be **much larger** than in 2002/2003, as China has a much bigger share in the global economy nowadays. Moreover, economies are much more interlinked than 17 years ago

With global economic growth already in a deceleration phase, the virus is another risk that supports our view that we will see global recession this year and that central banks in developed markets will probably have more work to do in terms of stimulus

Menno Middeldorp, Chief economist, Rabobank, Netherlands. https://economics.rabobank.com/publications/2020/january/economic-implications-of-the-coronavirus/

Coronavirus is more dangerous for the global economy than SARS. Bloomberg Business Week https://www.bloomberg.com/news/articles/2020-01-31/the-coronavirus-is-more-dangerous-for-the-economy-than-sars

Coronavirus could cost China's economy **\$60 billion this quarter**. CNN Business. https://edition.cnn.com/2020/01/31/economy/china-economy-coronavirus/index.html



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