On the use of an ALARA Tool to Countering Nuclear or Radiological Terrorism

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Abstract. European national emergency response plans have long been focused on accidents at nuclear power plants. Recently, the possible threats by disaffected groups have shifted the focus to being prepared also for malevolent use of radiation that is aimed at creating disruption and panic in the society. The casualties will most likely be members of the public. According to scenario, the number of affected people can vary from a few to mass casualties. The radiation exposure can range from very low to substantial, possibly combined with conventional injuries. There is a need to develop practicable tools for the adequate response to such acts and more specifically to address European guidelines for triage, monitoring and treatment of exposed people.

In the framework of the European Commission specially targeted research project TMT Handbook a number scenarios of malicious uses of radiation have been analyzed. This paper elaborates on the use of an ALARA tool such as Visiplan as viable alternative to perform consequence assessment studies.

1. Introduction

European national emergency response plans have long been focused on accidents at nuclear power plants. This has resulted in well developed, reviewed and exercised plans taking place at these fixed facilities. The evolution of nuclear emergency planning has led to the refinement of response plans away from fixed nuclear sites, such as the accidents involving the transport of radioactive material. The magnitude of these events whilst generally smaller due to the smaller quantities of radioactive material involved pose there own problems due to the difficulties associated with prior planning for location specific factors, high density populations, etc. More recently, the possible threats by disaffected groups have shifted the focus to being prepared for malevolent use of radiation that are aimed at creating disruption and panic in the society.

Scenarios that fall into this malevolent category host a whole range of issues that require consideration. Historically, the terms accident and emergency have been used interchangeably. Unfortunately, the political landscape has changed to such an extent that in an emergency situation the question “mistake or malicious” has to be asked. Whilst this may not render the actual response at an individual or operational level any differently, there are aspects in the strategic and tactical response that may vary. A whole host of questions is raised and needs to be answered, in part to ensure the safety of the emergency responders.

In order to provide practical guidance for responders in the event of the malevolent use of radiation a program of work developed the Triage, Monitoring and Treatment Handbook (TMT Handbook) [Rojas-Palma et al., 2009]. In a new application, this

paper reports on – without entering into details – the usage of an ALARA tool, such as Visiplan [Vermeersch, 2005]. Visiplan is a planning ALARA tool developed to estimate dose to workers and in this case, it has been used to estimate the possible consequences of an act of terrorism involving ionizing radiation, such a radiation exposure device, both in terms of received dose and number of affected people.

2. TMT Handbook

TMT Handbook was a special targeted research project of the 6th Euratom framework program that had as a primary objective the development of practical guidelines on the Triage, Monitoring and Treatment of the public exposed to the malevolent use of radiation.

Due to the focus on "accidental" releases much of the guidance is specifically focused towards these issues. The "malicious" event is one that is relatively new to our consciousness and therefore there is relatively little established guidance available specific to this situation. Whilst there are numerous overlaps with accidental situations in terms of the public protection a number of specific issues need to be considered,

- How do you ensure the effective triage of members of the public exposed to radiation or radioactive materials?
- What are the best means of monitoring members of the public, what strategies are adopted at a national level and what resources are available?
- Which treatments options are available and offer the most effective response?

This is of particularly significance in the malevolent event due to the potential for large numbers of people to be, or suspected to be, exposed. It is also apparent that whilst national plans have been developed to respond to these issues these have been, in the whole, developed in isolation. Any significant event could affect more than one country due to cross-border migration of contaminants, people, or transfer of goods.

Generic guidance on this topic has been published by national and international organizations. They are, however, not operational documents to be directly used in emergency situations. So, whilst depending on the scenario, the number of affected people can vary from a few victims to mass casualties; the radiation exposure can range from very low to substantial, possibly combined with conventional injuries. Therefore there was a need to develop practicable tools for the adequate response to such acts and more specifically to address European guidelines for triage, monitoring and treatment of exposed people. TMT Handbook developed consistent guidance on the response to the malevolent use of radiation that affects the public.

One of the first tasks in the development of the handbook was to analyze a number of potential scenarios which would result in a number of people being exposed to ionizing radiation. The analysis focused on the number of affected people and the dose distribution of this group. In most cases worst-case scenarios were adopted to give emergency authorities the opportunity to investigate whether present medical and first responders capacities were sufficient and adequate.

One of these scenarios was analyzed both qualitatively and quantitatively using the software package Visiplan. The novelty in the approach is that Visiplan is usually used for calculating occupational exposure of workers.

3. Radiation Exposure Device

In this scenario a hidden radioactive source is left in a public place with the purpose of irradiating as many people as possible. In this case, we have chosen a subway as a public place and the source is supposedly to be ^{60}Co. Here, ^{60}Co is a gamma emitter with a main energy of 1173 and 1332 keV.

We analyzed two cases: a) the source is left inside the car; b) the source is left on the platform at a given station, as shown in the figure below.


a) Hidden source left inside the subway car


b) A hidden source is left at the station platform

Information on time of the day (estimated number of people), car design parameters (materials composition, thickness), time spent at the station or on the train, etc., have been taken into consideration.

4. Results

The first case, a) would result in two forms of public exposure to radiation, namely those on board of the car and those standing at the platform once the train has arrived to the station. The dose expressed in mSv to people under those circumstances is shown in Figures a.1 and a.2, whereas the dose to people when the source is on the platform on the assumption that they will not wait for the train longer than 10 min is shown in Figures b.1 and b.2, respectively.

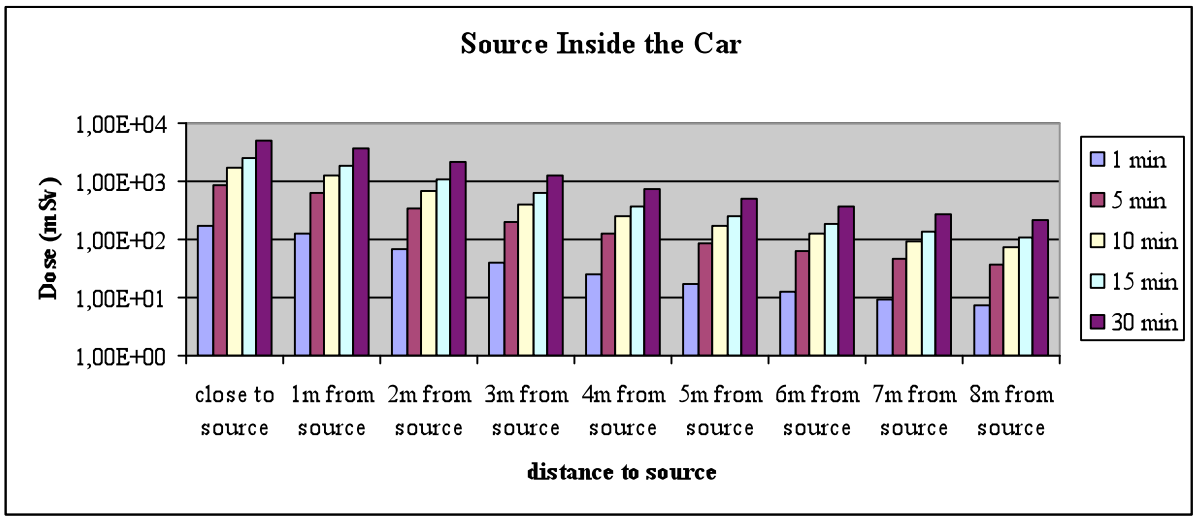

Figure a.1. Source assuming on the subway car as a function of the distance to the source and duration of the exposure

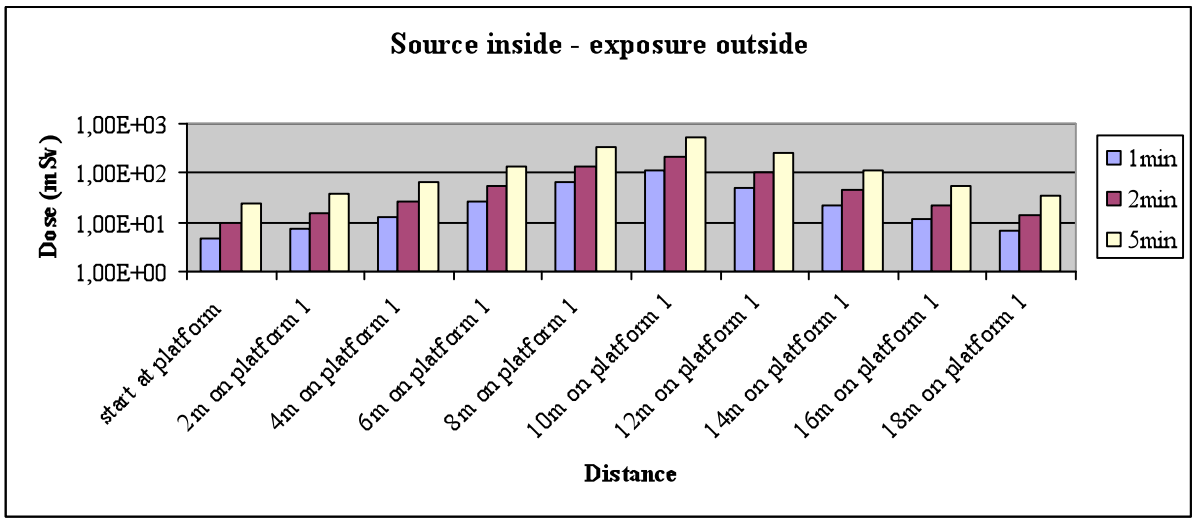

Figure a.2. Here it is assumed that the source is on board of the subway car and that people standing on the platform will be exposed for as long as the train has stopped and also as a function of distance to the source.

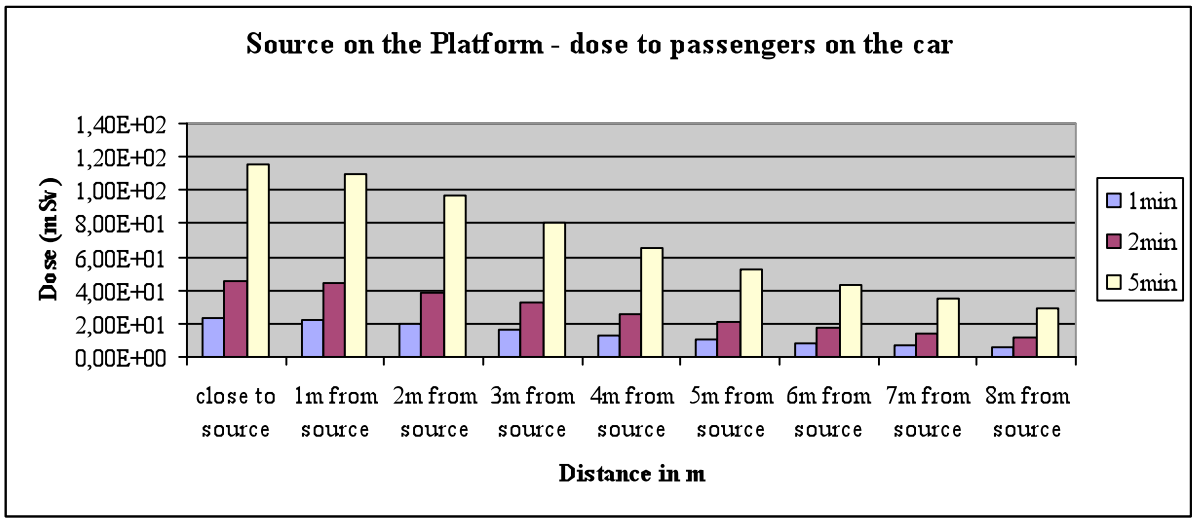

Figure b.1. The source is on the platform and it will irradiate people on the train as a function of distance and time spent at the station.

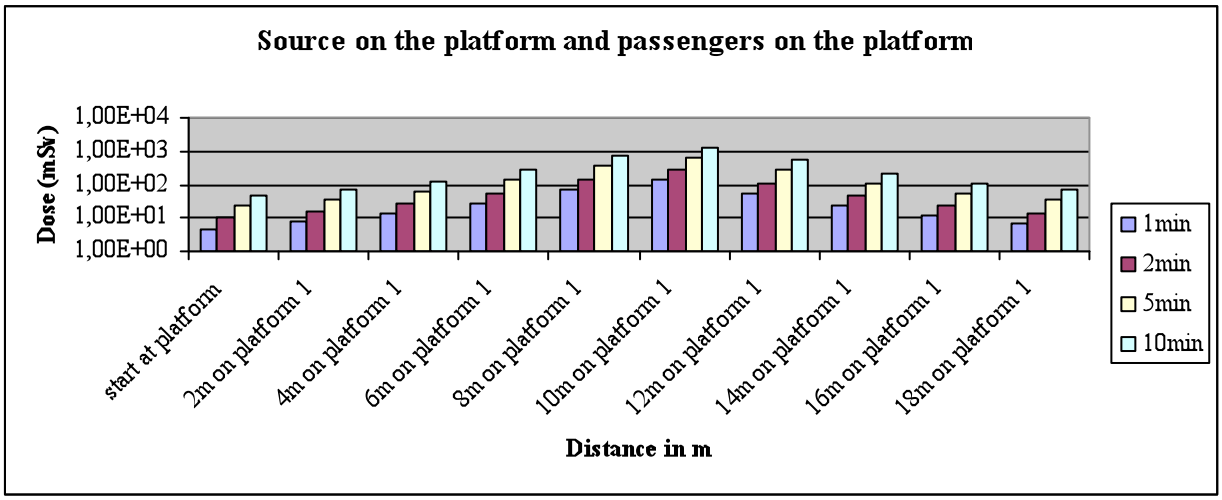

Figure b.2. Finally the source is hidden somewhere on the platform and the exposure of passengers is expressed as a function of the distance and time waiting for the train.

In order to perform a consequence assessment, the Table below shows the dose levels that would result in a medical emergency:

Dose (Sv)	Immediate	Delayed
0-0.1	None	Small risk of cancer or mutations offspring
0.1-0.5	Sometimes radiation disease	Early aging and risk cancer
0.5-1.5	Nausea, vomiting, spontaneous abortion, still-born	Reduction lymphocytes, damage offspring, cancers
1.5-2.5	Nausea, vomiting, diarrhoea, skin burns, dead embryo	Malfunctioning glands, possible death, healthy person may recover with probability to get cancer, etc.
2.5-6.0	List too long	< 60 days 50% mortality, survivors suffer from cancer, malfunctioning eyes, nerves
6.0-10		Death < 10 days
>10	Immediate death	None

Results of these VISIPLAN calculations were not only used for a consequence analysis of the RED scenario, but have also been used to establish a table-top exercise based on realistic assumptions and consequences, both with respect to the radiological and medical emergency response. This table-top exercise was given during the TMT Handbook course in February 2009 in order to train emergency response personnel in dealing with radiological emergencies due to malevolent acts.

5. Conclusions

Visiplan has proven to be a valuable and straightforward tool for estimating the possible consequences of a radiation exposure device in a scenario whereby the malevolent use of radiation will cause mass casualties and will also require trained personnel to treat and follow up the victims. The results of this research provided the TMT Handbook project with valuable information on the potential number of casualties exhibiting acute radiation syndrome, signs of overexposure to ionizing radiation and on the type of treatment they would require.
The same results of VISIPLAN provided a table-top exercise that adequately trains emergency response personnel in dealing with malevolent acts with radioactive material.

6. References

Carlos Rojas-Palma, Astrid Liland, Ane Naess Jerstad, George Etherington, Maria del Rosario Pérez, Tua Rahola and Karen Smith, eds. *TMT Handbook: Triage, Monitoring and Treatment of people exposed to ionizing radiation following a malevolent act*. Lobo Media AS, Norway 2009.

Fernand Vermeersch, Alara Pre-Job Studies Using The Visiplan 3d Alara Planning Tool, Radiation Protection Dosimetry (2005) Vol. 115, No. 1–4, pp. 294–297

7. Acknowledgements

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