Best Practice Guidelines for the use of atmospheric dispersion models at local scale in case of hazmat releases into the air

COST Action ES1006

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Best Practice Guidelines

for the use of Atmospheric Dispersion Models in Emergency Response Tools at local-scale in case of hazmat releases into the air

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COST Action ES1006
Evaluation, improvement and guidance for the use of local-scale emergency prediction and response tools for airborne hazards in built environments

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COST ES1006 Action

Introduction and outline

- COST Action ES1006 was dedicated to the "evaluation, improvement and guidance for the use of local-scale emergency prediction and response tools in case of airborne hazards in built environments" and took place between 2011 and 2014

- The activities were divided between Working Groups:
  - WG1 – Catalogue the threats and the experiments and models
  - WG2 – Benchmark the performance of models vs. wind tunnel and real scale trials
  - WG3 - Sub-project to bridge the gap between model developers and end-users

- A key output from the WG3 was the "Best Practice Guidance" (BPG) dedicated to the use of ADMs and ERTs in support of decision-making in an emergency involving the release of hazardous materials ("hazmat") into the atmosphere

- Outline of the presentation
  - Example of the same situation modelling with different kinds of models
  - Motivation of the BPG and illustration of what can be found in the BPG
  - Summary of the conclusions drawn by the BPG experts

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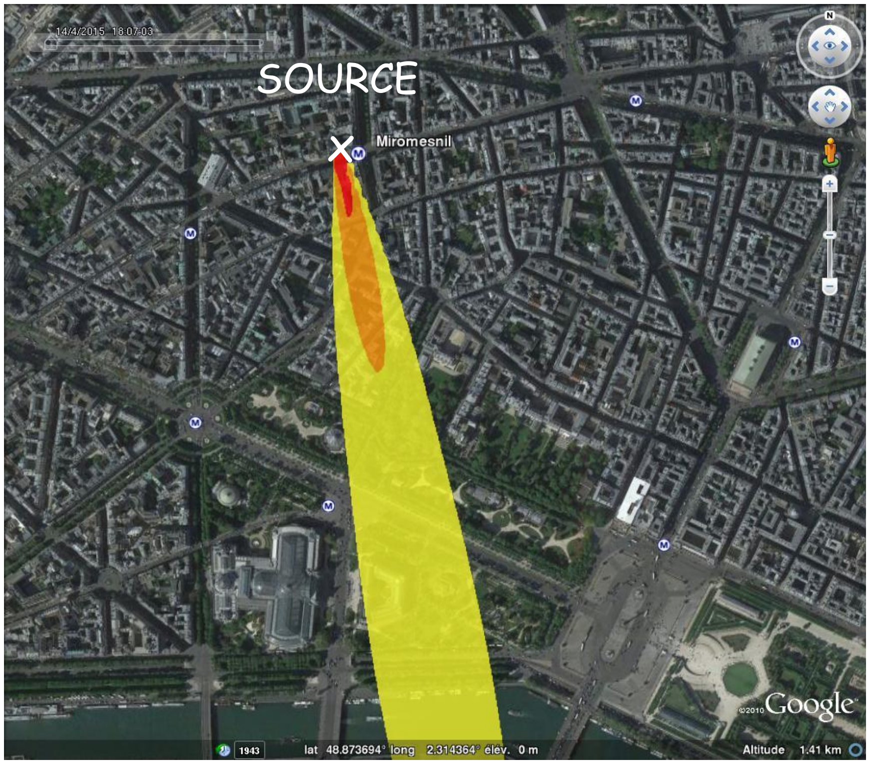
The paradoxical situation of ADMs in ERTs

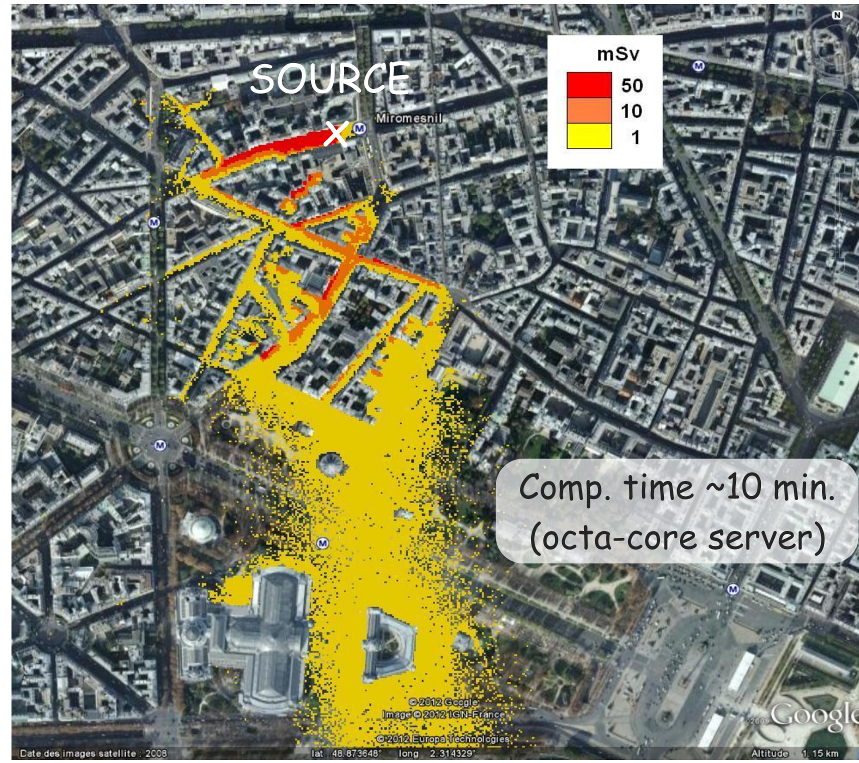
- Questionnaires were distributed to first responders and stakeholders in EU with the objective of identifying their perception and use of ADMs in ERTs
- According to some of the responses, the available ADMs are perceived as having low accuracy and significant limitations and their results are not always trusted unless they were presented along with *in-situ* measurements
- On one side, considerable progress has been made in the last decade that enable scientists and engineers to run realistic and accurate simulations of the flow and dispersion and to produce operational results (danger zones, intervention zones…)
- On the other side, most of the first responders still use or are provided with the results of simplified models not adapted to application in built-up environments
- Clearly, there is a huge gap between the stakeholders' state of mind regarding ADMs, the present capabilities of the models, and the efforts of developers to V&V model results and adapt ADMs to the needs of decision-makers

An exercise with the Paris Fire Brigade
The fictitious explosion of a "dirty bomb"

Cobalt-60 dispersion and dose computed with Gaussian (left) and Lagrangian (right) models

(wind from the North – source term due to the explosion from the ground to 20 m – 10 TBq)





>> The LPDM used in the exercise has been validated in WG2 (Duchenne et al., 2016)

>> The LPDM gives an accurate and informative prediction of the dispersion and exposure while the Gaussian model is not conservative contrary to a widespread belief

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The justification for the BPG

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- COST Action ES1006 focused on hazmat releases in complex built environments
  - Urban industrialized environments may be the place of accidents and terror events
  - Most severe consequences are likely to occur in the vicinity of the source (~ 1 km)
  - At the local scale, the dispersion and deposition have to be accurately modelled to reliably assess the health effects on the population and first responders
- This provides the justification for the development and detailed verification and validation of the various kinds of atmospheric dispersion models
- However it would be pointless to develop sophisticated dispersion models that are unknown or not used by the people actually facing emergency situations
- To raise awareness, the COST Action ES1006 decided to establish the BPG for using different ADMs whether they were integrated or not into ERTs
- Our aim is to promote effective and efficient knowledge transfer from the scientific community to the professionals involved in the preparedness and / or response to potentially hazardous dispersions of CBR species

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The meeting points of modelling and emergency

- To establish a common understanding of the fundamental principles, the BPG identifies the key issues linking modelling and emergency response relating to:
  - The different types of ADMs, their main features, advantages and drawbacks
  - The position of the ADMs in the chain of assessment in ERTs
  - The estimation of exposure produced by post-processing the outputs of ADMs
  - The reference threat scenarios to illustrate the potential use of ADMs and ERTs
  - The people involved in the different phases of the response (first responders, experts, decision makers...), their roles and their interest in ADMs and ERTs
  - The operational results provided by ADMs (danger zones, intervention zones...) which can be distributed to the first responders and / or decision-makers

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General sketch-up of the organization for handling an emergency

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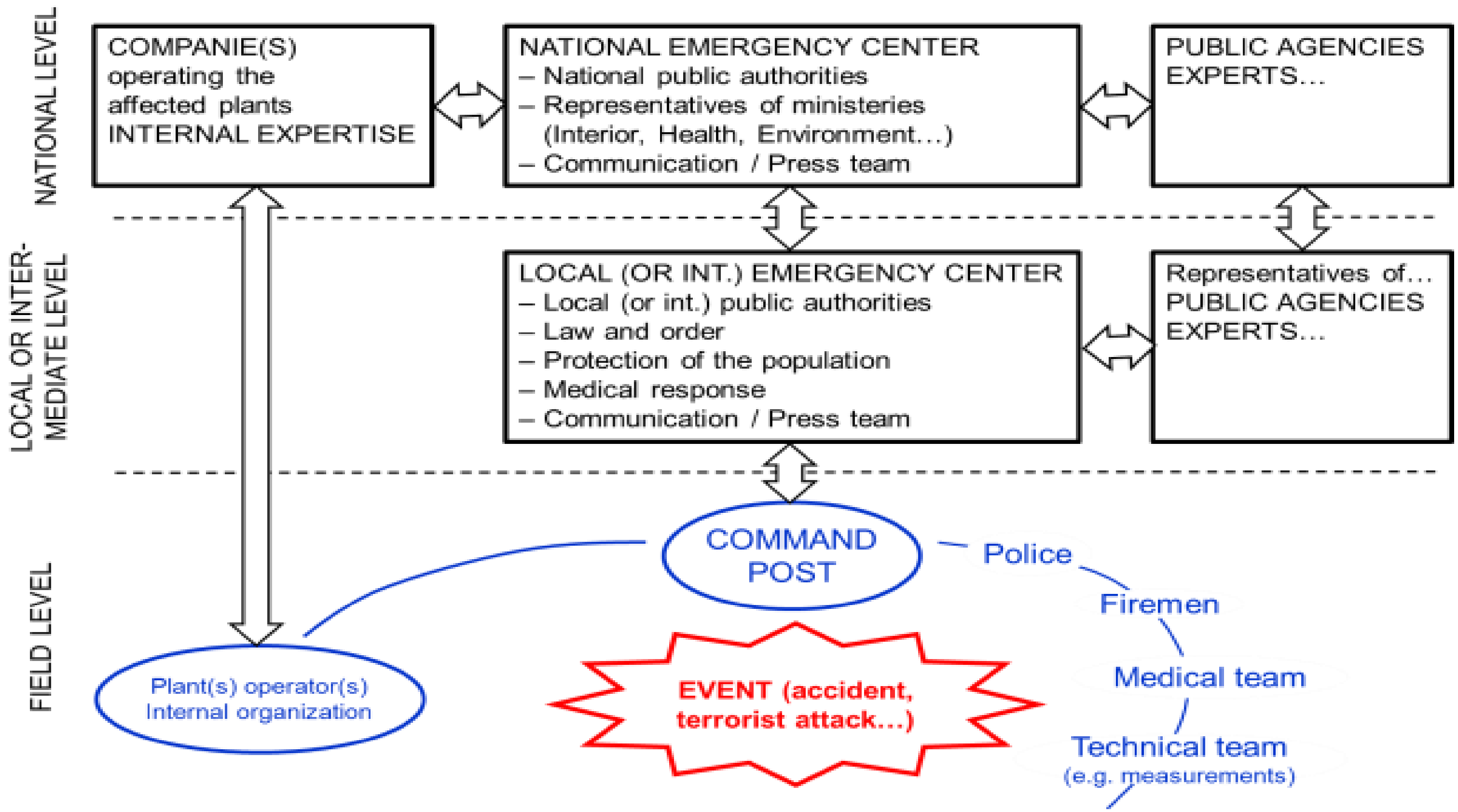
Simplified organizational diagram
applicable to a radiological or chemical emergency
involving an accidental or deliberate hazmat release



» At the field level, ADMs may support the operational decisions of emergency responders

» At the local or intermediate level, they may provide information to better understand the situation and anticipate its evolution

» At the highest decision making level, the results can be used to better handle the emergency and communicate with the population.

Recommendations given from different perspectives

1) The available level of information on the complexity of the situation, the environmental data, the release source, the meteorological input and all features of the event… … This is related to the available models and computational resources, resulting in a harmonized response-practice procedure and flow of actions (see Herring et al., 2016)

2) The successive and distinct pre-event, event, and post-event phases of the emergency, the operators of the ADMs or ERTs and the final users of their results with the goal of answering the questions: "what to produce, when, and for whom?"

3) The threat scenarios identified by the Action to give practical guidelines in case of:
   i. A neutrally buoyant release (e.g. small amount of chlorine within an urban area
   ii. A positive buoyancy release (e.g. toxic plume produced by a fire in a warehouse)
   iii. A dense gas release (e.g. leakage of many tonnes of (pressurized) chlorine or LPG)
   iv. A "dirty bomb" that produces an explosive release of radionuclides

4) The results of the three model comparison exercises conducted by the Action, reported in "ES1006 Model Evaluation Case-Studies" (see Trini Castelli et al., 2016)

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The classification by types of flow and dispersion models

The BPG is based on consideration of a full range of ADMs and ERTs which have been used for a long time or are at the leading edge of the technology

Model type	Flow model	Dispersion model	Execution time*
1	No computation of the flow	Gaussian plume / puff model standard or with possible sophistication taking account of buildings	Seconds to minutes
2	Resolution of the flow with simplifications (limited set of equations and / or semi-analytical relations around the buildings…)	In general, Lagrangian particle dispersion model	Minutes to hours
3	Resolution of the flow around the buildings with the complete set of equations (CFD methods such as RANS or LES)	In general, Eulerian transport and dispersion model	Hours to days

*On adapted computational resources, e.g. a basic laptop for type 1 to a large workstation for type 3

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Important statements in the BPG – 1

- ADMs and ERTs can provide supporting information whether the releases are long (some hours for continuous releases) or short (some seconds or minutes for puff releases) as, in the latter case, the end of the release is not the end of the crisis

- Experts agreed that throughout the emergency, a major challenge is to have the best possible representation of the past events and the evolution of the situation
  - Even if the nature of the release is not precisely known, a preliminary flow and dispersion computation is instructive
  - A realistic calculation performed during the early stages of an emergency can provide useful information regarding features of the dispersion in complex built-up environments that are not intuitive
  - This information can be valuable to decisions regarding the intervention of rescue teams, even if the exact concentration levels are not yet known

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Important statements in the BPG – 2

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- The availability of proper inputs plays a crucial role for obtaining reliable results
  - From sensitivity analyses, the more detailed these are, the better models perform
  - Nevertheless, the models appear robust even when dealing with poor driving information, as will be the general case following accidental releases
  - Thus, they are valid tools and can be applied with reasonable confidence, even considering the uncertainties when dealing with unexpected situations

- The choice of the modelling approach involves a balance between the model performances, its reliability, and the run-time effort
  - Different modelling approaches can be used in different phases of the response
  - A criterion to be considered when adopting a modelling tool is that a fast but inaccurate model output can compromise the effectiveness of a response action

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The final part of the BPG…

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- The final part of the BPG addresses commonly asked difficult questions such as:
  - How to deal with a lack or the uncertainties of the input parameters (source term, meteorological data…)?
  - How to use in-field measurements for improving ADM predictions?
  - How to produce reasonably conservative results?
  - How to overcome different results obtained by different models or operators?
  - How to reconcile the needs and demands of the emergency players?
  - Etc.
- The reader is referred to the BPG for the answers given by the group of experts…

Conclusion – 1

- Summary of the BPG statements and recommendations built on the consensus among the international experts involved in the COST ES1006 Action…
  - The use of ADMs in an emergency response does not correspond to the state-of-the-science of the 4D dispersion modelling and more efforts should be done to promote the use of up-to-date models for emergency preparedness and response
  - Simple Gaussian models are still the models most often used for risk assessment and emergency response; without enhancements to predict dispersion in industrial or urban built environments, these models may provide misleading outputs
  - Gaussian models might be advisable only on condition that they take account of buildings in some simplified way and are applied in the same configurations
  - Lagrangian models taking account of the buildings may give accurate results in the order of 10-30 minutes with moderate computational resources; input turbulent flow data models including buildings effects may be provided on-line by diagnostic flow or CFD RANS models with some approximations, or off-line by pre-computed and tabulated CFD approach (RANS or LES)
  - Eulerian models with the same input turbulent flow data as for Lagrangian models may be used when they are able to meet the time constraints of the event phase

Conclusion – 2

- The Action identified the necessity for modellers to engage with stakeholders, as this is a major condition for ensuring that the results from ADMs or ADMs results are trusted, and thus used by emergency responders and decision makers

- The development of ADMs in ERTs should not solely respect scientific criteria, but also meet practical criteria (about the response time, interface, outputs, etc.)

- R&D in the field of atmospheric dispersion and impact assessment should not only focus on physical modelling, but also consider the adequacy of the decision-support tools to meet the needs of the user organizations and civilian security missions

Questions?