Improving Airport Safety Against CBRN Threats

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TNO | Kennis voor zaken

Introduction

- How to balance protection versus economic value generation rate
- Threat evaluation as a tool to quantify the protection effort in airport safety
- How to select CBRN-scenarios
- Toxicity etc on the consequences of incidents
- Identifying the vulnerability of objects and the requirements for mitigation measures
- Effects of uncertainty in input parameters such as geometry, meteorology,

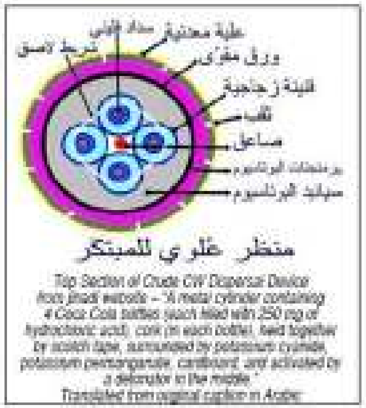
Introduction

- Traditionally CBRN associated with "catastrophic" large-scale events

- Modern opinion associates CBRN more and more with "opportunistic" terrorism
  - Purpose
    - *Create fear*
    - *Create big impact*
    - *Create logistic damage*
  - Psychological effect of CBRN incidents
  - number of casualties of secondary importance -the use of a HOAX already may be sufficient-

- Large diversity in high-value assets and strong dependency of society on these assets renders these as attractive targets for opportunistic CBRN attacks

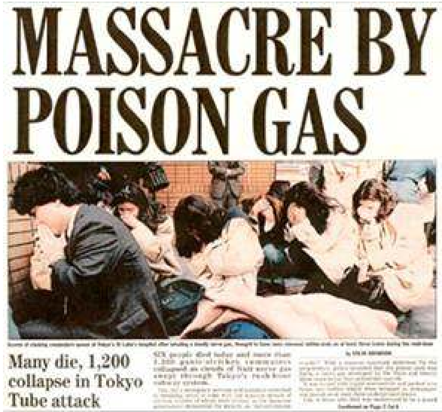
- Attacking a modern society is easy



Introduction

Need for building protection

- Modern society characterized by high dependence on a limited number of high-value assets
- Disruption of these assets may cause large economic, social and political damage
- Large number of these assets are concentrated to a fixed location/building
  - Political activity => e.g. parliament, ministries,
  - Logistics => e.g. airports,…
  - Health care => e.g. hospitals, …
  - Energy => e.g. power stations,…
  - Recreation => e.g. sport facilities


MASSACRE BY POISON GAS

Many die, 1,200 collapse in Tokyo Tube attack

- To protect society, protection of buildings against disruption is essential

How to quantify the protection effort

- Primary purpose of these assets is to generate (economic) value

- Installing measures to improve building safety will have an adversely affect to the (economic-)value generation rate

- 99.99….99 % of the time no incident ⇔ economic consequences of a single incident may be huge

- How to balance
  - Protection ⇔ (economic-)value generation rate
  - Threat evaluation as a tool to quantify the protection effort

Obtaining numbers by scenario analysis

- Obtaining numbers
  - extrapolating from previous incidents
    - Extremely little or no previous experiences
  - extrapolating from similar types of incidents
    - E.g bombings, however similarity is different
  - scenario development and scenario evaluation
    - The only limit is our imagination (which indeed may be too limited)

What is a Scenario?

- Scenario
  - Any story describing the unfolding of an incident and containing a combination of:
    a location, a time, a release method, an agent, incident response procedures, etc…
  - The combination of location, release method, etc…
    allows quantifying the consequences by simulation

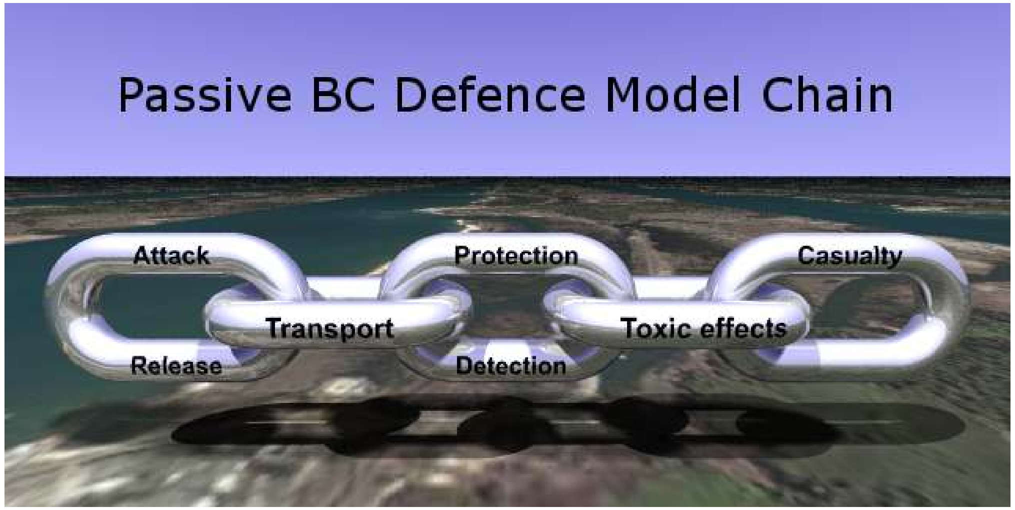
Scenario creation: parameters

Agent	Environment	Dispersion method	Consequence

Chemical
    Volatile
    Persistent
    Blistering
 	
Biological
 	
TIC
	Indoor
	    Layout
	    Ventilation
	    Number of people
	
	Outdoor
	    Nearby plant
	    Nearby building
	    Site
	
	Meteorological data
		Release
		    Evaporation
		    Dispersion
		    Aerosol
		    Vapour
		    Particles
		    Droplets
		
		Air conditioning
		    Control system
		    Filtering
		    Detector
			Casualties
			
			Epidemiological
			
			Logistic
			    Operational
			    Financial
			    Reputation
			
			Environmental
			
			Fear creation

Simulation tools for CBR(N) scenario analysis

- Required models for full analysis
  - HVAC operation,
  - Meteorology,
  - Release/dispersion/deposition of agents
  - Filter performance
  - Casualty development
  - Agent-fate
  - Evacuation
  - Panic
  - Etc…



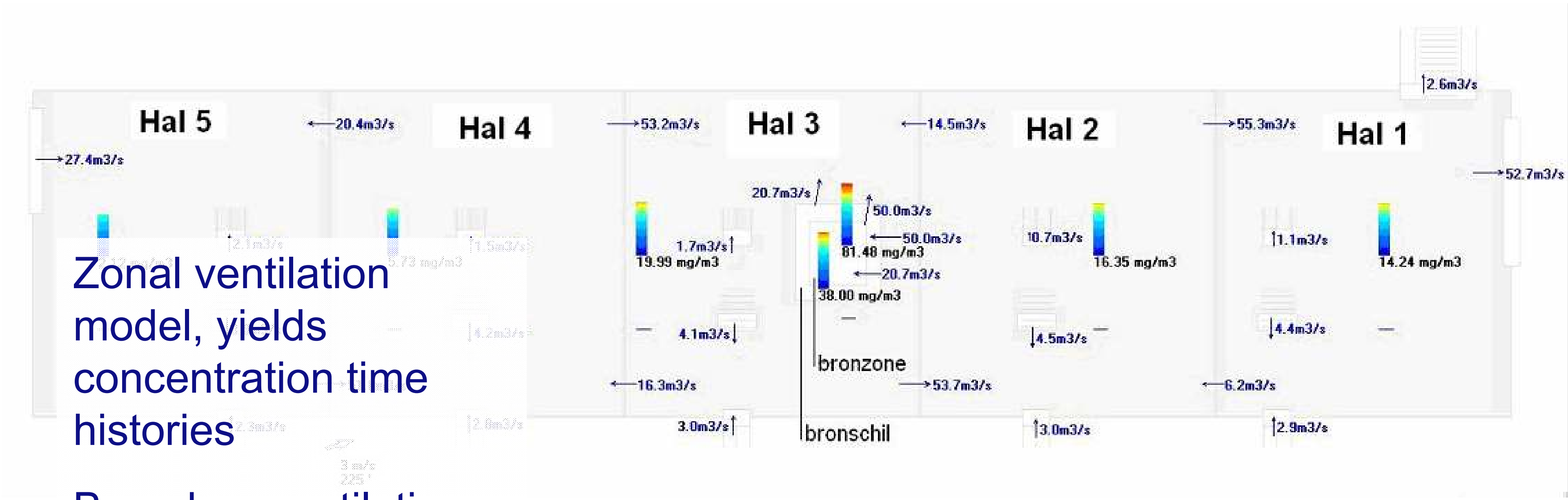
- For all the above mechanisms models are available in different levels of maturity,
- Nobody has been able to combine these into a consistent model chain that describes the whole incident
- Several attempts that describe a part of the chain

Example 1
A sarin incident in a railway station

- Scenario
  During rush hour a significant amount of Sarin (a few liters) is released in one of the major railway stations. The Sarin is carried in bag containing a few glass bottles and released by a small explosive

- N.B. This scenario is one of the largest technically feasible, thus should be considered as a worst-case scenario

Example 1
Indoor transport & Dispersion modeling



Zonal ventilation model, yields concentration time histories

Based on ventilation flows, external wind load, location of the people, filter location and filter performance etc…

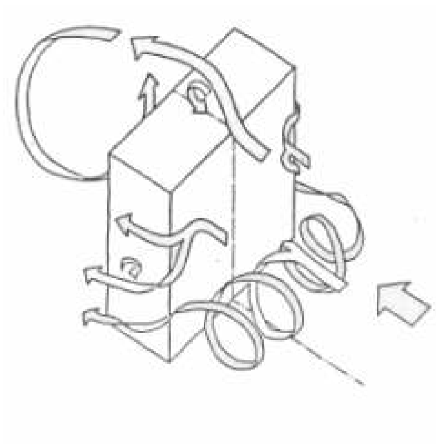


Figure 5: *Air flow around an isolated building*

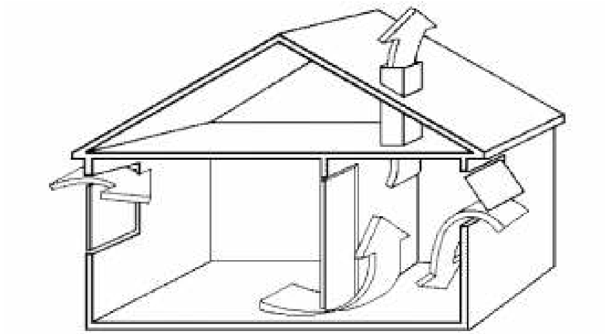
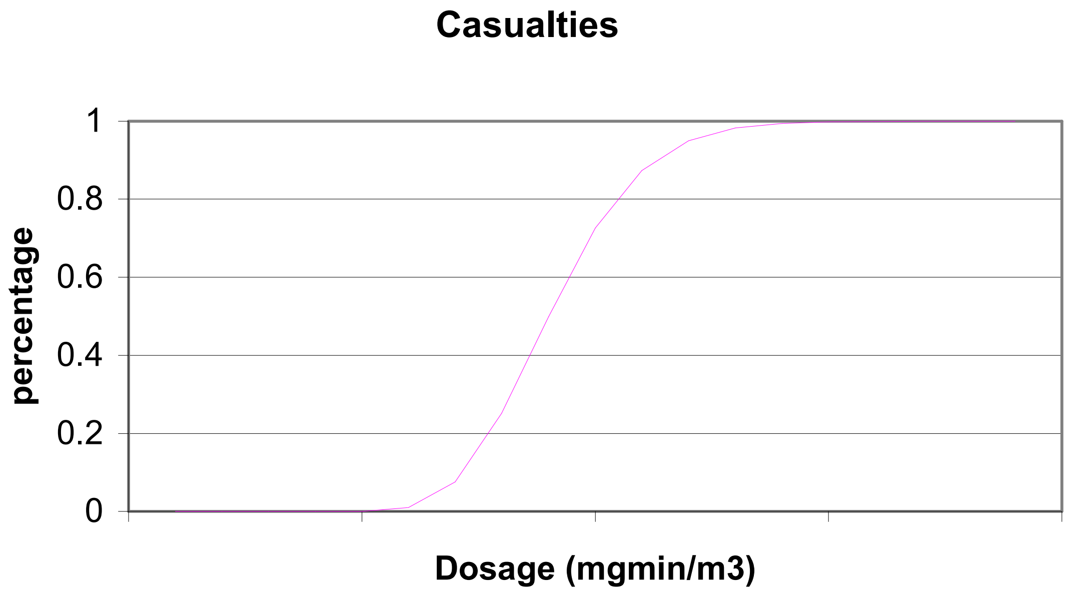


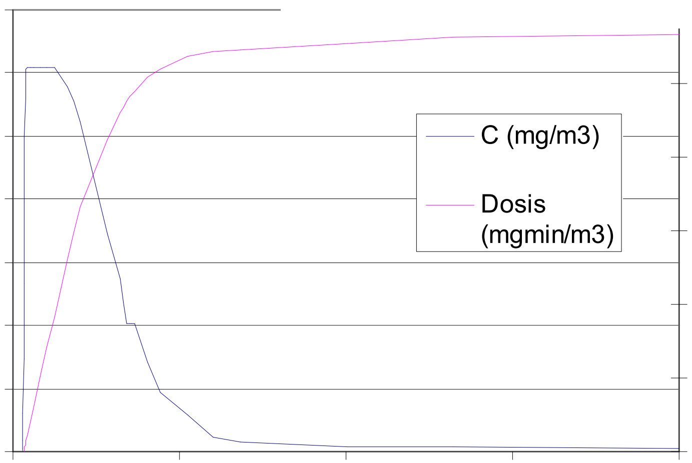
Figure 3: Example of a simple multizone structure (Liddament 1986)

Example 1
Casualty modelling

- Yields the number of causalties

- Based on concentration and dosage history





Example 1
Unfolding of the incident

Time	
1 min	People close to the release will suffer from mild intoxication 47 % of those present in will suffer from severe symptoms
5 min	People close to the release will have inhaled a deadly dosage 95% of the people in hall 1 and all people in the other halls will show at least mild symptoms
10 min	All the people still present show symptoms of poisoning halls 1, 2, 4 en 5 symptoms are mild hall 3, everybody fatally wounded.
15 min	All the people still present show symptoms of poisoning halls 1, 4 en 5: still mild hall 2 83% fatally intoxicated, rest shows severe symptoms
45 min	Everybody (expect those in hall 5) still present fatally intoxicated. 94% of the people present in hall 5 show severe symptoms. First responders in hall 3 only wearing gasmasks will start to show mild symptoms

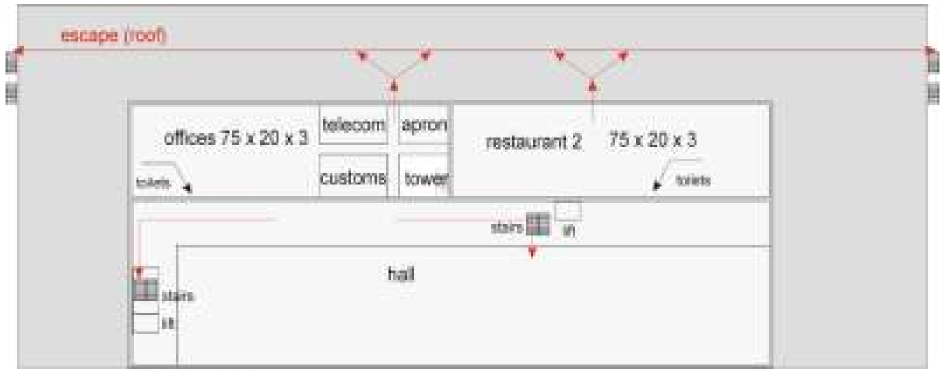
Example 1, results

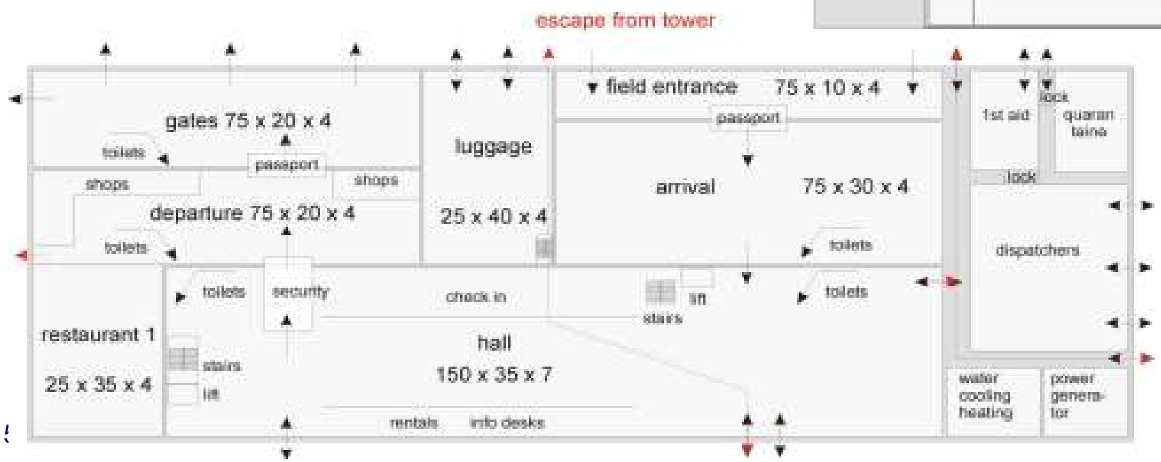
- The amount of casualties in this scenario can be very high
- Especially close to the release, the number of casualties develops very fast in time (in hall 3 large part of the people fatally intoxicated within 5 minutes)

- To prevent large numbers of casualties it is essential
  - to diagnose the incident within an extremely short time (< minutes)
  - to have a very efficient evacuation plan available

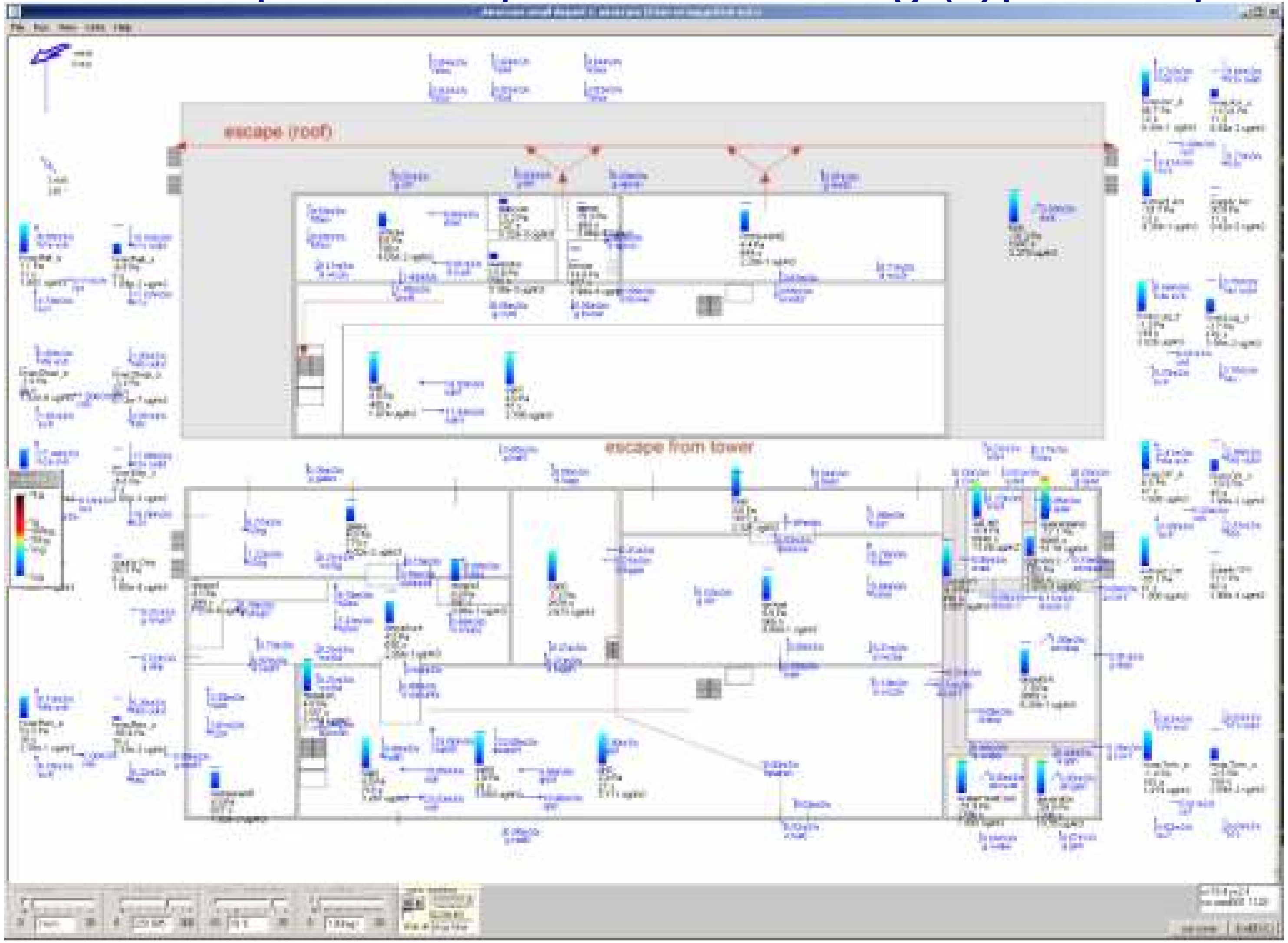
Example 2
Small scale scenario's in a typical airport

- Release of small amount of C-agent in an fictitious airport building (the dream house)
- Release of a small amount of B agent in HVAC system
- Release of a larger amount persistent B or C agent at the parking space outside the building





Example 2
Indoor transport & Dispersion modeling (typical airport)

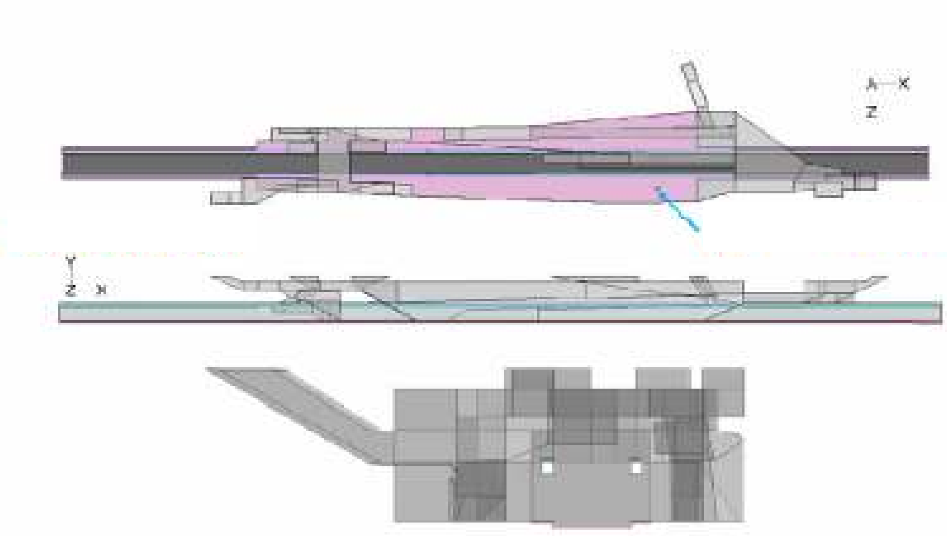


Example 2
Results of the typical airport analysis

- Again for in an “unprotected” building potentially a very large number of casualties
- Time to reach harmful dosages in the order of minutes
- Quick diagnosis of the incident essential
  - Good and well located detection equipment can initiate plans that save lives
  - Filtration in the HVAC system can reduce the number of casualties significantly

Example 3
Release in an underground station

- For diagnosis, a detection capability may be an option
- Sensor placement is often critical and may be strongly object dependent
  - Interaction with HVAC
  - Interaction with entrance and exits
  - Etc…
- Sometimes highly detailed simulation tools (CFD) are required



Benefits of scenario analysis

- Simulation based scenario analysis based shows
  - The vulnerability of objects
    - E.g. amount of potential victims,
  - Requirements for mitigation measures
    - The required escape route capacity
    - Response time/sensitivity requirements of optional sensors
    - Personnel protection requirements for first responders
    - Feasibility of filtering equipment as mitigation measure, etc..

- Using more detailed simulation tools (such as CFD for dispersion) may generate even more information
  - Optimum location for detectors
  - Identification of contamination-prone regions

  - But not always…..

Effect of uncertainty, release location

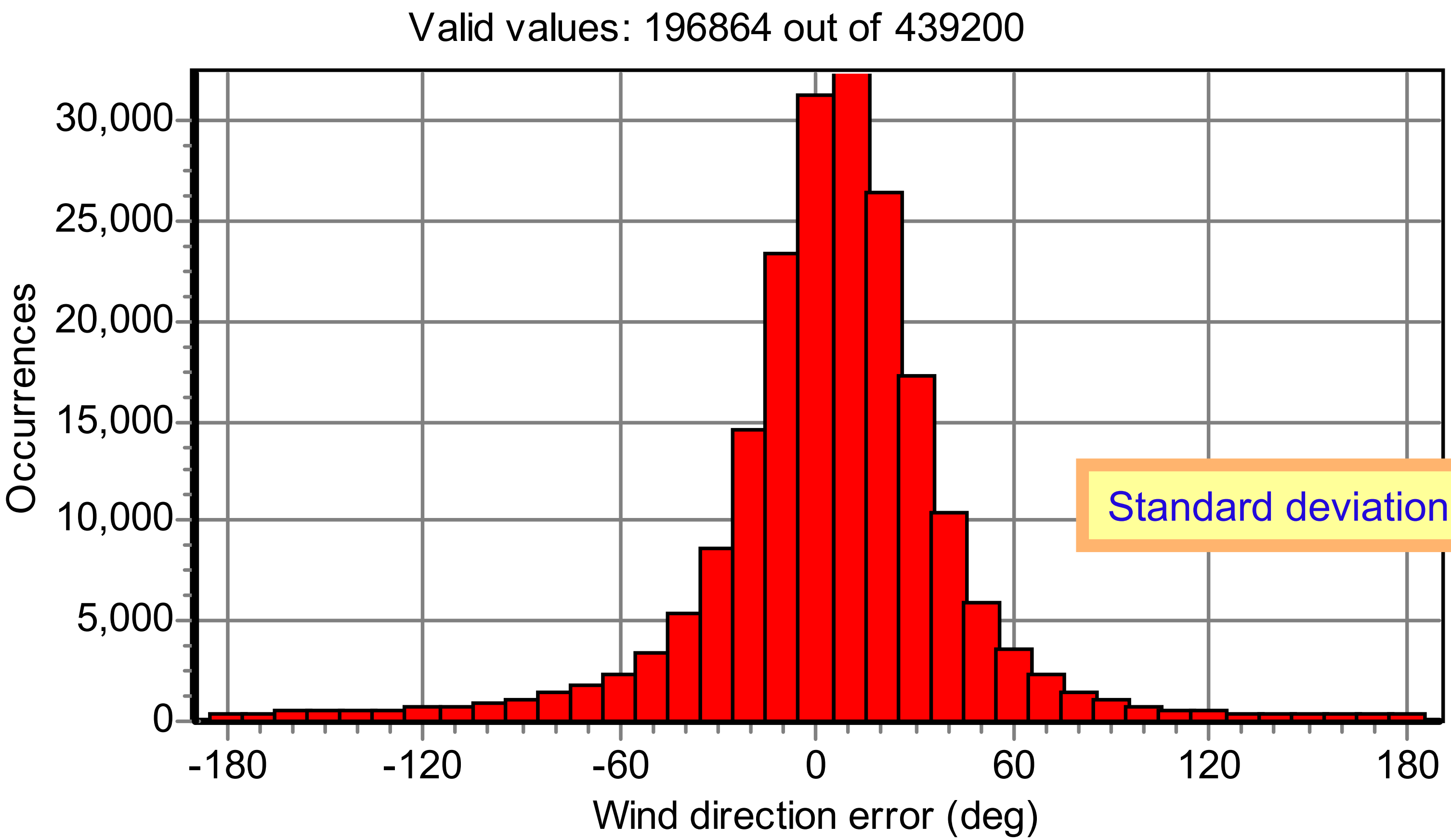
‘channeling’ along river

FAST3D-CT simulation, 2 identical releases at identical meteorological conditions at two different release locations

Additional spreading induced by dense building

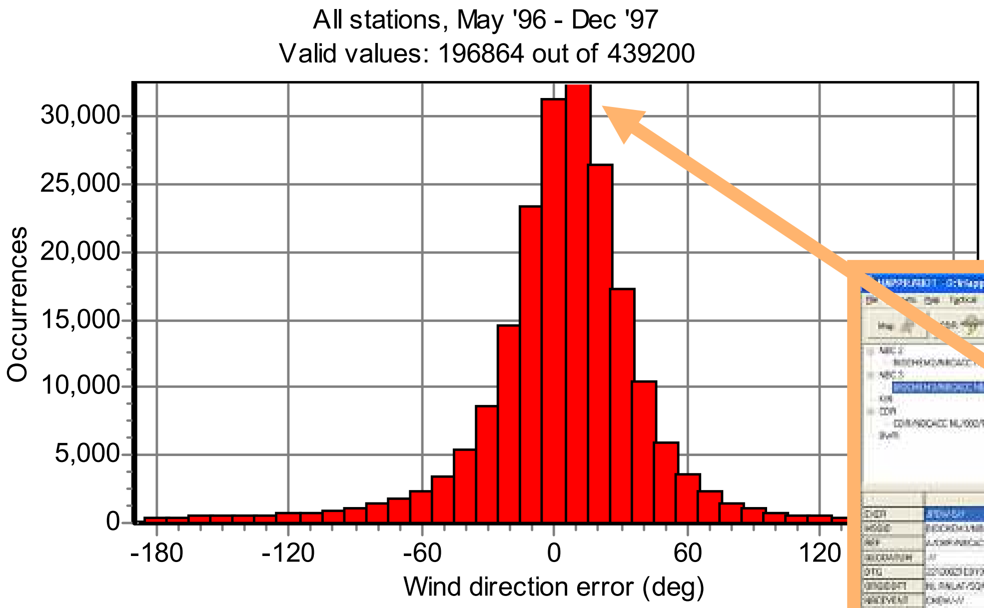
Effects of uncertainty: meteo

Error distribution between predicted wind direction and actual wind direction

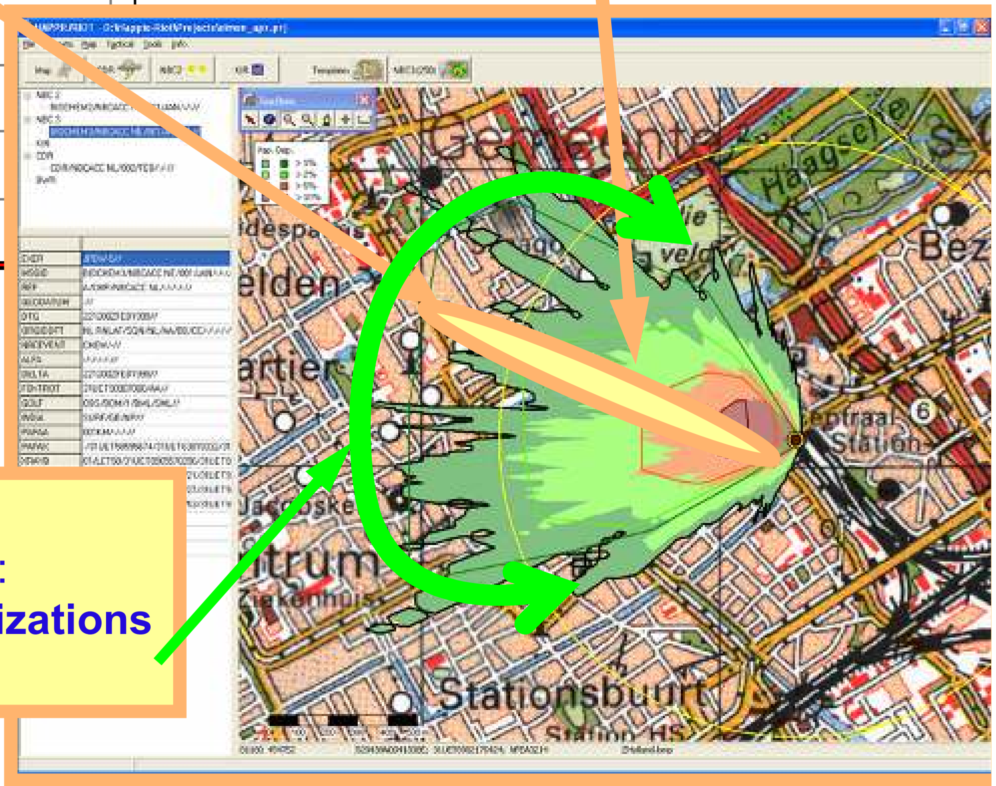


Standard deviation > 30°!

Effects of uncertainty: meteo



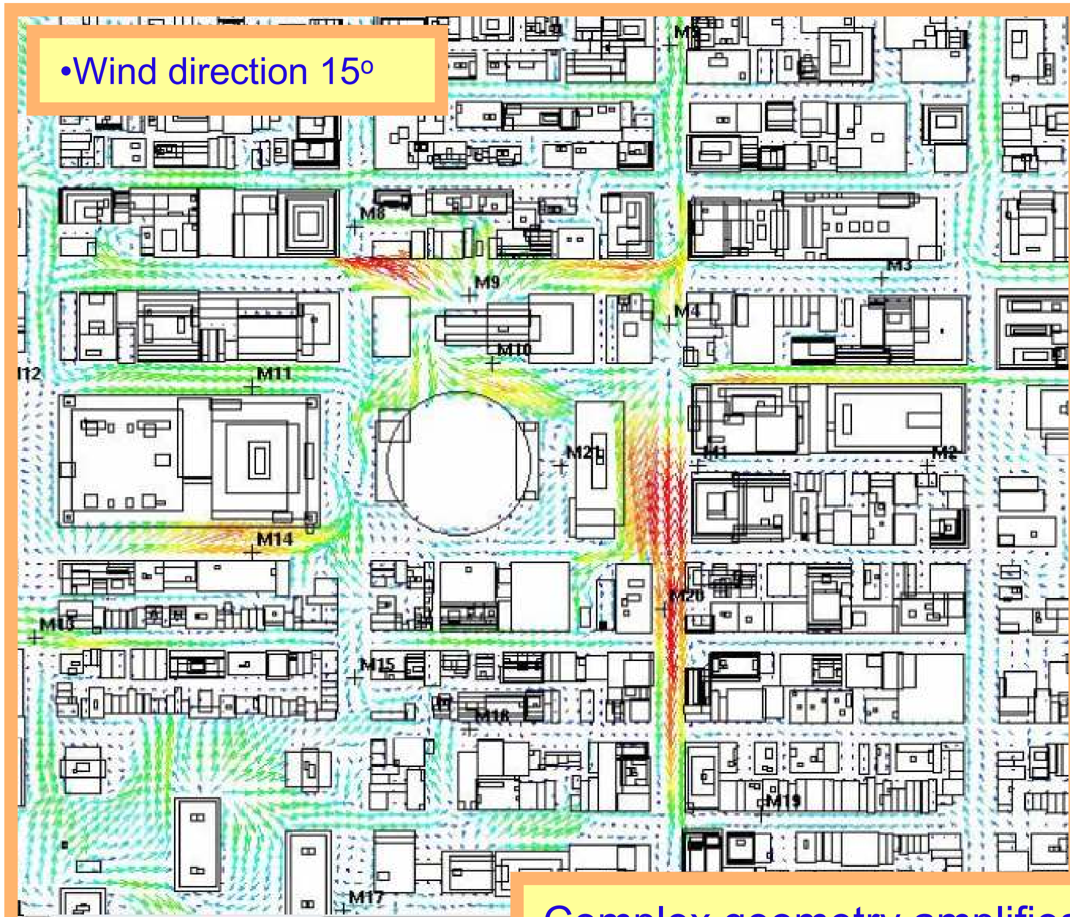
Single realization



For a comprehensive overview of the threat:
An ensemble of realizations is required

Effects of uncertainty: meteo

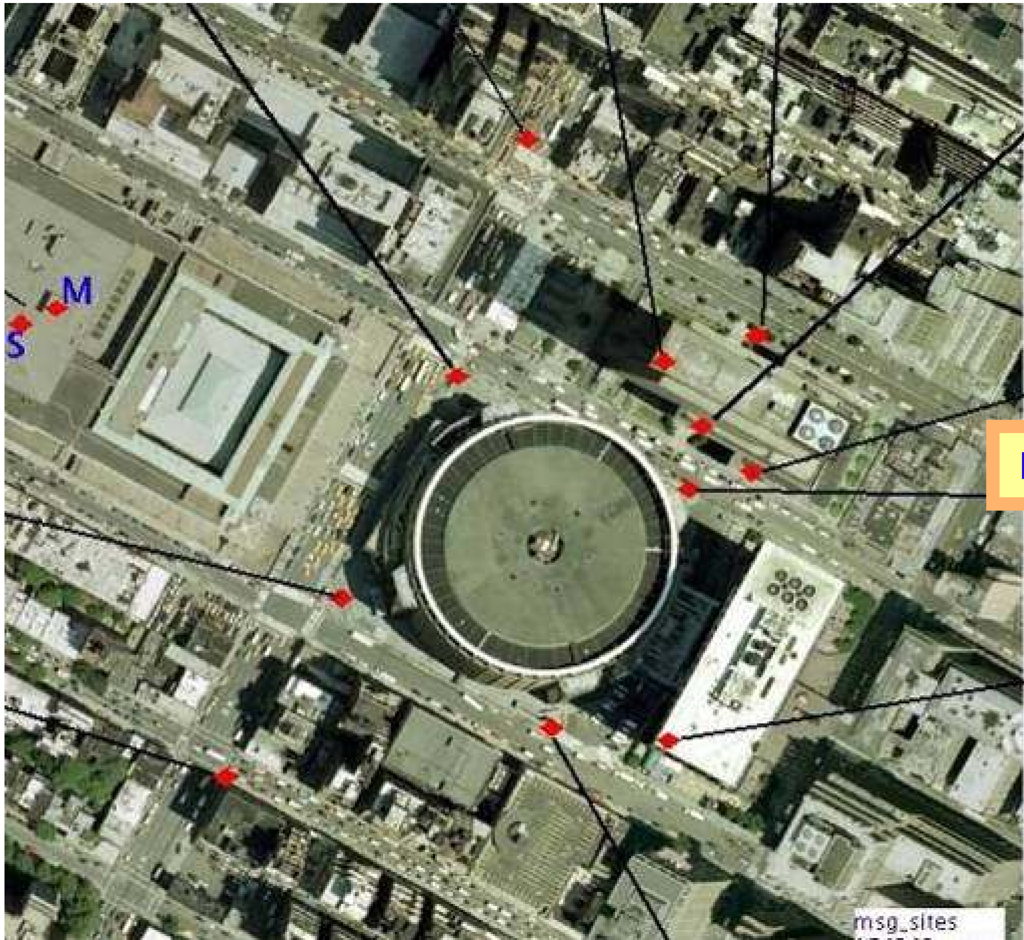
Effect of ‘external wind’ on local flow velocity

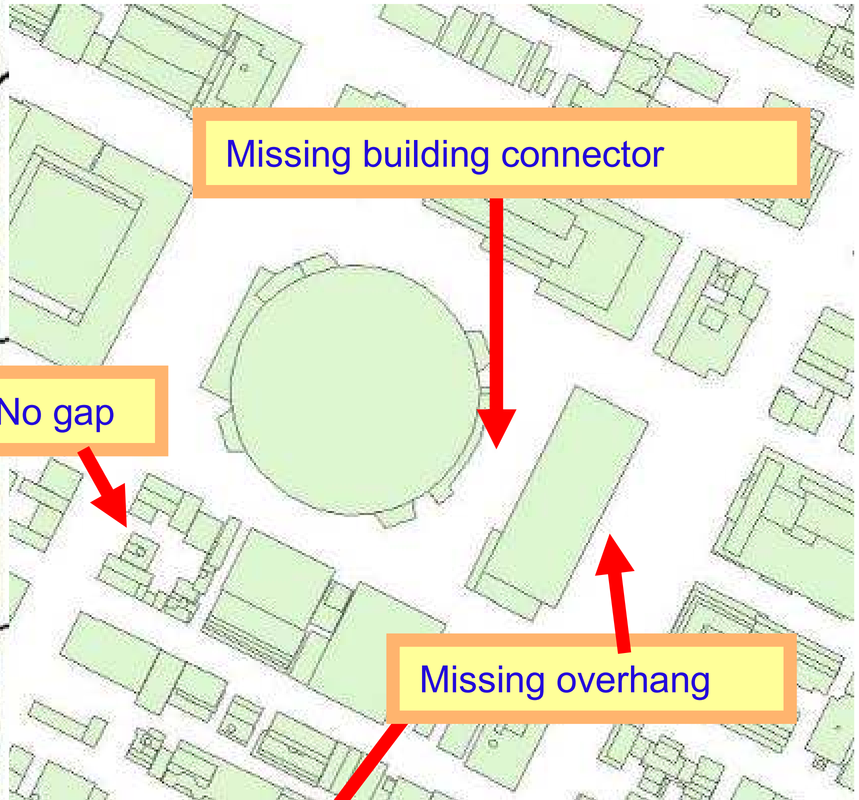


•Wind direction 15^{o}

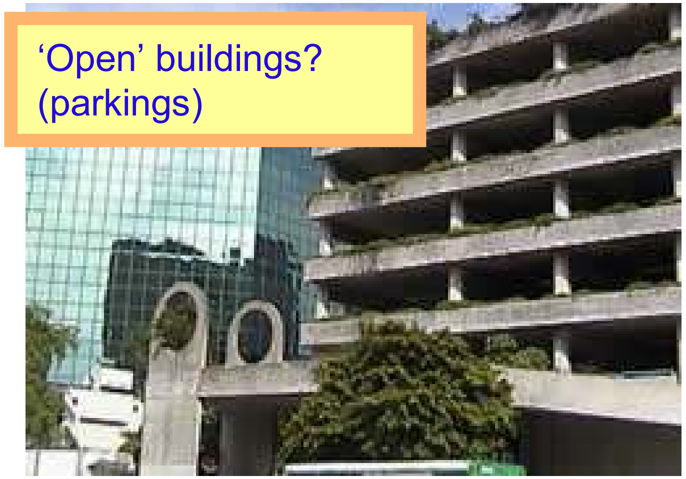
Complex geometry amplifies the effects of meteorological variations

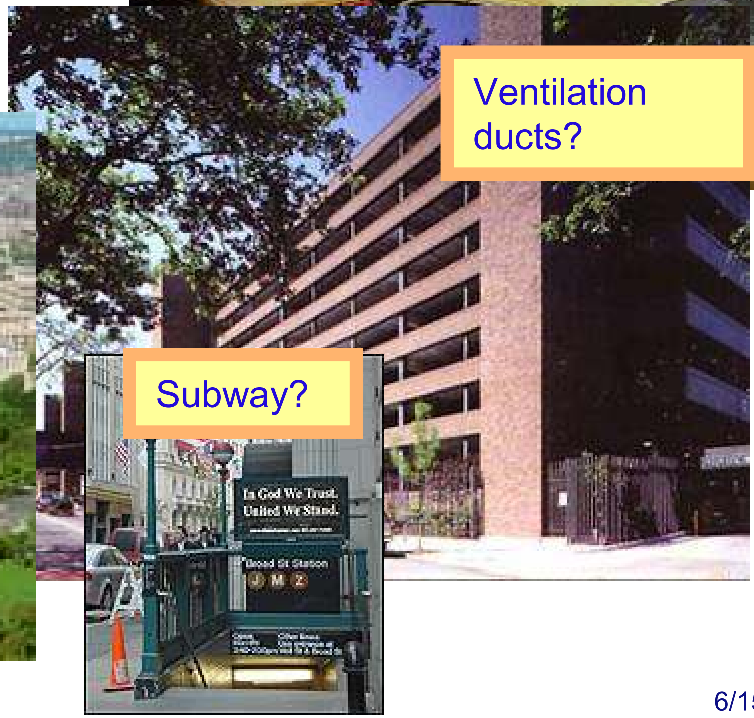
Uncertainty in input, geometry NYC Madison Square Garden simulation



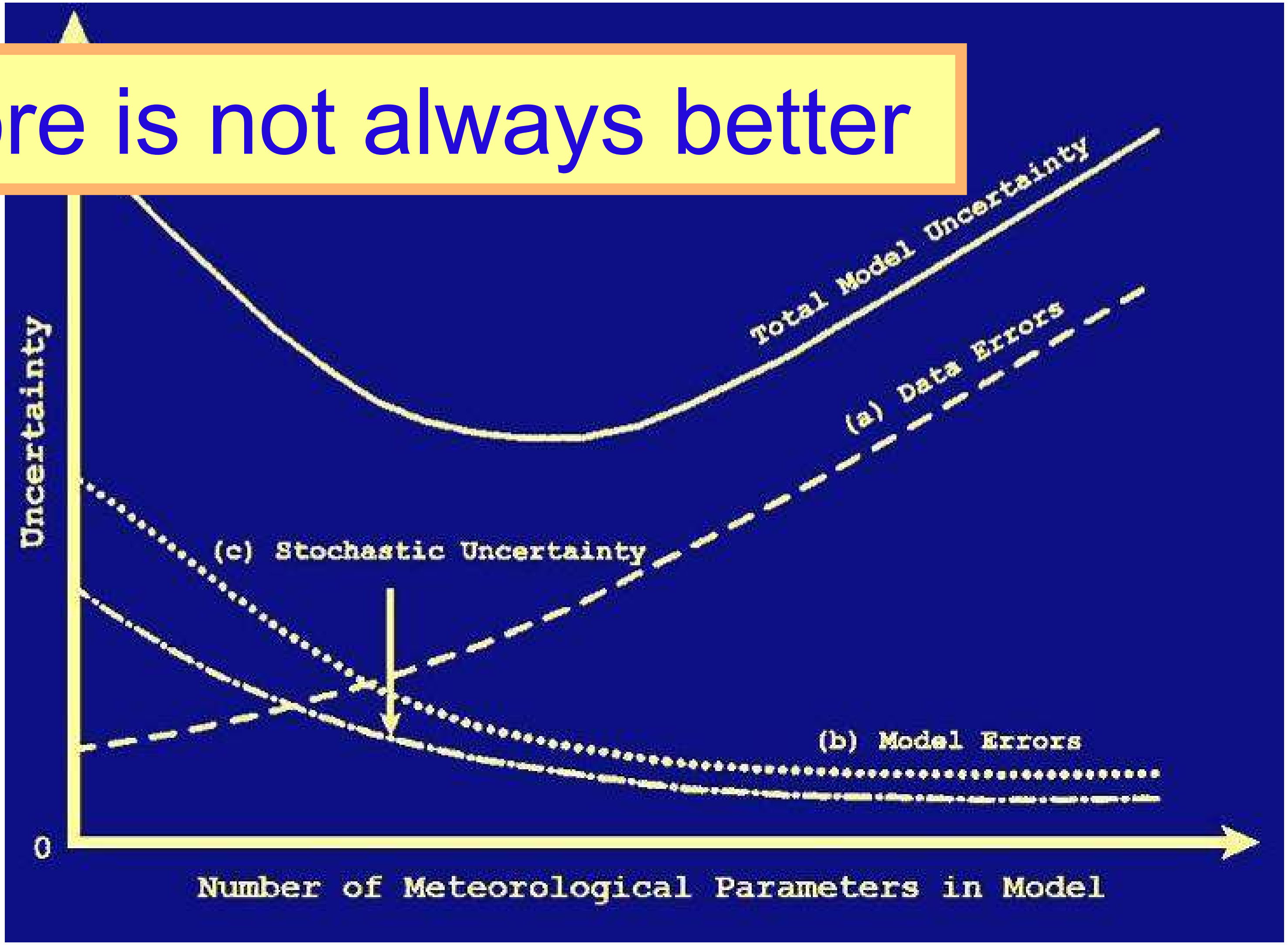


Uncertainty in input, geometry





A familiar plot…



more is not always better

Conclusions

- Improving building safety against CBRN requires
  - Careful balancing of the desired protection vs the burden on the (economic) value generation rate
- To obtain this balance quantitative information is required
- Simulation based scenario analysis is an excellent tool to produce quantitative information
- Simulation examples show that “unprotected” objects may be seriously vulnerable
- Economically feasible mitigation measures may be developed based on these simulation examples
- Key property of simulating CBRN incidents in asymmetric scenario’s is the inherent uncertainty in input parameters
  - => find balance between uncertainty in input parameters to the uncertainty of the simulation models