Offshore Consequence Analysis Using Grid-Based Approach

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Outline

- Background
- Grid-based consequence methodology
  - Fire consequences
  - Explosion consequences
  - Missile consequences
- Case studies
- Comparison
- Concluding Remarks

Background

- Scope
  - Enhancement of industrial safety through use of appropriate models for fire, explosion and missile fragment consequence analysis
- Motivation
  - Protection of people, environment, assets and production
  - Provision of grid-based consequence analysis package for offshore safety

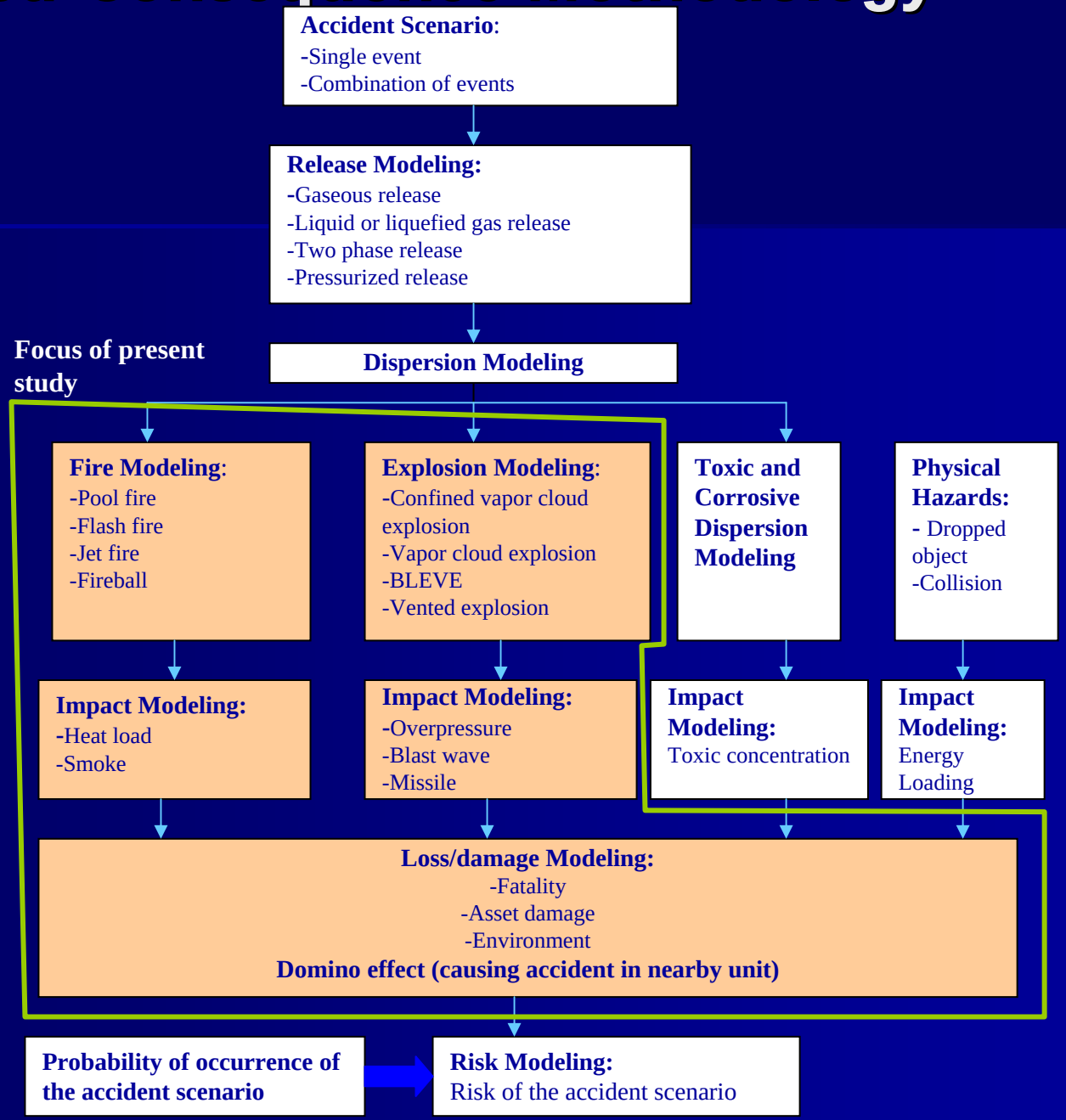
Background

- R. Pula, F.I. Khan, B. Veitch & P.R. Amyotte, *Revised Fire Consequence Models for Offshore Quantitative Risk Assessment*, Journal of Loss Prevention in the Process Industries, **18** (2005) 443-454
- R. Pula, F.I. Khan, B. Veitch & P.R. Amyotte, *A Grid Based Approach for Fire and Explosion Consequence Analysis*, Process Safety and Environmental Protection, **84** (2006) 79-91
- R. Pula, F.I. Khan, B. Veitch & P.R. Amyotte, *A Model for Estimating the Probability of Missile Impact: Missiles Originating from Bursting Horizontal Cylindrical Vessels*, Process Safety Progress, **26** (2007) 129-139

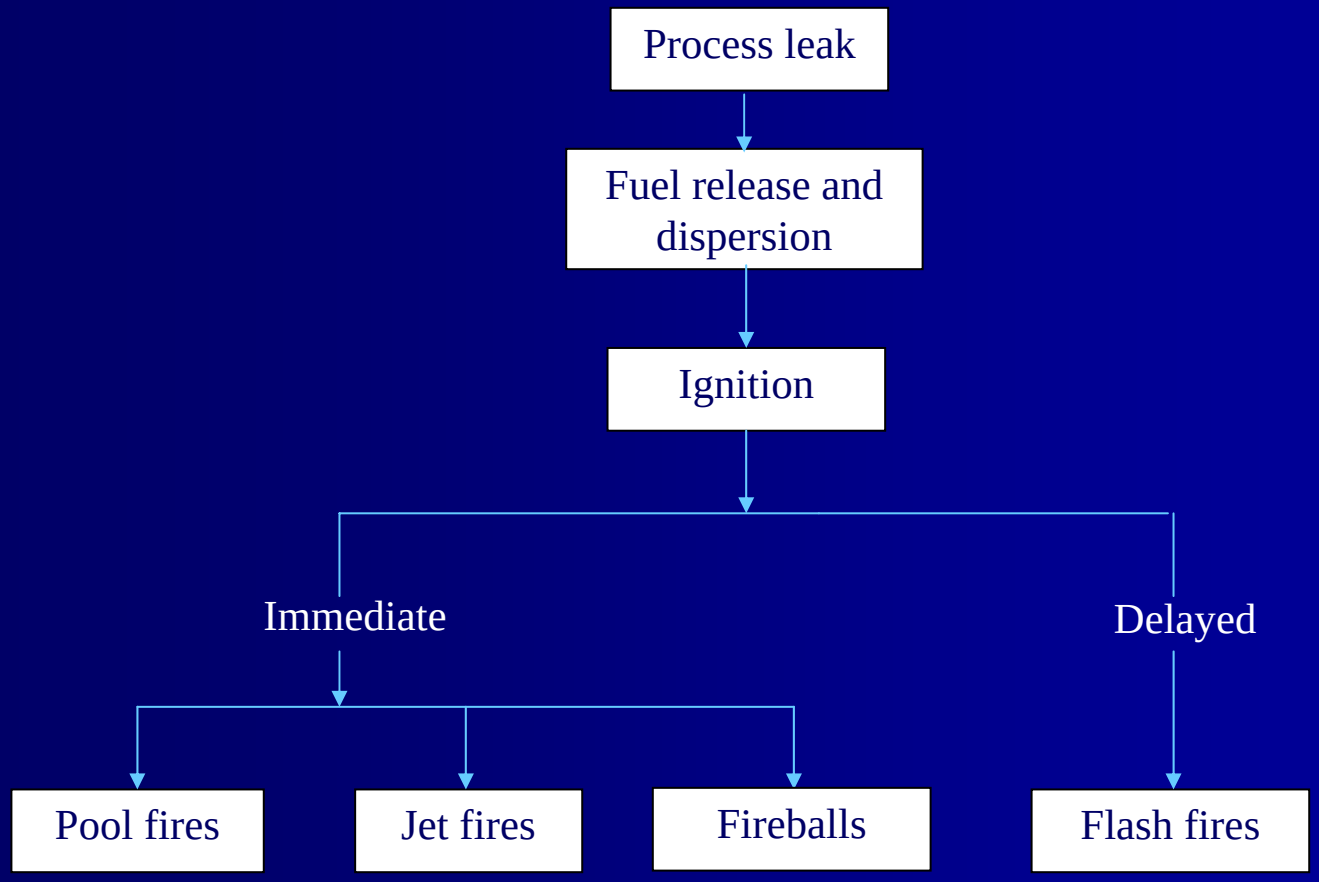
Background

- Simple Consequence Software
  - Advantages: simple, easy to run, less computational time
  - Disadvantages: less reliable results, unable to account for complexity in the system, overall conservative approach
- Complex Consequence Software
  - Advantages: Reliable results, able to incorporate system's unique features
  - Disadvantages: high computational time, highly dependent on input data, significant expertise to run

Grid-Based Consequence Methodology



Fire Consequence Modeling



Fire Classification

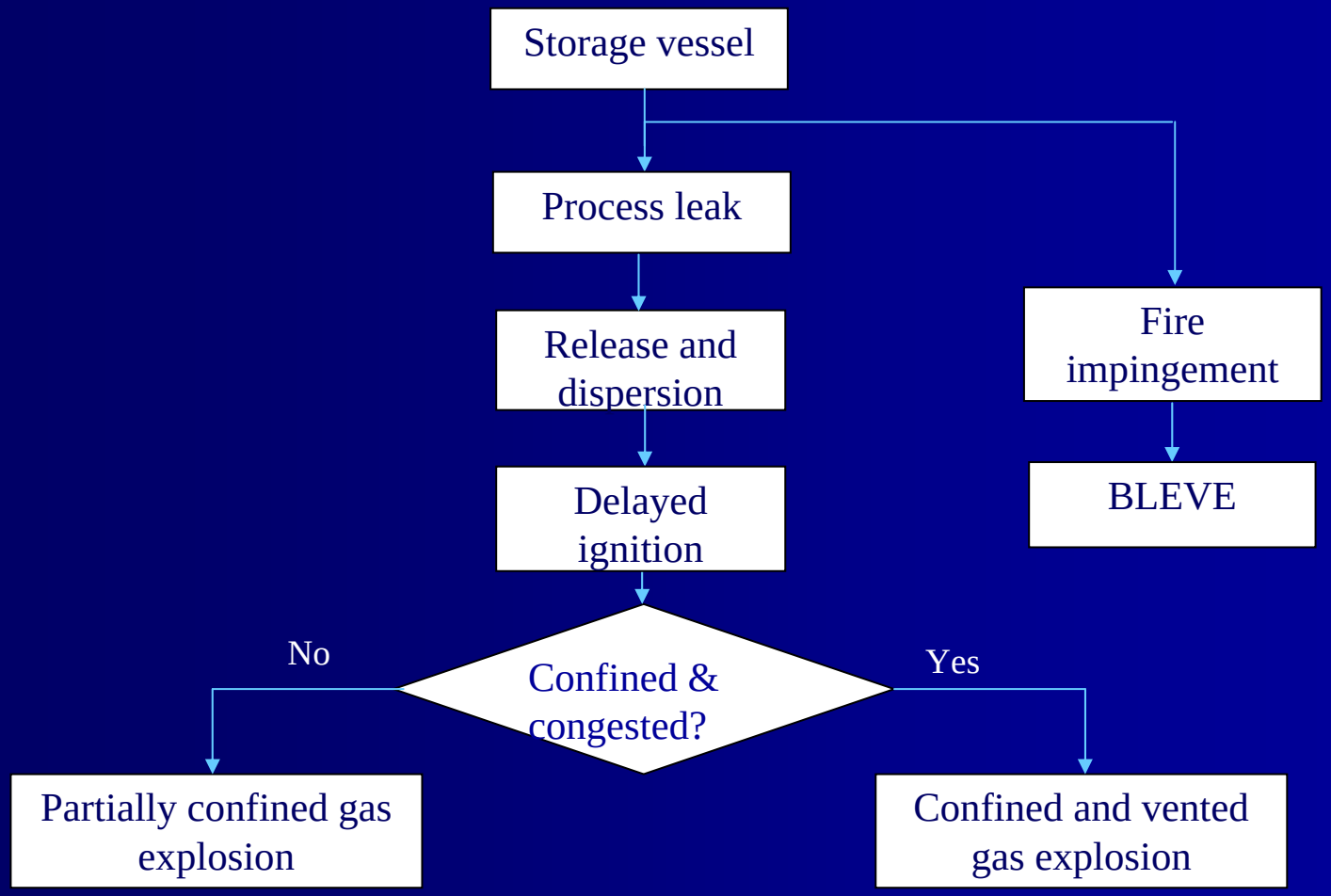
Pool fire

Jet fire

Fireball

Flash fire

Explosion Consequence Modeling



Missile Consequence Modeling

- Modeling Approach
  - Source Object: explosion source that generates fragments
  - Target Object: component that is vulnerable to the generated fragments (missile impact)

Missile Consequence Modeling

- Two credible scenarios
  - *Scenario 1: Impact due to missiles landing within the VA (Vulnerable Area)*
  - *Scenario 2: Impact due to missiles landing beyond the VA (colliding with the target object while in flight before reaching their final destination)*

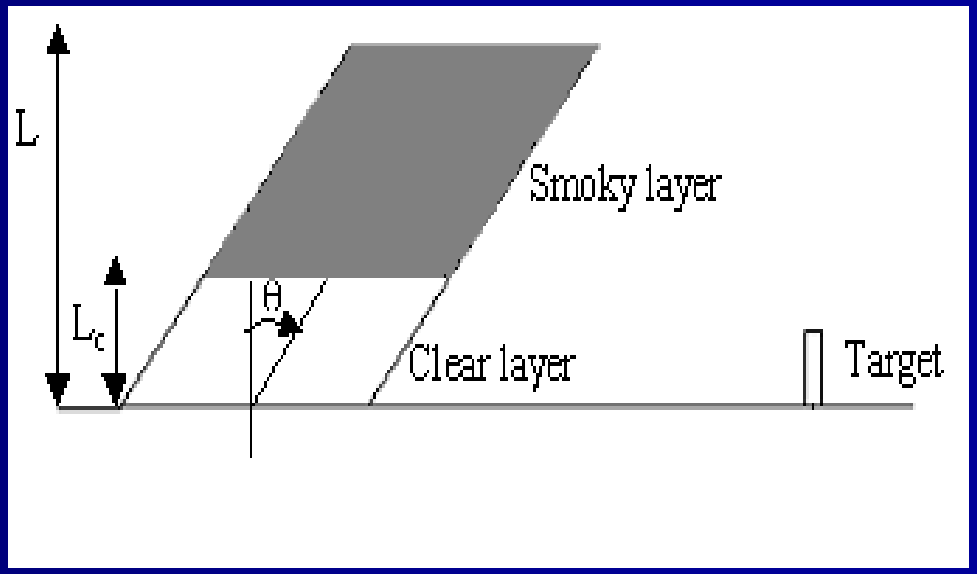
$$P_{overall}(impact) = P_1(impact) + P_2(impact)$$

Modeling Details

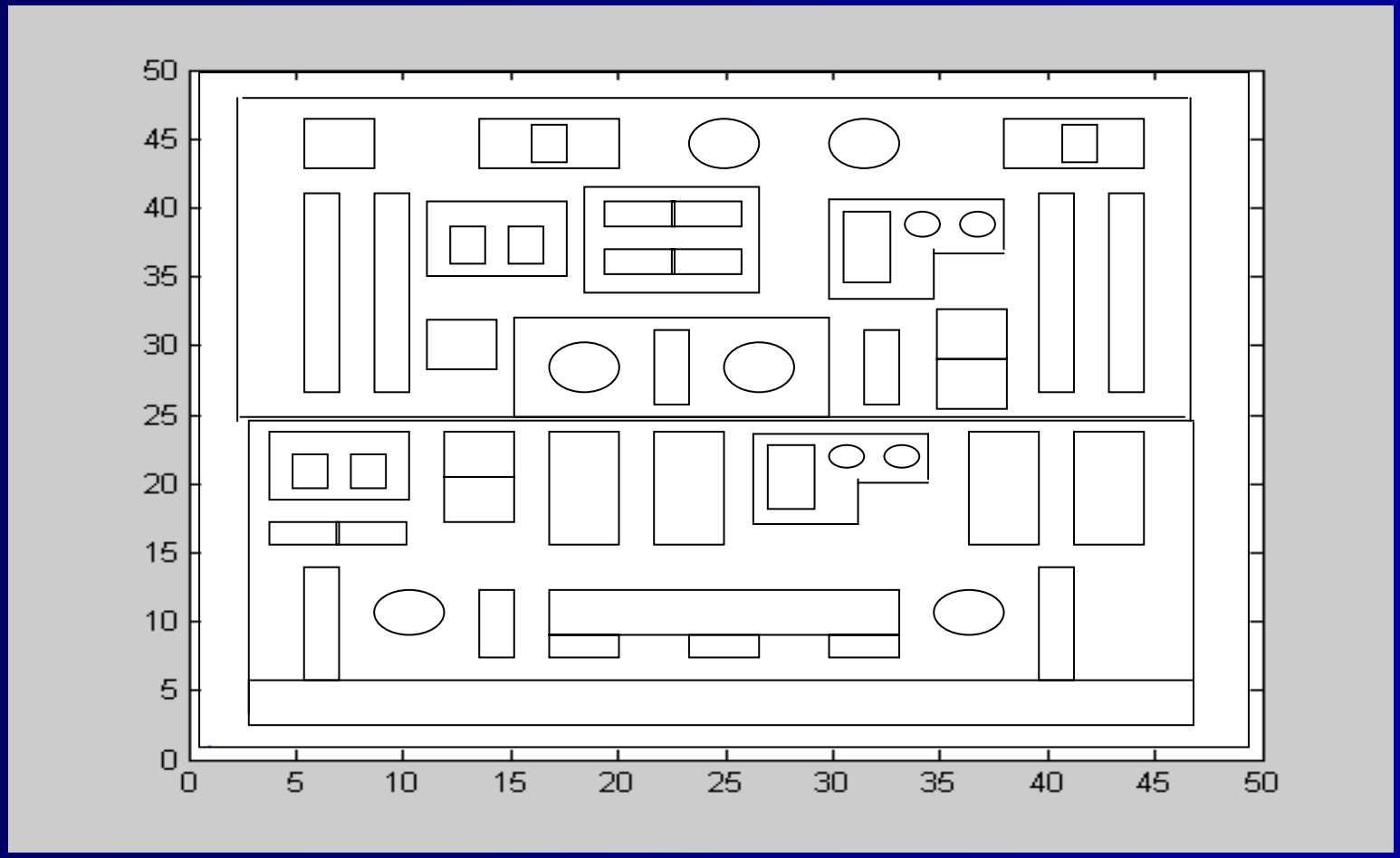
- FIRE MODELING: R. Pula, F.I. Khan, B. Veitch & P.R. Amyotte, *Revised Fire Consequence Models for Offshore Quantitative Risk Assessment*, Journal of Loss Prevention in the Process Industries, **18** (2005) 443-454
- EXPLOSION MODELING: R. Pula, F.I. Khan, B. Veitch & P.R. Amyotte, *A Grid Based Approach for Fire and Explosion Consequence Analysis*, Process Safety and Environmental Protection, **84** (2006) 79-91
- MISSILE MODELING: R. Pula, F.I. Khan, B. Veitch & P.R. Amyotte, *A Model for Estimating the Probability of Missile Impact: Missiles Originating from Bursting Horizontal Cylindrical Vessels*, Process Safety Progress, **26** (2007) 129-139

Example (Fire Model)

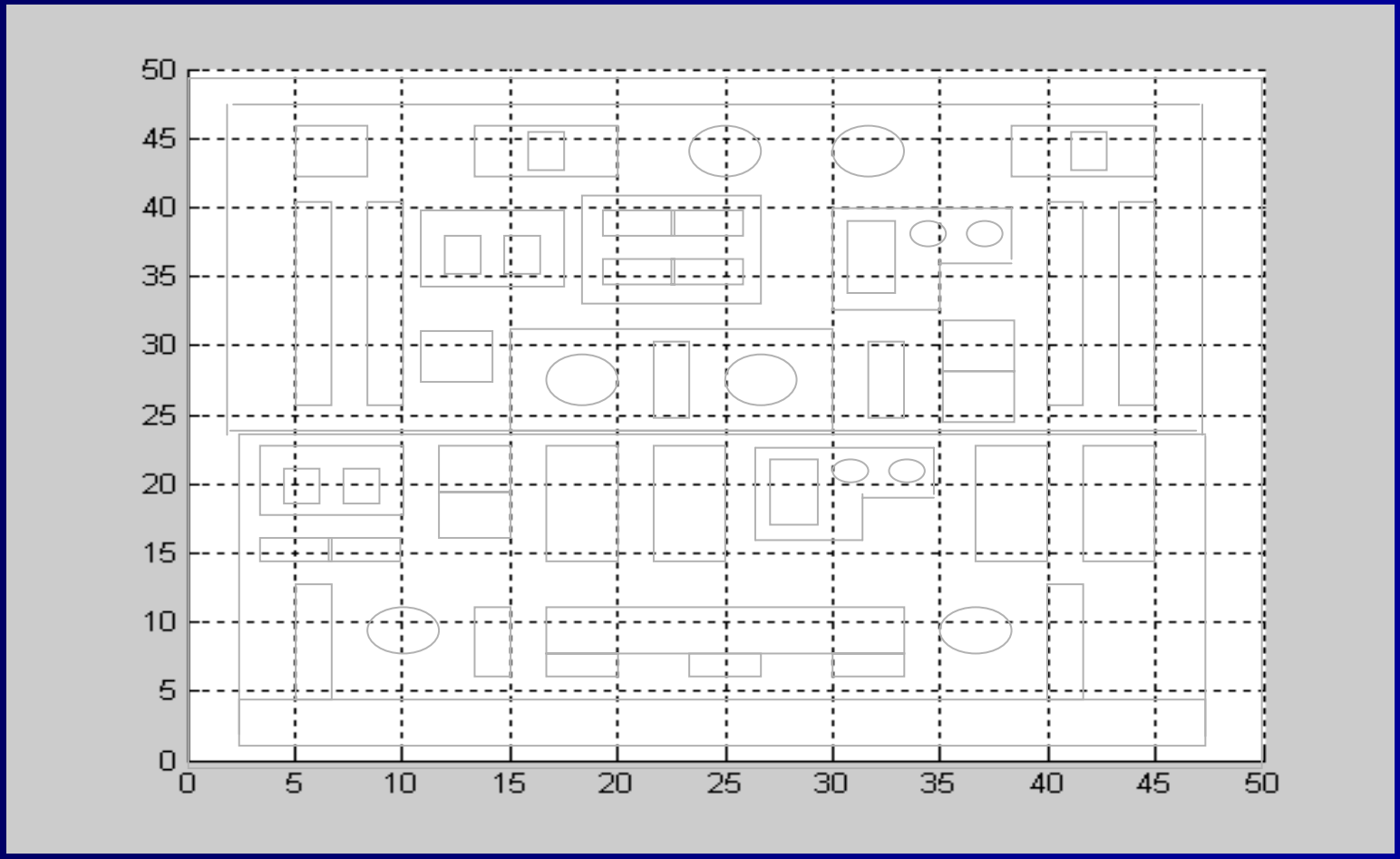
- Pritchard & Binding (1992)
- Johnson (1992) and
- **<u>Rew et al., (1997)</u>**



Grid-Based Approach



Grid-Based Approach



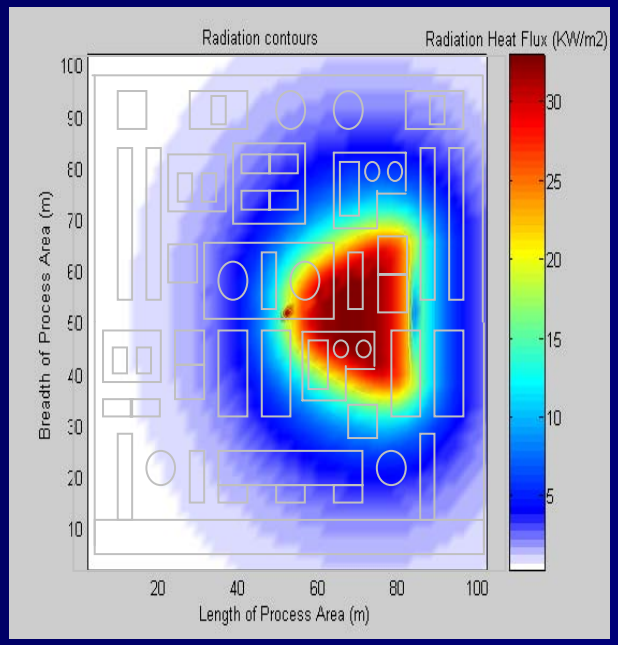
Case Studies

- **Scenario: Flash fire**
- **Results**

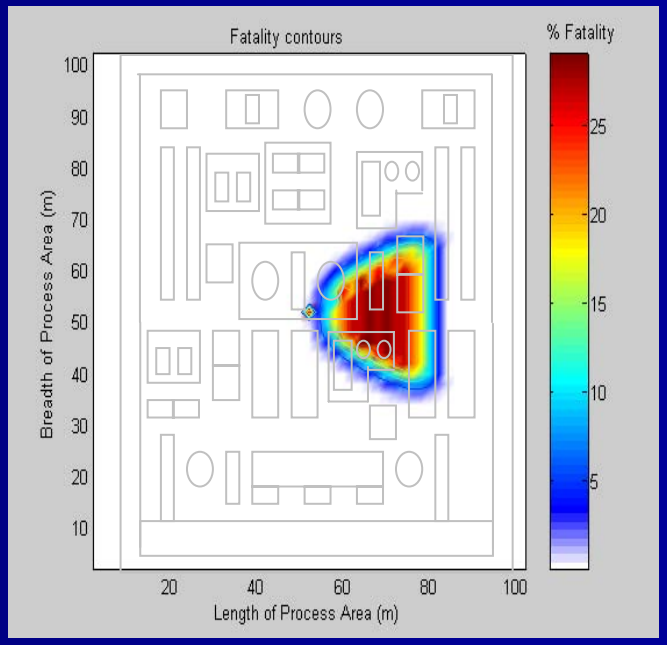
Type of release	SLAB dispersion model		Ignition model		Radiation model			
	Cloud Radius (m)	Cloud Height (m)	Prob. of Ignition	Time for Ignition (s)	Flame Height (m)	Flame Speed (m/s)	Maximum '*q*' (kW/m^2)	Cloud Burn Time (s)
Continuous (10 kg/s)	33.6	1.5	0.76	33	24.1	6	32.9	8

Case Studies

- **Scenario: Flash fire**
- Radiation and Fatality Contours



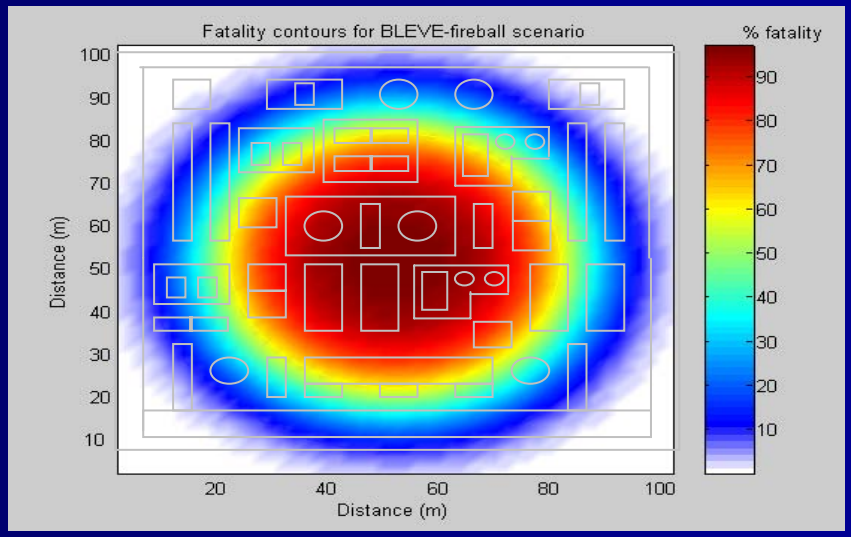
Radiation contours



Fatality contours

Case Studies

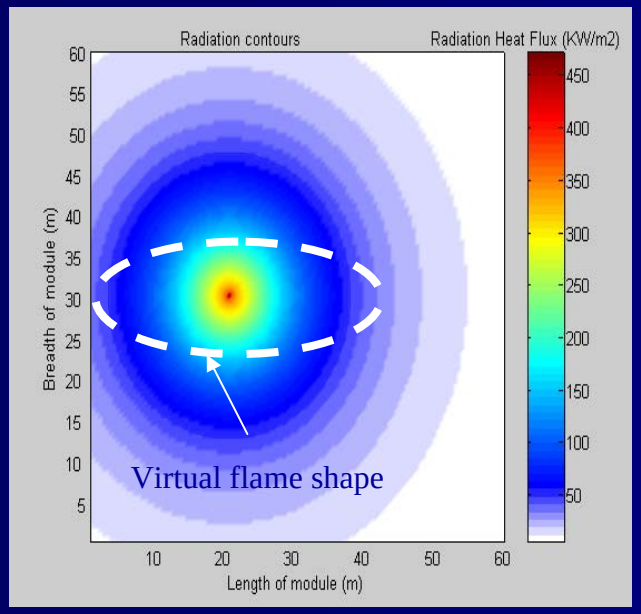
- **Scenario: BLEVE followed by a fireball in an oil separator**



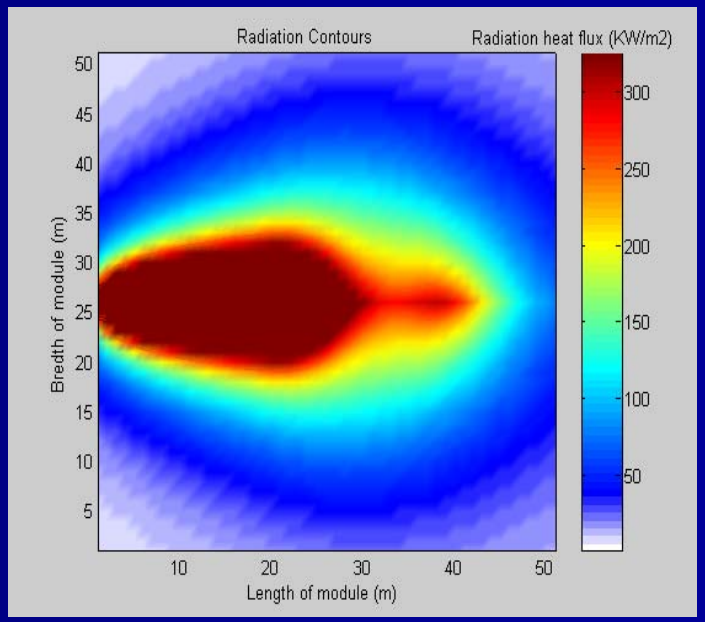
Lethality (overpressure & radiation) contours from a BLEVE - fireball scenario

Comparison

- Scenario: Jet fire
- Radiation contours



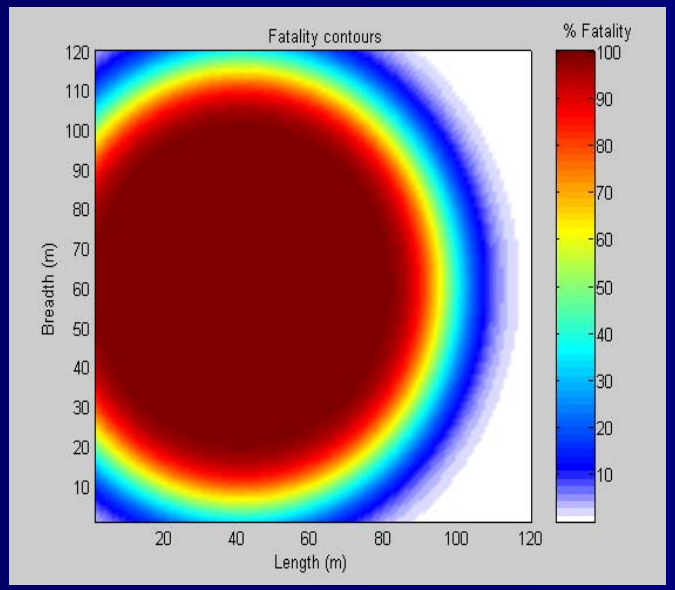
Point model: Plato



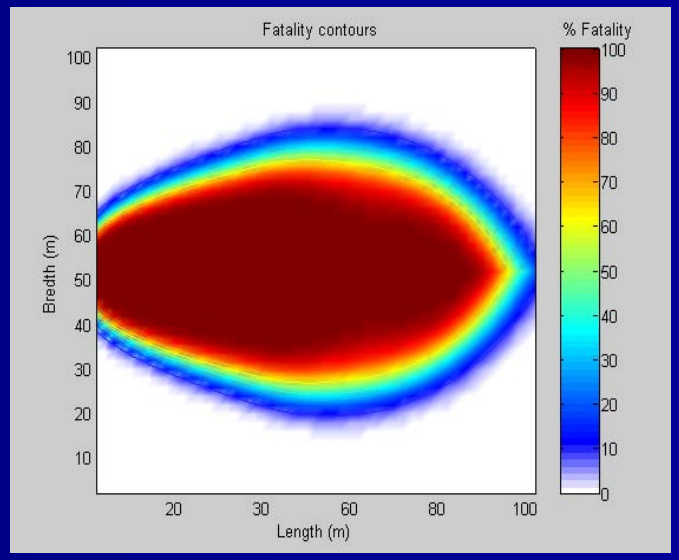
Grid-based approach

Comparison

- Scenario: Jet fire
- Fatality Contour



Point model: Plato



Grid-based approach

Concluding Remarks

Unique features of the discussed methodology:

- Phenomenological approach
- Easy to use
- Less computationally intensive (MATLAB)
- Revisions implemented:
  - Enhanced onsite ignition model
  - State-of-the-art fire and explosion consequence models
  - Fire overpressure model to investigate the possibility of blast effects from fires occurring in confined offshore modules
  - A new probabilistic model to characterize the effects of missiles on the escalation of accidents
  - A grid-based approach to enable better modeling and analysis of radiation and overpressure impact s

Acknowledgements

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