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A novel risk assessment method using dynamic simulation of fire and egress scenarios on off-shore platforms

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A novel risk assessment method using dynamic simulation of fire and egress scenarios on off-shore platforms

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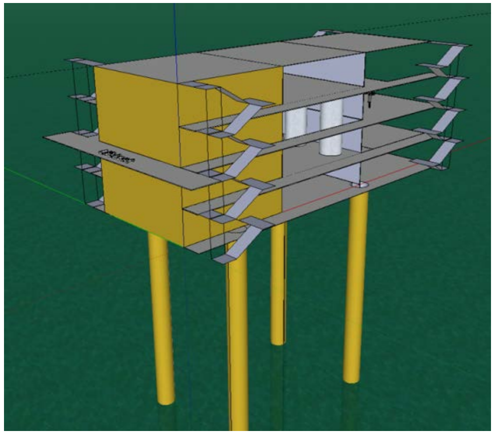
Introduction

- Oil & Gas production is a cornerstone of our society
- The production requires high safety standards
- Risk Assessment & Management is needed to establish and maintain safety standards

New approach feasibility study:

- OPHRA – Offshore Platform Hydrocarbon Risk Assessment
- Alternative QRA method using dynamic modelling



Why is an alternative QRA method useful?

Simplifying the logic

- Present RA apply conventional fault-tree FT and event-tree ET techniques
  - FT and ET easily grow very complex when capturing all possible accident scenarios
- The accident scenarios, e.g. loss-of-containment events, involve several agents and actions, with mutual dependencies
  - Are treated as "independent" and each may have its own timeline, e.g.:
    - Release – dispersion – ignition – fire and explosion
    - Detection - Alarm – escape from module – mustering – evacuation
    - Detection – shutdown and blowdown

Why is an alternative QRA method useful?

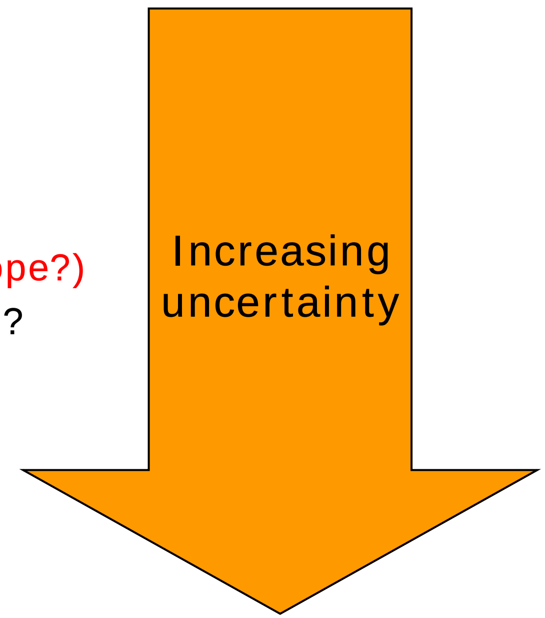
Verifying risk analysis outcomes

Risk analysis' objective is to predict the future

- The outcome cannot directly be validated
- But the assumptions can be reviewed (best knowledge and experience?)

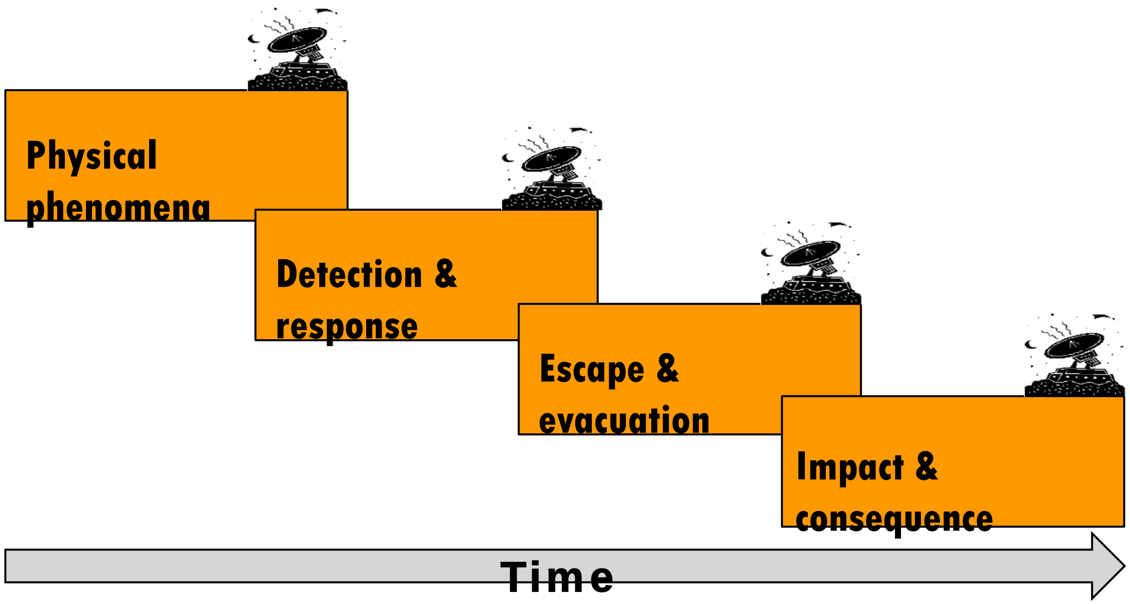
Knowledge and assumptions needed in QRA:

- Structure /operational data
  - Physical layout (simplifications to be made?)
  - Working practices, manning (up to date?)
- Modelling physical phenomena
  - Are models validated? (state-of-the-art? Within scope?)
  - Can models be applied (simplifications to be made)?
- Causal descriptions
  - Are scenarios applicable and consistent?
  - Are scenarios complete (all hazards covered)?
- Probabilistic information from statistics
  - Are statistics valid for the case?



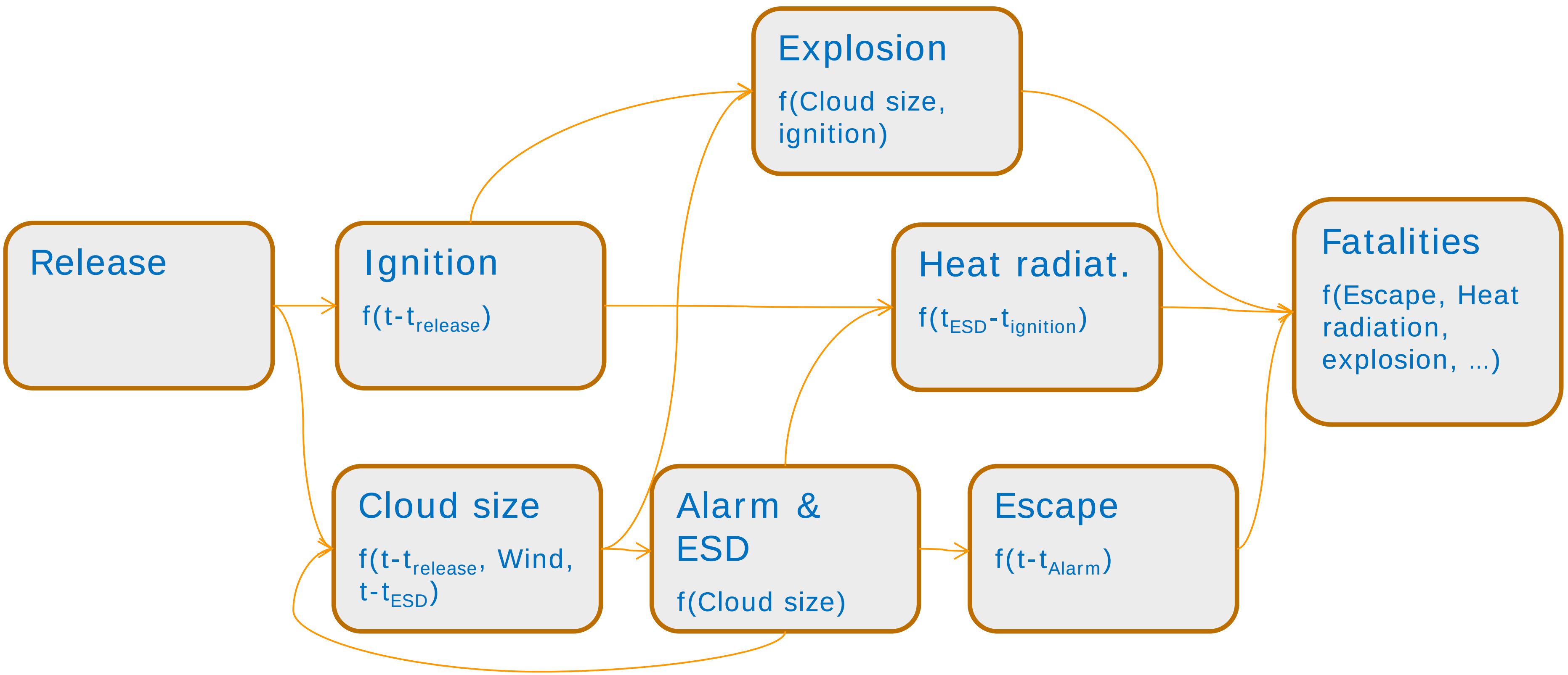
Why is an alternative QRA method useful?

Application of dynamic & dependent models



- The event sequences trigger each other and are simulated concurrently.
- Events taking place in one sequence change the conditions in the other sequences (dynamic interaction)

Interdependencies established

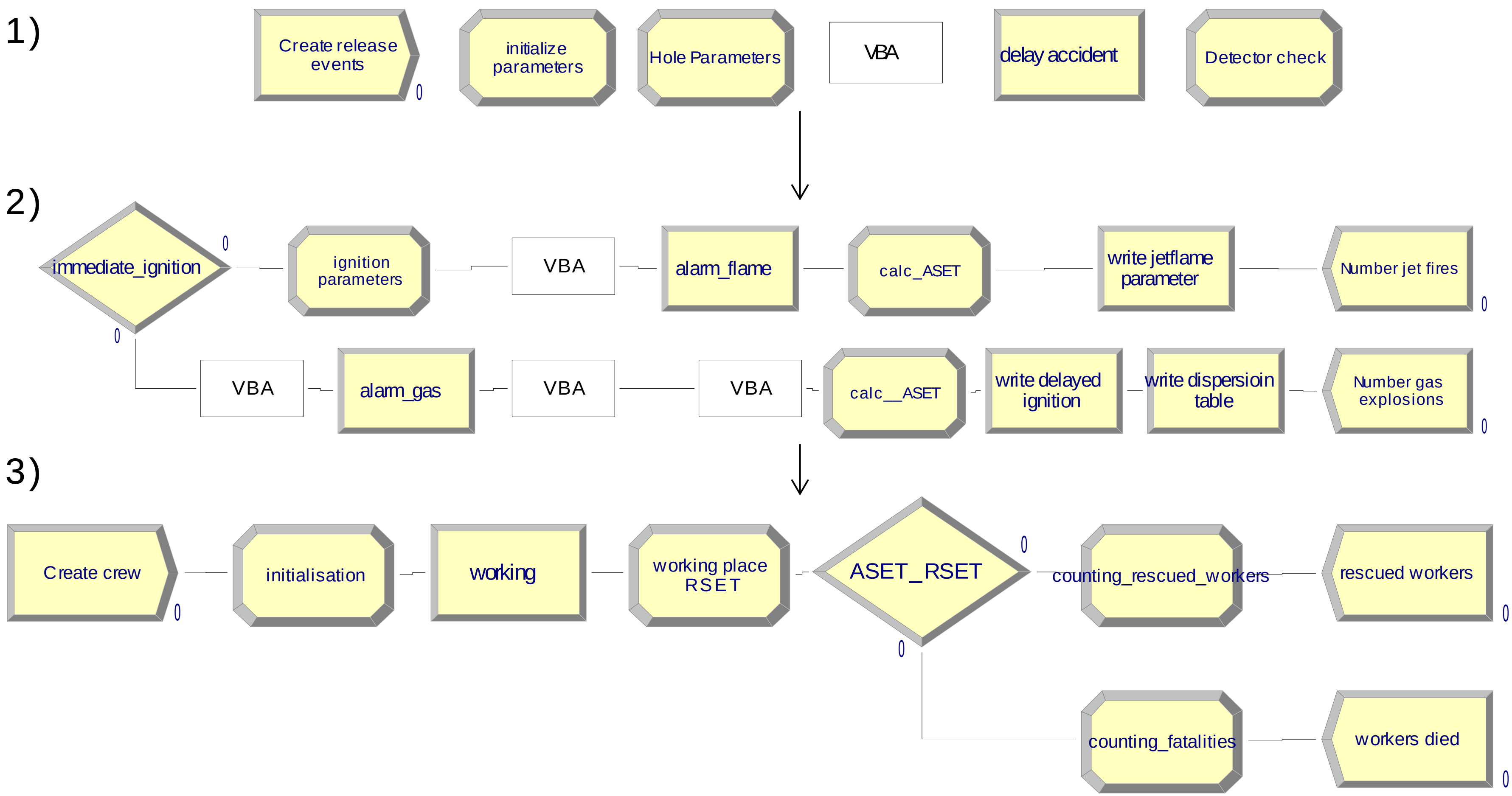


Discrete event simulation

- Event sequences are simulated in parallel.
- Dynamic interaction of events
  - Events taking place in one sequence change the conditions in the other sequences
- Data are sampled statistically,
  - e.g. hole size, wind speed, number and position workers
  - Multiple runs (many!) are performed to extract risk numbers (IR, PLL, group risk)
- Individual scenarios can be simulated graphically (animation)

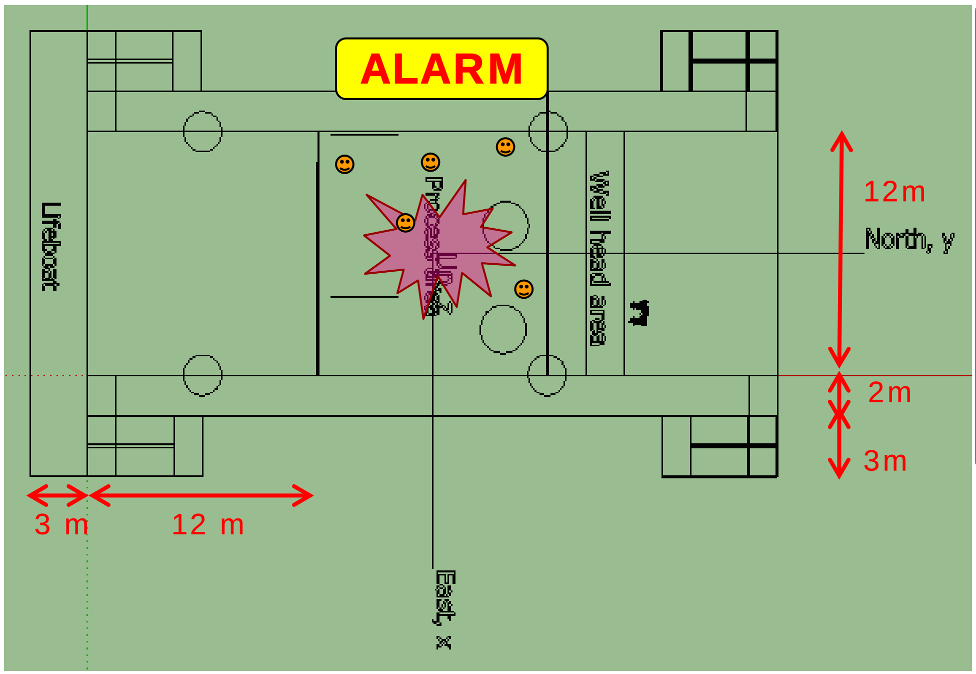
DES model logic

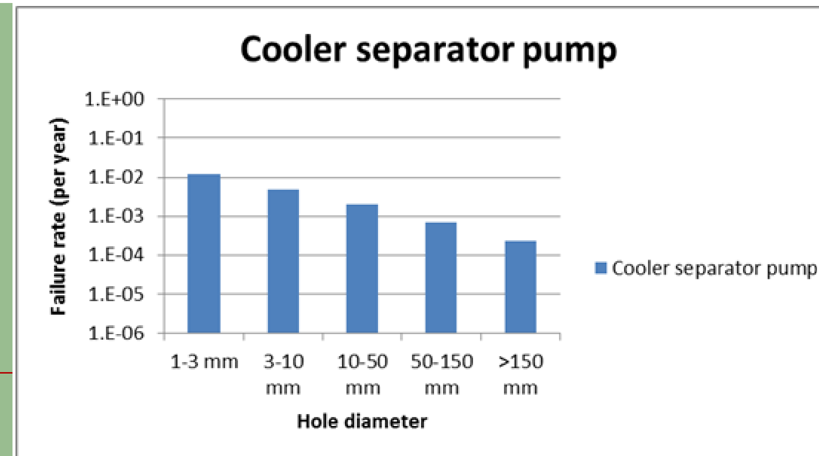
1) input parameters, 2) Consequences, 3) Evacuation

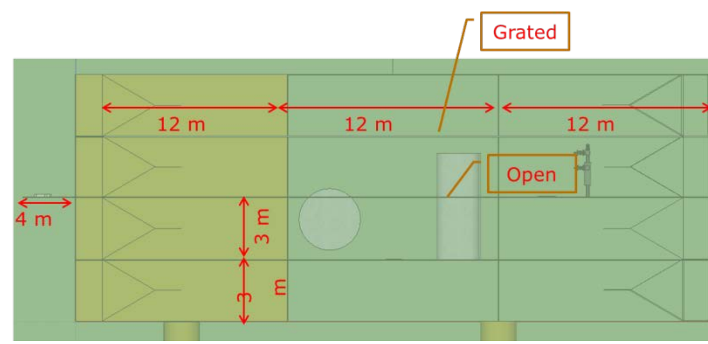


Rockwell 's Arena software

The off-shore platform





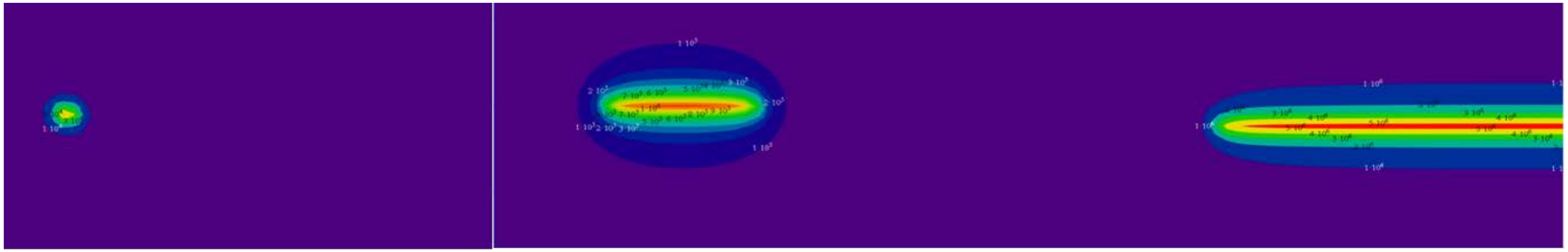


DES model validation

- Domain experts can participate actively in validation, as the models are simple to understand and a change in input can be immediately seen in output.
- Animation of scenarios facilitates significantly validation
- The models and data for each block can be verified or validated separately.
- DES models provide better transparency on applied models, assumptions made and output
- Models of the 4 sequences are validated using controlled input both for single runs and for batch simulations.

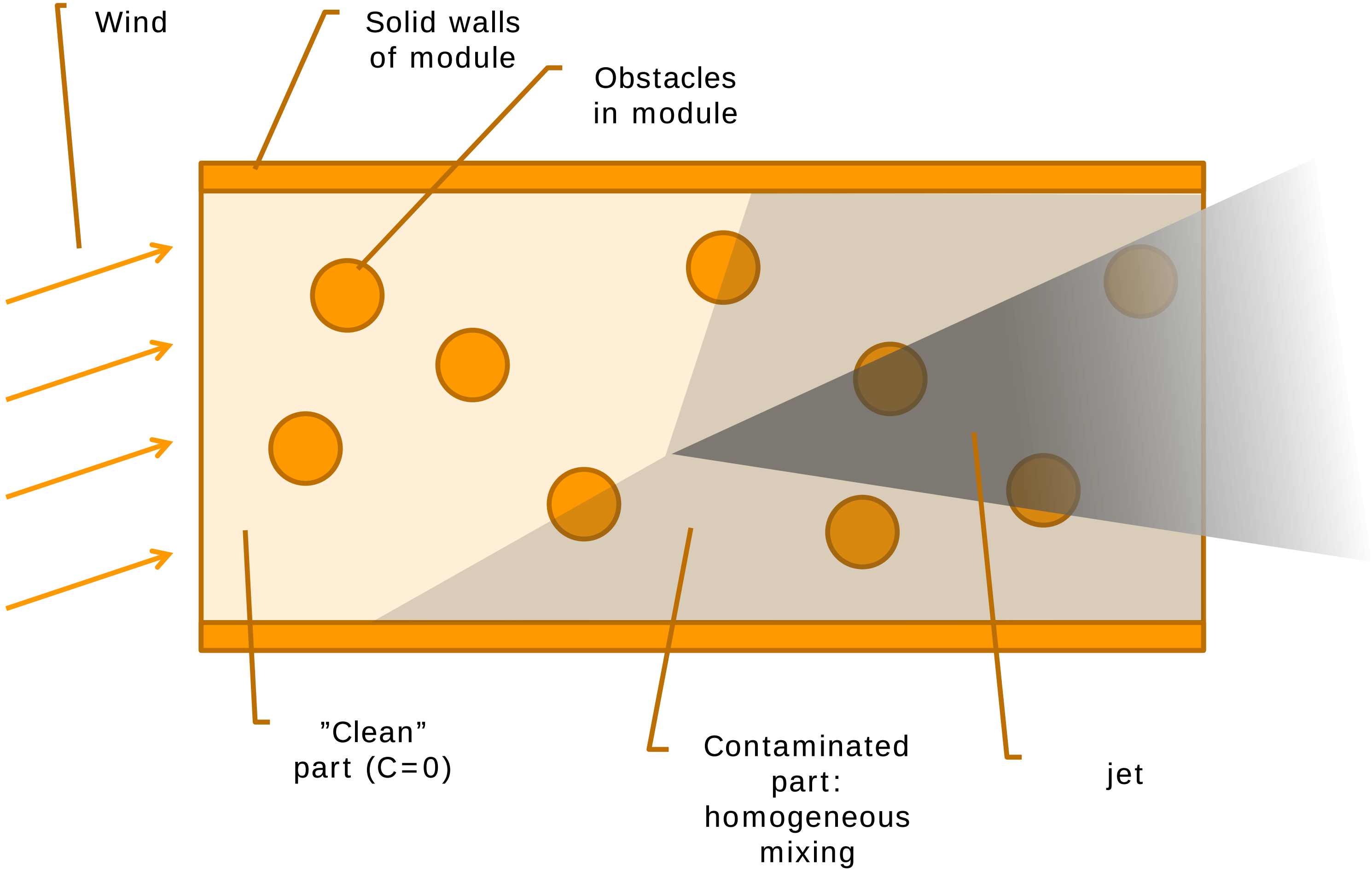
Data & Models

- At present a simple set of models included:
  - LoC frequencies: OGP data
  - Dispersion and ignition: (based on) EI/IP/UKOOA correlations
  - Jet fire: Chamberlain model (Yellow Book)
  - First approach to effect and egress models

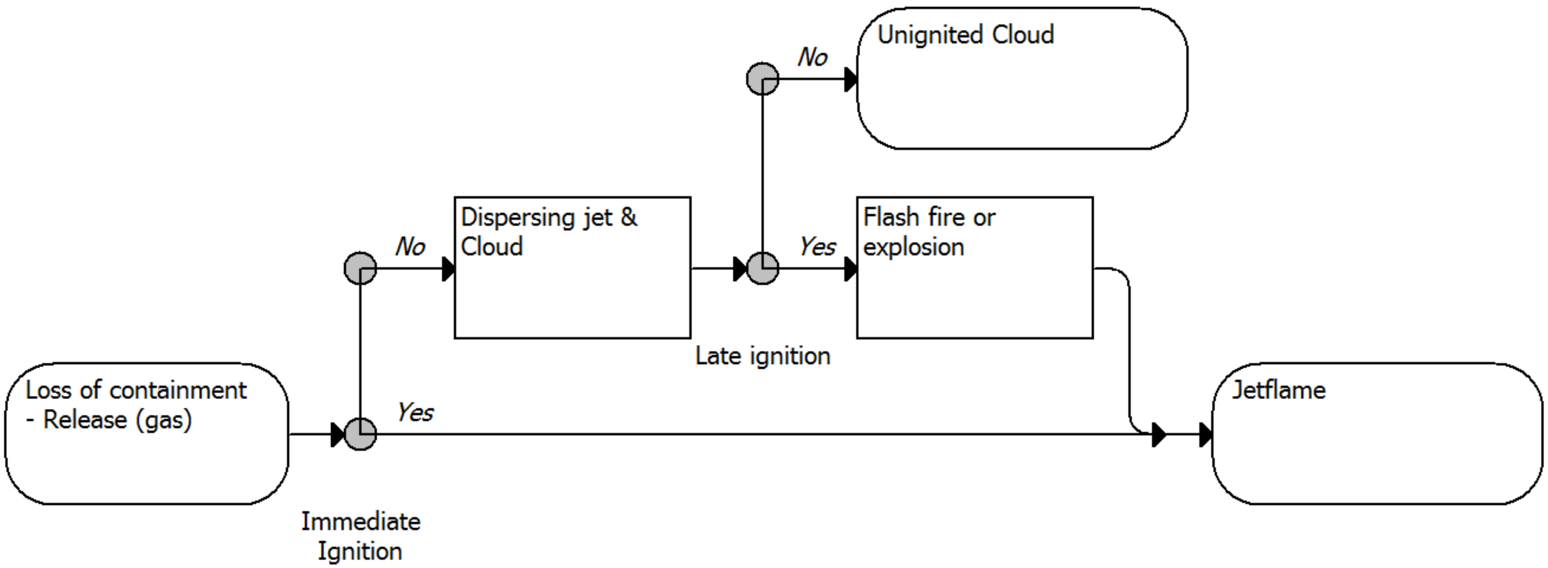


Mass rate 0.15 kg/s d= 4.7mm; 15 kg/s d=47 mm; 300 kg/s d= 200 mm; P= 50 bar

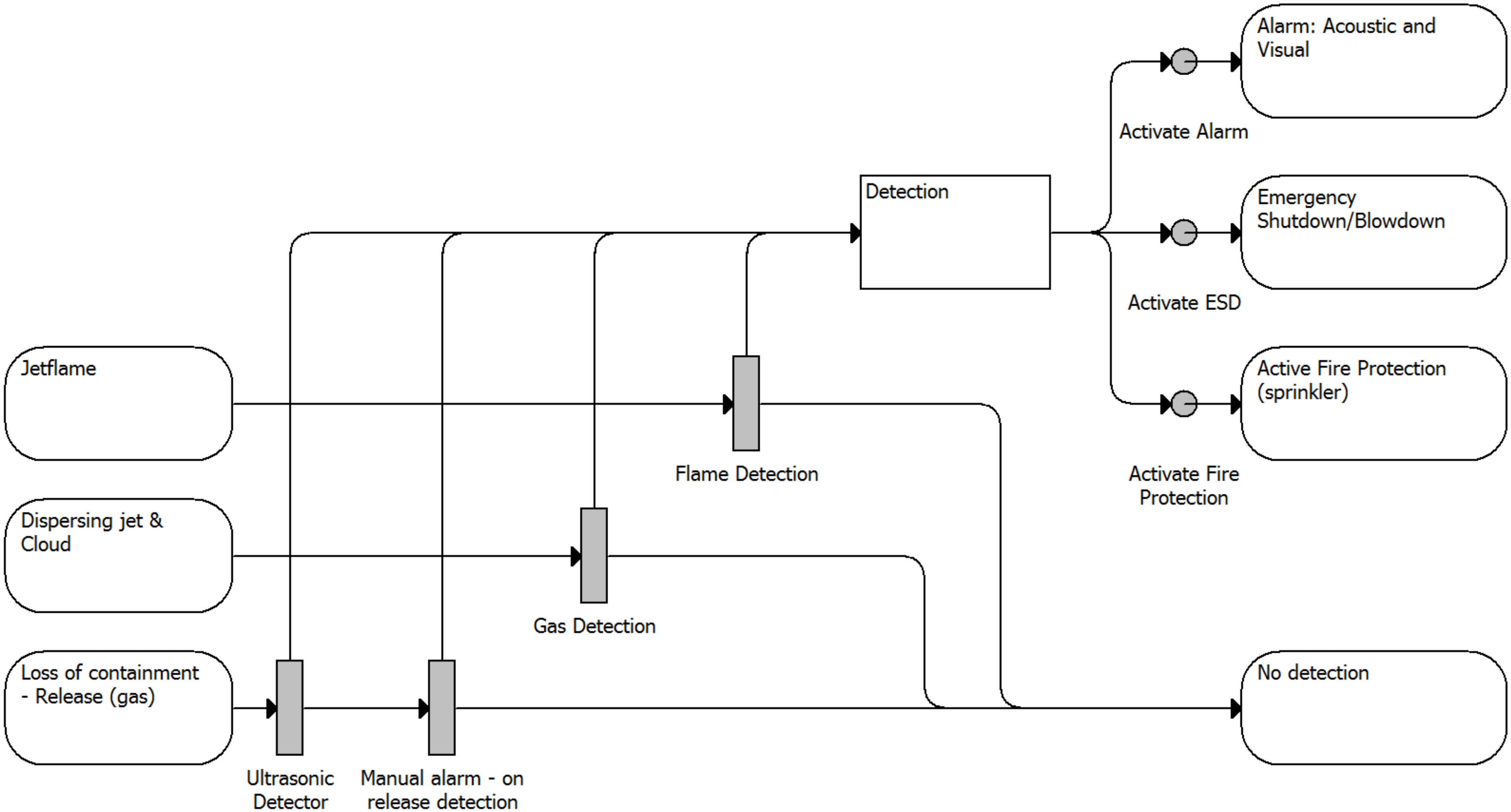
Dispersion-in-module model



1 - Physical phenomena

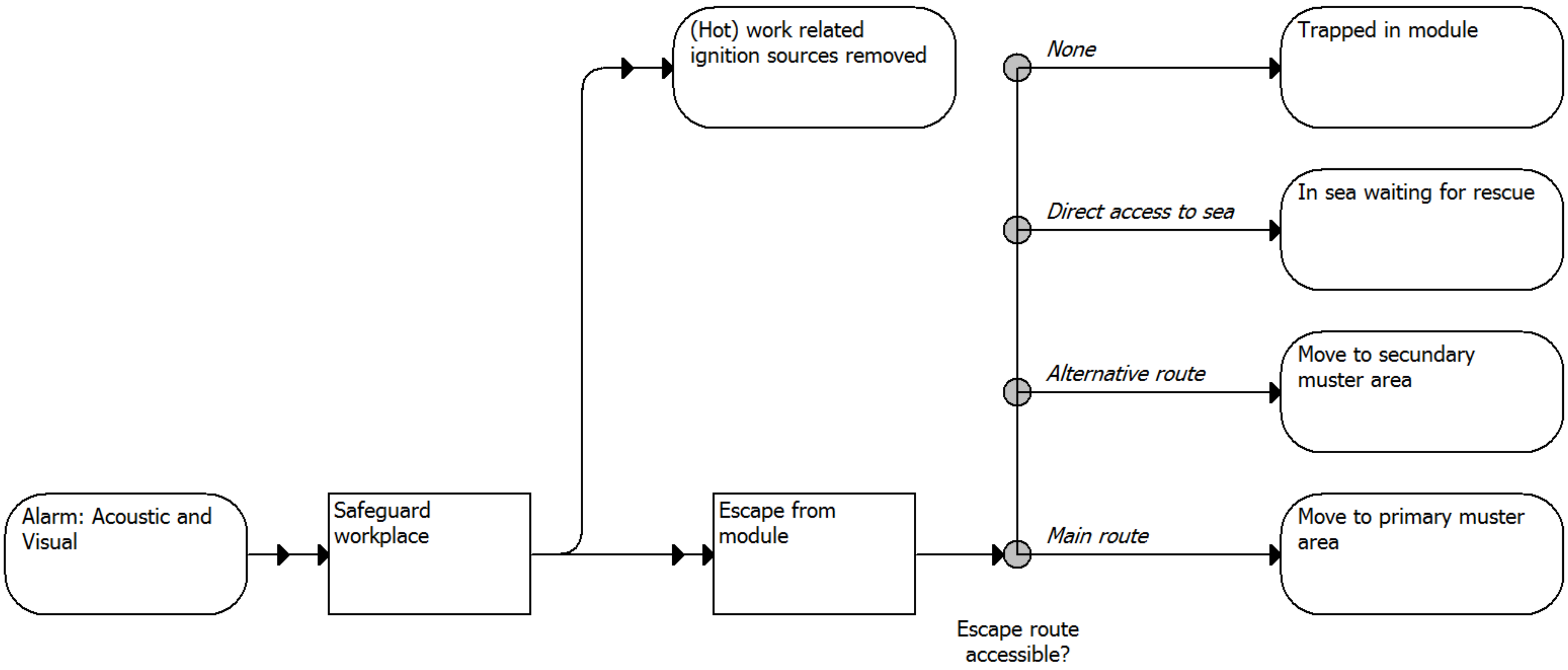


2 – Detection and response



4th Fire Safety Day June 12, 2014, DTU Byg, Kgs. Lyngby, Denmark

3 – Escape and evacuation



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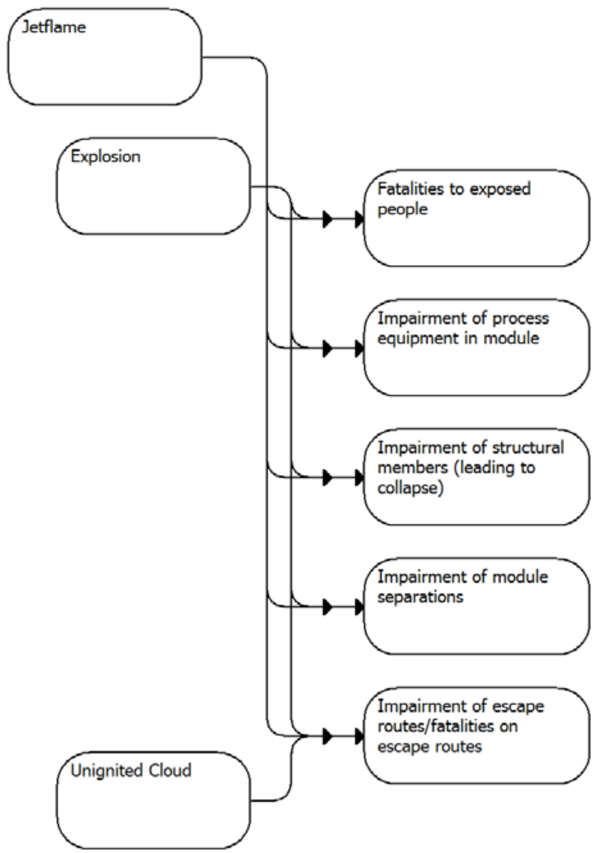
4 – Impact and consequence



Example results:

10000 simulation runs				
Input:	**average**	**st.dev.**	**min**	**max**
wind speed (m/s)	11	5	5	20
wind direction (degrees)	91	52	0	180
hole size statistic (mm)	12	28	1	200
No. workers at random positions	4		3	5
Output:				
wind speed in module (m/s)	0.6	0.3	0.1	1.4
mass flow (kg/s)	6.2	27.8	0.007	271.5
SEPmax jet flame (kW/s)	40	11	28	93
RSET (s)	240		176	301
ASET (s)	427		0	>600
No. fatilities per accident	1.3	1.8	0	5

Approach of our choice: Discrete Event Simulation

1. Models procecesses and events
2. Models are dynamic (vs. static conventional models)
3. Data are sampled statistically, e.g. hole size, wind speed
4. Easy housekeeping of models and results
   – transparency of calculations
5. Animation and graphical scenarios contribute to understanding and confidence
6. Domain experts understand models and influence their development
7. Easy integration of the technical part and human performance
8. Multiple runs are performed to extract risk numbers for assessing Individual Risk, Potential Loss of Life, Group Risk)

Concluding remarks

- Discrete Event Simulation modelling has proven viability for the risk analysis of different safety critical systems.

- It works and can produces a great deal of informative output and, in particular, probabilistic risk measures.

- The approach is highly applicable in other areas e.g. fire safety management

Thank you for your interest

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