



# Evacuation Simulation of Shipboard Fire Scenarios

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# Introduction – Ship Safety

Safety becoming target hard to achieve as ships are getting more complicated



Prescriptive rules outdated  
Alternative arrangements

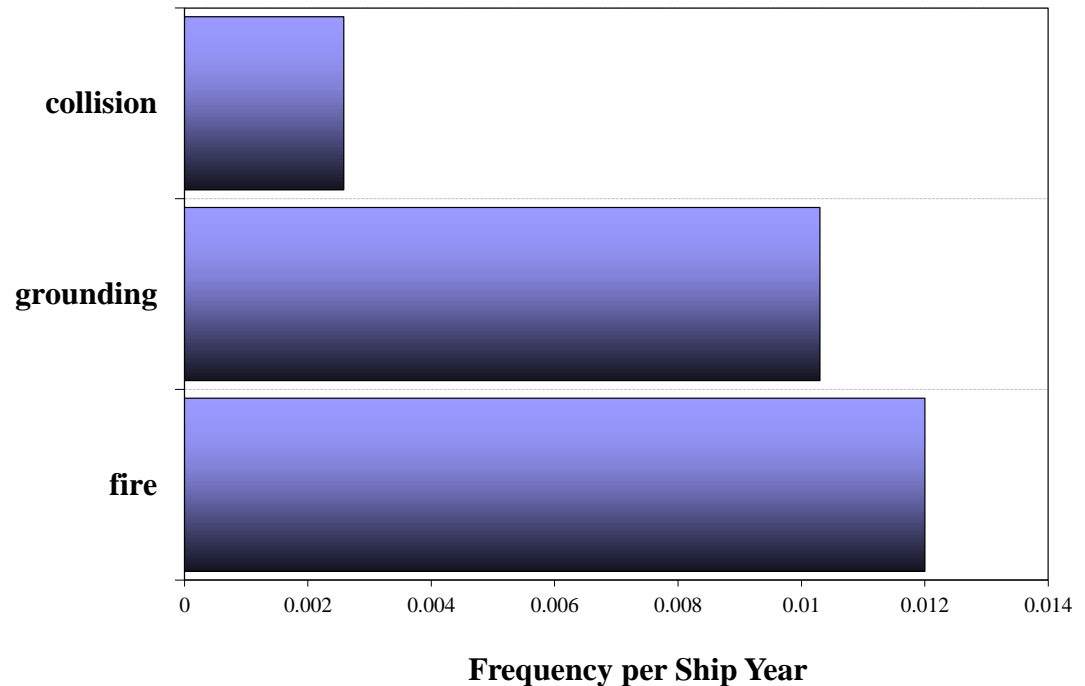
**Proactive approach**



# Introduction – Shipboard Fire

- Fires are statistically most frequent hazards that ships face at sea
- Shipboard fires are dangerous especially onboard passenger ships with dense occupancy

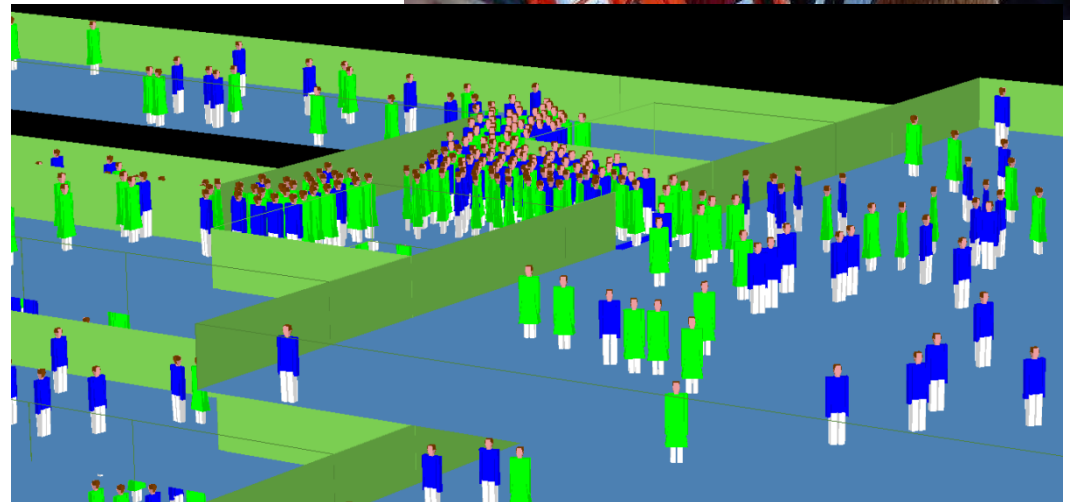
Source: DNV





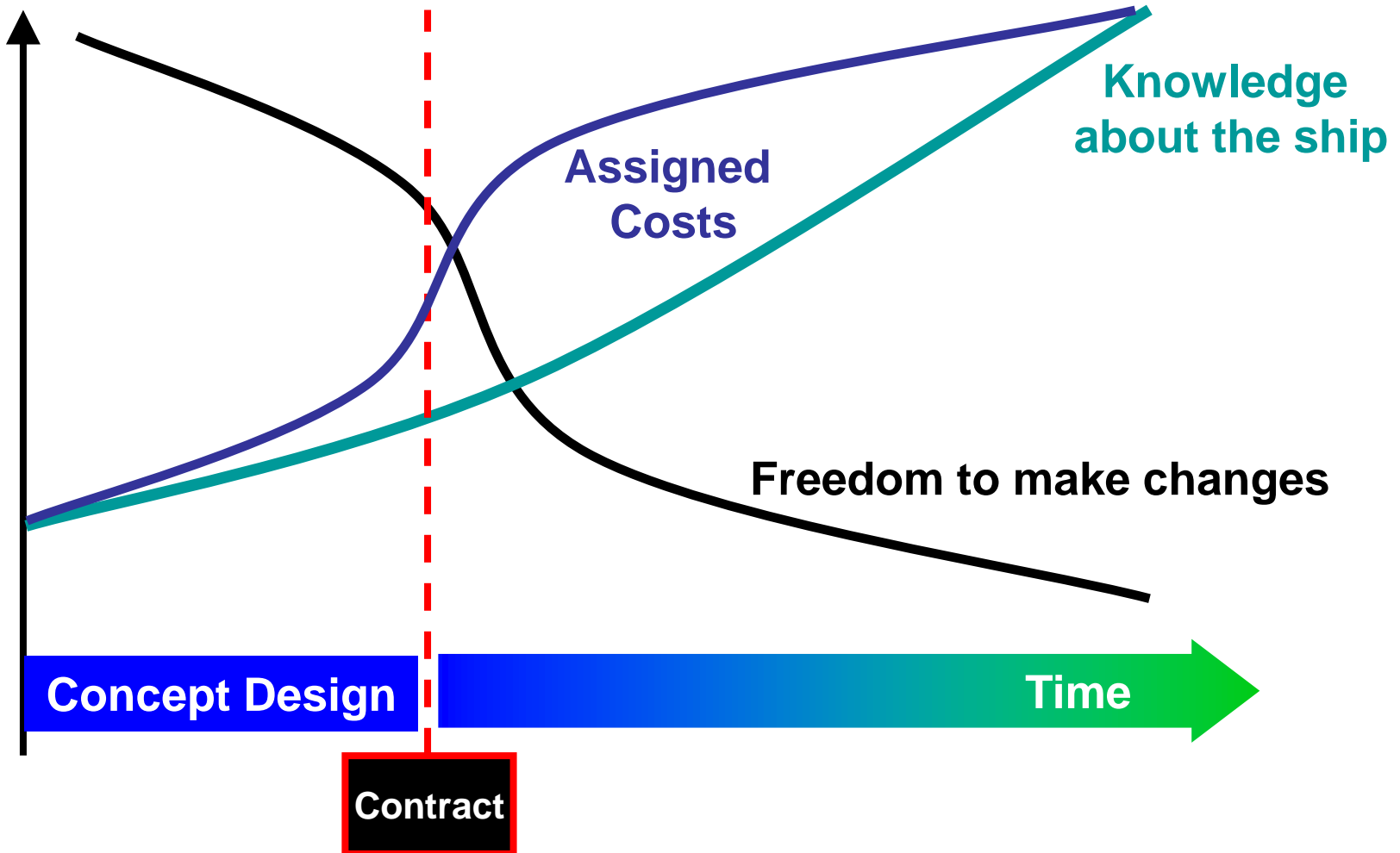
# Introduction – Evacuation

- Ease of evacuation is crucial under any hazardous condition
- Normal drills differ from actual evacuations in fire and flooding events
- Evacuation assessments are better done through modelling



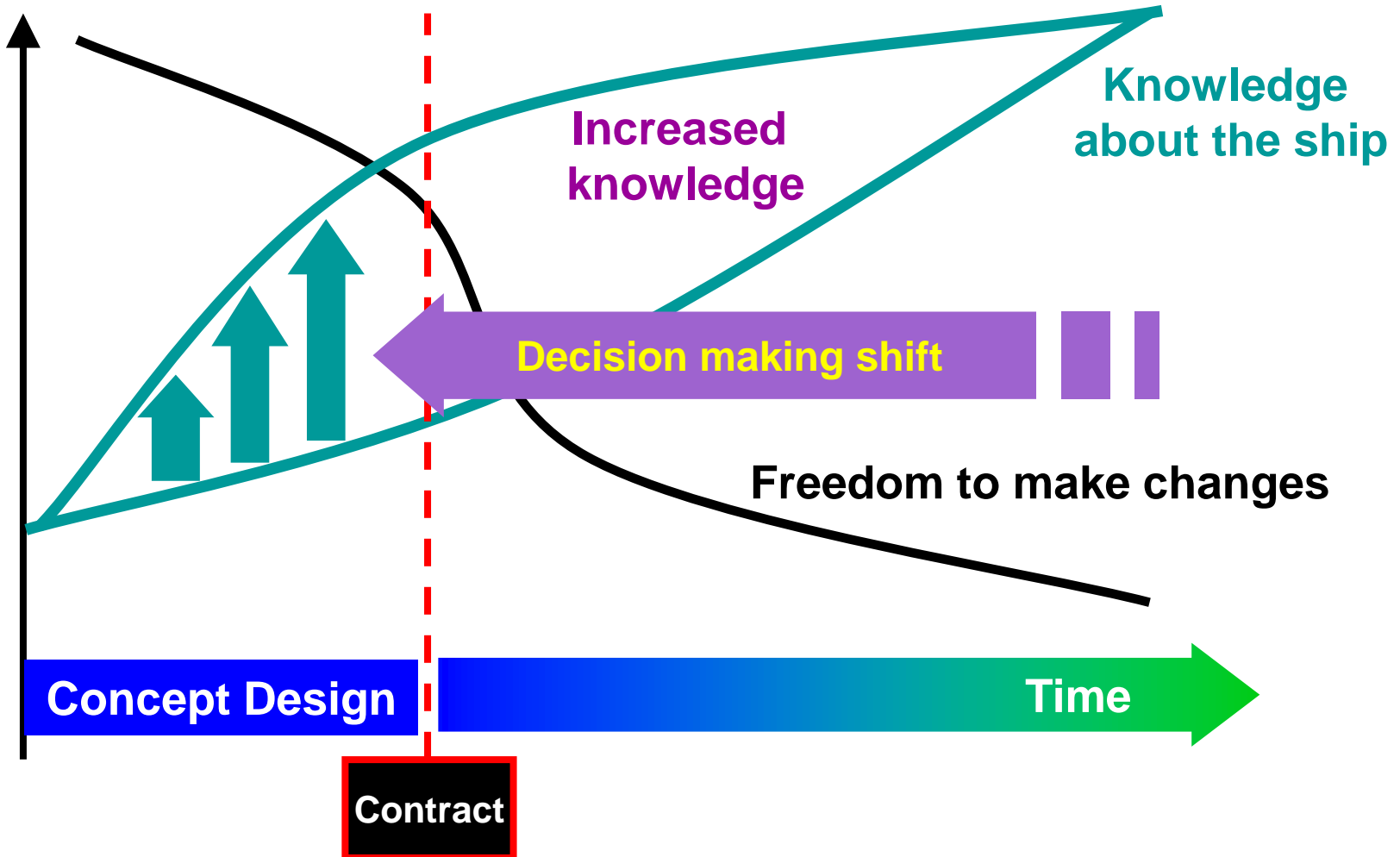


# Introduction – Ship Design





# Introduction – Ship Design





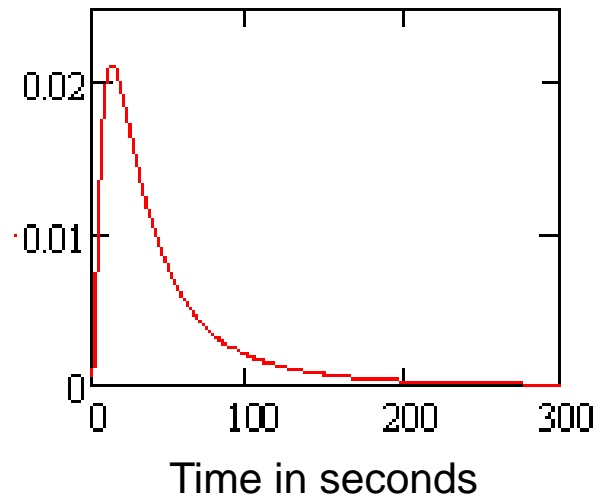
# IMO Guidelines on Evacuation



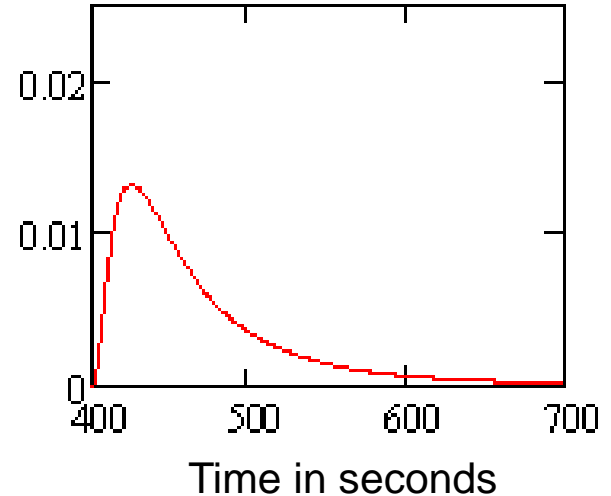
- Demographic distribution of passengers
- Walking speed according to demographics and route type

Response time follows lognormal distribution

Day case



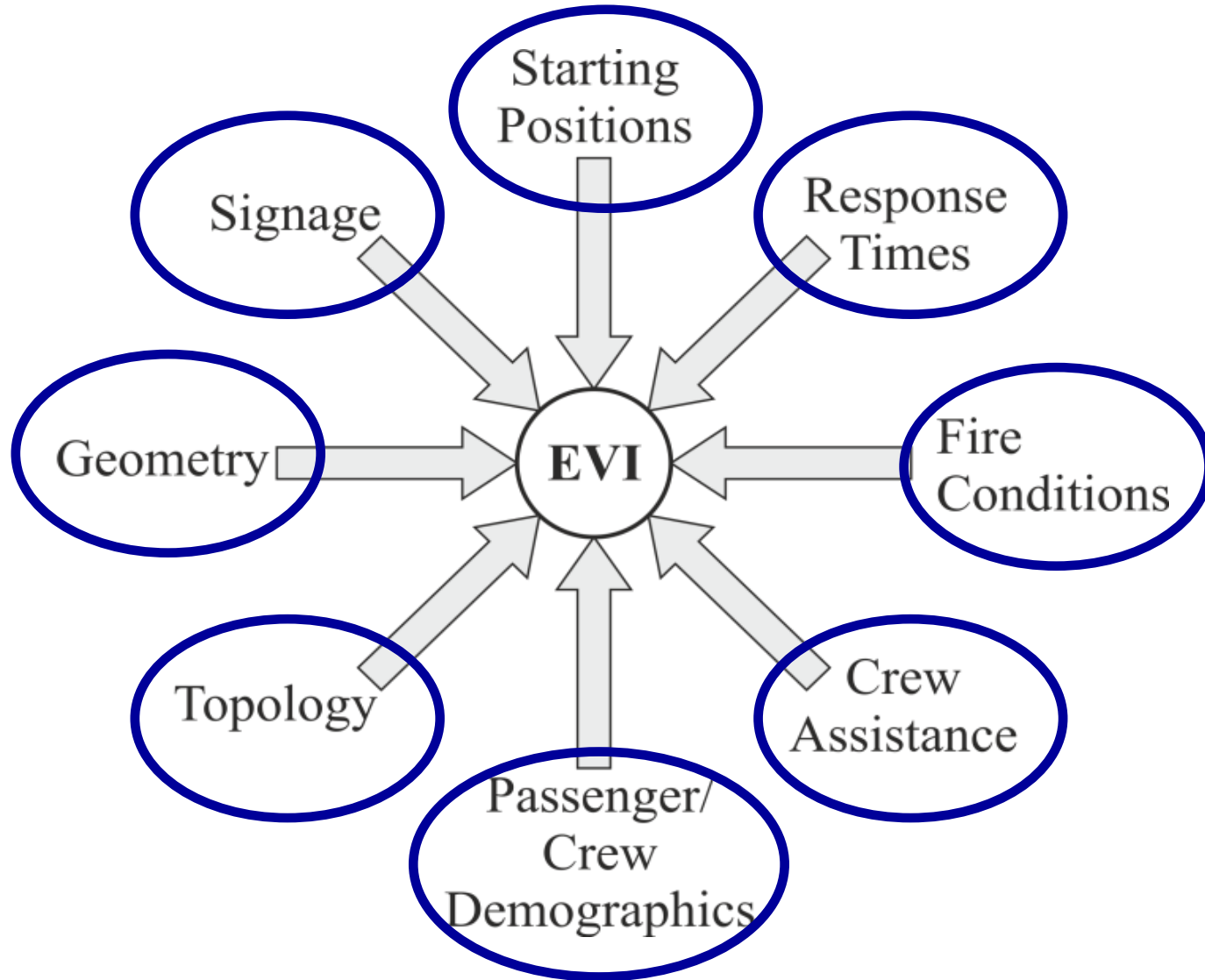
Night case







# Modelling Approach





# Quantification of Fire Effects

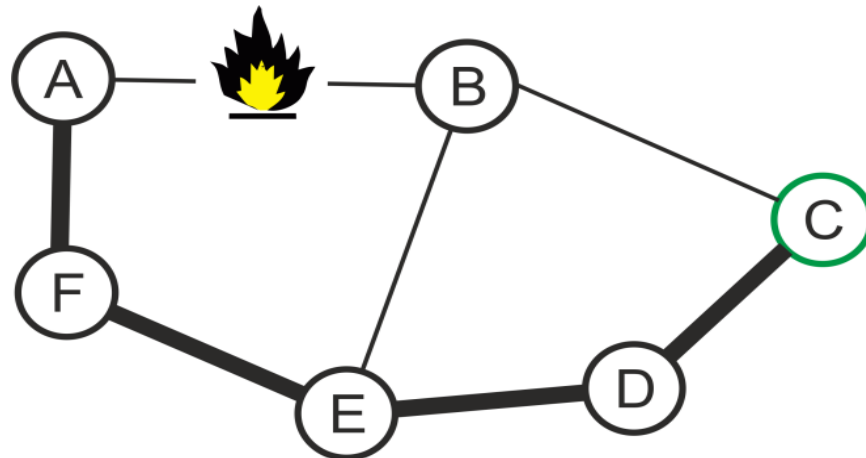
- Fire effects on human life safety
  - Toxicity (CO, CO<sub>2</sub> and O<sub>2</sub>)
  - Heat (convection and radiation)
  - Visibility impairment (walking speed reduction)
- Health status categories at different Fractional Effective Doses (FED)

FED Range	Category
$0 \leq \text{FED} < 0.3$	Negligible
$0.3 \leq \text{FED} < 0.7$	Mild injury
$0.7 \leq \text{FED} < 1$	Serious injury
$1 \leq \text{FED}$	Fatality



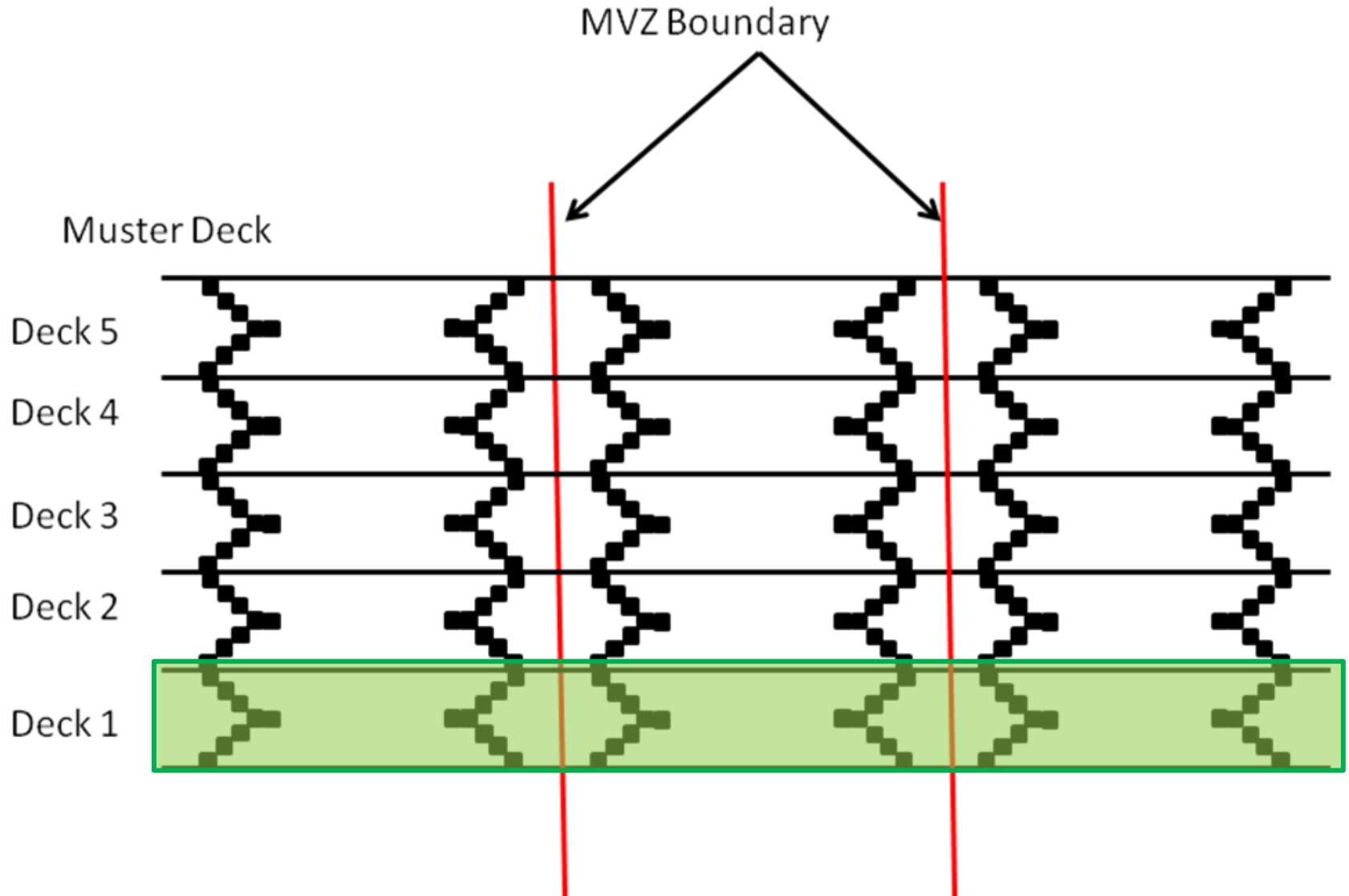
# Evacuees Reaction to Fire Effects

- Initially passengers are assigned response times
- Reaction lag ignored and evacuation triggered
  - directly exposed to fire effects
  - alerted by other passenger or crew
- Avoid hazardous areas: modified graph





# Case Study





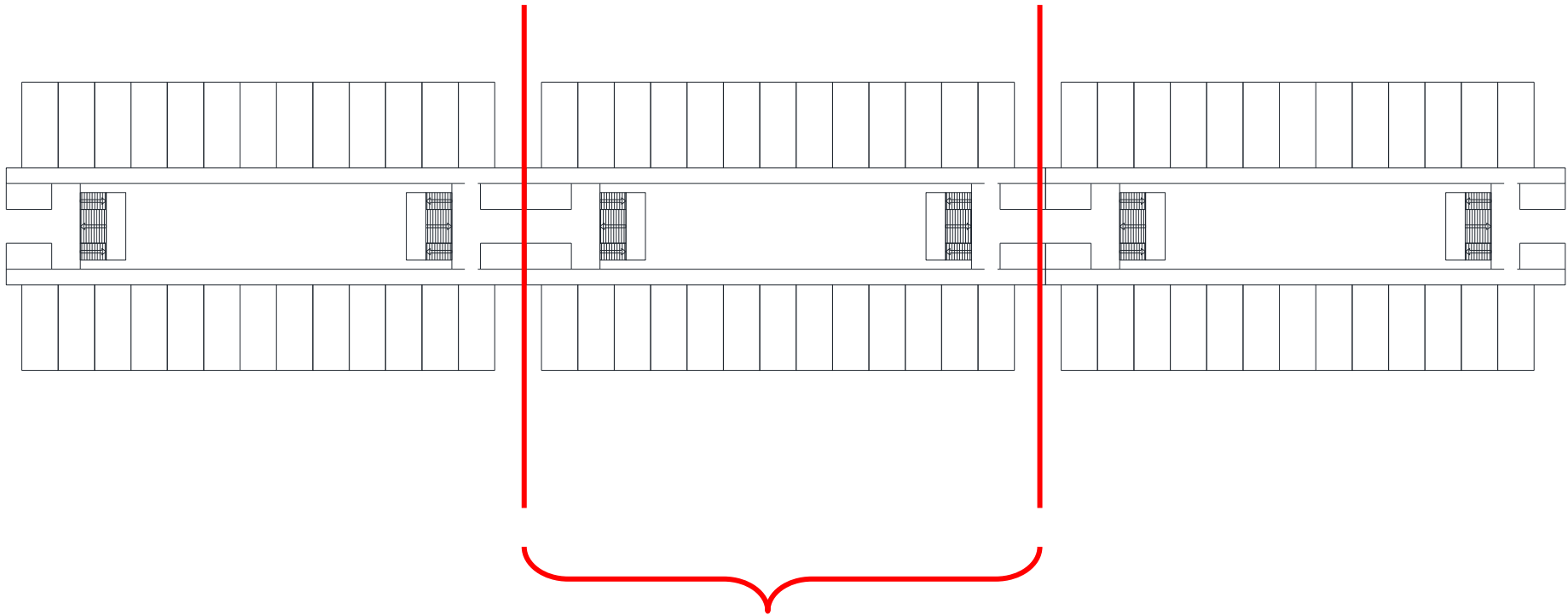
# Case Study



MVZ 1

MVZ 2

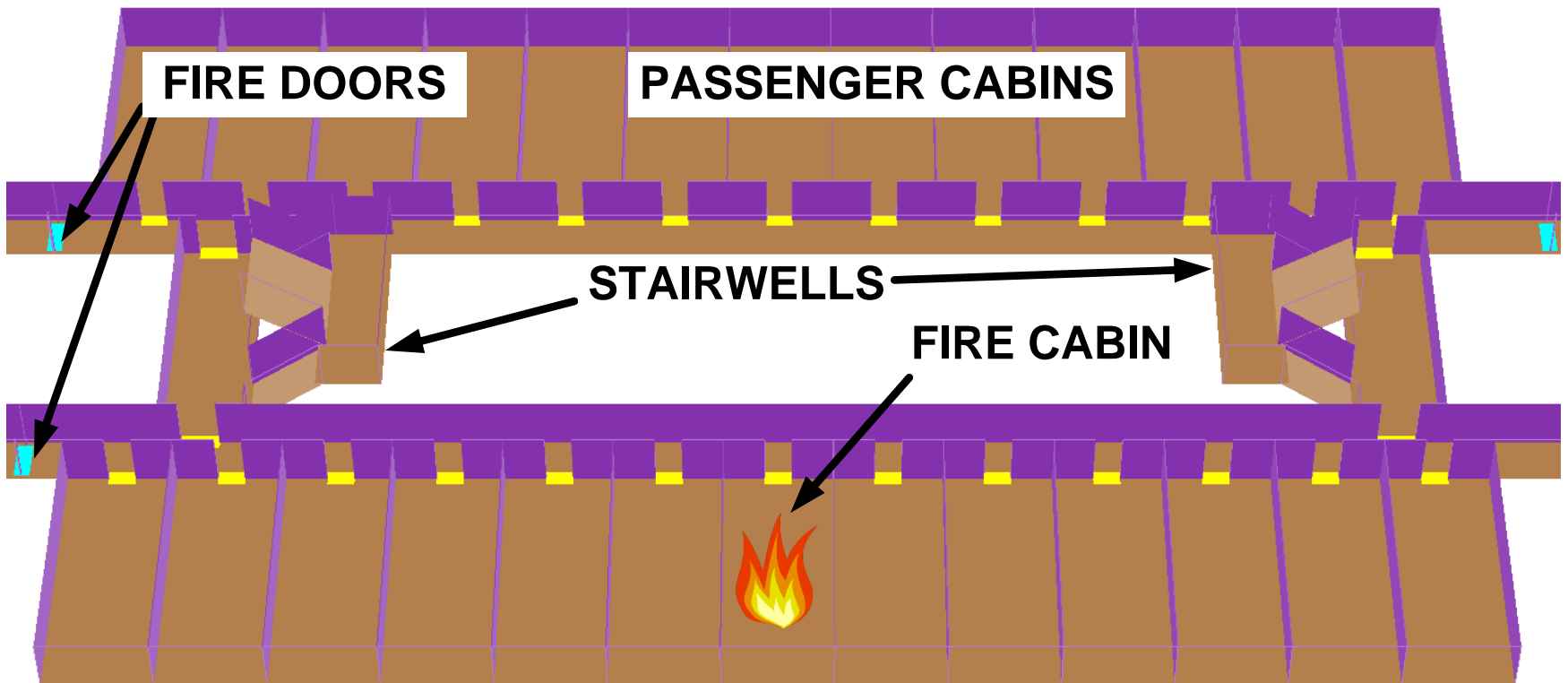
MVZ 3



**Zone affected by fire conditions**

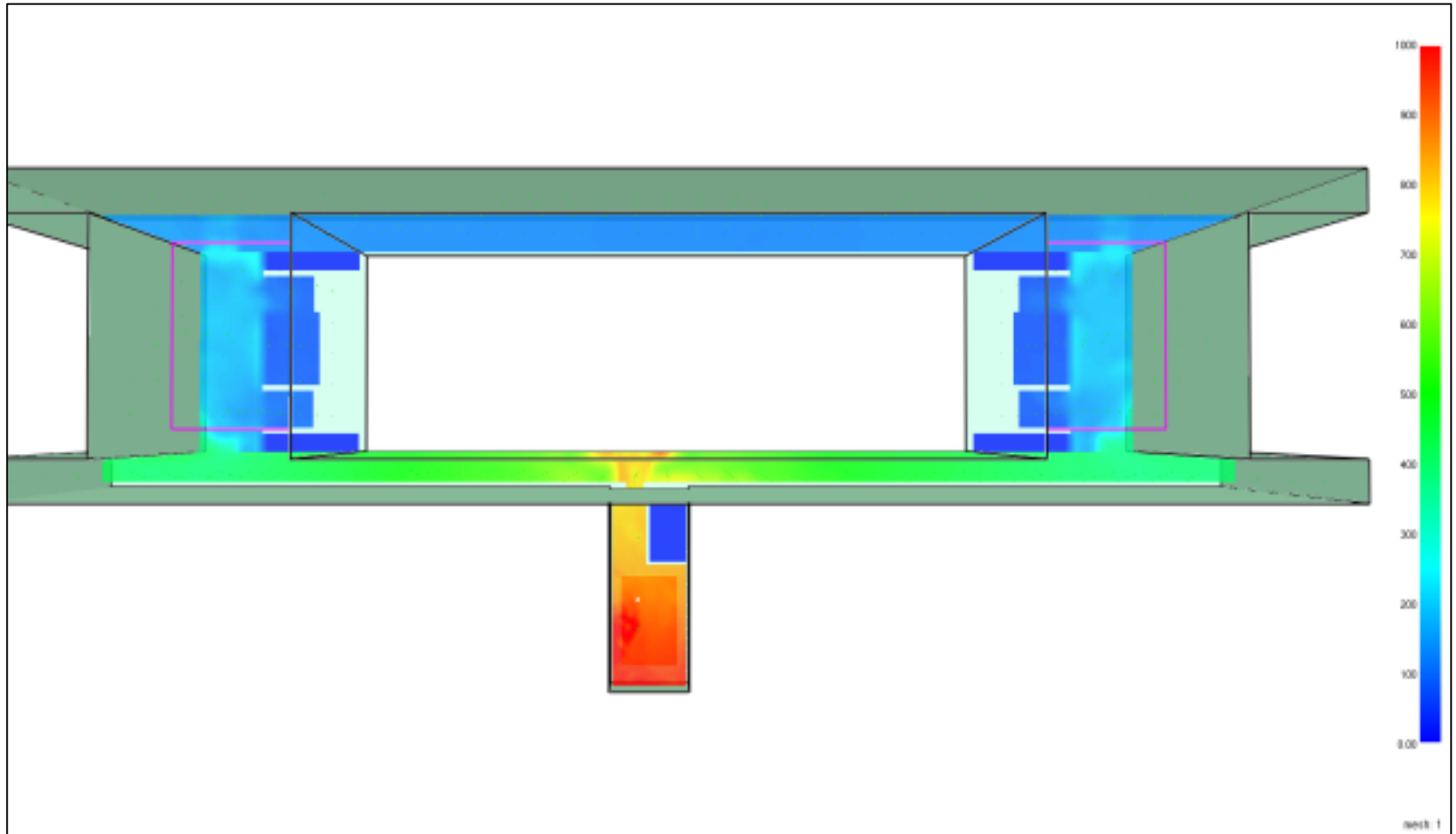


# Case Study



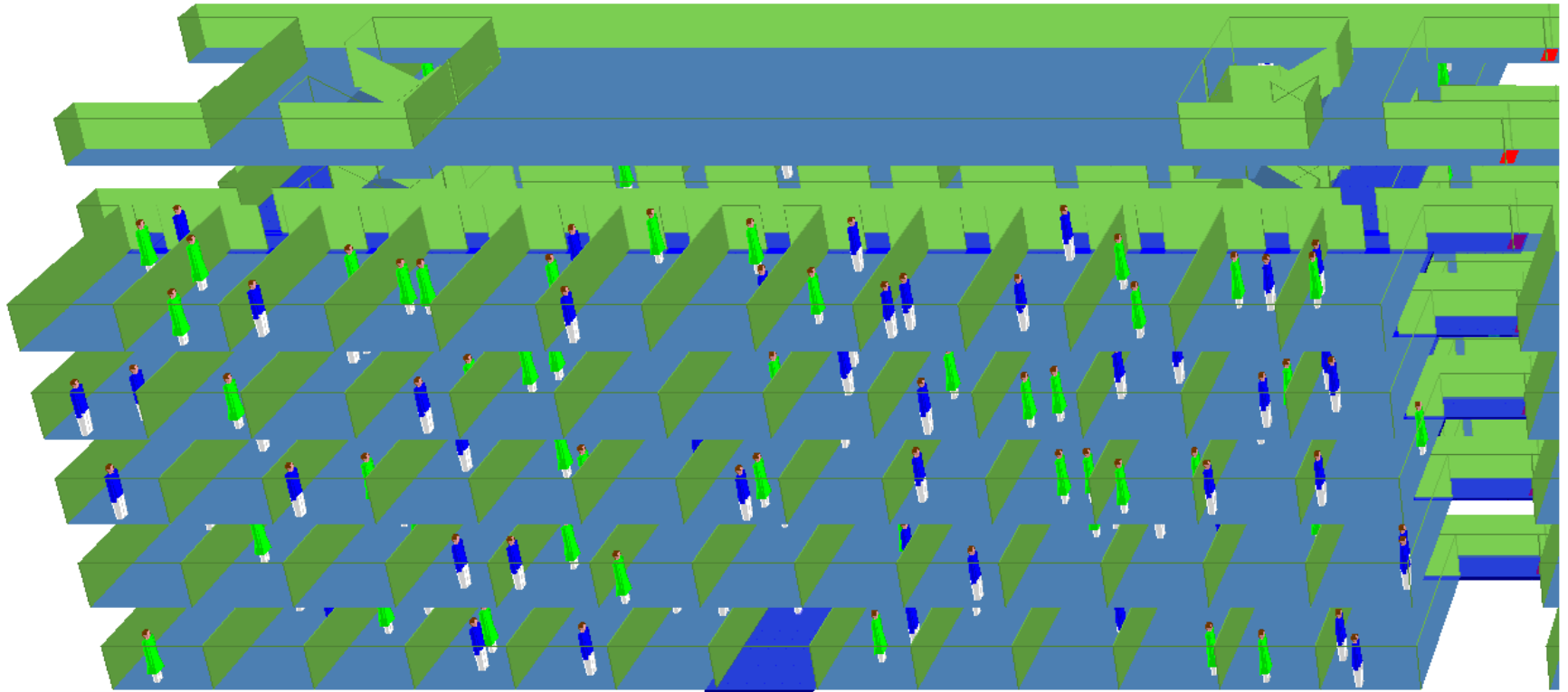


# Fire Simulations





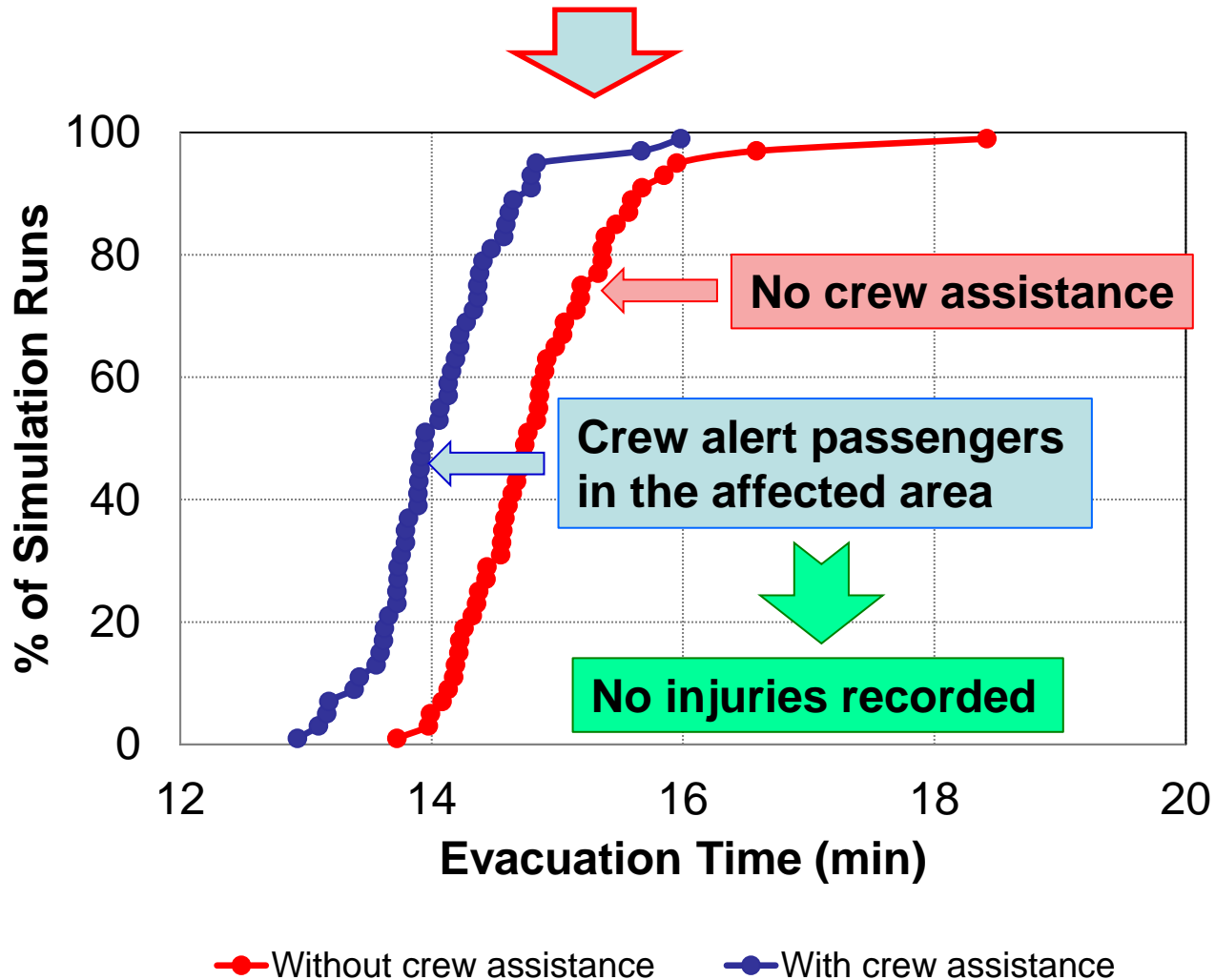
# Evacuation Simulations





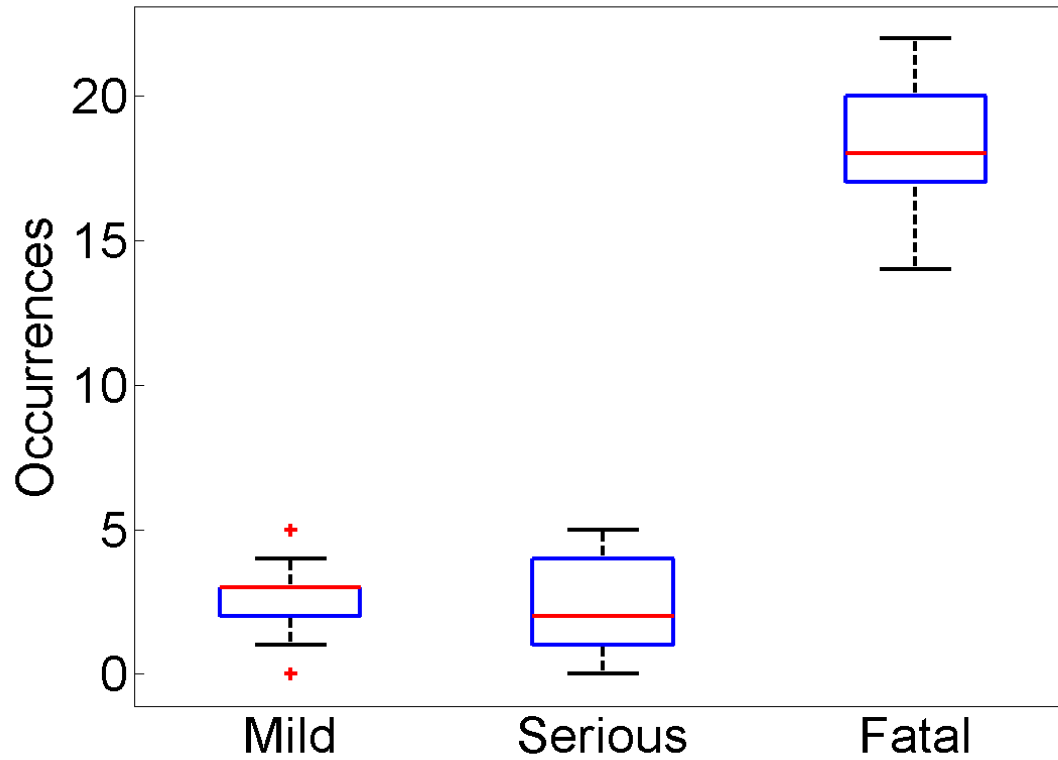


# Cumulative Evacuation Time





# Injuries and Fatalities





# Conclusions

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- Difficulties of evacuation at sea: complex geometry, familiarity and fire effects
- Study case highlights importance of crew assistance
- Human behavior and decision-making currently simplified
- Further development required based on observations from reported accidents



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[www.fireproof-project.eu](http://www.fireproof-project.eu)*



**THANK YOU**