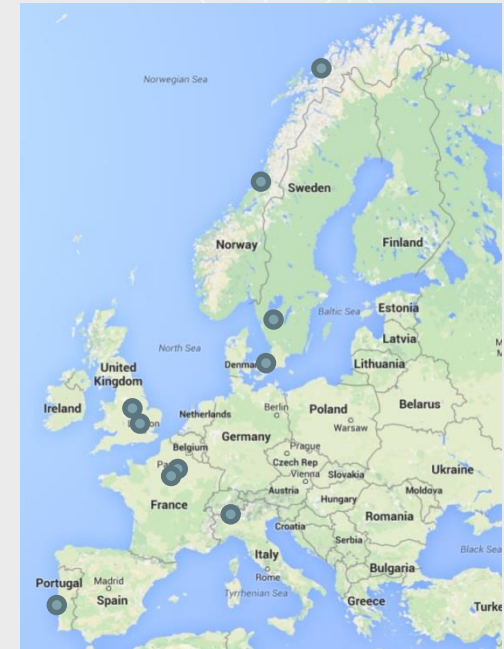


Identification of risk-related hazard events to assess the living lab's resilience.

IMPROVER

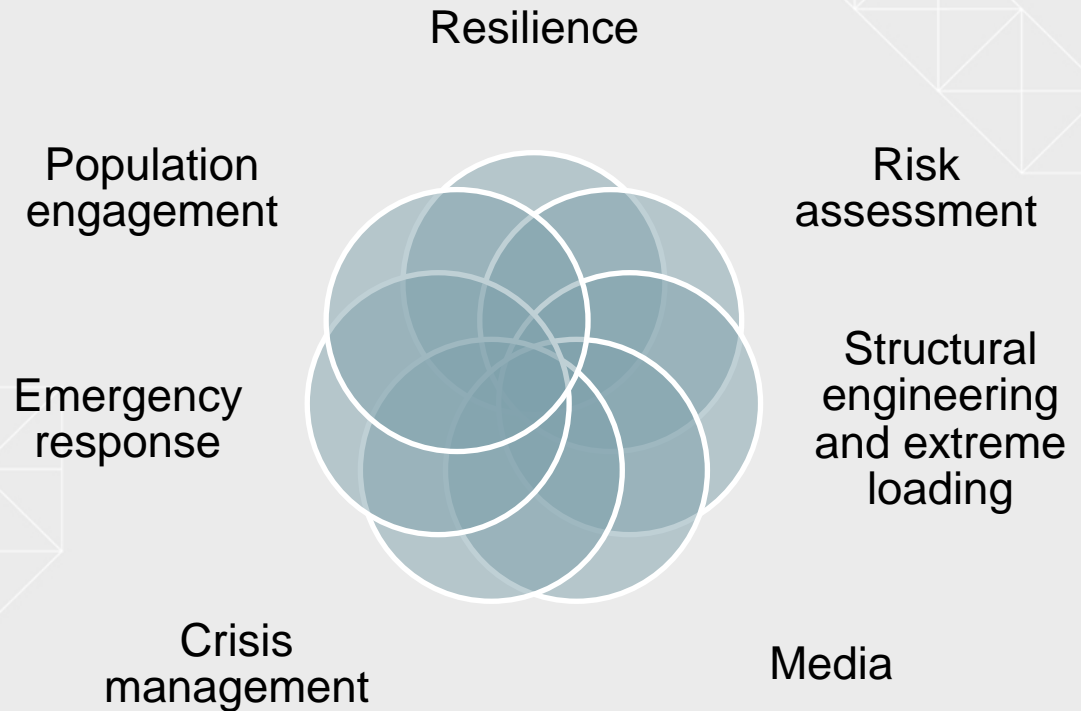
- 10 partners
- 7 different countries

(It would take 53 hours to drive the 5165 km from the northernmost partners home city to the southernmost partners home city)



IMPROVER

- Multi-disciplinary consortium



IMPROVER

- What is critical infrastructure?

Critical infrastructure is an asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions. Examples of critical infrastructure include supply of basic services like water, food, energy, transport, housing/shelter, communications, finance, health

Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection. Official Journal of the European Union, 23 December 2008.

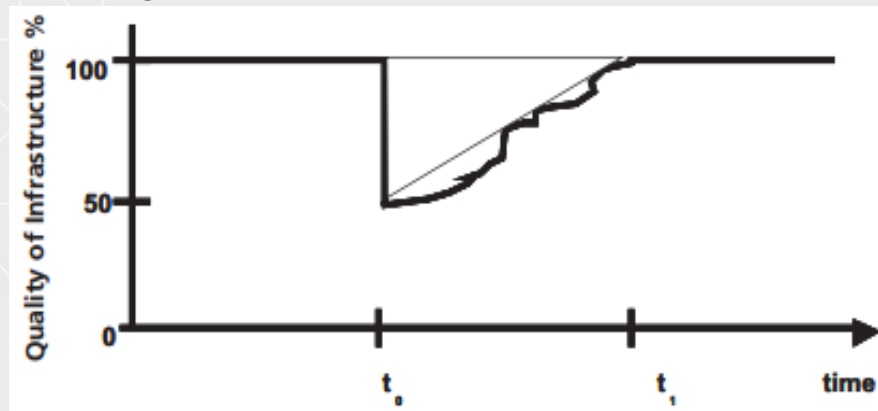
IMPROVER

- What is resilience?

“The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions”

2009 UNISDR terminology on disaster risk reduction

- The resilience triangle...



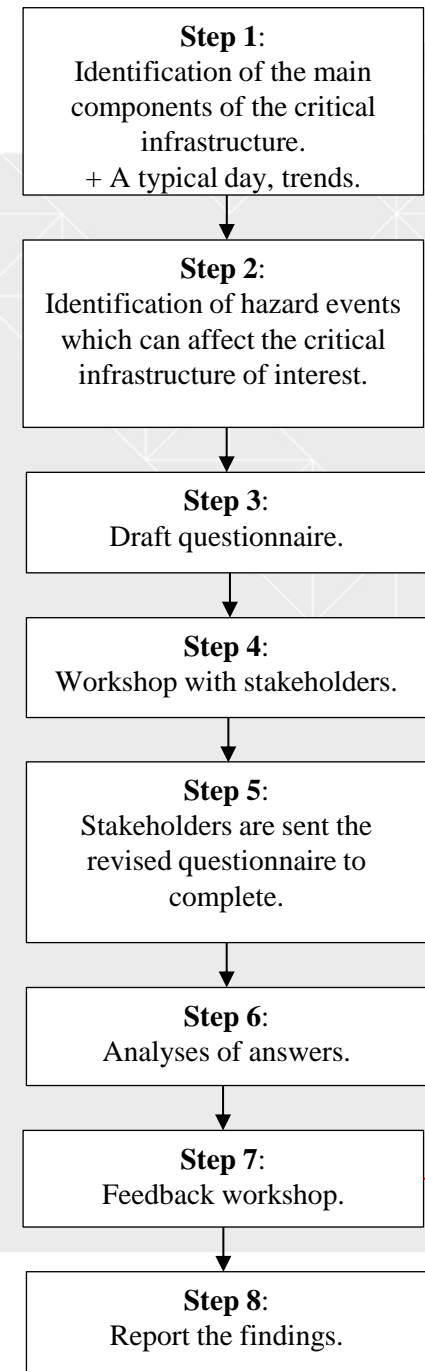
Tierney, K. and Bruneau, M. (2007) Conceptualizing and Measuring Resilience: A Key to Disaster Loss Reduction, TR News 250, Transportation Research Board, pp-14-15, 17.

Literature Review – Existing Methodologies

- Identification of risk-related hazard scenarios in order to assess the resilience of critical infrastructure.
 - Risk factor = Likelihood x Consequences
 - Common sense and Engineering Judgement.
 - Did not account for the uncertainty in the estimates, compares hazards such as natural and terrorists events which are of very different nature.

Methodology - Scenarios

- Hazards:
 - **Natural.**
 - Malicious Human Induced.
 - **Operational.**
 - Market/Economy/Political.
- Consequences:
 - **Disaster:** Catastrophic consequence, major disruption to the infrastructure and which has a severe impact to the region.
 - **Emergency:** A medium consequence hazard event which causes severe disruption to the infrastructure in the region and a moderate impact to the cities it serves.



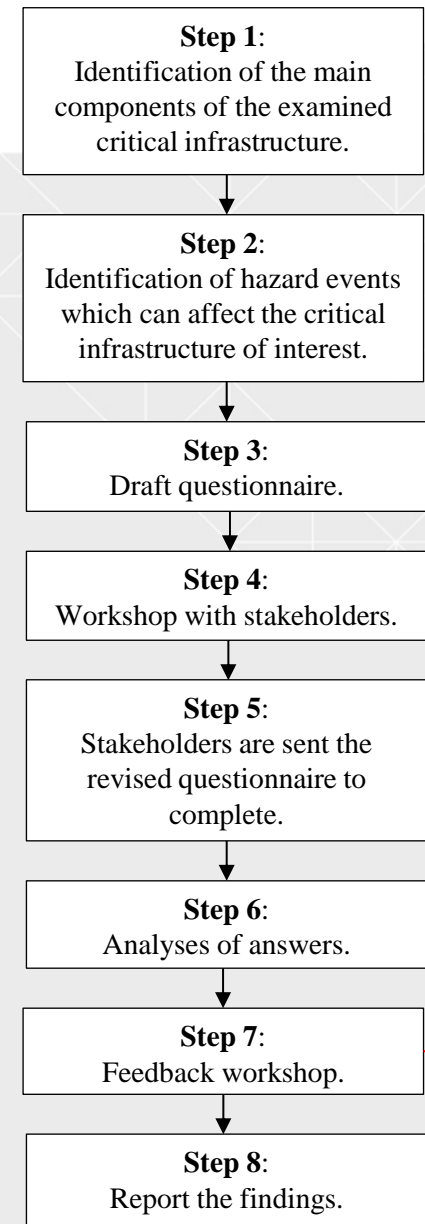
Methodology - Scenarios

- Paired comparison with probabilistic inversion:

	Hazard Event 1	Hazard Event 2	...
Hazard Event 1		> = <	
Hazard Event 2			
....			

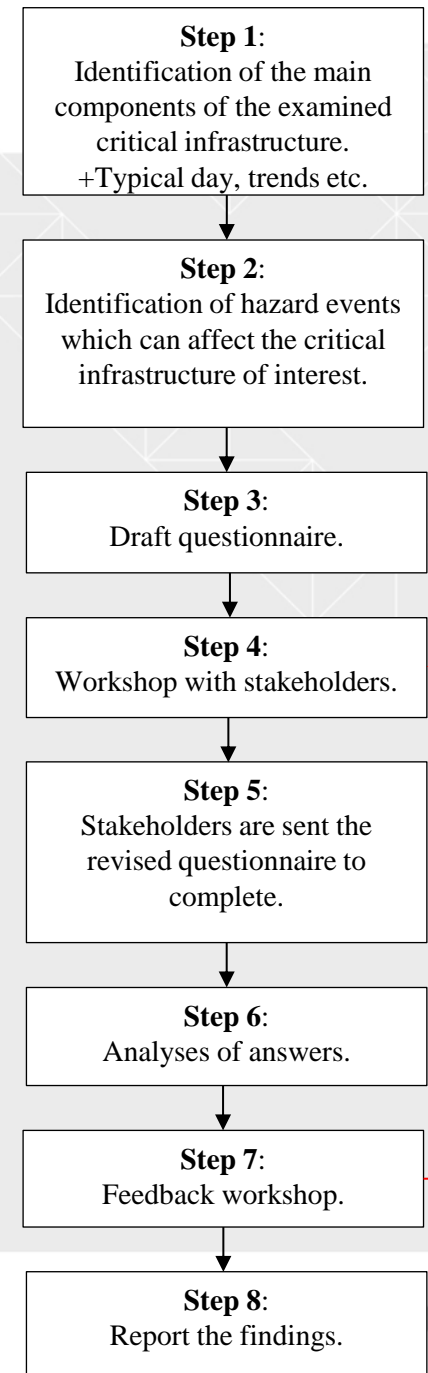
– By comparing two hazards identify, which of the two:

- Is more likely to occur in the next 5 years.
- Is more likely to cause emergency or disaster.



Methodology - Scenarios

- Paired comparison with probabilistic inversion:
 - Reproducibility.
 - Accountability.
 - Neutrality.
 - Fairness.
 - Empirical control.



Living Labs Background:

1. Port of Oslo.
2. Oresund crossing.
3. A31 Highway.

Background – Port of Oslo

Oslo Harbour:

- **Close** to Oslo city centre.
- 35 companies.
- Container harbour.
- Handles **50%** of Norway's oil supply.
- Handles **all fuel** to Oslo airport.



Background – Port of Oslo

A: Storage of barges and smaller vessels.

B: Container depot

C: Storage, loading unloading salt, fertiliser, animal feed, cement ect.

D: Workshop building, garage, boat space.

E: Loading, Unloading containers.

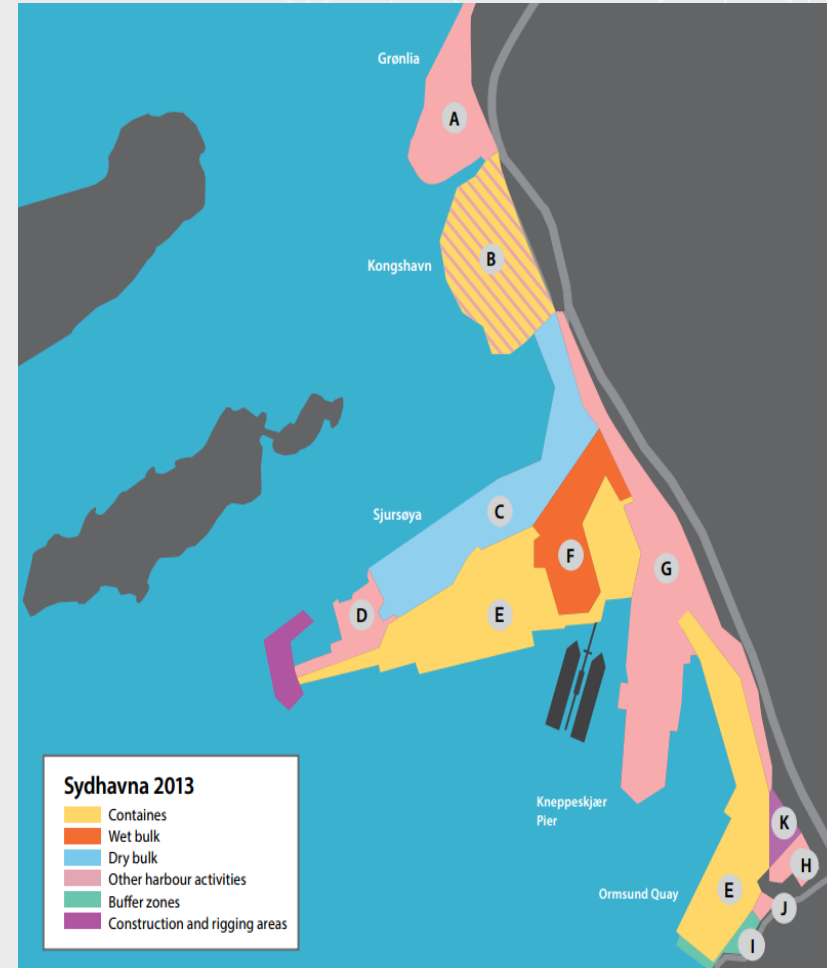
F: **WET BULK TERMINAL** Oil terminal:

Tank pier, tank depot, filling racks offices

G: Used for car imports, building materials and domestic costal traffic.

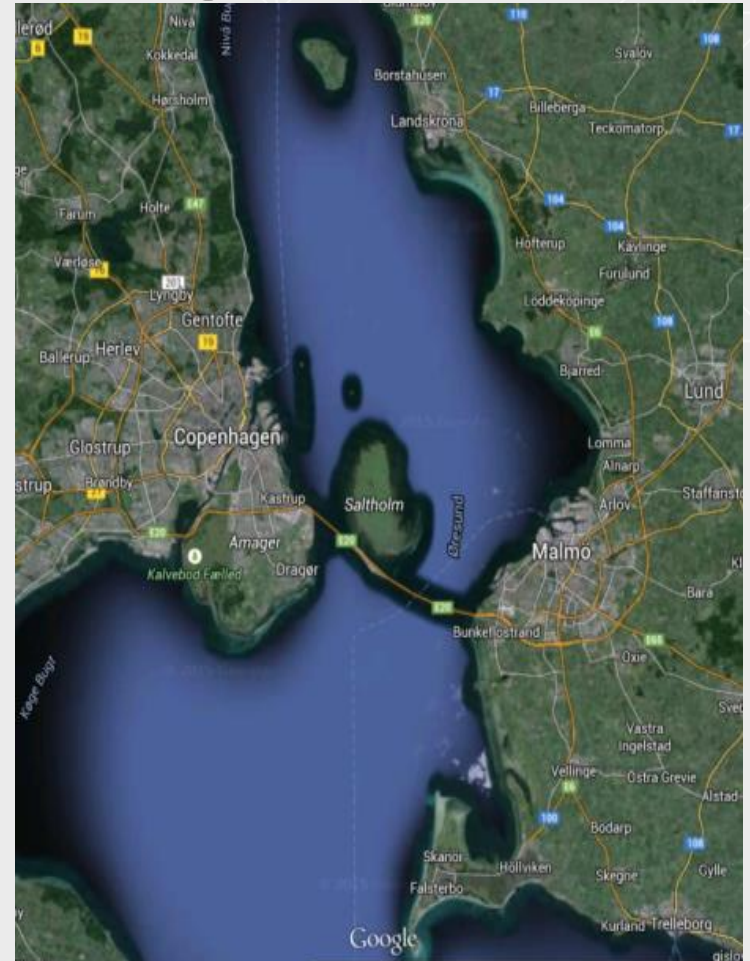
H&K: Bekkelaget Treatment Plant

I&J: Harbour's offices.



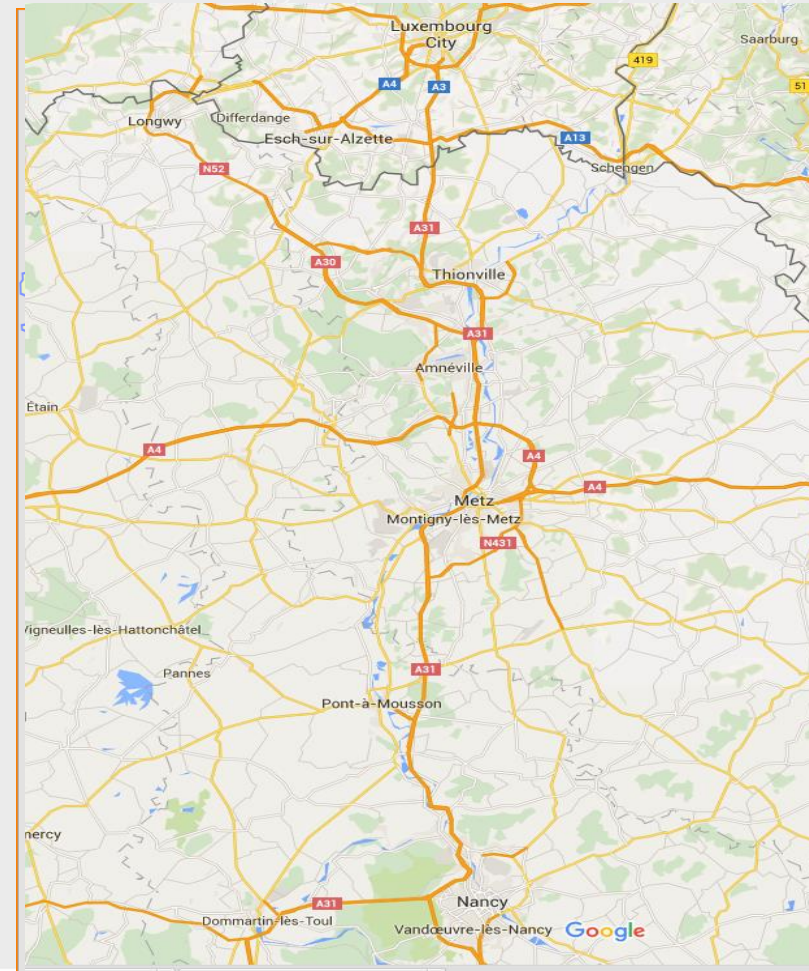
Background – Øresund Crossing

- 3.2million people in the Øresund region.
- Links:
 - Øresund crossing:
 - Tunnel.
 - Bridge.
 - Ferry from Helsingborg and Elsinore.
 - Cargo ships.
 - Kastrup/Malmo airport.
 - Railway network.
 - Telecommunications.
 - Power.
 - Oil storage.



Background – A31 Highway

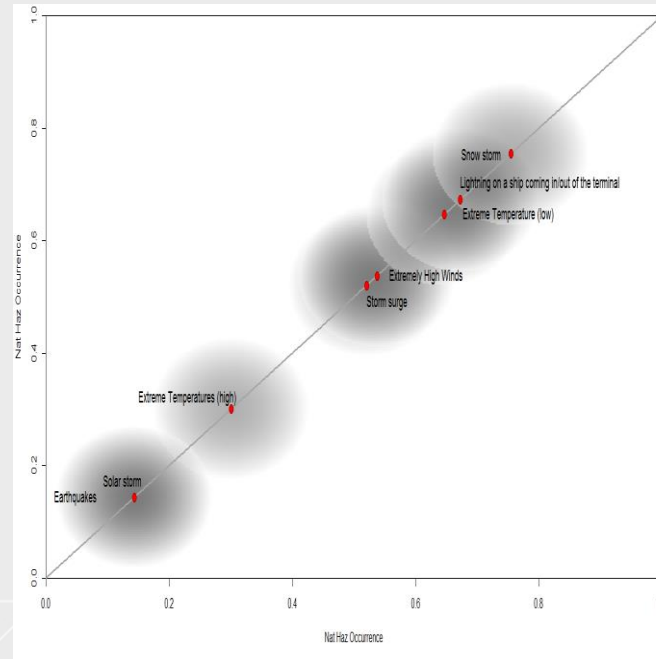
- Is 351 km long.
- Serves the cities of Dijon, Nancy, Metz and the Luxembourg City.
- Used by:
 - 80,000 to 96,000 vehicles per day.
 - 10,000 heavy vehicles.
- The study focuses on the Nancy-Luxembourg part of the A31 highway.



Natural Hazards

Scenario	Port of Oslo	Øresund Crossing	A31 Highway
Earthquake	X	X	X
Solar Storm	X	X	
Extremely high winds	X	X	X
Extreme Temperature (low)	X	X	X
Extreme temperature (high)	X	X	X
Lightning	X	X	
Storm surge	X	X	
Snow storm	X	X	X
Wildfire			X
Flooding			X
Landslide			X

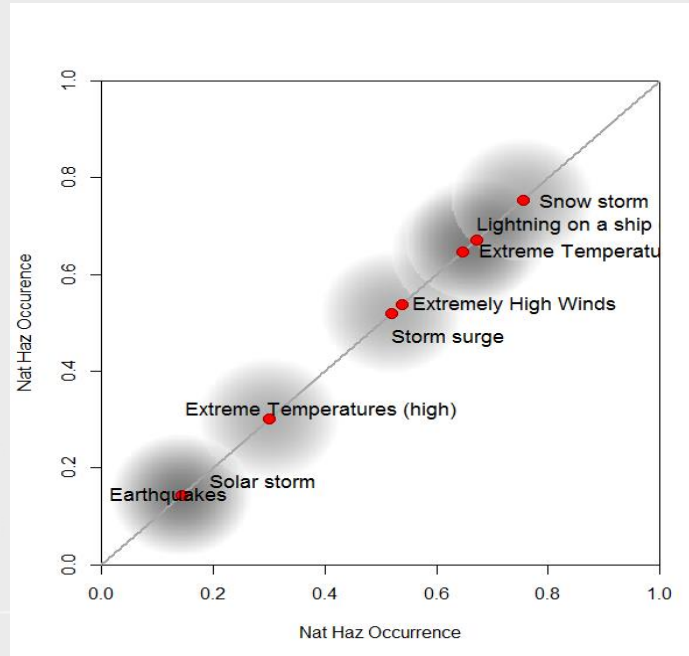
Results – Port of Oslo – Lik of Occurrence



- Individual participants are consistent.
- The group ranking are not random.
- There is moderate agreement within the group of the 7 participants.
- **Least likely to occur : solar storm +earthquakes.**
- **Most likely to occur: Not clear.**

Stats	Value
Coef. of Agreement	0.53
p -value (group)	0.00
p -value (individual)	$\ll 0.05$

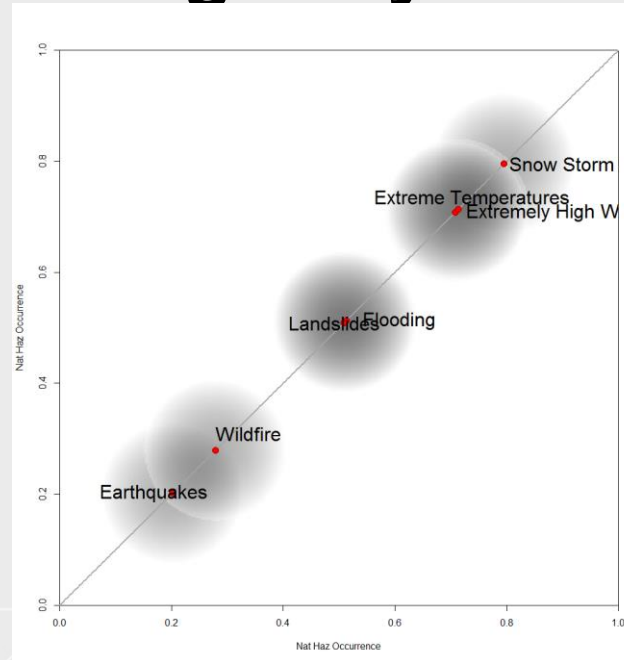
Results – Øresund – Lik of Occurrence



- Individual participants are consistent.
- The group ranking are not random.
- There is moderate agreement within the group of the 8 participants.
- **Least likely to occur: Earthquake + Solar storm.**
- **Most likely to occur: Lightning + Extremely high wind.**

Stats	Value
Coef. of Agreement	0.60
p -value (group)	0.00
p -value (individual)	$\ll 0.05$

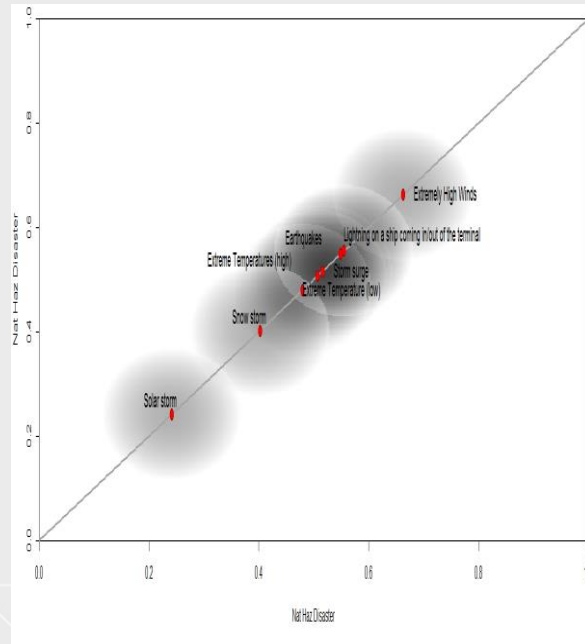
Results – A31 Highway – Lik of Occurrence



- Individual participants are consistent.
- The group ranking are not random.
- There is notable degree of agreement within the group of the 5 participants.
- **Least likely to occur: Earthquake + Wildfire.**
- **Most likely to occur: Snow Storm + 2.**

Stats	Value
Coef. of Agreement	0.60
p -value (group)	0.00
p -value (individual)	$\ll 0.05$

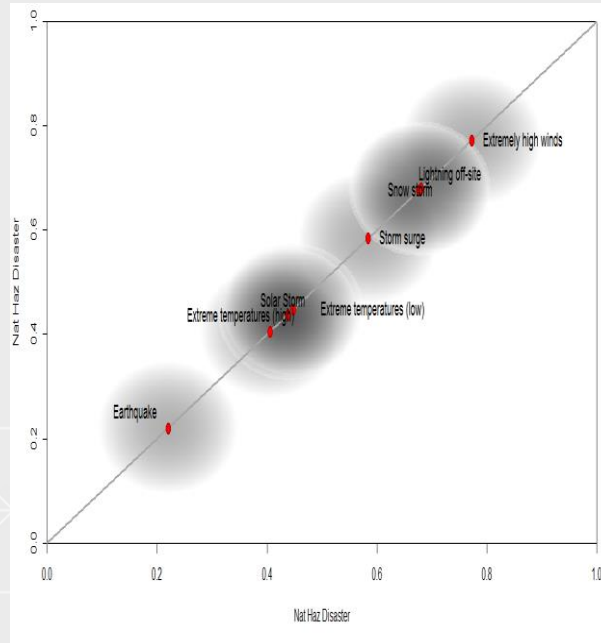
Results – Port of Oslo – Lik of Disaster



- Individual participants are consistent.
- The group ranking appears to be random.
- There is virtually no agreement with the 7 participants.
- **Least likely to cause disaster: solar storm.**
- **Most likely to cause disaster: (extremely high winds?).**

Stats	Value
Coef. of Agreement	0.00
p -value (group)	0.50
p -value (individual)	$\ll 0.05$

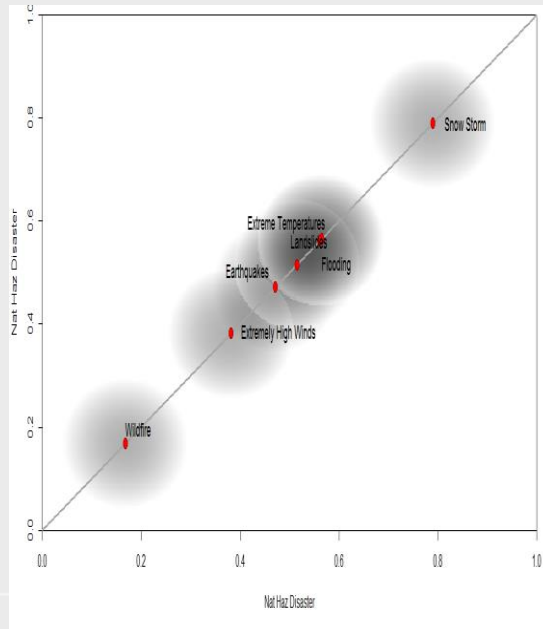
Results – Øresund – Lik of Disaster



- Individual participants are consistent.
- The group ranking appears to be random.
- There is virtually no agreement with the 8 participants.
- **Least likely to cause disaster: Earthquake**
- **Most likely to cause disaster: 3 Scenarios.**

Stats	Value
Coef. of Agreement	0.15
<i>p</i> -value (group)	0.00
<i>p</i> -value (individual)	<< 0.05

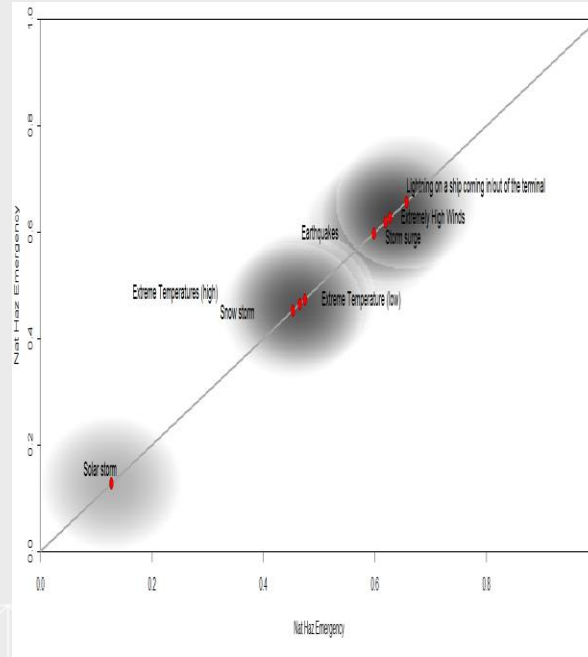
Results – A31 Highway – Lik of Disaster



- Individual participants are consistent.
- The group ranking is not random.
- There is low degree of agreement with the 5 participants.
- **Least likely to cause disaster: Wildfire**
- **Most likely to cause disaster: Snow Storm.**

Stats	Value
Coef. of Agreement	0.27
<i>p</i> -value (group)	0.00
<i>p</i> -value (individual)	<< 0.05

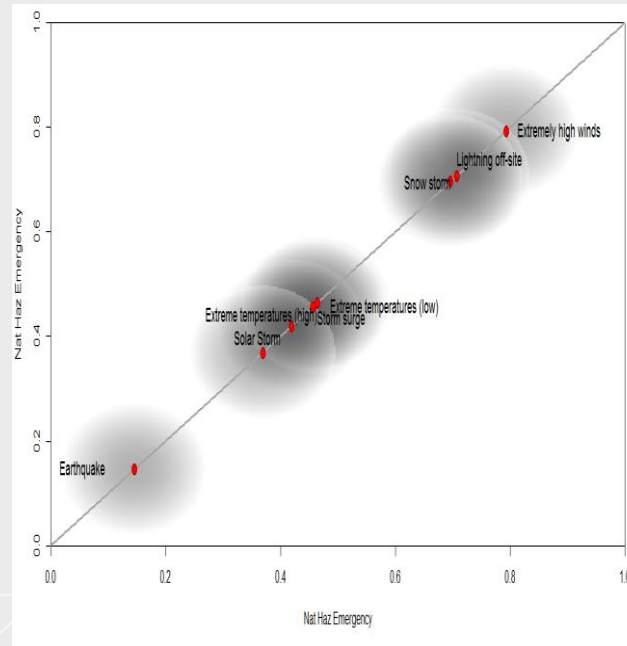
Results – Port of Oslo – Lik of Emergency



- Individual participants are consistent.
- The group ranking is not random.
- There is virtually no agreement with the 6 participants.
- **Least likely to cause emergency: solar storm.**
- **Most likely to cause emergency: (4 scenarios).**

Stats	Value
Coef. of Agreement	0.07
<i>p</i> -value (group)	0.04
<i>p</i> -value (individual)	<< 0.05

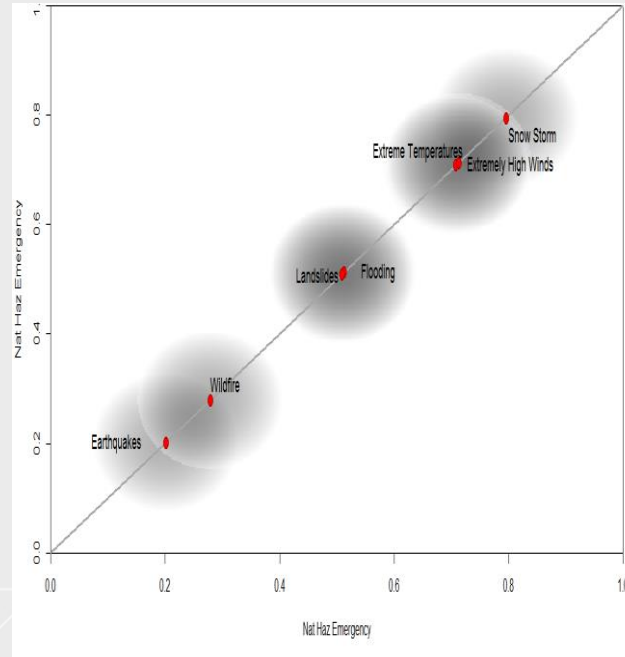
Results – Øresund – Lik of Emergency



- Individual participants are consistent.
- The group ranking is not random.
- There is low level of agreement with the 8 participants.
- **Least likely to cause emergency: Earthquake.**
- **Most likely to cause emergency: 3 scenarios**

Stats	Value
Coef. of Agreement	0.27
<i>p</i> -value (group)	0.00
<i>p</i> -value (individual)	<< 0.05

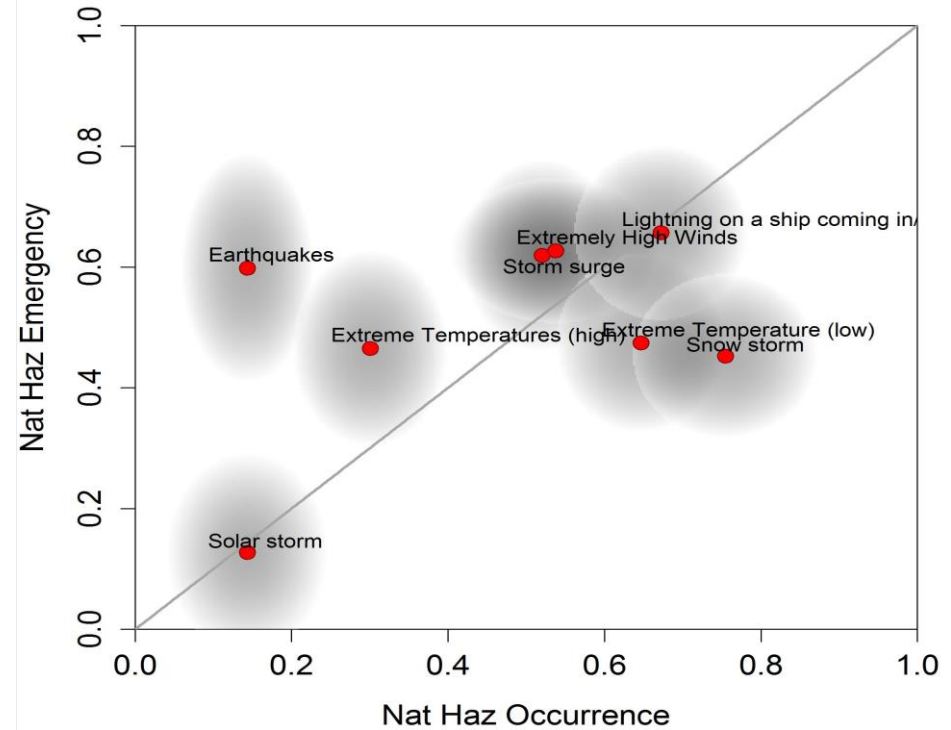
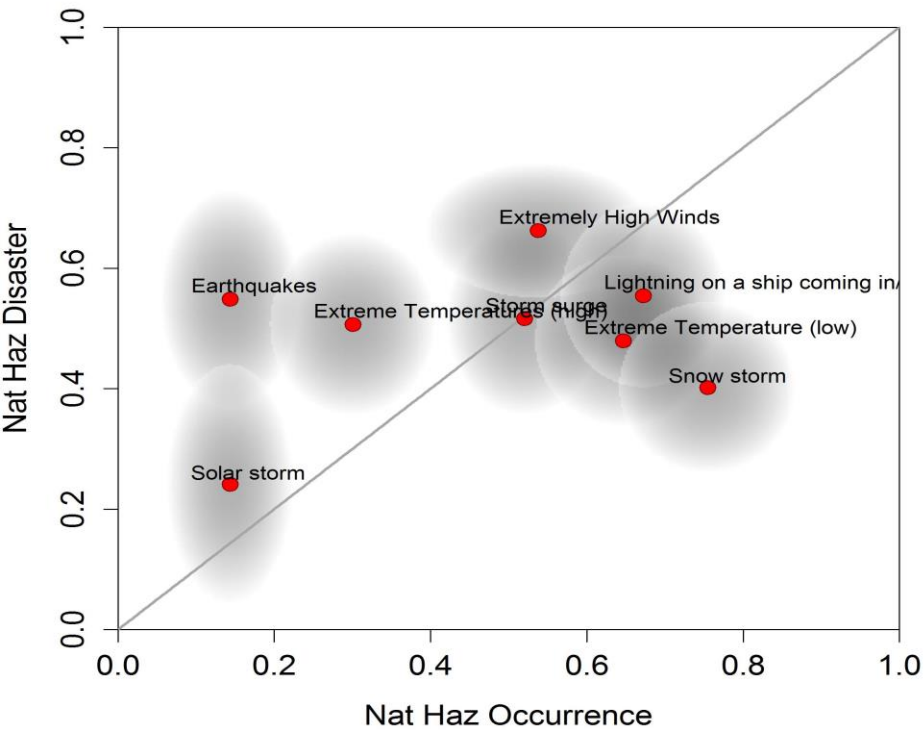
Results – A31 Highway – Lik of Emergency



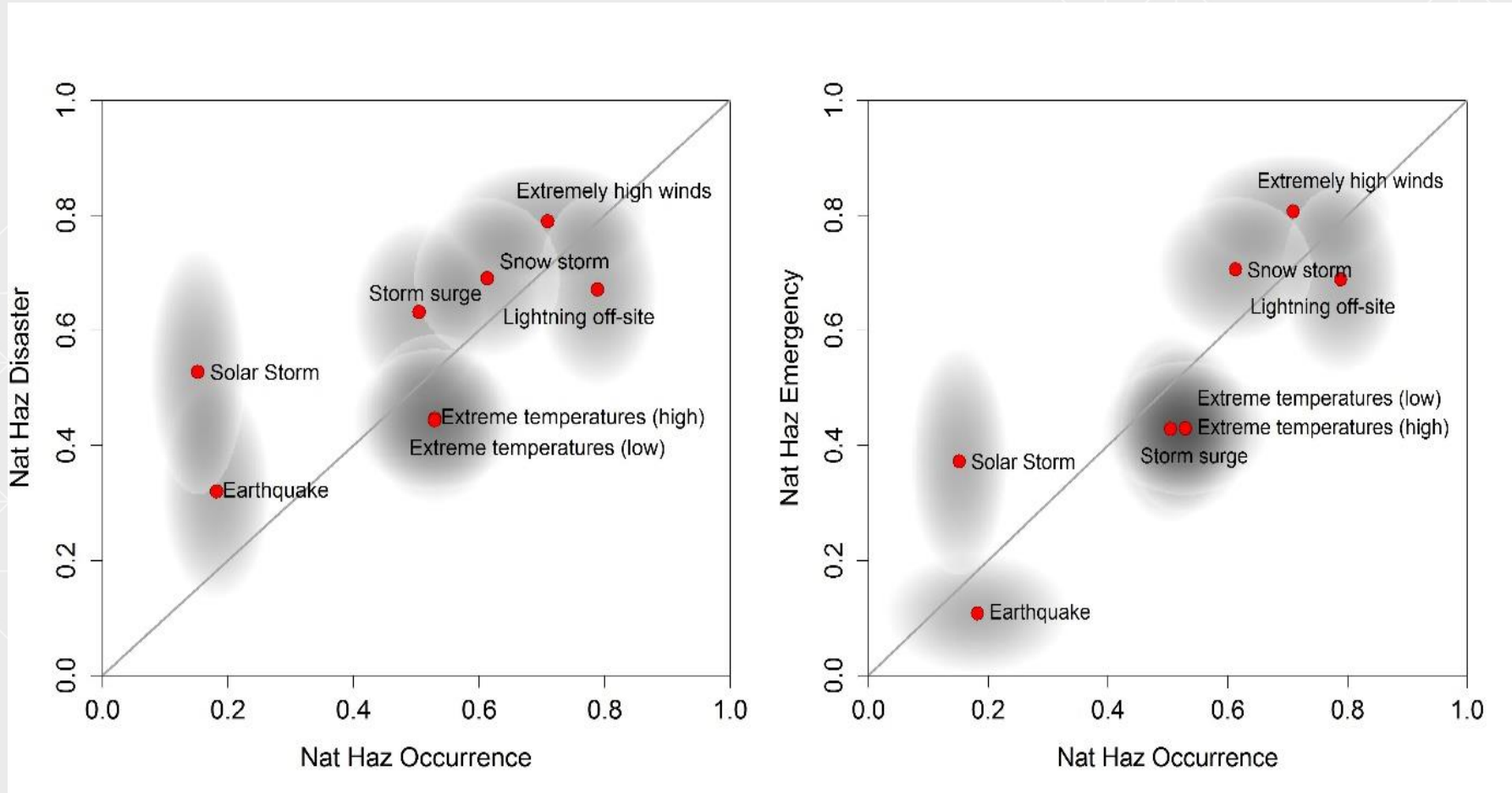
- Individual participants are consistent.
- The group ranking is not random.
- There is low level of agreement with the 5 participants.
- **Least likely to cause emergency: Earthquake.**
- **Most likely to cause emergency: 2 scenarios**

Stats	Value
Coef. of Agreement	0.27
<i>p</i> -value (group)	0.00
<i>p</i> -value (individual)	<< 0.05

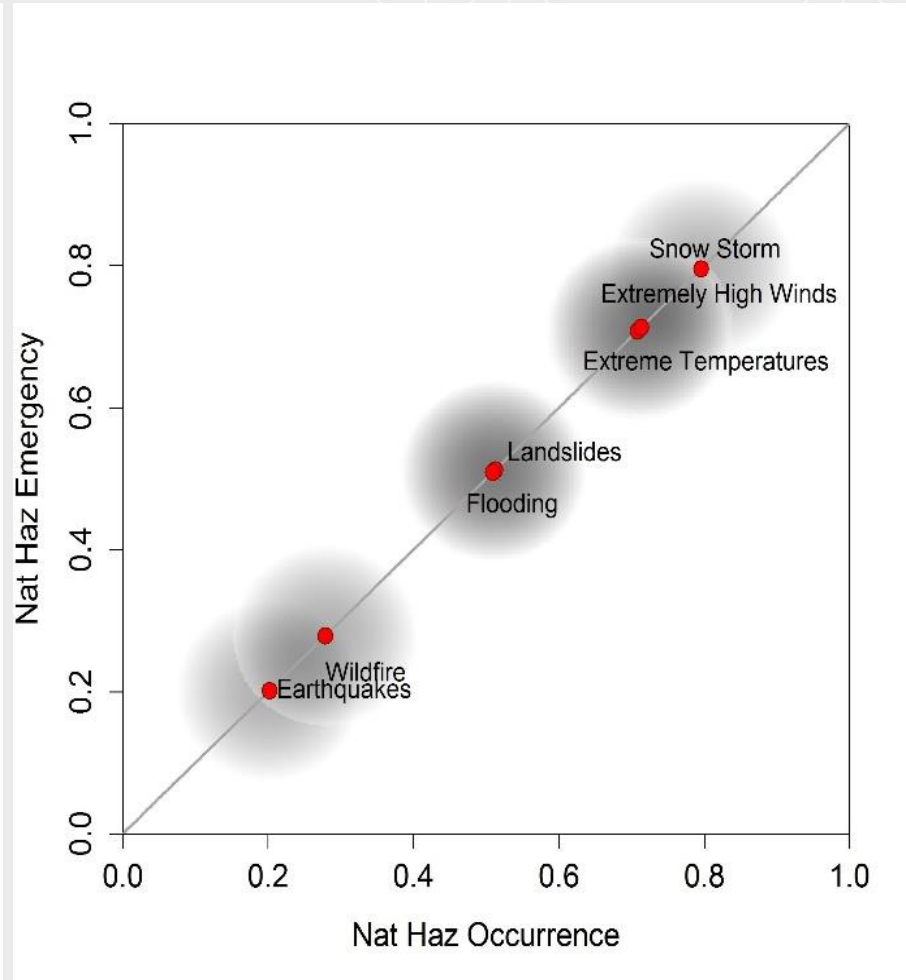
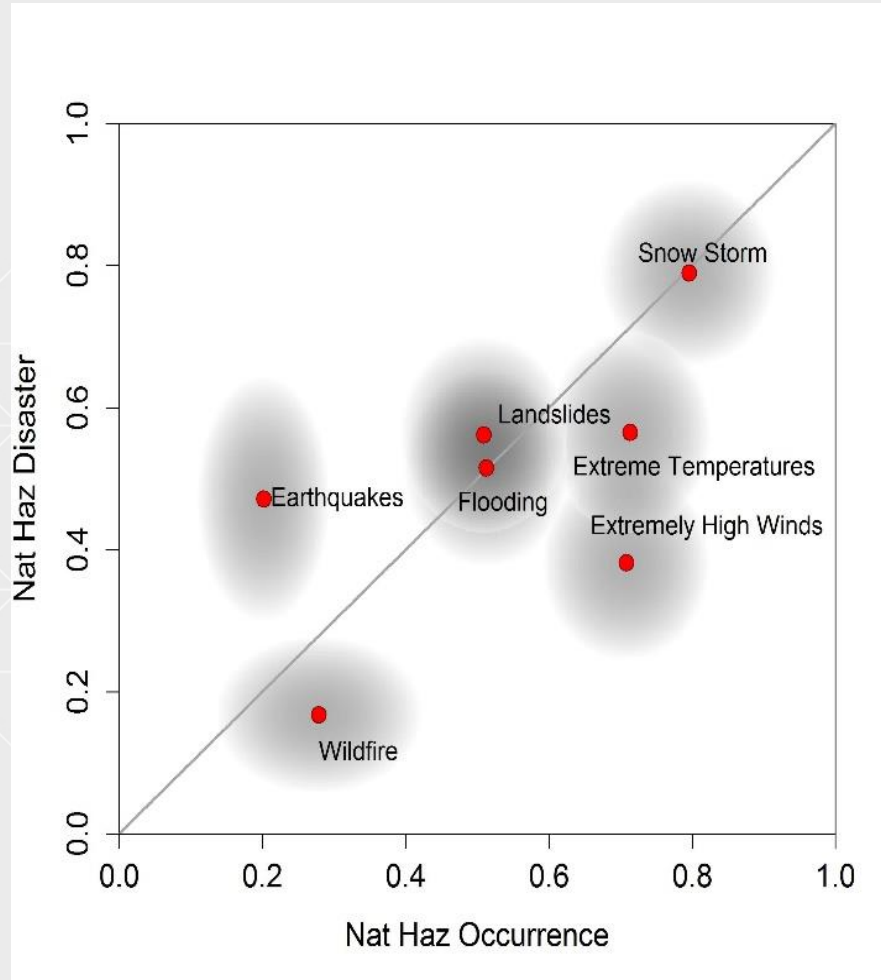
Results – Port of Oslo



Results – Øresund



Results – A31 Highway



Operational Hazards

- Scenarios more than 10.
- Scenarios for different component of the network.



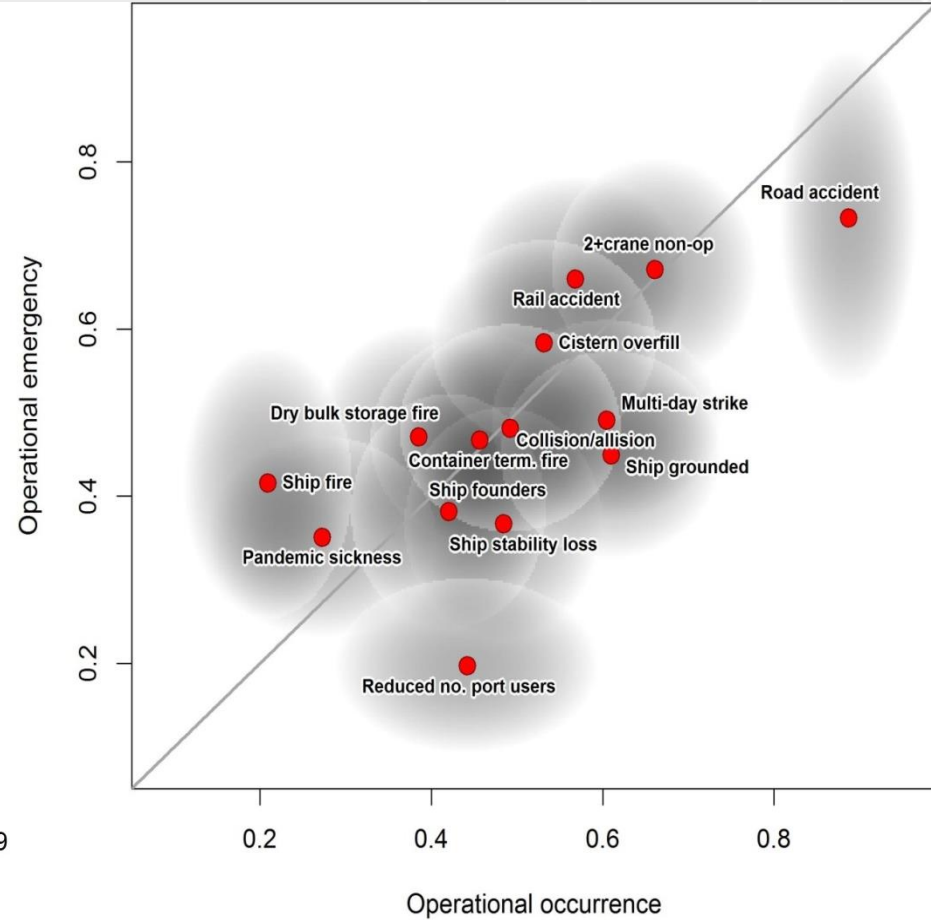
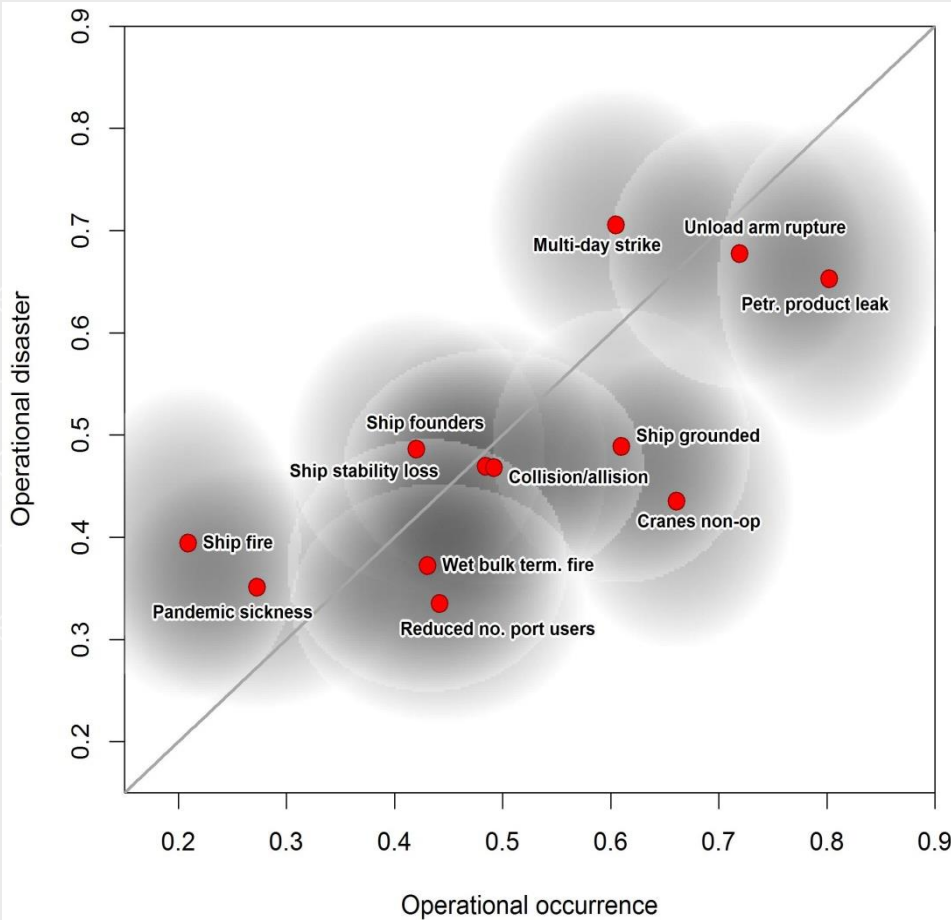
Operational Hazards – Port of Oslo

Operational Hazards Scenario	Likelihood of		
	Occurrence	Disaster	Emergency
Road accident.	√		√
Rail transport accident.	√		√
More than one crane are non-operational.	√		√
The majority of cranes needs replacement.		√	
Fire/ explosion in dry bulk storage.	√		√
Fire/ explosion at the container terminal.	√		√
Fire/ explosion at the wet bulk terminal.	√	√	
Pandemic (25% of staff on sick leave).	√	√	√
Multiple day industrial action of staff	√	√	√
Gasoline leakage at the wet bulk terminal.	√	√	
Rupture of an unloading arm at the wet bulk terminal.	√	√	
Overfilling of wet bulk storage cistern.	√		√
Loss of stability of a ship in fjord.	√		√ ^{**}
Loss of stability of a container ship blocking the entrance in the wet bulk terminal.	√	√ [*]	
Foundering of a ship in the fjord.	√		√ ^{**}
		√ [*]	√ ^{**}
Grounding of a ship in the fjord.	√		√ ^{**}
Collision / allision of ships in the fjord.	√	√ [*]	√ ^{**}
Fire/ explosion on a ship in the fjord.	√	√ [*]	√ ^{**}
Reduction in the number of users of the port.	√	√ [*]	√

Operational Hazards – Port of Oslo

Stats	Likelihood of		
	Occurrence	Disaster	Emergency
Coef. of Agreement	0.014	0.00	0.00
p -value (group)	>0.05	$\ll 0.05$	>0.05
p -value (individual)	$\ll 0.05$ (3/7)	$\ll 0.05$	$\ll 0.05$

Operational Hazards – Port of Oslo



Conclusions

- A methodology to identify risk-related scenarios for critical infrastructure is developed.
- The application to 3 living labs identified the complexity of the task.
- The stakeholders were more comfortable with the natural hazards.
- The feedback workshop is necessary.

Thank you

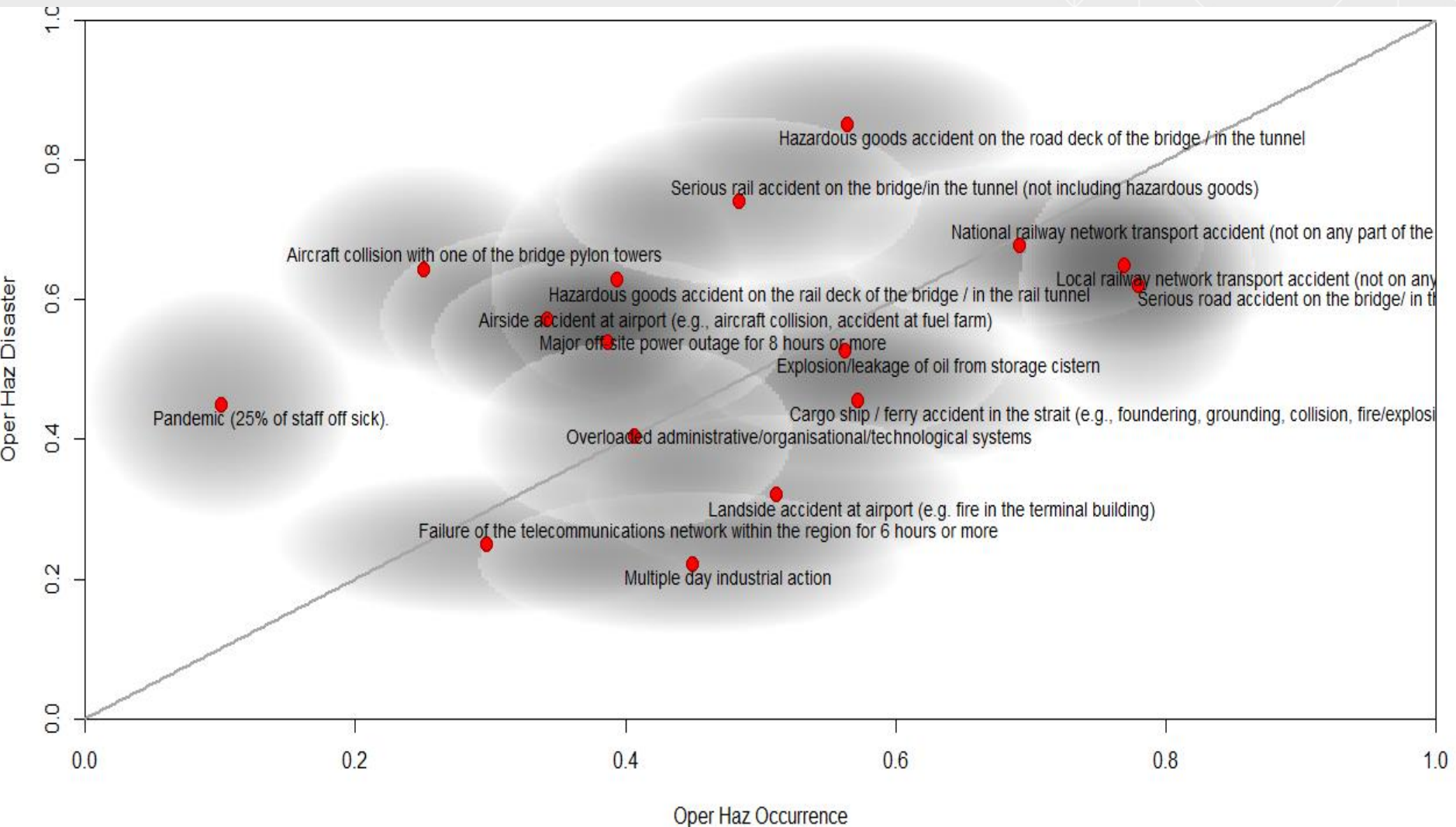
Operational Hazards – Oresund

Operational Hazards Scenario	Likelihood of		
	Occurrence	Disaster	Emergence
Pandemic (25% of staff off sick).	√	√	√
Multiple day industrial action.	√	√	√
Overloaded administrative/organisational/technological systems.	√	√	√
National railway network transport accident (not on any part of the Öresund link).	√	√	√
Local railway network transport accident (not on any part of the Öresund link).	√	√	√
Cargo ship / ferry accident in the strait (e.g., foundering, grounding, collision, fire/explosion, loss of stability).	√	√	√
Aircraft collision with one of the bridge pylon towers.	√	√	√
Hazardous goods accident on the road deck of the bridge / in the tunnel.	√	√	√
Serious road accident on the bridge/ in the tunnel (not including hazardous goods).	√	√	√
Hazardous goods accident on the rail deck of the bridge / in the rail tunnel.	√	√	√
Serious rail accident on the bridge/in the tunnel (not including hazardous goods)	√	√	√
Failure of the telecommunications network within the region for 6 hours or more.	√	√	√
Major off-site power outage for 8 hours or more.	√	√	√
Explosion/leakage of oil from storage cistern.	√	√	√
Airside accident at airport (e.g., aircraft collision, accident at fuel farm).	√	√	√
Landside accident at airport (e.g. fire in the terminal building).	√	√	√

Operational Hazards – Øresund

Stats	Likelihood of		
	Occurrence	Disaster	Emergency
Coef. of Agreement	0.01	0.01	0.22
<i>p</i> -value (group)	0.06	>0.05	<<0.05
<i>p</i> -value (individual)	<<0.05	<<0.05	<<0.05

Operational Hazards – Øresund



Operational Hazards – Øresund

