



# Bridging the Gap

## Preparing for Long-Term Infrastructure Disruptions

Rasmus Dahlberg, PhD Fellow  
Danish Emergency Management Agency  
Copenhagen Center for Disaster Research

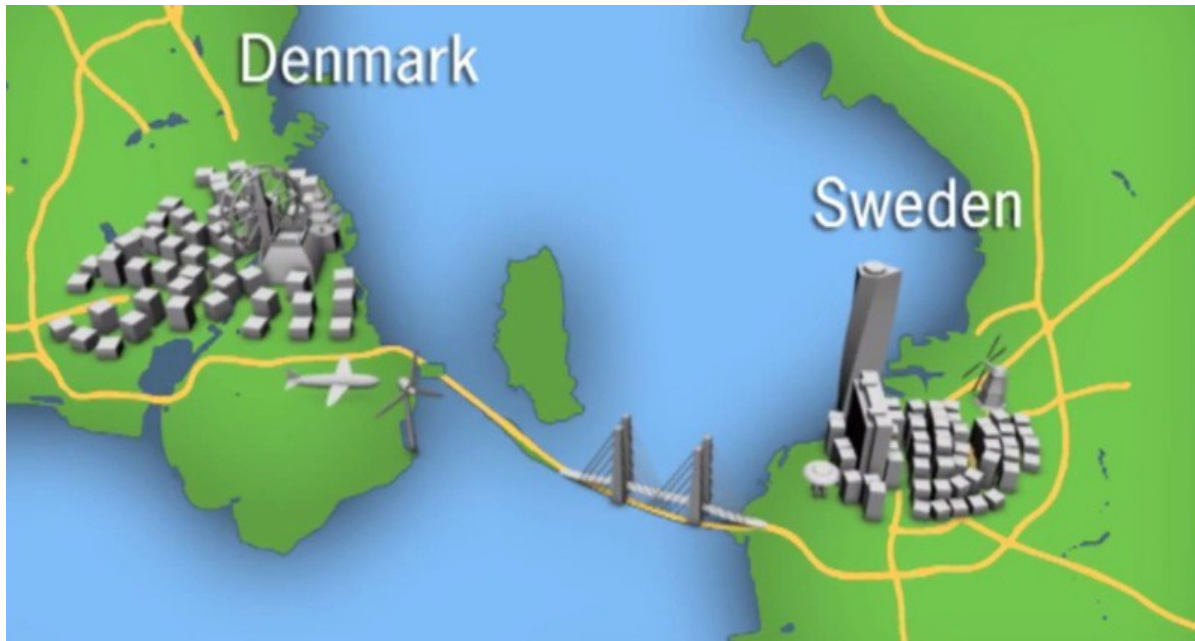


# Øresundsbron (Øresund Bridge)



- connecting Denmark and Sweden since 2000

# Øresundsbron (Øresund Bridge)



Copenhagen: pop. 600,000  
Malmö: pop. 300,000



# Øresundsbron (Øresund Bridge)

## Hard facts:

- 70,000 travellers per day (rail + road)
- 160 passenger trains per day
- More than 10,000 daily commuters and appr. 25,000 regional “critical travels”
- Most commuters live in SE, work in DK

# The nature of infrastructure

“Infrastructures are matter that enable the movement of other matter”

Larkin, Brian. 2013. “The Politics and Poetics of Infrastructure.”  
*Annu. Rev. Anthr.* 42: 327-343

“Infrastructures are by definition invisible, and the only become visible when they break’down”

Star, Susan Leigh. 1999. “The ethnography of infrastructure.”  
*American Behavioral Scientist* 43 (39): 377-391.

# The nature of infrastructure

- Infrastructure duality:
  - Tangible technology
  - Intangible process
- A bridge with traffic is an infrastructure – without it's just a technology!

# A critical infrastructure?

“...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”

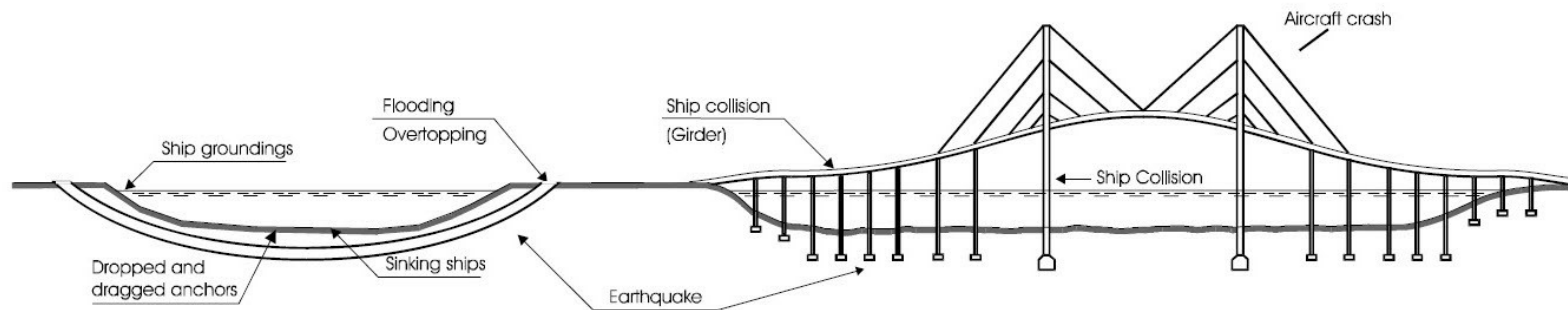
(Council Directive 2008/114/EC)

# A critical infrastructure?

- A 2010 report by Incentus Partners concluded that the Øresund Bridge is NOT an EU Critical Infrastructure
- Nevertheless, the Swedish Ministry of Transportation states that the bridge is of "high importance" and that alternative connections must be established in case of long-term disruptions (30+ days)
- This raises the question of what options exist for delivering service for "critical transportation needs"
- Danish-Swedish work group was tasked with mapping, analyzing and recommending a contingency plan for disruptions (final report presented March 2016)

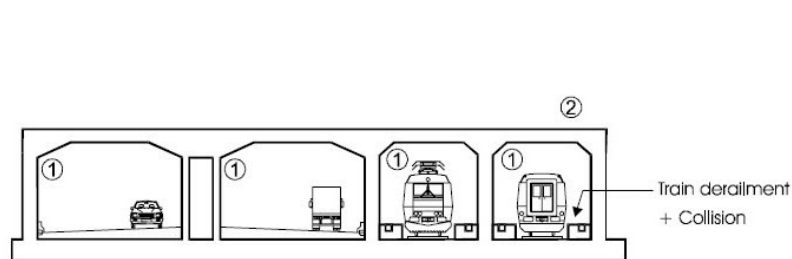


# Long-term disruptions



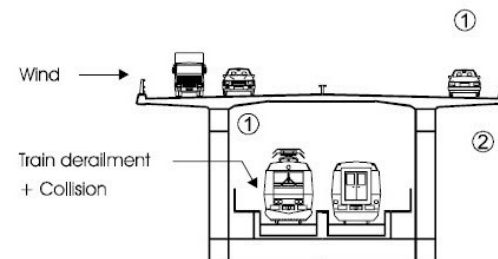
Tunnel

Bridge



- ①
- Fire
  - Explosions
  - Toxic releases

- ②
- Design and construction errors
  - Operator and procedure errors



# Long-term disruptions

- 2008 Operational Risk Analysis (ORA) estimates the probability of a long-term (30+ days) closure of the bridge at 3,7 % for the fixed link's entire expected lifetime (100 years)
- Considerably higher risk for tunnel closure due to collisions (26,3 %)
- 100+ days disruptions: less than 2 %

# Probabilistic vs. possibilistic thinking

- Probabilistic Risk Assessment (PRA) is often perceived to be more “objective”
- PRA requires solid data and thorough understanding of system and process
- Lee Clarke proposed in 2006 “possibilistic” thinking as an antidote/complement to probabilistic thinking

# Probabilistic vs. possibilistic thinking

- Probabilism:
  - Quantification of events over time
  - Application of statistical tools
- Possibilism:
  - Low probability, high impact events (long tails or “Black Swans”)
  - “Worst Case Scenarios”

# Probabilistic vs. possibilistic thinking

Scenario for low-probability long-term disruption of the fixed link:

“There was a heavy fog. A northbound container ship hit one of the protective islands of the high-level bridge pillars. Through the collision some containers fell into the sea, one of them containing carbide. The container, which for security reasons had been placed as far as possible away from the crew and the machine room, was damaged when it fell into the sea. Water came in and acetylene gas was formed, which caught fire through the formation of sparks between the hull, which turned to the north, and the container, which scraped against the side of the hull. A rather powerful explosion followed and fire started in the bow. The bridge pillar was enveloped in flames and it was feared that the concrete would become weakened, so the traffic on the bridge was closed down.”

Paulsson, Ulf (2003): *Supply chain flows in and across Öresund before and after the Öresund Link – facts, risks and a risk analysis model*. Lund University.

# Response and recovery

- Denmark: *Trafikal genoprettelsesgruppe* (Traffic restoration group)
- Swedish transport authorities



Emergency Management Cycle



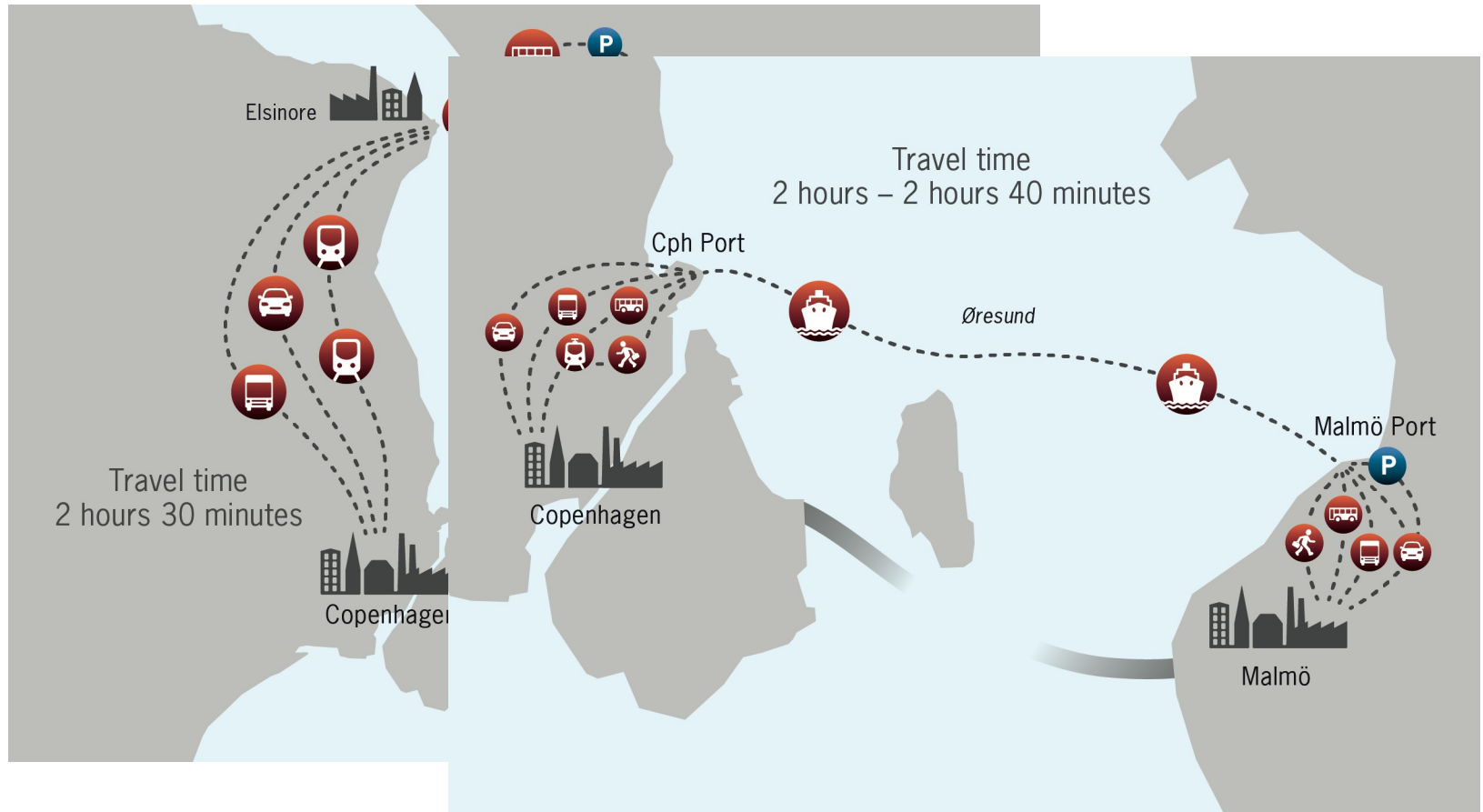
- Denmark: NOST
- Swedish crisis management system



# Contingency planning

- 10,000+ daily commuters
- 10,000 daily travellers to and from Copenhagen Airport (4,000 business)
- Options:
  - Existing ferry route to the North
  - Temporary ferry connection between Copenhagen and Malmö

# Contingency planning





# Contingency planning

- Long-distance freight will self-organize
- Challenges:
  - Delays in market-driven responses (3 to 6 months could be difficult)
  - Very dense traffic in central Copenhagen causing delays
  - Rail: Limited rolling stock available
  - Regional/local freight reloads to road

# Lessons from Lake Champlain and Forth Road Bridge closures



Lake Champlain Bridge  
New York/Vermont, Oct 2009



Forth Road Bridge  
Edinburgh, Scotland, Dec 2015

# Lessons from Lake Champlain and Forth Road Bridge closures

- Over time communities grow together (health/rescue services, business etc.)
- Affected people react publicly and demand action and information from authorities and CI operators/owners
- Both closures were due to slow wear and tear unnoticed by the operator!

# Absorption and adaptation

- **Absorptive capacity** is the capacity to limit the extent of sudden performance reduction
- **Adaptive capacity** is the degree to which the system is capable of self-organization for coping with the unexpected and to adjust to novel conditions of operation.

***Source:** Framework for Maintaining Resilience Capability against Critical Infrastructure Disruptions. READ Project, working paper.*

# Absorption and adaptation

- Adaptiveness means being able “to adjust to changing circumstances during a disruption by developing **new plans, taking new actions, or modifying behaviors** so that you are better able to withstand and recover, particularly when it is not possible or wise to go back to the way things were before”
- “Adaptiveness suggests **flexibility** – the ability to apply existing resources to new purposes or for one thing to take on multiple roles.”

Rodin, Judith (2015): *The Resilience Dividend: Managing disruption, avoiding disaster, and growing stronger in an unpredictable world*. London: Profile Books.

# Exploding adaptive capacities

- Small qualitative *gonzo* survey
- Conducted on the trains between Copenhagen Airport and Malmö Central on June 16 2015
- n=45 (only 2 refused to talk to me)
- No selection of respondents, only a broad diversity in gender, age etc.
- Avg. length of interviews: 3 minutes
- Number of Øresund crossings: a lot!!

# Explosing adaptive capacities

All respondents were asked about:

- Their thoughts about short-term disruptions of the fixed link (1 day)
- ...medium-term disruptions (1 month)
- ... and long-term disruptions (1 year)
- ... as well as their expectations for the traffic companies, authorities etc.

# Short-term disruption (1 day)

- Stay home for the day (26 comments)
- Travel via Elsinore-Helsingborg ferry (10 comments)
- No idea (6 comments)
- Use personal network (3 comments)
- Panic! (1 comment)



# Medium-term disruption (1 month)

- Change travel patterns (20 comments)
- Utilize flexibility (9 comments)
- Lower travel frequency (6 comments)
- No idea (6 comments)
- Relocate to other side of Øresund (3 comments)

# Long-term disruption (1 year)

- Change travel patterns/frequency (18 comments)
- Relocate to the other side of Øresund or look for a new job (17 comments)
- Utilize flexibility (6 comments)

# Absorptive capacities

- “I would have called my boss and told him that I couldn’t come in today.” (10)
- “Worked from home, no problem. Tried it before.” (16)
- Would just have worked from home. “I don’t really relate to that, I just stay home and get my things done. [laughs]”. (22)
- “I would have stayed home, just like when there is a snow storm.” Cannot work from home, but okay for one day. (32)
- “Just stayed home. Can’t work from home, but I would have registered it as a day off.” (34)
- “Then I would have had to call my boss and tell him that I couldn’t go to work today.” (40)
- “I would have worked from the hotel.” (42)

# Adaptive capabilities

- “I would relocate my office” in case of a 30 day disruption. That is feasible “with computers nowadays”. (4)
- “In my situation, being as young as I am, I would probably start looking for another job.” (14)
- “Then I would change my work so I could work from home. I have functions that I could do from home.” (32)
- “Then we have a problem! [laughs]” Would use the flexibility of his job to adapt: longer work days, planning ahead, writing reports from home etc. (36)
- “Then I would have taken a different connection to Malmö – would probably have flown somewhere else.” (42)
- “I would have gone via H-H. I have traveled this route for eight years so I know it very well.” Would travel by car or train depending on when he is informed of the disruption. (43)

# Expectations for the CI operators, traffic companies and authorities

- Most of the respondents do not hold the authorities solely responsible for disruptions to the fixed link between Denmark and Sweden: "I would think that there is a reason why it is closed today." (1)
- "When traveling you never know if you should expect things to work." (9)
- "No, not really. I would use the available news and solve the problem myself." (43)
- "I don't really have any expectations for the role of the authorities. I would probably just solve the problem myself. I would find a Plan B or a Plan C." (45)
- Would not expect any assistance from the authorities to find new routes to destination. "I rely on my skills to do it, to rearrange it. Kind of a survival task [laughs]." (8)
- Information, information, information!!!

# Preliminary conclusions

- Most people are positive about coping with even long-term disruptions
- A lot of people DO have a kind of Plan B
- Many commuters are very flexible
- People take a lot of responsibility for solving problems themselves
- Low expectations for the authorities

# Early recommendations

- Develop **enabling strategies** aimed at strong nodes in commuter networks (help organize car pooling etc.)
- Work with **employers** (commuters seem to turn to them before the auth.)
- Consider reminding users that the service **may be** interrupted one day (ask "Do you have a Plan B?")

# Further info and contact

## **Rasmus Dahlberg**

Danish Emergency Management Agency  
Copenhagen Center for Disaster Research

dahlberg@sund.ku.dk

The READ project:

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

