Extreme Weather Impacts on European Networks of Transport
- summary of relevant findings

Project for the call TPT.2008.1. Assessing disruptive effects of extreme weather events on operation and performance of EU transport system

WEATHER project Final Conference
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VTT Transport & Logistics
Bio of Pekka

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Vice-President  Jaakko Pöyry Group subsidiary JP-Transplan
Corporate Analyst  Finnish Railways (VR Group)
Road Policy Engineer
R&D Manager  Finnish Road Administration S-E district
Consultant  Finnmap Ltd.

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Adjunct professor, University of Oulu, dept. of industrial engineering and management, *business and investment analysis in transportation*

Adjunct professor, Technical University of Tampere, dept. of logistics and business information management, *transport and logistics*
Goal and research strategy

The goal of EWENT project is **to assess the impacts of extreme weather events on EU transport system. These impacts are monetised.** EWENT will also evaluate the efficiency, applicability and finance needs for adaptation and mitigation measures which will dampen and reduce the costs of weather impacts. The methodological approach is based on generic risk management framework that follows a standardised process from identification of hazardous phenomena (extreme weather), followed by impact assessment and closed by mitigation and risk control measures.

EWENT will start this **by identifying the hazardous phenomena, their probability and consequences** and proceed to **assessing the expected economic losses** caused by extreme weather when it impacts the European transport system, taking also into account the present and expected future quality of weather forecasting and warning services within Europe.

EWENT will apply **the IEC 60300-3-9 risk management standard framework** all the way through its research process and the project’s work breakdown also follows the standard structure.
OBJECTIVE: Risk management strategy for the EU transport system to prepare for and mitigate the impacts and costs of extreme weather phenomena

WP1: Extreme weather phenomena that have potential internal and external cost impacts on EU transport system; the threshold criteria for weather parameters

WP2: The probability of extreme weather and scenarios for increased probabilities and intensity

WP3: Impact mechanisms for system failures or disturbances (mobility meltdown, reduced safety and security) and operational failures (predictable mobility of passengers and goods); impacts on selected transport system performance indicators

WP4: Estimation of expected costs of extreme weather on time axis, based on identified impacts and scenarios: infrastructure (material damages), operations and traffic (accidents, time delays)

WP5: Evaluation of likely scenarios and most relevant costs; listing of prospective mitigation and adaptive strategies; risk panorama for EU transportation system

WP6: Assessing the effectiveness and preliminary investments required by different mitigation strategies on time axis; e.g. new weather information services, new institutional co-operative models (especially between authority functions and across national boundaries), development needs of standards and engineering guidelines for transportation infrastructures
The consortium

<table>
<thead>
<tr>
<th>Beneficiary Number</th>
<th>Beneficiary name</th>
<th>Beneficiary short name</th>
<th>Country</th>
<th>Date enter project</th>
<th>Date exit project</th>
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<tbody>
<tr>
<td>1 (Coordinator)</td>
<td>VTT Technical Research Centre of Finland</td>
<td>VTT</td>
<td>FI</td>
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<td>2</td>
<td>German Aerospace Center</td>
<td>DLR</td>
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<td>3</td>
<td>Institute of Transport Economics</td>
<td>TÖI</td>
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<td>7</td>
<td>Österreichische Wasserstraßen GmbH</td>
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<td>8</td>
<td>European Severe Storms Laboratory</td>
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<tr>
<td>9</td>
<td>World Meteorological Organisation</td>
<td>WMO</td>
<td>UN</td>
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</table>
Depth of analysis | Aviation | Land transport | Marine & waterways |
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<tbody>
<tr>
<td></td>
<td>Passenger</td>
<td>Freight</td>
<td>Road</td>
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<td>Detailed</td>
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<td>Brief</td>
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<td>Excluded</td>
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The transport system is viewed from three angles:

- **infrastructure**: these are direct material damages or deterioration of physical infrastructures
- **operations**: these are harmful impacts on traffic safety and transport reliability (both freight and passenger)
- **indirect impacts to third parties**, e.g. supply chain customers and industrial actors.
Cost impact vs. cost absorption

System impact disruptive level

Intensity

*rain fall
*snow fall
*wind speed
*etc.

Impact

Disruptive level

Costs associated!

Cost absorption
Impact analysis – example railways

Phenomena | Impact | Consequences
--- | --- | ---
Thunderstorms | Lightning strikes | Electricity shocks | Traffic control systems | Time delays
 | | Power failures | | Accidents
Storm winds | Falling trees | Line cuts | Power supply systems | Customer dissatisfaction
 | | | | Disturbances is operations
Snow storms | Stacking snow | Frozen switches | Switches | Increased maintenance / repair costs
Schedule & other info

• The project started in December 2009.
• Duration: 30 months.
• Total budget: ca 2 MEUR
Status in April 2012

- WP1 100%: deliverable + VTT Working Papers
- WP2 100%: deliverable + FMI Publications
- WP3 100%: deliverable + DLR Research Report
- WP4 80%: draft deliverable
- WP5 90%: draft deliverable
- WP6 60%: draft deliverable

- Number of papers, presentations, published sub-deliverables, etc.

- Many parties volunteered to join the network, e.g.:
  - OECD, CER, SNCF, EASA, companies, other research projects

- Project web-site: [http://ewent.vtt.fi/](http://ewent.vtt.fi/)
WP1 - Phenomena
What’s in it?

- Long list of extreme weather phenomena with critical threshold values
- A set of causal maps
- Analysis of >200 media reported cases
- Review of 150 scientific and professional publications
Table 8. Threshold values for winter conditions.

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Impacts</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 0°C</td>
<td>This is an important threshold related to slipperyness (ice formation, form of precipitation: rain/sleet/snowfall). The temperature itself is rather a modifier of hazardous conditions for transportation than a main cause. Low temperature combined with precipitation and wind can have a disruptive effect on traffic. Occurrence of freezing drizzle, increased frequencies of freeze-thaw cycles.</td>
<td>Increased accident risk in road traffic. The occurrence of freezing drizzle might be hazardous for aviation and road traffic. Premature deterioration of road and runway pavements.</td>
</tr>
<tr>
<td>≤ -7°C</td>
<td>The effect of salting for ice removal decreases in low temperatures. So, even relatively small amounts of snowfall can cause slippery conditions on highways when packed on the road surface by traffic. Rail points may get stuck by drifting snow in low temperatures (observed in Finland and Canada). Ice formation on rivers may start if there are many cold days in a row. Some vehicles might have fuel problems (&quot;summer diesel sort&quot;).</td>
<td>Increased accident risk, delays and cancellations in road and rail traffic (e.g. Eurostar trains during winter 2009/10). Inland waterway transport might be disrupted.</td>
</tr>
<tr>
<td>≤ -20°C</td>
<td>Some vehicles might have fuel problems (Oslo, winter 2009/10). Rivers get ice-covered if there is a long-lasting cold period. Dangerous wind chill conditions occur when moderate winds prevail.</td>
<td>Public transport may encounter breaks due to fuel problems. (Oslo, winter 2009/10), riverboat traffic may stop. Limitations to transport personnel working outdoors.</td>
</tr>
</tbody>
</table>
Conceptual zoning

Climatic zones
- Scandinavian
- Temperate
- Alpine
- Mediterranean
- Maritime (N/S)
The true climate zones
<table>
<thead>
<tr>
<th>Date</th>
<th>Event Type</th>
<th>Conditions</th>
<th>Location</th>
<th>Sector</th>
<th>Description</th>
<th>Relevant Links</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.11.2007</td>
<td>Heavy snow</td>
<td>Strong wind</td>
<td>More than ten centimetres of snow</td>
<td>Sweden</td>
<td>Roads</td>
<td>Large numbers of motorists trapped in their cars on snow-blocked road, snowploughs and gritting trucks have been unable to get through, military all-terrain vehicles were able to help get control of the situation</td>
</tr>
<tr>
<td>24.12.2007</td>
<td>Hail</td>
<td>First flush - &quot;mud flush&quot; (mudslide)</td>
<td>40cm of water on the streets</td>
<td>Spain</td>
<td>Roads Public</td>
<td>Hail/slush storm in Vélez-Málagay Torre del Mar. The big amount of hail came down in 15 minutes. Roads A-7 needed to be cut between Velez-Malaga and Torrox in 7 kilometres. Lot of flooding and stream came with the power in Torre del Mar, Caleta, Algarrobo Costa and Mezquitilla.</td>
</tr>
<tr>
<td>26.12.2007</td>
<td>Heavy rain</td>
<td></td>
<td>45 litres of water per square metre</td>
<td>Spain</td>
<td>Roads</td>
<td>Heavy rain brings flooding to the Western Costa del Sol. The main A-7 road was closed to traffic. Christmas Eve saw a spectacular hail storm in parts of the Axarquia, causing traffic problems and damage to crops in the area.</td>
</tr>
<tr>
<td>1.1.2008</td>
<td>Heavy snow</td>
<td>Strong wind</td>
<td>wind speed 70km/h</td>
<td>Romania</td>
<td>Aviation</td>
<td>Snow storm in the whole country. Many national roads and a highway were closed, maritime ports from the Black-sea were also closed, the traffic on the Danube-Black sea canal was restricted, delays in road and rail traffic. The Henri Coanda airport and Baneasa airport from Bucharest were closed for several hours, many flights delayed</td>
</tr>
</tbody>
</table>

Media data file including > 200 cases
Extreme heat
Heavy rain
Strong wind
Heavy snowfall or extreme cold
Extreme heat
Drought
Visibility

Road transport
Air transport
Rail transport
Waterborne transport
Walking and cycling

A = Accidents
I = Infrastructure; damage or maintenance problem
T = Time delays
O = Operations failures; passenger & freight
WP2 - Probabilities
Six regional climate models

The chosen regional climate change projections are:

- SMHIRCA-ECHAM5-r3
- SMHIRCA-BCM
- SMHIRCA-HadCM3Q3
- KNMI-RACMO2-ECHAM5-r3
- MPI-M-REMO-ECHAM5-r3
- C4IRCA3-HadCM3Q16

Projections for 2020 and 2050

- 2011-2040
- 2041-2070
Source: FMI
Summary map of the mean changes by 2050s:

- Extremes are growing?
- Underestimation of heat-related problems?
- Precipitation increasing slightly and drought increasing strongly…?
Fog-hours in three major airports for 1975-2009

- Zurich
- London Gatwick
- Oslo
Status of the European Severe Weather Database

Application, e.g., tornado incidence

Tornado
1990 - 2009

ESWD
www.eswd.eu

Output formats at essl.org/ESWD/:
- Public: Map, HTML text table
- Users: also ASCII + CSV raw data

26/04/2010 n = 24688 reports since 1950

Source: Dotzek / ESSL
WP3 - Consequences
<table>
<thead>
<tr>
<th>Forecast per region</th>
<th>Nordic</th>
<th>Temperate</th>
<th>Alpine</th>
<th>Mediterranean</th>
<th>Maritime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windgusts</td>
<td>-1.5% to 0.3%</td>
<td>-2.1% to -0.2%</td>
<td>-0.4% to 1.5%</td>
<td>-1.3% to 0.5%</td>
<td>-1.1% to 0.8%</td>
</tr>
<tr>
<td>Snowfall</td>
<td>-7.7% to -2.6%</td>
<td>-14.2% to -7.2%</td>
<td>-3.1% to -0.8%</td>
<td>-7.4% to -1.2%</td>
<td>-4.5% to -0.9%</td>
</tr>
<tr>
<td>Heat Waves</td>
<td>0% to 4.0%</td>
<td>0.1% to 6.5%</td>
<td>0.1% to 7.0%</td>
<td>2.8% to 18%</td>
<td>6.2% to 14.6%</td>
</tr>
<tr>
<td>Cold Waves</td>
<td>-16% to -7.8%</td>
<td>-41% to -22%</td>
<td>-8.8% to -0.5%</td>
<td>-25% to -5.3%</td>
<td>-15% to -5.1%</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Delay</th>
<th>Nordic</th>
<th>Temperate</th>
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<td>Road</td>
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<td>Rail</td>
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</tbody>
</table>
WP 4 - Costs
Valuation and pricing

• For accidents, calculated as statistical value of life for fatalities, using also unit values for severe accidents and slight injuries (definitions as applied in European transport sector analysis)

• For time costs, using the official valuations of time used in the cost-benefit calculations (usually referred to as "time savings") the values of time where applied to selected case studies

• For aviation, the industry provides European level official figures that were used in the calculation, which has led to more comprehensive European level estimate of time costs
Cost estimates – road passenger transport

• Accident costs at present in EU27: 20.7 billion euro
• Accident costs in 2040: 6.5 billion euro
  (10% of the total reduction due to changes in climate between now and 2040)
• Accident costs at 2070: 4.5 billion euro
  (20% of the total reduction due to changes in climate between 2040 and 2070)
• Time costs at present: Not available at the European level, collected through selected case studies that are based on commuter volumes and the estimated average delays
• Road transport especially vulnerable as users have different skills and perceptions in terms of how to manage a situation
• Note: The major part of future decrease in the accident costs will be due to improvements especially in the vehicle safety technologies, not due to changes in weather directly!
Cost estimates – rail passenger transport

- Accident costs: Lower as amount of users lower than in road transport, and due to the fact that the system is more “professional” and “controlled”


- Time costs: Calculations show that impacts are much lower than in road transport, mainly due to the lower volume of passengers
Cost estimates – waterborne transport

• Accident costs: Less than 100 million annually, inland waterways and maritime transport combined
• Will decrease further by 2040 and 2070

• No time costs calculated (due to the nature of the waterborne transport, most volumes of passengers are leisure travellers, so also the value of time lost would have been lower than in other transport modes – and borne by the users)
Cost estimates - aviation

• No accident costs calculated, as there is a non-significant number of accidents in aviation

• At European level significant: One day of airspace closure (as in the case of volcanic ash from Iceland) costs several billions of euros

• This is a result of two factors: operator costs and passengers travel time losses

• According to 2040 and 2070 estimates depending on the climate zones a diversified picture emerges about the changes in costs
Cost estimates – freight transport

Six Empirical Studies of Bad Weather Impacts on Freight Transport, Logistics and Infrastructure Providers

1. Two surveys of business practitioners on bad weather impacts on road and rail freight transport, and infrastructure systems in the UK, Poland, Sweden, Switzerland, Finland, Austria and Norway, and preparedness quality

2. Modeling of impacts of two natural disasters on HGV traffic breakdowns and cost increases for road hauliers, logistics providers and shippers

3. Calculations of delayed cargo tonnages per freight train in Finland during 2008-2010 and values of time lost

4. Calculation of proportion of weather-induced delays in all delays of freight trains in Finland over 2008-2010

5. Modeling of co-variation between the odds for duration of freight train delays and aggregate weather indicators (mean monthly temperatures, precipitation averages and minimum and maximum temperatures) depicting weather conditions over Finnish rail network during 2008-2010.
WP5 – Risk panorama
The logic

\[
\text{Risk} = \text{Hazard} \times \text{Vulnerability}
\]
Hazard indicator calculus

- *Hazard indicator* is a probabilistic product of mode-specific and climate impact specific indicators in a country:

\[
[\text{Hazard indicator}] = \sum \{ [\text{probability of hazardous phenomena}] \times [\text{probability of negative impacts}] \times [\text{probability of negative consequences}] \}
\]

- Maximum probability maps have been used to prioritize the most relevant phenomena, impacts and consequences using Bellman’s optimality principles
- The probabilities are partly absolute (empirical), partly discreet
Vulnerability indicator calculus

• **Vulnerability indicator** is a product of mode-specific, infrastructure, economic and spatial indicators in a country:

\[
\text{[Vulnerability indicator]} = \sum \{ [\text{traffic volume}] \times [\text{population density}] \times [\text{infrastructure quality}] \times [\text{GDP/capita}] \}
\]

• The standard available Eurostat data is used
• Vulnerability indication is discreet
The product “Risk” is therefore *not* an *absolute measure* of risk, but a *ranking system*!

\[
\text{Risk} = \text{Hazard} \times \text{Vulnerability}
\]
Passenger transport system vulnerability indicator
Example: road system’s risk for delays in different EU27 countries