WEATHER

Weather Extremes: Assessment of Impacts on Transport Systems and Hazards for European Regions

---

Adapting Transport to Extreme Weather Events

Summary Report of the 3rd WEATHER Workshop,
Rotterdam, 20. May 2011

Venue:
STC-Events Conference Centre, Lloydstraat 300, 3024 JC Rotterdam

Status: Public

Version: 1.0 (final)

Date: 5.9.2011

Authors: Claus Doll, Stefan Klug (Fraunhofer ISI)
with input from participants and partners

Document details

This document should be cited as:

Doll, C. and S. Klug (2011): "Adapting Transport to Extreme Weather Events - Summary Report of the 3rd WEATHER Workshop, Rotterdam, 20. May 2011" Report prepared within the research project WEATHER (Weather Extremes: Impacts on Transport Systems and Hazards for European Regions) funded under the 7th framework program of the European Commission. Project co-ordinator: Fraunhofer ISI. Karlsruhe, 5.9.2011.

Document title:	Adapting Transport to Extreme Weather Events - Summary Report of the 3rd WEATHER Workshop, Rotterdam, 20. May 2011
Lead author:	C. Doll, S. Klug (Fraunhofer)
Contributions:	Project partners and workshop participants
Version:	1.0 (final)
Date:	5.9.2011
Status:	Public
Quality review:	

:

The WEATHER project:

Full title:	WEATHER – Weather Extremes: Impacts on Transport Systems and Hazards for European Regions
Duration:	November 1st 2009 to April 30th 2012
Funding:	Call 2008-TPT-1, 7th framework program of the European Commission, Directorate General for Research and Technical Development
Contract:	Grant Agreement no. 233 783
Consortium:	Fraunhofer Institute for Systems and Innovation Research (ISI), Karlsruhe – project co-ordinator Fraunhofer Institute for Transportation and Infrastructure Systems (IVI), Dresden , Centre for Research and Technology Hellas (CERTH), Helenic Institute for Transport (HIT), Thessaloniki Société de Mathématiques Appliquées et de Sciences Humaines - International research Center on Environment and Development (SMASH-CIRED), Paris Karlsruhe Institute for Technology (KIT), Institute for Industrial Production (IIP), Karlsruhe Institute of Studies for the Integration of Systems (ISIS), Rome HERRY Consult GmbH, Vienna Agenzia Regionale Prevenzione e Ambiente dell'Emilia Romagna (ARPA-ER), Servizio Idro-Meteo-Clima (SIMC), Bologna NEA Transport Research and Training, Zoetermeer
Internet:	www.weather-project.eu
Contact:	Dr. Claus Doll Fraunhofer Institute for Systems and Innovation Research (ISI), Breslauer Str. 48, 76139 Karlsruhe, Germany, T: +49 721 6809-354, E: claus.doll@isi.fraunhofer.de

Content

1 Introduction

The WEATHER project funded under the European Commission's 7th RTD framework programme has foreseen three workshops to discuss preliminary findings on vulnerability aspects, emergency management and adaptation strategies with external experts, stakeholders and the project advisory board. This last event was held on May 20th in Rotterdam with 22 external experts and the WEATHER project team. Presentations and discussions came from all modes of transport with focus on road and rail.

In the forefront of this workshop an input note had been distributed to all participants. It was aimed to guide the discussion in two parallel sessions on two important field of transport adaptation strategies within the 3rd WEATHER workshop by drafting the preliminary findings of the research team.

The workshop was divided into four parts, which is a morning plenary with presentation, two parallel working sessions in the afternoon on

- infrastructures and transport planning (Session 1) and
- vehicle technology and operations (Session 2),

concluded by a final plenary. The objective of the workshop was twofold:

1. **Set of adaptation measures**: The project team has provided a set of possible adaptation measures per mode and field of action. which should be commented and – if possible extended by the participants.
2. **Ranking of measures**: the WEATHER assessment framework has developed a rough multi criteria systematic to roughly evaluate and rank measures. The weights for the criteria proposed should be discussed by the participants.

To achieve these goals, participants have been handed out a questionnaire to be returned to the project team. The replies are considered in this documentation.

2 Presentations and Discussions

The following paragraphs provide a brief overview of the content of the workshop. The respective presentations may be accessed through the weather website at http://www.weather-project.eu/weather/inhalte/adaptation-workshop-may-2011.

2.1 Plenary I: Introduction and Sister Projects

The WEATHER project is embedded in a cluster of EU and nationally funded activities researching the resilience and adaptation options of transport with respect to climate change and weather extremes. A part of this cluster has been presented at WEATHER workshop 3.

Introduction: The WEATHER project and the workshop concept (Claus Doll, Fraunhofer ISI, Riccardo Enei, ISIS and Anestis Papanikolaou, CERTH-HIT)

The presentation introduced the recently submitted project reports on the Vulnerability Assessment (Deliverable 2) and on Crises and Emergency Management (Deliverable 3). The main messages from the project work so far are that total costs of extreme weather conditions range around €2.5 billion per year for the EU plus Switzerland and Norway. Related per passenger or ton kilometre this seems not to be dramatic, but given the great uncertainty of input data and methodological approaches the true figures may be much higher. Across all modes and regions, infrastructure damages by floods are the most costly event, followed by winter conditions. For crises and emergency management a number of good practices on information provision and emergency plans exist. But there is still much education work and institutional arrangements ahead to ensure good preparedness across Europe.

Discussion: The question arose whether the future development of weather phenomena has impacts on the policy recommendations worked out within the project. Although the data collection phase in the WEATHER project is closed, the recommendation framework will be sufficiently open to incorporate the future development. Policy guidelines consist of general principles carried out for the local situation, but most of them are as well applicable on the national level.

European Vulnerability and Adaptation Scenarios: Preliminary Findings of the EWENT Project (Pekka Leviäkangas, VTT)

The EWENT-Project (Extreme Weather Impacts on European Networks of Transport, www.ewent.vtt.fi) is funded under the same call as WEATHER by the European Commission. The EWENT approach strictly follows international risk management frameworks by considering cost impact and cost absorption of events. For each of the six climate zones regional climate change projections are used and samples of transport infrastructure (freight corridors, sea transport routes, airports) are investigated. The consequences of all weather phenomena assessed by the project are time loss and accidents, for which empirical material has been found. Although impacts, consequences, climate scenarios, technological responses etc. are uncertain, it seems that the consortium is able to point out where the gravest risks in terms of safety and efficiency seem to lie.

Relationships between extreme weather and transport disruption (Chris Baker, University of Birmingham

Chris Baker reported from the relationships between extreme weather and transport disruption in Britain as a preliminary result of the FutureNet-Project. Using the UKCIP projections (= British climate change scenarios) it tackles two basic questions: estimating the (physical) nature and shape of UK transport system in 2050 which will be most resilient to climate change. For both road and rail infrastructure several student projects have investigated correlations between weather data and transport disruption, respectively accidents. In the result it can be stated that correlation does exist, but only if we take spatially and temporarily average data. An impact could not be observed for extreme weather events. However, by taking very local weather data, a correlation can be expected.

National correlation for extreme weather events is indeed sometimes difficult to identify due to the varied summaries of weather data over large geographical areas coupled with the implementation of wide spread degraded service operation. It is true that more accurate correlations can be identified when analysed in more detail on a region by region basis, and it is by these standardised local methods that a more accurate national assessment should be created in the future.

2.2 Plenary II: Transport Modes

Adapting Rail Infrastructure: Findings of the ARISCC Project and UIC activity "Winter and Railways" (Enno Wiebe and Alex Veitch, UIC)

Plenary II was opened by a shared presentation from the International Union of Railways (UIC) on railways facing the challenges of climate change and extreme winter conditions. Alex Veitch showed some results of the two year project ARISCC

(= Adapting rail infrastructure to climate change). The aim is to find and disseminate good practise for weather event/ natural hazard management and propose new management approaches that can adapt to climate change. One important approach is to produce vulnerability and risk maps by screening today's and past weather, investigating priority areas and doing detailed on-site investigations. As a result adaptations measures and strategies such as alarm systems, monitoring systems, protective measures, change of standards and relocation of assets are suggested. It turned out that it is much better to consider climate change when building new infrastructure, rather than to retrofit existing infrastructure. The question remains whether the railway sector have close enough links with the climate forecasting community and whether future climate changes are being considered for new infrastructure projects and maintenance programs.

In the second part of the presentation, Enno Wiebe focused on the problem of winter seasons. The historic data evaluation of the project "Winter and Railways" raises the question whether we have forgotten what "winter" is. A survey among the train operation companies showed that the main problem is train design, including the current collection by pantographs, frozen doors or destroyed windows. The Infrastructure Managers regard switches and crossings as most vulnerable and often miss equipment for snow clearance. There are various best practises to prevent the rolling stock from winter problems, such as de-icing boogies and wagon bodies and snow deflectors. The problem with switches and crossings can be tackled by appropriate systems to assist snow clearance. Moreover, the consequence of winter problems in operations can be eased by adapted capacity plans and reduced service provision, accompanied by comprehensive communication via radio, news and internet. The UIC confirmed output recommendation stressing the requirement of "Severe Weather Incident Management & Communications" as agreed at UIC Winter & Railways Stockholm 03 May 2011.

Adaptation Strategies in Road Infrastructure (Michel Ray, EGIS Group)

Since 2004 EGIS works in the field of adaptation to climate change and participates in research projects concerning roads. The finding so far is that adaptation measures for road infrastructure are quite different. The existing network will require the heaviest investment to future-proof it against the potential consequences of climate change. Important key constraints for an appropriate investment strategy are that climate change is a multi-sectoral issue, which is not limited to transport infrastructure, and that a high level of investment funding is required, which is difficult to schedule. Moreover, there are few strategies in the area of existing networks, even though there is now an emerging awareness of this issue. There are various options of strategy development in the road sector: from strengthening the preventive maintenance, over a modal and intermodal redundancy development strategy to strict selection and scheduling of new investment strategy. The proposed investment strategy will be a combination of this various elements. Learning from past experiences (pedagogical effect) is of special importance.

Curtailing the impact: approaches for recovery management in transport systems (Henrik Ammoser, TÜV Rheinland Intertraffic GmbH)

Finally, the presentation of Henrik Ammoser provides insights into transport, communications and disasters as well as the planning and recovery software VISMOD development within a TU Dresden research project. Transport and communication systems are expected to work independently from weather effects. Indeed, not every extreme weather event must be a disastrous event causing problems in a transport network. But these systems are vulnerable, because of their complexity, the rising value of facilities and the high urban density. Moreover, infrastructure is usually underfinanced so that one has to invest money every year to repair the damages of hard winters. The Technical University (TU) Dresden conducted a computer based analysis of causality networks and simulated the evacuation process in case of disasters using the example of the recent flooding of the River Elbe in 2002. The software VISMOD is able to show the impacts on urban transport networks, whereas VISEP is an Evacuation planning software tool. Synthetic data were produced by modelling and simulation because empirical data were difficult to get. Ammoser pleads for establishing a risk culture involving the transport system and service provider. Important elements are the communication to users and public and media competence, which avoids any panic. During the discussion it has been noticed that problems sometimes can be solved outside the transport system. In some cases it might be the better and more efficient way instead spending more and more money into the infrastructure.

Summary remarks (Hedi Maurer)

In summary of the first part of the workshop **Hedi Maurer** stated that European regulations on infrastructures are often opposed to the market (transport operations). Moreover, uncertainty for future climate effects seems to be the main factor for not acting.

2.3 Parallel Session 1: Infrastructures and Planning

Chairs: Stefan Klug, Fraunhofer ISI and Georg Förster, Fraunhofer IVI

The first out of the two parallel afternoon sessions discussed infrastructure-related issues of adapting transport to the consequences of weather extremes and climate change. The general discussion was introduced by introductory presentations on rail and port infrastructure. Thereafter, the results of the general discussions and the information provided by the questionnaires are presented in turn.

2.3.1 Initial Presentations

UK Railways and weather phenomena (Paul Arnold, Network Rail)

From the perspective of UK railways the implementation of a “Seasons Management Team” constitutes an important adaptation measure. This team is engaged in Route Seasonal Preparedness Meetings with Train Operating Companies and is led by a dedicated National Weather Strategy Specialist. Furthermore, there are web based adaptation measures undertaken by Network Rail, such as SMT Weather, which assist in the efficient management and communications of processes during times of severe weather disruption.

However, the recent winters have highlighted the requirement to improve communications amongst relevant partners within Europe. For a proper preparedness for winter and other weather extremes, a Europe-wide coordination of communication structures, as currently brought forward by a UIC Recommendation, is of utmost importance. This recommendation will be actioned via the creation of RAILMET - Severe Weather Incident Management & Communications to the Rail Industry.

Rotterdam Port Authority's Adaptation Measures to Meet with Extreme Weather Events and Climate Change (Rinske van der Meer, Rotterdam Port Authority)

Rinske van der Meer illustrated the impacts of climate change on the Dutch Delta and explained both mitigation and adaptation measures. To mitigate the climate change Port & City of Rotterdam has launched a Climate Initiative programme aiming to reduce CO_2 levels of 1990 by 50% in 2025 by growing sustainably. In order to adapt to climate change, the port has prepared for higher water levels, considering a wide range of possible scenarios. Moreover, the 'inland transport capacity' during low river discharge will be guaranteed (e.g. by expanding the storage areas and optimal waterway management (ICT solutions)). A third important adaptation measure is to guaranty the fresh water supply even at low water levels.

2.3.2 Discussion of the Measures

After getting some practical examples of adaptation measures from these presentations the aim of the session was to have a structured discussion on the base of the list of measures proposed within the Input Note, Methodological aspects on the evaluation of adaptation measures and strategies are discussed jointly for both parallel session in Section 0.

The discussion on adaptation strategies moved along the following issues:

- The maintenance of infrastructures is considered as a key factor for network resilience. However, before thinking of optimised and improved maintenance procedures, one should recollect the **"good old" maintenance**, i.e. the regular and careful supervision and timely repair, rehabilitation or replacement of infrastructure assets. Due to cost pressure and budget constraints high maintenance and asset value standards are often neglected nowadays.
- Moreover, **organisational** measures must not be forgotten when drafting adaptation strategies. It is considered highly important giving appropriate incentives to stakeholders to apply and maintain adaptation measures. Target groups to address are policymakers, users and facility owners, managers and operators. An example given where the instrument of climate change plans in the UK, which has to be elaborated by certain stakeholders according to the Climate Change Act. In this context, **regulation** schemes have been regarded as equally important as physical adaptation measures during the discussion.

- Measures for adaptation are not necessarily independent of each other and may show mutual **interrelations** and impacts on other policy areas. Therefore it is necessary to estimate how one measure would affect the other in a comprehensive national or regional adaptation strategy. Several projects developing systemic models to combine different strategies are currently underway on the international level.
- Beyond the suggested ‘hard’ measures that aim to protect new and existing infrastructure from weather impact, it is also needed to include some **measures for quick recovery** after extreme events have happened.
- For the field of flood protection it has been emphasised that it is very necessary **to learn from other regions and actors**. Due to the different climate zones within Europe a lot of possible extreme events happened already somewhere in Europe. Thus it is important to focus on transferable measures. Furthermore, an **international cooperation** is essential in case of cross-border issues like a major river or the coast line. However, there is a general conflict between shipping business and water safety/ flood protection. Best practices can help to find the right measure for other countries
- For the application of the measures it is also important to consider the differences in **risk culture** among the European countries, which might challenge the international dialogue.
- In terms of the infrastructure technology, it has been concluded that many technologies are already known, but often not applied due to a lack of awareness/ qualification. Thus, measures should focus on the **education and training of civil engineers**.

Table 1 compiles the measures proposed in the workshop input note, the suggestions from the presentations and the results of the discussion for infrastructures and transport planning (Session 1). The measures are grouped according to activity field and, where appropriate, by transport mode.

Table 1: Discussed and proposed measures for infrastructures and transport planning

Measure	Hot spot	Comments
Infrastructure protection (road and rail)		
(Improved maintenance supervision)	all	maintenance of existing infrastructure = challenge; climate optimized maintenance planning Source: Ray (slides 3,10)
(construction of subsurface drains)	Rain/floods	Those measures should be designed locally specific (e.g. drains in very dry regions, which may be full of sand when needed)
Defining role of public and private sector	all	e.g. Incentives within contracts will influence adaptation measures in road/ urban transport infrastructure
Implementation of a Seasons Management / Integrated Natural Hazard Management	Winter	e.g. RAILMET - uniting European rail systems via a single web based Management & Communications source. Source: Arnold (slide 10); Veitch (slide 8)
Implementation of Seasons Management Conferences	Winter	e.g. RAILMET - Recognition and Notification of impending pan european severe weather disruption. Source: Arnold (slides 10)
SMT Weather	Winter	e.g. RAILMET - Collection of live weather data to assist in pan european operating decisions. Source: Arnold (slides 10)
Infrastructure protection (specific measures for rail)		
alarm and monitoring systems	Winter, storms	Source: Veitch/ Wiebe (slide 10)
Preventive maintenance on critical assets	Winter	Source: Veitch/ Wiebe (slide 22)
Switch protection by brushes (train-side), heating (8°C – 10°C) and covers (wood, plastics)	Winter	Source: Veitch/ Wiebe (slide 27)
Infrastructure protection (specific measures for road)		
mow wider strips along shoulders	heat+fire	Source: Ray (slide 10)
Hardening or semi-hardening highways	winter	Source: Ray (slide 13)

Giving up, if maintenance costs prohibitively high	winter	Source: Ray (slide 11)
Flood protection (maybe together with infrastructure protection)		
Port area adaptation strategy to cope with higher water levels	Rain and floods	Development of a toolbox with public stakeholders in order to prevent causalities and social disorder Source: van der Meer (slides 8,14)
Develop islands in front of the coast line	Rain and floods	
Apply software for traffic planning and evacuation	Rain and floods	Ex. VISMOD + VISEP (TU Dresden) Source : Ammoser (slide 14)
Develop a risk culture with communication to all stakeholders involved	Rain and floods	Source: Ammoser (slides 16-18)
Network planning in general		
Robust network planning	Rain, floods and mass movements	instead of deconstruction (because redundant emergency infrastructure is needed)
Build new infrastructure at the right place	Rain, floods and mass movements	Instead of • Displacement of infrastructures to safe areas • More resilient infrastructures in areas at risk • Low cost infrastructures in areas at risk
More efficient use of infrastructure by ICT	Rain, floods and mass movements	
relocation of assets (railway)	Rain, floods and mass movements	Source: Veitch/ Wiebe (slide 10)
Network investment as systematic approach / scheduled investment	Rain, floods and mass movements	incl. modal and multimodal redundancy and elaborating a transport master plan, Source: Ray (slide 8)
Soft measures	Rain, floods and mass movements	e.g. capitalisation of experiences, new decision and governance structures Source: Ray (slide 16)
Road/ Rail infrastructure technology		
Good infrastructure management	all	Most important measure, because extreme conditions may be partly normal by 2050
rail: change of standards	Winter	Source: Veitch (slide 10)

rail: Enabling passenger platforms for easy snow removal	Winter	Source: Wiebe (slide 22)
Inland Waterways		
Guarantying 'inland transport capacity' during low river discharge	Heat	• expansion of storage areas • effective modal shift during low water periods • optimal waterway management (ICT solutions) • infrastructure measures: canalization, building of groynes and locks Source: van der Meer (slides 8, 23)
Guarantying fresh water supply	Heat	High sea water levels in combination with low river discharge causes salt intrusion Source: van der Meer (slides 8, 24)

2.3.3 Assessment of the Measures

Table 2 shows the average range of weighting proposed by the eight participants who have completely filled and returned the questionnaire during or after the workshop. To avoid presenting the maximum ranges across the entire table edge values have been cut off if stated only once. The evaluation scheme for the five criteria is defined in Section 0. The measures written in bolt have been added by the experts.

Table 2: Evaluation of adaptation measures for infrastructures and transport planning

Measure	Potential of risk reduction	Feasibility	Flexibility	Ecological/ societal impacts	Range of costs
Infrastructure protection (road and rail					
Improved maintenance supervision (with special focus on the most vulnerable parts of the network)	1-3	1-3	2-3	0-+1	1-3
construction of hillside-fixing	1-3	2-3	1	-1 - 0	2-3
Construction/ **maintenance** of subsurface drains	1-3	2-3	0-2	-1 - +1	1-3

National Policy to change incentives in concession contracts	*2*	*2*	*3*	*2*	*1*
Floating construction			*1*	*0*	*3*
Other design-rules for bridges/ tunnels	*2*	*2*	*3*	*0*	*1*
Flood protection					
Construction and reinforcement of dikes and embankments	2-3	1-3	1-3	-1 - 0	2-3
Enlargement and deregulation of river beds to increase capacity	1-3	0-2	1-3	-1 - +1	2-3
Develop automatic monitoring of dike solidity*	3	2	1	0	1
Network planning in general					
(Deconstruction and) more efficient infrastructure use **+ Intelligent Transport Systems**	1-3	1-3	0-3	0 - +1	1-3
Robust (redundant) network planning	*3*	*3*	*3*	*+1*	*2*
Road infrastructure technology					
Deployment of heat (*and water*) resistant material/asphalt of paler colour	1-3	1-3	1-3	0 - +1	1-3
Improved climate control of electronic infrastructure (traffic signals, traffic control units)	1-3	1-3	1	0	1
Tools to help decision makers to invest right for adaptation measures (i.e. GIS based at section level, strategic approaches at regional level	*3*	*3*	*3*	*0*	*1*
Use ICT for information for traffic	*1*	*1*	*3*	*+1*	*0*
Rail infrastructure technology					
Deployment of heat resistant material	1-3	1-3	1-3	0 - +1	2-3
Replacement of rail overhead wires by integral track power supply	1-3	0-2	0-2	0	2-3

2.4 Parallel Session 2: Vehicle Technology and Operations

Chairs: Hedi Maurer, Panteia-NEA and Claus Doll, Fraunhofer ISI

The second parallel afternoon session discussed technological and operational issues of adapting transport to the consequences of weather extremes and climate change. The general discussion was introduced by introductory presentations on road logistics and climate adaptation of the aviation sector. Thereafter, the results of the general discussions and the information provided by the questionnaires are presented in turn.

2.4.1 Initial Presentations

Logistics under the Challenges of Climate Change (Feliks Mackenthun, ISL)

The project "northwest 2050" investigates clusters energy, nutrition and port/ logistics for the metropolitan area of Bremen-Oldenburg northwest. It is based on an empirical study, expert interviews, workshop and a supply chain analysis. One important finding from the empirical study is that more than 90% of respondents did not notice any influence on their business though climate change. However the logistic cluster is partly affected by increase of storms, rise in sea-levels, higher wind speed, extreme heavy precipitation and increase in heat waves. Measures have been realised in different areas: building-related, resource-related, vehicle-related, organisational as well as employee-related. Moreover the cluster already realises many measures according to climate protection (mitigation).

Update on EUROCONTROL ATM Climate Adaptation Work (Rachel Burbidge, EUROCONTROL)

AS a follow up to EUROCONTROL's presentation at WEATHER Workshop 1 (September 2010), Rachel Burbidge provided an update on the EUROCONTROL Challenges of Growth ATM Climate Adaptation Work. Its aim is to scope the environmental constraints which may impact ATM's ability to meet projected growth in demand, and to make the identified risks more tangible and specific by conducting a set of case studies. Although ATM already deals with extreme weather a further increase may impact the performance (delay, capacity, route efficiency etc.). Therefore various scenarios are considered.

Discussion: It should be noted that increased extreme weather events are just one of the potential challenges which climate change may pose for the aviation sector; network impacts may also be experienced in the medium to long-term though loss of airport capacity due to sea-level rise and through changing (tourist) demand patterns instigated by changes in climate. However, research carried out for the case studies suggests that increased incidences of extreme weather (storminess) are likely to be experienced in the short to medium term (as early as 2020). This may result in a need for greater predictibility, flexibility and information management: the Single European Sky ATM Research Programme (SESAR) is already addressing requirements for improving ATM performance in each of these areas. EUROCONTROL will take the specific issue of climate change adaptation forward into the SESAR P16.3.7 Environmental Regulation and Risk Project.

2.4.2 Discussion of the Measures

After getting some practical examples of adaptation measures from the initial presentations the aim of the session was to have a structured discussion on the base of the list of measures proposed within the Input Note, Methodological aspects on the evaluation of adaptation measures and strategies are discussed jointly for both parallel session in Section 0.

The discussion on adaptation strategies moved along the following issues

- Both presentations suggested that **supply and demand patterns** may change due to climate change. This implies that production sites may shift away from vulnerable coast-lines. In the airline industry first changes in demand, driven by climate change are predicted, i.e. the loss of demand to traditional (tourist) destinations. Conversely potential increases in demand to alternative destinations are possible. Also infrastructure projects, such as the choice of airport locations, might be affected and thus climate change impacts need to be taken account of in the business case for infrastructure projects with a life expectancy of longer than around 20 years.
- Large parts of the logistics sector are subject to global risk and many operations are characterised by multi-modal chains, involving a variety of players and consisting of global links. Therefore the global forwarding of goods is particularly vulnerable to extreme weather events. Due to the **heterogeneity of the logistics sector** the awareness with respect to climate change varies. Extreme weather events are often regarded as one-off events which do not require fundamental change of business operations or technologies.

- Weather impacts on logistics are a major issue for the **regional level**. It is a matter of awareness for the affected stakeholders. One reason for this is the **complexity** of logistic chains, which leads to different perception by local or global operators.
- In the long term impacts of adaptation measures, as well as of not adapting to climate change and weather extremes, on **modal shifts** within the transport sector have to be considered. Concentrating on highly cost-efficient measures can help maintaining the current market positions of transport modes. But this is strongly dependent on regions, climate conditions and the level playing field of transport market participants.
- Logistics undertakings as well as airlines focus on mitigation policies to reduce their carbon footprint and to calm other external effects. Adaptation to climate change is not yet recognised an important field of action by the market players.

One of the central conclusions in the discussion was that **uncertainty regarding the occurrence of extreme weather events** is likely to be the key for not acting. Adaptation strategies are applied where it proves to be economically viable or where it provides a competitive advantage. Legislative pressure presents a further argument for implementing adaptation measures.

Table 3 compiles the measures proposed in the workshop input note, the suggestions from the presentations and the results of the discussion for vehicle technologies and fleet operations (Session 2) The measures are grouped according to activity field and, where appropriate, by transport mode.

Table 3: Discussed and proposed measures for operations and vehicles.

Measure	**Hot Spots**	**Comments**
Logistics		
New vehicles and containers	Winter, floods, storms	Required: test cycles for weather proof of several construction and design forms. Medium-run availability,
New packing equipment (foils, covers)	heat	Weather-resistance of cargo. Low to medium costs, available in short-run.
Heavier constructed warehouses	Winter, storms	Facility management of shippers and forwarders; indirectly linked to transport.
Increase intermodal flexibility	All hazards	In order to react on closed connections

Aviation		
(More flexible air traffic management)	all	Has been underlined by Burbidge's presentation (dealing with changes in demand, delays, regulation); the Single European Sky ATM Research Programme (SESAR) is already addressing requirements for improving ATM performance these areas.
Considering partnerships/ global view	all	New measure (also between different actors/ stakeholders/ BUT cooperation with other modes not popular/ rather seen as competitors); Integrated international approach to address potential system-wide impacts.
Changes of design of routes/ mix fleet	All hazards	Common practice by air traffic control. Options: more flexible procedures
Rail		
Reduce speed and service patterns	winter	Plans must be transparent and communicated to users via several channels (Source: Wiebe)
Minimise splitting of trains	Winter	Problems with materials and couplings. (Source: Wiebe)
Systematic testing and winter preparation of vehicles	Winter	Possibly expensive and difficult when rolling stock is constantly in use. (Source: Wiebe)
Advanced de-icing boogies and wagon bodies	Winter	More winter maintenance than adaptation activity. Adaptation of de-icing procedures and provision of sufficient de-icer. (Source: Wiebe)
Covers for automatic coupling (UK)	Winter	Presumably cost efficient. (Source: Wiebe)
Improved train design (snow socks for horns, air filtering)	Winter	Cost efficient measures, short-run availability, preventing from repair. (Source: Wiebe)
Snow deflectors	winter	(Source: Wiebe)

2.4.3 Assessment of the Measures

Table 4 shows the average range of weighting proposed by the eight participants who have completely filled and returned the questionnaire during or after the workshop. To avoid presenting the maximum ranges across the entire table edge values have been cut off if stated only once. The evaluation scheme for the five criteria is defined in Section 0.

Table 4: Preliminary evaluation of adaptation measures for infrastructures and transport planning

Measure	Potential of risk reduction	Feasibility	Flexibility	Ecological/ societal impacts	Range of costs
Generic operation structures					
Comprehensive risk mapping	2-3	1-3	2-3	0-+1	0-2
Cooperation with other companies (intra-modal)	1-2	1-3	1-3	0-+1	0-2
Multi-modal measures					
Improved aerodynamics for side wind resistance (road and rail)	1-2	1-2	1/ 3	0	1
Cooperation between modes (inter-modal)	1-2	1-3	1-3	0	1
Road vehicle technologies					
Advanced Driver Assistance Systems (ADAS)	1-3	1-2	2-3	0 - +1	1-3
Rail					
Enabling of rolling stock to get energy supply from track side supply facilities	1-2		1	0	2-3
Use less double deck passenger trains	1-2	1-2	1	-1 - o	1/ 3
Aviation					
More flexible air traffic management	1-3	1-3	1-3	-1 - +1	1-2
Airborne sensors/ weather radars for all types of aircrafts	1-2	2-3	3	0 - +1	1 -3
Inland waterway transport					
Increase of the vessel measures “length” and “width”	1	3	1/ 3	0	2-3
Maritime shipping					
Smart technologies for abnormal events detection	2-3	1-3	1-3	0 - +1	1-3

2.5 The Assessment Framework

As concerns the proposed methodology the participants confirmed the usefulness of collecting and assessing measures as proposed by the project team. But it was strongly recommended that one should refrain from pursuing a quantitative priorisation of the suggested measures from the questionnaire.

The questions of weighting the criteria risk reduction potential, feasibility, flexibility, side effects and life cycle costs has been tackled in the two sessions. However, due to the complexity of the matter the agreement on a consensus appeared to be difficult. The range of measures from long life infrastructure investments to managerial and operative measures required separate assessment schemes, respecting the local and mode-specific conditions and sensitivities. Nevertheless, the discussion focussed on the highest importance for the two most obvious criteria, which is the risk reduction potential on the one hand and the directly associated monetary costs of implementation, maintenance and operation (life cycle costs) of the measure.

The discussion reached consensus that the criteria benefits and costs, and finally cost effectiveness, are of key importance for the ranking of measures, while feasibility, flexibility and side effects are of secondary importance as long as they do not add details to these factors. Both, costs and benefits, must be considered through the entire life cycle of the projects; considering initial costs and short run benefits are not enough. With respect to the partly vague situation of data availability participants suggested to directly estimate benefit-cost-ratios rather than to collect and assess data for both indicators separately. However, on European and national level detailed guidelines for benefit cost assessments exist and is common practice in transport planning. It is recommended that these should be adapted to adaptation measures to arrive at a standardised European evaluation scheme on life cycle basis.

With reference to aviation it was proposed to additionally consider the short- and long-term reaction of customers on the introduction or non-introduction of specific climate adaptation measures. Moreover, the strong dependence of the evaluation of the measures on the related area has been emphasised. For instance air traffic has a huge importance for interregional transport in Australia and cannot be substituted by other modes, while there is intensive intermodal competition in Europe.

Supported by proceeding works of the project partners on infrastructure planning issues, asking mainly European experts on a similar ranking of criteria, the following figure shows preliminary results of expert responses.

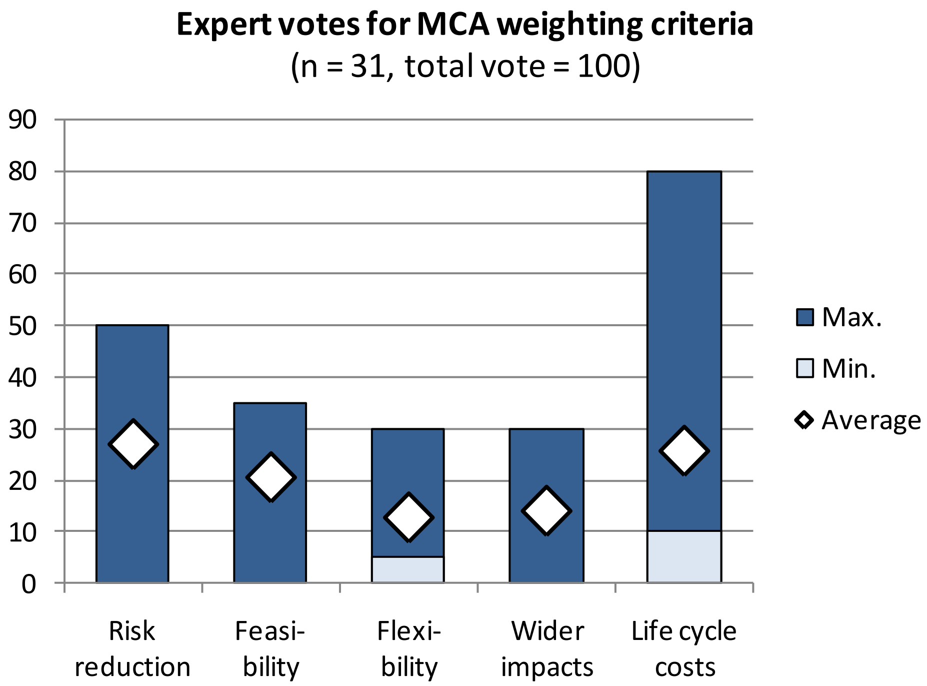
The underlying rating of the five criteria refers to a course quantification of the magnitude of impacts on a scale from zero to three. Details on the evaluation scheme are given in Table 5.

Table 5: Preliminary assessment criteria and valuation principles

Criterion		Weight	Value	Comment
A	Risk reduction	0...100	0…3	Is it possible to reduce the hazard using the adaptation measure? (0=no risk reduction, 3=very good risk reduction)
B	Feasibility	0...100	0…3	How simple/feasible is the implementation of the measure in practice? (0= no feasibility / high resistance, 3= very good feasibility)
C	Flexibility	0...100	0…3	Can the measure, once implemented, be adapted to changing developments of the hazard category addressed? (0=no flexibility, 3=high flexibility)
D	Wider Impact	0...100	-3…+3	What is the magnitude of positive or negative side effects on environment and society/Are there side effects using the measure?(-3=very negative impacts, +3=very positive impacts)
E	Range of costs	0...100	0…5	What are the likely costs for the affected infrastructure manager, transport operator, user or the state? (in share of respective life cycle costs: 0=<1%, 1=2% - 10%, 2= 11% - 25%, 3=26 – 50%, 4=51 – 100%, 5=>100%)
		100	**Weighted sum**	

The compiled results in Figure 1 in first place confirm the suggestion of the experts to give the highest weights to the risk reduction potential and the life cycle costs of the measures. But the comparison of max and min values also reveals a very high level of uncertainty behind these averages. These high deviations of single expert judgements are certainly driven by the vague formulation of the quantification indicators, the very different nature of measures and contexts, as well as the manifold issues related to the more soft factors other than direct benefits and costs.

Figure 1: Preliminary expert votes on rating MCA criteria



All in all, however, the discussion and the compilation of expert votes strongly suggest to apply a simple cost-benefit- or cost-effectiveness-analysis rather than a multi-criteria-approach.

3 Additional information

3.1 Acknowledgement

This document constitutes preliminary minutes and results of the third WEATHER project workshop held in Rotterdam, May 20th 2011. The report is published on the WEATHER website at www.weather-project.eu. Here, all presentations given at the workshop have already been provided for download.

The results of the workshop will be part of WEATHER Deliverable 4: “Adaptation Strategies”. This is currently under production and will be available at end of October 2011.

At this stage the WEATHER project team would like to express thanks to all participants attending, contributing to and supporting this last workshop of the project and providing valuable comments and additions to this report.

3.2 Context: The WEATHER project

There is a clear evidence of rising damages by natural catastrophes and extreme weather events, which can at least partly be attributed to climate change. While many studies focus on CO_2 mitigation in transport, research on the vulnerability of the sector on climate driven effects, such as extreme weather events, is coming up only recently.

The WEATHER project concentrates on singular weather events which either exceed the long term average of comparable meteorological activities and/ or have considerable negative impacts on assets and operation, human health or lives. It aims at analysing the economic costs of more frequent and more extreme weather events on transport as well as on the wider economy. Furthermore we explore adaptation strategies for reducing these costs in the context of sustainable policy design. The assessment includes all 27 EU Member States plus Switzerland and Norway.

The research is carried out by an international team of eight European institutes, lead by the Fraunhofer-Institute for Systems and Innovation Research (ISI). The project runs for 30 months from November 2009 until April 2012. Further details are available at www.weather-project.eu.

3.3 Contact information

WEATH’E’R project coordination

Fraunhofer Institute for Systems and Innovation Research (ISI)
Breslauer Str. 48, 76139 Karlsruhe, Germany
Fax: +49 721 6809-135, web: www.isi.fraunhofer.de.

Dr. Claus Doll (claus.doll@isi.fraunhofer.de, Tel.: +49 721 6809-354)

Dr. Stefan Klug (stefan.klug@isi.fraunhofer.de, Tel.: +49 721 6809-410)

Dr. Jonathan Köhler (jonathan.koehler@isi.fraunhofer.de, Tel.: +49 721 6809-377)

3.4 List of Participants

Participant	Affiliation
External exterts and speakers	
Hendrik AMMOSER	TÜV Rheinland InterTraffic GmbH
Paul ARNOLD	Network Rail
Chris BAKER	University of Birmingham
Niels BEUCK	CLECAT - European association for forwarding, transport, logistic and customs services
David BONILLA	Oxford University
Rachel BURBIDGE	EUROCONTROL
Christophe HEYNDRICKX	Transport & Mobility Leuven
Alexandre KADDOURI	SNCF - French National Railways
Pekka LEVIÄKANGAS	VTT
Feliks MACKENTHUN	ISL - Institut für Seeverkehrswirtschaft und Logistik
rancoise NEMRY	JRC-IPTS
Tabea NEUMANN	BASt - Bundesanstalt für Straßenwesen
Robert RAUSCH	DRK - German Red Cross
Michel RAY	EGIS Group
Ron RECK	VKT GmbH
Lori TAVASSZY	TNO

Barry UBBELS	Panteia-NEA
Thierry VALENDSLANDER	Univ. of Antwerp, Fadulty for Applied Economics
Alex VEITCH	UIC - International Union of Railways
Enno WIEBE	UIC - International Union of Railways

Project team members

Pier Paolo ALBERTONI	ARPA-EMR
Claus DOLL	Fraunhofer-ISI
Riccardo ENEI	ISIS
Etienne ARNAUD	Fraunhofer-ISI
Manuel GUTBERLET	Fraunhofer-ISI
Jan KIEL	Panteia-NEA
Stefan KLUG	Fraunhofer-ISI
Hedi MAURER	Panteia-NEA
Evangelos MITSAKIS	CERTH-HIT
Anestis PAPANIKOLAOU	CERTH-HIT
Ina PARTZSCH	Fraunhofer-IVI
Valentin PRZYLUSKI	SMASH-CIRED
Norbert SEDLACEK	HERRY Consult
Christian TRINKS	KIT-IIP / CEDIM