



MANAGEMENT OF **WEATHER** EVENTS IN THE **TRANSPORT** SYSTEM

## Project Final Report

Co-funded by the European Commission under the 7<sup>th</sup> Framework Programme,  
SP-1 Coordination

Grant agreement no: 314506

Coordination and Support Action

Project:	Management of weather events in transport system (MOWE-IT)
Document Title:	Project Final Report
Work-Package:	WP1 (Management)
Deliverable Type:	Report
Contractual Date of Delivery:	M24
Actual Date of Delivery:	12.11:2014
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## Executive Summary

MOWE-IT project has brought together the state-of-the-art knowledge of impacts of extreme weather events and natural hazards on the transport system. The 2-year project has utilised information from previously conducted research (such as the EWENT, WEATHER and ECCONET projects) as well as new analytical work performed by the consortium. The project has 12 partners, led by VTT, Technical Research Centre of Finland. The project aimed to produce a set of six high quality, visually attractive, guidebooks, meant to promote dissemination of the available information about ways to improve the resilience of transport networks. Other deliverables of the project focused on exploration of cross-modality opportunities within Europe in greater detail, short-term measures to improve resilience, and long-term policy guidelines to promote transport resilience, and a research agenda for R&D activities supporting the short term and long term policies and measures. This review work was complemented by dissemination activities, ranging from website management to newsletters, resource materials collection and publication at the website and regional conferences to disseminate the project results.

Project results show that a lot that can be done and many lessons to be learned in terms of improving resilience. Many endeavours can start right now, but more important is the accumulation and consolidation of measures over time, as we have learned from earlier experience, R&D efforts, and gained more insights about the extent and impacts of climate change. However, the general awareness of the public, operators and decision-makers is not particularly high on the matters of extreme weather resilience. This is shown by repeated patterns of activities in Europe, where year in and year out certain phenomena cause a disruption, despite their relative frequent occurrence. The MOWE-IT project has tried to highlight these phenomena and also to suggest ways in which to deal with them.

In its output the project has emphasized visualization of the phenomena. For example, a visualization tool was developed. This interactive tool allows the user to specify the time period of present or a future climate scenario (2040/2070) in which one wishes to study travel options, in particular the switch from air to other modes (notably road & rail). The purpose is to show the ways in which early preparedness to potential disruptions can offer travel alternatives, if and when the passenger is aware of such options. Naturally there are limitations to such alterations in travel patterns, as changing from one transport mode or route to another usually comes with a cost, if the already made arrangements need to be altered, whereas also the competition for – temporary. – scarce capacity tends to push up



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prices. However, this is perhaps a topic for discussion as a way forward in improving individual travellers resilience to disruptions.

In terms of infrastructure development, better planning is the key way forward. Events such as flooding, fog, snow, wind gusts etc. can be to a large extent localised and the ways to mitigate them at areas of occurrence should be included in the planning. However, this requires that those in charge of the planning are aware of these events and the role they can play in operations of the planned infrastructure. Better collaboration between weather agencies and transport planners is therefore required. Similarly, better preparedness, so as to minimize effects of hazards on operations, in particular requires *better cooperation and information sharing* between a sufficiently wide array of actors in and around the transport system.

For a host of reasons, many of the proposed resilience enhancing measures will not happen automatically. Sometimes, implementation of measures needs support from preceding research and/or product development. Individual parties may be often unwilling to carry the (full) cost of such R&D work. In other cases the benefits of measures may accrue to others than the organisation carrying the cost of the measures, thereby reducing the interest to engage in such measures. Transparency and adequate monitoring of punctuality performance (and closely related features) of transport systems form a crucial building block for enabling change. If travellers and public authorities (in case of public service contracts for rail and bus services) are enabled to adequately inform themselves about the performance of transport providers, the latter appear to respond quite clearly to punctuality performance signals out of fear of losing market share or future bidding options for public service contracts.

Further research in forecasting and nowcasting of extreme weather events is conducive for transport safety, but can – in conjunction with weather & information service development – also help to reduce the occurrence of delays. It is possible (and partly already happening) to develop advanced information systems providing – both localized and pan-European – capacity restraint projections based on weather forecasts (and possibly other disturbance factors), which can be subsequently used to develop and communicate an optimal capacity allocation plan. The realization of such a package of tools and protocols requires close cooperation and speedy information sharing between many actors.

The above examples provide enough grounds for policies in which public authorities and EU and Member State level provide a policy framework which contains monitoring and information obligations, rewarding and sanctioning incentives to reduce delays and improve cooperation even among competitors, some minimum standards to protect passengers, at least vulnerable ones, and support for resilience oriented R&D with



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significant societal benefits but limited private benefits. Since most passenger transport companies suffer from rather weak profit performance, it should be taken care that regulations do not unduly burden economic performance of these companies. Therefore also in this respect it is important to stipulate sufficient cooperation between different types of actors, and address incentives to the actors with obvious responsibilities and abilities to act for considered effects. Where the management of the transport infrastructure is separated from the actual running of (passenger) transport services, both types of actors should be addressed in regulations, and possibly still other actors as well.

The project has shown that opportunities exist for much greater resilience. The ultimate question that remains is that what will be done to enhance these opportunities in the future? How will the information available translate into concrete measures to improve infrastructure resilience? How will policies in the future better direct people and their choices?



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## 1. PROJECT OBJECTIVES AND CONTEXT

The European transport system has shown vulnerability to external shocks, which have partially or, in some cases, totally shut down part of the transport system. Particularly *the aviation industry has been disrupted by natural disasters and extreme weather events*, leaving other transport modes with no adequate plans and resources to deal with the responses required. The problem is complex by its nature, due to the fact that the *networks operate interchangeably both passenger and freight transport but even more as there are no official coordination mechanisms that would enhance cross-modality substitution in the transport system*. Any robust assessment of cross-modality potential should, as the starting point, address these issues and try to seek in what ways the dynamics of the European transport system can be better improved.

The goal of the MOWE-IT project was to *identify existing best practices and to develop methodologies to assist transport operators, authorities and transport system users to mitigate the impact of natural disasters and extreme weather phenomena on transport system performance*. The weather phenomena, their impacts and their magnitude have already been identified previously in the 7<sup>th</sup> Framework Programme project EWENT (Extreme weather impacts on European networks of transport). This research will also utilise information from other recent and on-going projects such as WEATHER. In general, what has been established through research so far is that extreme weather phenomena induce specific issues for each single transport mode. Similarly to extreme weather events, natural disasters can also be classified with respect to their likely impact on various transport modes. In addition, there are issues that are relevant to cross-modal approach, particularly to the management of logistics chains at the European level and more globally as well. This research intends to address via the concept of cross-modality the possibilities to shift between two or mode transport mode for alternative travel/route options. Supply chains in freight transport, including multimodality, will be also investigated and reviewed.

MOWE-IT addressed specific research questions in certain transport modes by identifying *practical applications to manage transport networks* more effectively in the future. MOWE-IT will also evaluate the possibilities to utilise technologies to create platforms, which can be aide to treat similar phenomena in other regions and climatic zones as well. Combination of latest technology available to transfer weather-related information with best accurate forecasting models will generate state-of-the-art solutions that benefit decision-makers, companies and transport infrastructure managers, operators and users. As problems related to each transport mode differ from one another, MOWE-IT focused on identifying the benefits for infrastructure users, operators, managers and decision-makers, wherever appropriate.

One of the crucial aspects of transport system is that *actors and operators are interlinked, thus separate analysis of an actor or transport mode yield non-meaningful results* as the



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interactions with other parts of the system have to be factored in. There is a degree of substitutability within the entire transport sector, which is not clearly defined and does not apply to all mode-to-mode changes. For certain routes between nodes in transport network a form of transport can have a default position, but this may change when external conditions change. This information can be used to identify bottlenecks in the transport system and which preventive measures can be taken to avoid the failure of the transport system as a whole between different nodes in the transport system. For instance, crossing the English Channel is known for ferry and air transport but after the construction of the Tunnel, surface transport has partially gained a substitution position in the United Kingdom as to travelling to France and the rest of continental Europe.

From the outset, it is also evident that not all transport modes, regions and types of transport interact in the same way. In some cases there is no meaningful substitution available, which is a fact that needs to be taken into consideration. For instance, the fact that passenger transport on ships is mainly for leisure travel purposes means that people are less interested in reaching the destination as such but more focused on the travel experience. Nevertheless, when encountered with extreme weather or natural disaster the safety of passengers becomes an important issue, such as in any other case of passenger transport in any other mode.

The project-specific objectives of MOWE-IT were the following and they were studied accordingly step by-step:

1. Addressing the cross-modal features of European transport system, key determinants of travel choice and distance-destination relationships between transport modes across Europe (WP2)
2. Mode-by-mode (road, rail, aviation and waterborne transport, WP3-6) review of impacts and mitigation strategies of natural disasters and extreme weather events currently available for industry, operators and regulators.
3. Preparation of short-term options to dealing with induced disruptions, including the availability of alternative transport options in the form of less affected transport mode options (WP7)
4. Providing policy recommendations for longer term solutions to reduce disruption to the European transport system caused by extreme weather phenomena (WP8).
5. Involving stakeholders, including the transport industry, and authorities from a variety of fields (border and customs control, emergency services, health sector etc.) in order to create an arena in which the adaptation process can be discussed in a cross-modal perspective and a wide geographical scope (WP9)

The work packages had an interaction mechanism, which was based on the sequencing of the activities between work package 2 and work packages 3 to 6 and further between work packages 2 to 6 and work packages 7 to 8. By starting the work package 2 before the mode-specific work packages 3 to 6 the structure ensures that the cross-modal considerations will be embedded into mode-specific reviews. As the work package 2 continued after the work packages 3 to 6 were concluded the feedback to cross-modal considerations was ensured. The start of work packages 7 and 8 overlapped with the

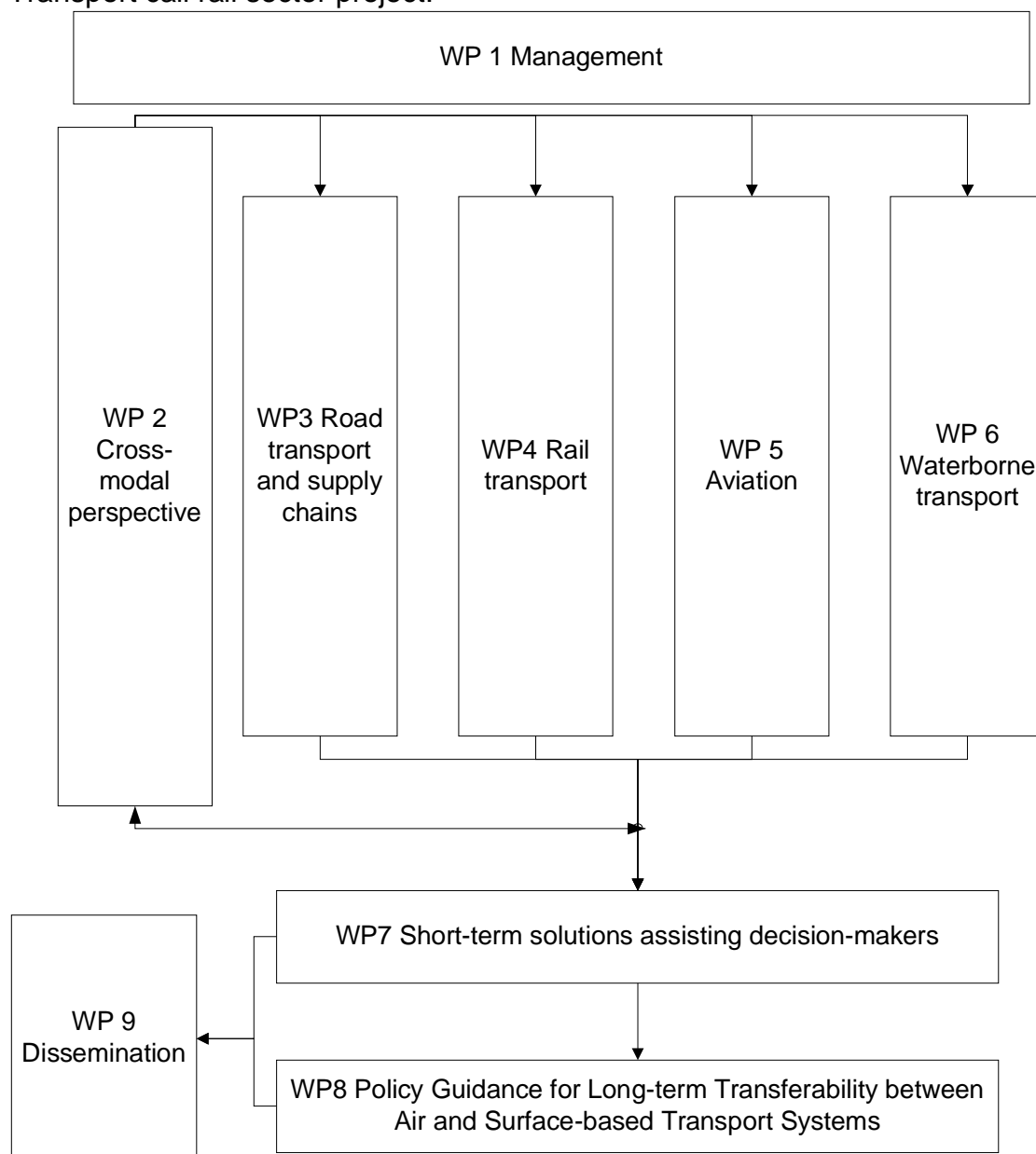




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completion of work packages 2 to 6, again ensuring that the conclusions were driven from the reviews conducted. Key participants of work packages 2 to 6 had also membership in work packages 7 to 8, again ensuring that the findings were translated into roadmaps and policy guidelines.

The structure of the work plan and sequencing of work packages is shown in the Figure 1 below. The mode-specific work packages can also dialogue on specific issues that cover a subset of transport modes (from the weather phenomena or natural disaster point of view or a specific cross-modality issue) and other EU research projects, such as the FP7 Transport call rail sector project.



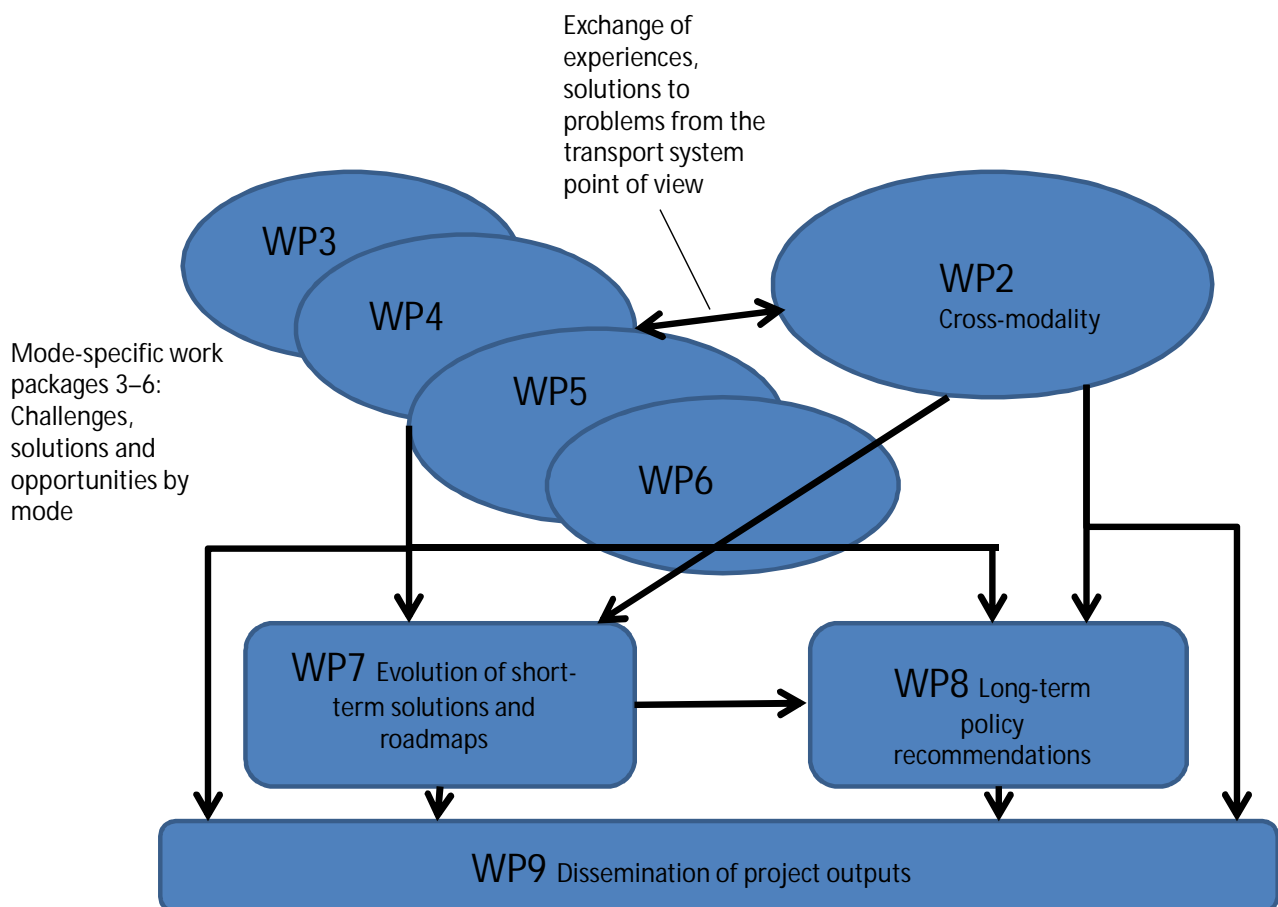
**Figure 1. The structure and interlinkages of work packages in the MOWE-IT project.**



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Due to the fact that the EWENT and WEATHER projects can provide a thorough understanding of the transport-mode specific disruptions caused by extreme weather, the work in MOWE-IT utilised this information as a platform of analysis. No major state-of-the-art review was needed; rather the focus was on moving to analysing what alternative solutions can be identified to problems. In some transport modes, like road transport, methodologies to utilise weather-related information already exist. Similarly, the research agenda on rail and aviation is advanced by the EU through separate projects and programmes, from which experiences can be used to support this project without duplication of efforts. The consortium composition reflected these potential areas for synergies.

Figure 2 shows the interaction mechanisms between operational work packages of the MOWE-IT project. The structure utilises memberships of key partners in various work packages as well as the dissemination of various outputs of the work packages through WP9.



**Figure 2. Interaction patterns between functional work packages.**





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When it comes to understanding how the cross-modality in real life works, passenger and freight transport are responding to different incentives. *In passenger transport the decisions of modal change are based on the substitution rate between the duration and the cost of travel involved, following a relationship between distance and options for travel*, in terms of what substitutability is sensible over distance or route. In freight transport the cross-modality is driven on the other hand by the cost resulting from delay of goods transported, including travel time and reliability, and on the other hand also by the specific characteristics of goods transported (fresh food items, organs etc.)

The European transport system consists of several transport modes, which may or may not be substitutes for each other. The substitutability is really a location-specific choice model of available alternatives and the associate cost-benefit assessment of the cross-modal decisions. The work package structure of MOWE-IT covered all transport modes (road, rail, aviation and waterborne transport). However, the novelty of the approach is to combine mode-specific issues with inter-modality considerations. For certain types of travel and distance combinations there are alternative travel options, in which time spent in travel becomes a factor, when a mode shift is needed. *The timeliness of information is crucial for users of the transport system and should cover both the anticipated delay/consequences with respect to the original choice of transport mode and the alternative options available to reach the original destination.* Moreover, from the operators' perspective, of great importance is the existence of robust organizational and cooperation networks (among the various transport operators) which are based on a concrete legislative structure capable of safeguarding the rights of passengers and users and of promoting 'cross-modality'.

As the project funding was CSA/SA type, the main focus was not on the research but the utilisation of experiences and results from previous and/or on-going projects that have produced results relevant for the scope of MOWE-IT. In some areas where no previous research exists, *MOWE-IT identified and reviewed the possibilities for future research.* As the consortium members represent academic institutions, research institutions and private sector, during the project duration some innovative solutions to existing challenges were generated as the result of the expertise and interests of the partners.

## **2. CROSS-MODALITY WORK PACKAGE RESULTS (WP2):**

### **Overview of the work**

Keeping in mind that MOWE-IT is a CSA-SA type of project, it is not possible to carry out research activities within the project scope. As there is no real database available on



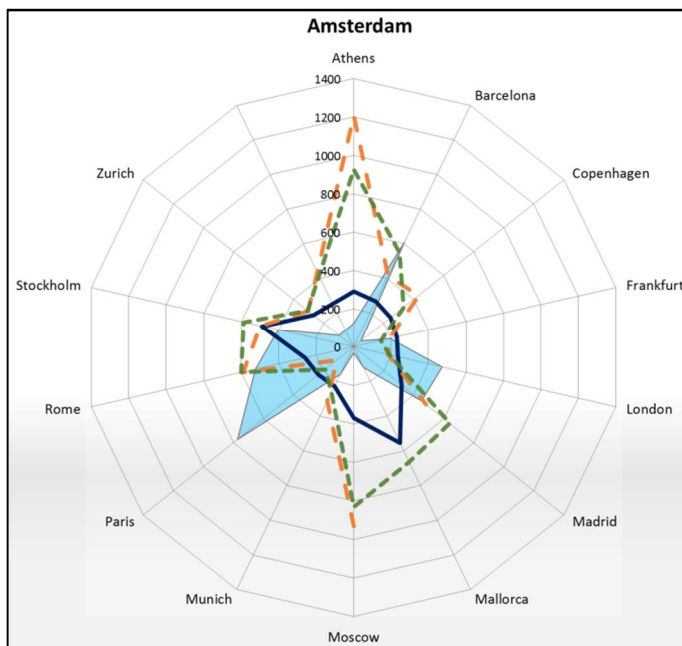
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cross-modality opportunities at the European level, it was decided that a database and tool to visualize it would be developed within the project to showcase the alternatives for mobility of people and goods in the case of disruptions.

Starting point was to select a network of major airports in Europe to prepare a core network of connections for analyses. Passenger and trade volumes data were starting point of analyses. Of latter we have taken notice of poor data availability of goods transported in terms of content, value and destinations within Europe.

The work carried out in work package 2 was documented in D2 of the project. Based on the airport passenger flows data, combined with cost and time data of travel on alternative transport modes, a comprehensive mapping of travel alternatives in Europe was completed. Based on these results, the interactive tool to map out developments was created. The tool utilises future weather scenarios and helps to predict alternative travel scenarios for present and future predicted weather conditions.

CERTH-HIT utilised the collected data to develop a framework, which would allow modelling of the cross-modal opportunities. This framework very clearly explains the travel choice patterns, when the parameters of travel are clear. The framework was adjusted to also analyse the future opportunities, and with more data added to the framework it can be even developed further. Figure X below illustrates the framework of analyses.



**Figure 3. Generalized cost from Amsterdam to all other connections (orange: rail transport, Green: road transport, Blue: air transport, Light blue: demand)**



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The interactive tool is available at the MOWE-IT website and will be also linked to have access through Commission's climate change website for use beyond MOWE-IT project timeline. In the future, it is possible to update the tool with more locations, more accurate weather data and new future weather conditions data. In addition, cost and time factors may also change, but can be updated as well. The principles of the tool are presented in greater detail in the following section.

### **Interactive tool**

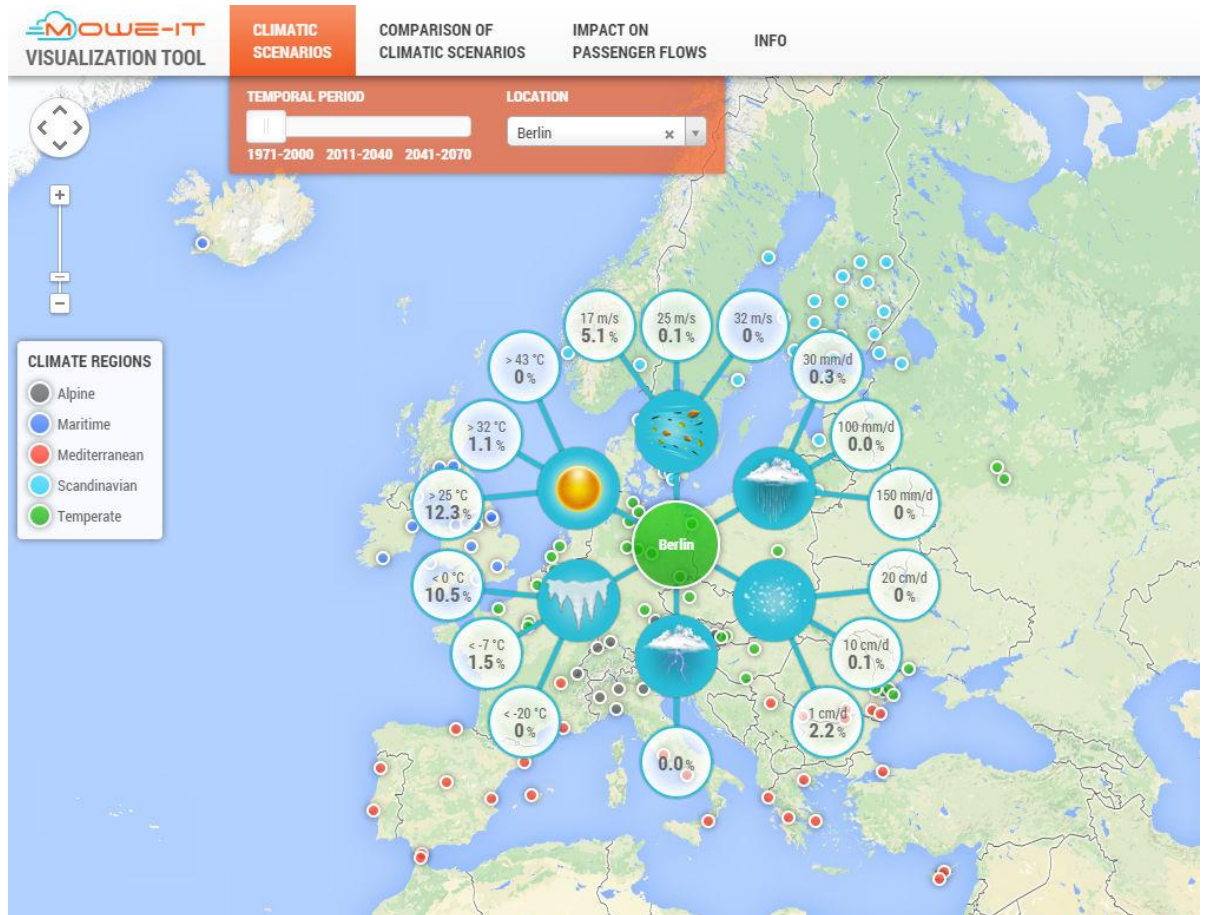
#### User interface functionality

The client-side user interface (UI) is divided into four modes: Climatic Scenarios, Comparison of Climatic Scenarios, Impact on Passenger Flows, Info.

#### Climatic Scenarios

The UI of Climatic Scenarios mode consists of a map, timeline for different temporal periods and a search field for locations. The map shows a small dot for each of the 134 European locations that have existing weather phenomena data. For displaying the data, the user can click a location dot or type the desired location into the search field, and choose one of the three temporal periods from the timeline. This action leads to data to be visualized with a tree structure on top of selected the location. Figure 4 depicts an illustration of the tree structure.

The tree structure consists of location name and the data for each weather phenomena. Each weather phenomenon has its own icon which acts as an on-off switch for showing a tree branch containing the corresponding weather phenomenon data. Thus, the user can decide which phenomena data are visible. If the temporal period is changed, the shown data are changed automatically in order to correspond the selected period.

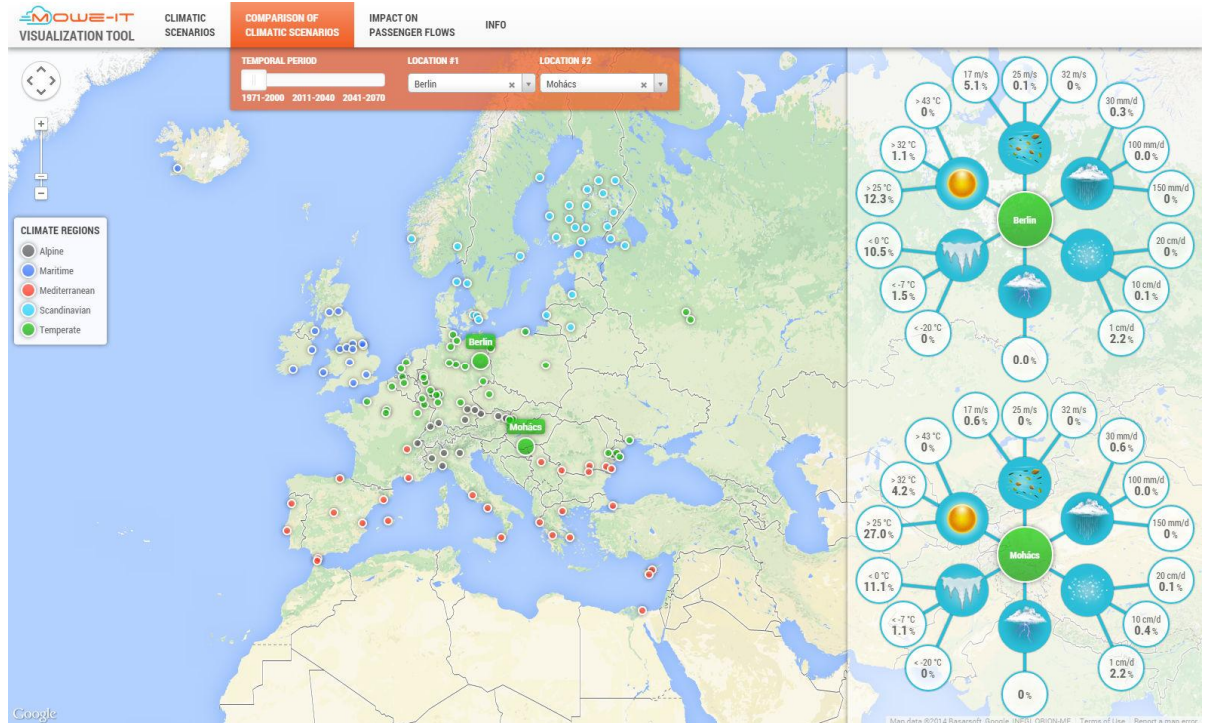


**Figure 4. Data-tree visualization in Climatic Scenarios mode.**

### Comparison of Climatic Scenarios

This mode is similar to the Climatic Scenarios since the source of data is the same and the same tree visualization is used. The main difference is that the user can select two different locations and see the visualizations of the corresponding data on top of each other on the right side of the view, as can be seen in Figure 5.





**Figure 5. Data-tree visualization in Comparison of Climatic Scenarios mode.**

### Impact on Passenger Flows

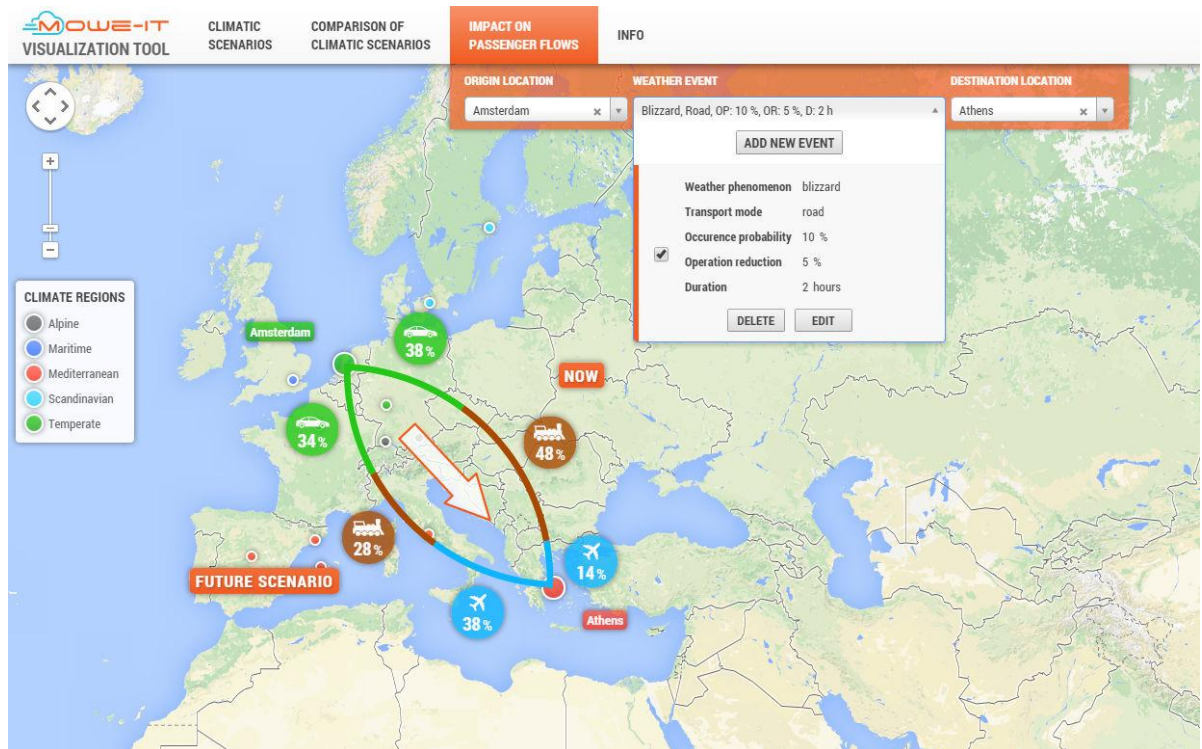
In the case of Impact on Passenger Flows the UI consists of a map, search fields for locations, a list of extreme weather events added by the user and a form which is used for adding the new events. The map shows a small dot for each location belonging to a group of 14 pre-selected European locations. Before the user can see any visualizations he is required to assign at least one weather event to some location and define type, transport mode, occurrence probability, operation reduction and duration for it. The user can, in addition to adding new events, modify and remove existing events.

The location, to which the event is assigned to, will be the origin of the connection. At this point, the user is able to click one of the other 13 locations (or choose from a drop-down list) which will then be assigned as the destination for the connection. The passenger flow data is then visualized using two curved lines connecting the two locations (Figure 6). One line presents the current situation ignoring the added weather events and the other shows the future scenario which is calculated using the added events. Both lines are composed of three parts each representing one of the three transport modes (air, rail and road). A line is divided amongst these three modes by their percentage of the



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total number of trips combined from all three modes. The user is able to reverse the direction of the connection by clicking an arrow button in the between the two lines.



**Figure 6. Passenger flow data visualization in Impact on Passenger Flows mode.**

### Info

The info mode contains a description of the visualization tool, including backgrounds, purpose and usage guide, as well as a button for downloading the all the data used by the tool as an Excel file.





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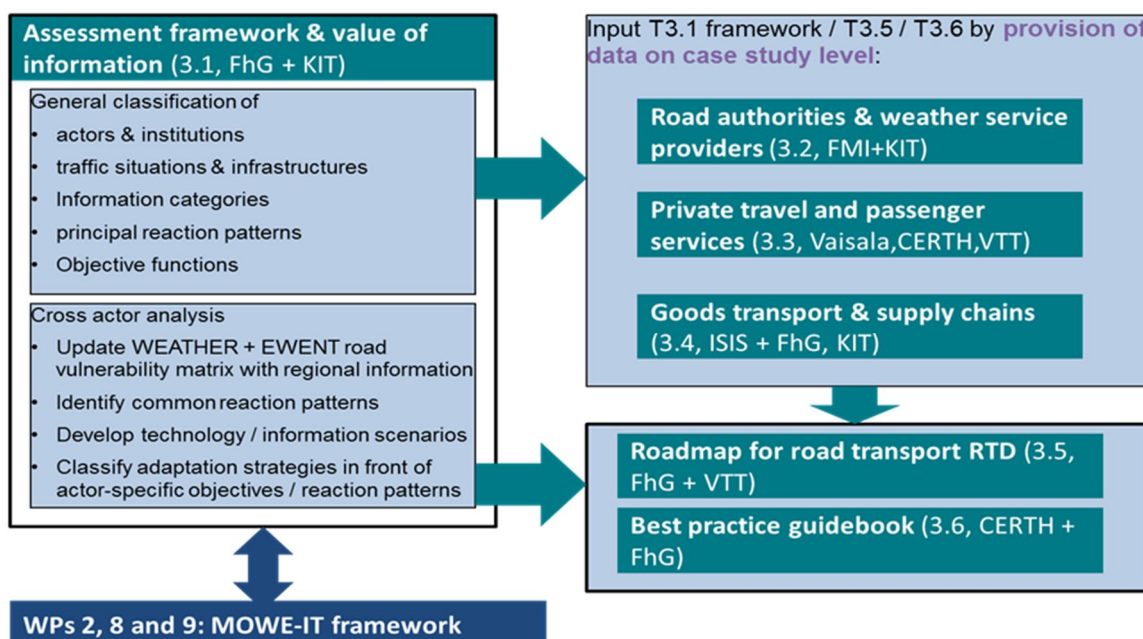
### 3. ROAD TRANSPORT WORK PACKAGE RESULTS (WP3)

#### Overview of progress

Work Package 3 of the MOWE-IT project was dedicated to road transport. More precisely the WP looked at the vulnerabilities and to resilience-related issues of road operations from the viewpoint of road users. These include individual persons travelling by foot, bike, car or coach, as well as freight forwarders using road haulage services. Road infrastructure damages and adaptation options for road infrastructure owners and managers are more indirectly included as of course road damages and road works impact system availability for the users. Within this framework the objectives of WP3 can be formulated as follows:

- Describe in detail the vulnerability to weather extremes in road operations, private travel and commercial passenger and freight services across Europe
- For each actor group identify reaction patterns in emergency situations and work out areas of potential improvement (including intermodal coordination).
- Identify information and technology availability and development needs, including targeted weather data provision, for more resilient systems for all road transport actors.

To meet these objectives the WP has been broken down into 6 tasks, dealing with the overall methodology (Task 3.1), reviews and case studies for the three main types of actors (Tasks 3.2: road authorities and weather services, 3.3: passengers, 3.4: freight forwarders) and the WP's outputs (Tasks 3.5: RTD roadmap, 3.6: Guidebook). The crosswise relations of these tasks to each other are best described by the following flow chart:





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Work package 3 was lead by Fraunhofer ISI and supported by FMI, Vaisala, KIT, ISIS, CERTH-HIT and VTT. Major highlights of the work packages were:

- Organisation of a workshop on road transport resilience at September 22<sup>nd</sup> in Brussels with presence of major European institutions and presentation of relevant European and international projects.
- Presentation of the Road Transport Guidebook at TRB (Washington D.C, USA, January 2014), RMIT University (Melbourne, Australia, April 2014) and TRA (Paris, April 2014).

The following sections will briefly provide the main findings of the six tasks.

### **Task 3.1: Assessment guide and the value of information**

A review of current literature and a look at current conferences show that there is numerous information available on the impact of natural hazards on settlements, economy and transport. Also we find a great number of studies on adaptation options. With a few examples, however, these incident reports and scientific analyses are readily usable for decision makers in public administrations and road authorities.

By a meta analysis of different cases we find the general story line that preparedness – usually based on exploiting previous experiences – helps to reduce damages and entailed economic costs. Great examples in this respect are the series of storm surges in the US (Katrina, Rita, Irene and Sandy) or the two one-in-100-years floods in Germany and bordering countries (1999, 2002 and 2013). The international Road Association PIARC has recognized the value of this information and published a number of guidelines for road users. Also the World Bank and the European Environment Agency (EEA) started endeavours to assess and share such information.

Recognising this, but also acknowledging the lag of systematic collection and spreading of experiences on events, good or bad preparedness and other lessons, Task 3.1 has developed a reporting form for case studies for road transport. This was used by later tasks to report on selected cases. The respective case study reports are made available on the MOWE-IT website. However, we have to place the disclaimer as MOWE-IT as a CSA project is not allowed to conduct original research the templates have been filled with information available through literature reviews only. Later research may extend them by interviews, data analyses or other original inputs. The reporting form was structured as follows:

- General description: weather conditions. location & time, general impacts
- Specific impacts on roads: infrastructure failures, operations, specifics on WP2 corridors, duration and recovery times, financial impacts.
- Response: Actors, preparations in advance, emergency response, effectiveness, institutional learning, repair and adaptation procedures, road industry issues,

The related case studies will be addressed in the specific sections below.



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### **Task 3.2: Road authorities and weather service providers**

The potential impact of extreme weather on road transport depends also on the awareness of the road stakeholders and authorities, i.e. to the level of risk management applied. This calls for a sufficient weather observation network and skillful numerical weather prediction models. Good co-operation and coordination between all involved authorities, as well as effective communication and exchange of information are needed to mitigate the impacts of harmful weather. Of importance is also the clear definition of responsibilities of all parties in emergency situations in order to achieve coordination..

Short and long term impacts of climate change may necessitate more frequent maintenance and reconstruction. Recent research and support activities developed a number of risk assessment tools which are available to road authorities and which give advice on the usefulness and costs of various measures to improve resilience. These are the RIMAROCC methodology developed by the ERA-NET ROAD programme and the CAPTA model prepared by the U.S. Transportation Research Board. Good national examples can further be found in Switzerland, Finland and the UK.

Proper risk mapping is inevitable in particular for flood risks, but often lacking. Given the demographic development in Europe, which results in stagnating or even declining transport demand volumes, the maintenance of existing roads should gain more attention.

In the past, the decisions about necessary actions (e.g. on gritting and salting) were the responsibility of the road maintenance personnel. In addition: to ensure an efficient and effective road management, the establishment of a common crisis management (including businesses, public and private road users) and the introduction of contingency plans are necessary.

Task 3.2 has conducted the following case studies:

- Infrastructure impacts of UK floods 2007
- RWIS in the 21<sup>st</sup> century
- Car crashes in Helsinki 2012

### **Task 3.3: Road passenger transport**

Different countries have developed various good practices and methods that aim towards improving the service provided to road users, and some countries even monitor citizens' satisfaction with the information provision by respective surveys. A survey among 24 regions in 16 European and 5 world countries by PIARC reveals that Internet, radio, SMS-services and variable (road side) message signs (VMS) constitute the most frequently used sources of pre- and on-trip information by road users.

Of increasing importance is the information exchanged between vehicles, road operators and drivers. Car-to-car or car-to-Infrastructure communication systems are not anymore pure research



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subjects, but are installed in vehicles and roads today linking car manufacturing closer to road operators and weather data providers. But there still are serious concerns on the following or warnings and traffic advices by actual users. Here behavioural research and personal information channels are needed.

Concerning vulnerabilities statistics mainly from the US find that 5% to 10% of traffic incidents and around 10% of congestion is inflicted by harsh weather conditions. In both cases heavy rain and wet pavement are the main sources, which can be explained by two facts: rain occurs way more frequent than other extremes and people get more cautious under winter and storm conditions than with rain. Comprehensive European data is missing.

Task 3.3 has conducted the following case studies:

- Winter cycling in Oulu, northern Finland.
- Short- and long-term emergency management operations for EWE/NH impacted passenger transport during the 2007 wildfires in Peloponnesus.
- Inundation of Lyon and Mâcon in March 2001.
- Winter 2009 Impacts on London Public Transport.
- Organisation of emergency bus services in Munich.

### **Task 3.4: Freight transport and logistics**

The adaptation of logistics and freight transport to climate change, also referred to as “adaptive logistics”, considers how such systems can better respond to the impacts of climate change. Coping with the impacts of extreme weather events for several modes simultaneously is one of the main challenges to be addressed for the freight and logistics sector.

The impacts of weather extremes on freight transport and logistics are poorly documented in the public domain due to commercial privacy reasons of transport and industry sectors. They regard service disruption, economic losses, trip re-scheduling and re-routing and delays in deliveries. Among other extreme weather events, floods and severe rainfalls can lead to accidents, transport infrastructure disruptions and closures. The economic impacts on the overall industry can be in the order of millions of euros.

Trucks are generally more weather-resilient than cars. Weather does not play a major role for truck safety as vehicles are heavy; speeds are lower than in car travel and drivers are trained. Translating general US delay statistics to the milder conditions in Europe and the more stable driving cycles in road haulage we may estimate weather share at truck delays below 5 %. These figures, however, do not contain trip cancellations or shifts in time.

Task 3.4 has conducted the following case studies:

- Impacts of flood events on the Greek road logistics sector.



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- Flood impacts on road logistics in Germany, Austria and the Czech Republic, Summer 2013.
- UK construction sector and extreme weather events.
- Transportation sector's response to and recovery from the hurricane Katrina and the effect these disruptions had on the national-level movement of freight.
- Economic impact of the storm-related closures of several highway segments in the winter 2012 on road logistics.

### **Task 3.5: RTD roadmap**

The road transport adaptation roadmap was built on the basis of literature statements, expert interviews and the road transport workshop conducted in Brussels, September 22<sup>nd</sup> 2014 in the ECTRI offices. Statements of road operators, PT, coach and logistics operators associations, meteorologists and researchers the following set of recommendations was developed:

#### Understanding user behaviour

- Explore user needs for personalised emergency warnings and travel recommendations
- Rebound effects of safety technologies: explore the impact of increased passive and active safety technologies on driving habits in critical situations and on drivers' readiness to prepare for adverse weather conditions.

#### Technology development

- Improve the liability of driver assistance systems with regards to fatigue control, the recognition of non-motorised traffic participants in the blind angle at low speeds or skid control on slippery (icy or wet) pavements.
- Develop intelligent feedback systems in vehicles keeping the users' attention even despite possible frequent false alarms, etc.

#### Economics and incentives

- Develop sustainable business models for the provision of high quality, multi-modal and personalised emergency information systems.
- Work out guidelines for benefit cost assessment of increased reliability of transport undertakings, for the company itself and for the society as a basis for defining appropriate public support schemes.

These recommendations were taken up by MOWE-IT Deliverable 8.1, which formulated a RTD roadmap for all modes and in particular for intermodal issues.

### **Task 3.6: Road transport guidebook**





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The guidebook on road transport constitutes the main output of WP3. It is mainly organised by actors to be addressed (weather services, road operators, passengers, freight forwarders and RTD institutions). Besides describing the main vulnerabilities and the respective state-of-the-art technologies procedures for their mitigation it presents a set of detailed recommendations for more resilience in road transport.

As all other project material and together with the 11 case studies elaborated in the project, the Guidebook is available via the MOWE-IT website.

### **Key findings of work package 3 (road transport)**

**Organisational and decision making structures:** Long-term, strategic measures on policy level, issues on legislation, regulations, and standardisation, high level collaboration, roles and responsibilities for formulation of policies and strategies.

Establish networks of urban, regional and national stakeholders: transport companies, authorities and users. These shall enable mutual support in case of an emergency and the exchange of experiences

Conduct public campaigns for awareness raising on local hazard situation to the general public. The aim of such campaigns should be to raise awareness for good technical preparedness of vehicles and for higher levels of pre-trip information

Set and implement international standards for weather and emergency information in order to support cross border emergency missions

Explore options to co-operate with competitors under adverse conditions, including the formulation of cost and burden sharing for a fair allocation of risks and benefits

Give priority to the establishment of efficient passenger information strategies, including passengers in the system and potential clients

Support road authorities and transport service providers by issuing guidelines, leaflets and other education and information material on maintenance, good preparedness, contingency planning and procedures in emergency cases. PIARC and UKRLG guidelines provide excellent starting points, but need to be translated to national and regional contexts

Pave the legal and knowledge grounds for innovative procurement and supply models for road authorities. These could be on de-icing salt, sand bags, snow ploughing equipment, etc. Insurance solutions could be an option

Consult and co-ordinate with other highway authorities, subcontractors, suppliers and key stakeholders to adjust strategies, e.g. when defining strategic maintenance networks or materials and equipment supply

### **Technical options and possibilities to reduce risk:**

Operational level actions on physical infrastructure (repair, maintenance, installations) – before, during, after a hazardous weather event





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Provide sufficient shelter for non-motorised transport (bike parking, waiting facilities) according to protect from most relevant local hazards

Regularly clear cycle lanes and sidewalks in winter- or clearly communicate alternative strategies

Prepare for sufficient salt stocks and road clearing equipment availability before and during winter or storm seasons. UK winter experience e.g. recommends 12 days salt stocks. Innovative and / or collaborative procurement models could be interesting

### **Procedural and operational options to mitigate the risk:**

Managerial procedures, action plans, decision-making and responsibility assignments, adaptation of working modes, collaborative actions between stakeholders to mitigate risk – before, during, after a hazardous weather event

Evaluate the possibility of compulsory safe driving training for all drivers. Furthermore support the training of drivers and other staff in the transport sector. While the trainings and certificates could be issued by private players or associations, e.g. automobile clubs, the contents should be defined by public authorities to ensure regional consistency and completeness

Develop risk maps for the local area and derive from that appropriate action plans according to the risk mapping. This should ideally be supported by national or European risk mapping activities

Establish priority plans for road clearance with regard to maintaining access to emergency stations, hospitals and for public transport within and beyond city boundaries

Organise the supply of trapped drivers / passengers with the help of volunteers and aid organisations. To be prepared, collaborative contingency plans and contracts should be established beforehand

Keep track of chain reactions of weather extremes in particular in agglomeration areas

The freight marketplace is characterised by the presence of several companies, often SMEs with self-employed owners. The success of warning alerts and communications policies from public authorities preventing extreme weather episodes, rely on timely communication and coordination plans involving stakeholders and freight operator associations

Freight transport are linked to a complex infrastructure-network, and to multimodal links over vast territories. The effectiveness of policies depend on the coordination of emergency plans amongst transport modes (infrastructure managers) and networks, e.g. national, regional and local roads, ports and the rail network

In hazard prone regions establish procedures to adapt time tables and service intensities under inclement weather conditions

Review maintenance contracts and procedures to be flexible and effective even under rapidly changing weather conditions. Regularly clearing of cycle lanes and sidewalks in winter- or communication of alternative strategies

Implement appropriate risk management procedures in order to be prepared to adverse conditions. This includes risk mapping, staff training, communication structures and the identification of actions



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Define priority routes for road clearance in case of large scale impacts, such as icing, snowfall, flooding, landslides or storms. These should include all strategic roads and access to key facilities. Strategic routes should be selected on seasonal rather than average annual traffic volumes

**Information flow, ICT support (e.g. monitoring by satellites) and passenger services:** Development & implementation of ICT technologies and services for passenger and freight transport

Use different channel and information supplies to regularly check for emergency warnings and recommendations. Select and adapt the source best suited to your personal habit and mobility style. However, do not over-emphasise their precision

In public transport provide reliable, instant and - if feasible – personalised information on duration of the incident and on travel options

At company level, in particular with SMEs, who lack of business continuity and financial means of bigger companies, public policies reducing underinsurance and providing services and information (via internet and social network) may improve the resilience of company supply chain to extreme weather events

Explore user needs for personalised emergency warnings and travel recommendations

Develop sustainable business models for the provision of high quality, multi-modal and personalised emergency information systems

Develop intelligent feedback systems in vehicles keeping the users' attention even despite possible frequent false alarms, etc.

Foster the operational-, physical -, technical -, procedural - and institutional integration of weather and traffic control services

Prepare timely and broad communication on disruptions and alternatives with the public, using different communication channels (radio, internet, social networks, etc.)

Improve the liability of driver assistance systems with regards to fatigue control, the recognition of non-motorized traffic participants in the blind angle at low speeds or skid control on slippery (icy or wet) pavements

Standardize weather information and hazard warnings across Europe. These should ease the co-operation of meteorological institutions and support suppliers of trans-European transport services

Rebound effects of safety technologies: explore the impact of increased passive and active safety technologies on driving habits in critical situations and on drivers' readiness to prepare for adverse weather conditions

### **Decision and risk models:**

Development of risk and decision-making models and impact assessment and evaluation procedures.

Assess the company's risk exposure and establish appropriate adaptation, emergency preparation and emergency response plans. Inform and train the staff regular basis

Work out guidelines for benefit cost assessment of increased reliability of transport undertakings for the



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company itself and for society as a basis for defining appropriate public support schemes

#### **4. WORK PACKAGE RESULTS 4 (RAIL TRANSPORT)**

##### **Guidebook for Enhancing Resilience of European Rail Transport in Extreme Weather Events**

The goal of this work package was to identify existing best practices and to develop methodologies to assist rail operators, infrastructure managers and system users to mitigate the impact of natural disasters and extreme weather phenomena on rail system performance. A large-scale review of case studies of the impact and management of extreme weather events over recent decades in Europe and beyond was conducted. These case studies built on existing examples from the EWENT, WEATHER and FUTURENET projects, but also included numerous novel studies which had not previously been developed. These were divided into three broad categories: heavy rain/flooding, wind, and snow/winter conditions. The case studies used were as follows:

##### Heavy Rain

- Saxony Flooding 2002
- Alpine flooding 2005
- UK summer flooding 2007
- Intense convective storms UK June 2012

##### Wind/storm

- Storms Lothar and Martin 1999
- Windstorm Gudrun in Sweden 2007
- Storm Kyrill over Western Europe 2007

##### Snow/winter conditions

- Heavy winter conditions in Stockholm 2001-2002
- Exceptionally hard winter conditions in Sweden 2009-2010
- Impact of winter conditions on Eurostar services 2009
- Exceptionally hard winter in Southern Finland 2009-2010
- Winter 2009-2010 in Europe

Guidelines and recommendations were derived from the case studies and split into long-term planning and resilience building measures and actions which can be implemented before, during and after a given event. A number of recommendations and guidelines for the reduction of weather impacts on rail operations were synthesised from the experiences reported in the case studies. These included a range of actions such as improving the resilience of physical infrastructure to



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specific weather conditions, learning from past events and dealing with affected passengers. As well as weather-specific guidelines, a number of broad recommendations that are applicable to most weather-related events were also formulated. These were divided into the different areas of the railways including vehicles, infrastructure, equipment, operations, information, cooperation, staff and weather forecasts. The output from this sub task included 13 detailed case study reports (including several additional reports that were excluded from later discussion for brevity), three weather-specific documents synthesising the findings and discussion, and a draft summary guidebook.

The MOWE-IT rail workshop was held in Brussels on the 17th of September 2013 and was tasked with synthesising guidelines and recommendations on how extreme weather events can be managed. 17 invited participants took part. These mostly came from large European infrastructure managers and railway companies such as Network Rail, ProRail, SNCF and ÖBB, but also had from weather service providers (UbiMet) and industry bodies (UIC). The participant group was supplemented with members of the MOWE-IT advisory board and project partners. The event focused on several areas, including the management of different types of weather events and the higher-level governance and structures that must be in place to implement successful strategies during extreme events.

Participants were sent draft guidelines and recommendations that had been drawn up by the MOWE-IT Work Package 4 team as well as links to the three weather-specific documents. The individual case study reports were also available on the day for discussion in the break-out groups.

During the event discussion focused on the following areas:

- The feasibility and effectiveness of the proposed measures.
- How overarching strategies can be put in place to implement the measures during an event.
- How skills and expertise of dealing with weather events can be captured and retained in an organisation.

The recommendations were broadly supported by the participants, but with a number of important modifications and additions that should enhance their applicability to the industry. The weather-specific recommendations were given useful contextual information based on the experiences of the participants, uncovering additional advice not contained in the case studies. Much of this advice centred on cutting-edge hazard modelling and improved local-scale weather/hazard forecasting so that preventative action and better prioritisation of resources can be made in the build-up to an event. In the afternoon session a wide-ranging discussion was made on the higher-level management and governance needed to ensure that the individual measures can be implemented in a holistic manner during an event. Discussion was also made of how important experiences and tacit knowledge gained during an event can be captured and retained within organisations and perhaps shared at an international level. Funding options and possibilities of future collaborations at a European level were also discussed.



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The input from the workshop was fed into the final version of the guidebook. The document addresses governments and the management and board of railway companies (infrastructure and transportation). It does not directly address working and operative staff of railways. The authors recognize that these individuals are doing a good job in case of extreme weather conditions and do their best on the basis of information and equipment they have in case of hazards. Looking at the recommendations in this guidebook three aspects have to be mentioned:

- Most of them are very well known by experienced people in railroading, especially operative staff on the track, the control centres and the work-shops.
- Gaps, short-comings and difficulties are often a result of bad preparation, lack of buffers, resources for preventive maintenance and the number of skilled staff among others. These deficiencies result from political and/or management decisions.
- Without skilled and motivated staff we still have in railway companies, impacts of hazards can become even worse, staff-balance short comings mentioned above and in the guidebook. Unfortunately the number and motivation of local working and operative staff is shrinking in most railway companies. Coming from overstaffed public enterprises we now recognize lacks of staff in some railway systems.

The recommendations and findings are results of the case studies and the experiences in extreme weather conditions the authors identified from desk research or having been involved is as railway passengers. They should be taken into account for strategic decisions and adopting the rail system for extreme weather events. Indeed the recommendations are not rocket science. Some of them have already been established previously but have been forgotten, neglected or disestablished in the only economical design of railways.

### **Key findings of work package 4 (rail transport)**

**Organisational and decision making structures:** Long-term, strategic measures on policy level, issues on legislation, regulations, and standardisation, high level collaboration, roles and responsibilities for formulation of policies and strategies.

raise awareness of adaptation to climate change.

establish greater regional and international exchange of good practice.

#### **Technical options and possibilities to reduce risk:**

Operational level actions on physical infrastructure (repair, maintenance, installations) – before, during, after a hazardous weather event

#### **Long term, advance preparation:**

install local weather forecasting systems where needed

assess weather-related infrastructure problems identified during previous events



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assess vulnerabilities of vehicles to specific weather types observed during previous events; adapt and enhance resilience

improve, maintain and monitor infrastructure (e.g. drainage network, areas close to tracks and catenaries clear of vegetation and dangerous objects)

install redundancy and emergency capacity (pass-by trucks, switches, operation on opposite lane)

enhance flood resilience of infrastructure where necessary or provide movable flooding walls.

ensure equipment, spare parts and availability of diesel engines as replacement traction; plan storage

prepare logistic plans to deploy equipment and spare parts in case of hazards.

### **During hazardous event:**

use weather forecast systems to determine most heavily impacted areas and deploy equipment, staff, and prepare vehicles accordingly

deploy diesel engines and drivers in case of damage to electrical system

emergency maintenance; deploy teams to observe vulnerable infrastructure (catenary, drainage, track); concentrate equipment and staff to handle equipment to the most affected area

keep vehicles operational (heat/cool/clean/cover when appropriate) and check for weather related issues (e.g. frozen couplings, bogies and doors, fit with extra equipment appropriate, spare parts etc.)

### **After event:**

repairs & reconstruction; upgrade resilience to future weather events; reinforce embankments susceptible to landslides

identification of critical locations; construction of further sub-surface drains in problematic flooding areas

### **Procedural and operational options to mitigate the risk:**

Managerial procedures, action plans, decision-making and responsibility assignments, adaptation of working modes, collaborative actions between stakeholders to mitigate risk – before, during, after a hazardous weather event

### **Long-term advance planning:**

strategies for cutting departures and reducing passenger capacity (rerouting models, special timetables))

plan for replacement services (bus). Important because replacement by bus has been a previous problem.

emergency planning and preparation with fire brigade and other emergency services; practice emergency plans for severe weather (with emergency repair work)

train personnel and subcontractors on clean-up and repair works and to understand winter operations.





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train for troubleshooting and information provision in case of events and in abnormal operation

build local troubleshooting teams with defined responsibilities

foster cooperation among undertakings and institutions; organise joint training exercises with local emergency services

foster vertical and horizontal cooperation of public and private bodies

### **Before and during event:**

cooperate with local emergency service; prepare emergency teams; deploy staff to locations of event.

install common control and steering centres including rail and emergency services

quick responding and decision-making according to advance plans, e.g. reduce speed limits or cancel traffic; use special timetables where traffic lines need to be reduced; provide replacement services or halt operations, if necessary).

inform staff in case of emergency and have extra personnel or standby to help during the event.

take care of communication(staff, passengers);

**After:** update of plans and strategies (lessons learned) after hazardous weather events

**Information flow, ICT support (e.g. monitoring by satellites) and passenger services:** Development & implementation of ICT technologies and services for passenger and freight transport.

integrate different types of asset-monitoring databases.

prepare information systems for passengers and clients (online but also locally such as displaying emergency time tables.)

during event: provide real time info to passengers (e.g. internet, mobile data and traditional formats such as flyers and bill boards).

### **Decision and risk models:**

Development of risk and decision-making models and impact assessment and evaluation procedures.

flood & wind/storm prediction models incorporating better weather forecasts and much more detailed info on topography, infrastructure, geology and hydrology..

flood & wind/storm response strategies; establish meteorological thresholds and triggers for actions and refer to asset condition databases for local adjustments.

hazard, vulnerability & risk mapping in cooperation with weather services.

consider infrastructure interdependencies, especially applies to ensuring energy supply.

design a risk-based approach for speed restrictions and line closures.



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incorporate climate change projections into the design of drainage to cope with predicted future flooding frequency and magnitude

### 5. KEY FINDINGS OF WORK PACKAGE 5 (AVIATION)

#### **Guidebook for Enhancing Resilience of European Aviation in Extreme Weather Events**

Various adverse weather events occurring over the European continent have a potential to impact the European aviation system. Due to locally varying conditions these events are more frequent in some regions than in others. However, their potential to impact the aviation system depends also on the awareness of the aviation authorities. Due to a changing climate it has to be expected that the patterns of adverse weather change to some degree.

The aviation guidebook addresses the most important types of adverse weather for aviation including information on their geographical and seasonal relevance; the expected changes until the 2050s (and 2020s, if significantly different); typical duration and warning times and their impact on aviation transportation networks in more detail. It has to be noted that regional climate models cannot reproduce all types of weather events with the same accuracy and that results partially disagree between the models.

#### Weather events

Regional weather events such as thunderstorms, fog, and hail are difficult to capture by forecasts and climate models. An improvement of local forecasts would allow an extension of planning horizons for air-traffic stakeholders.

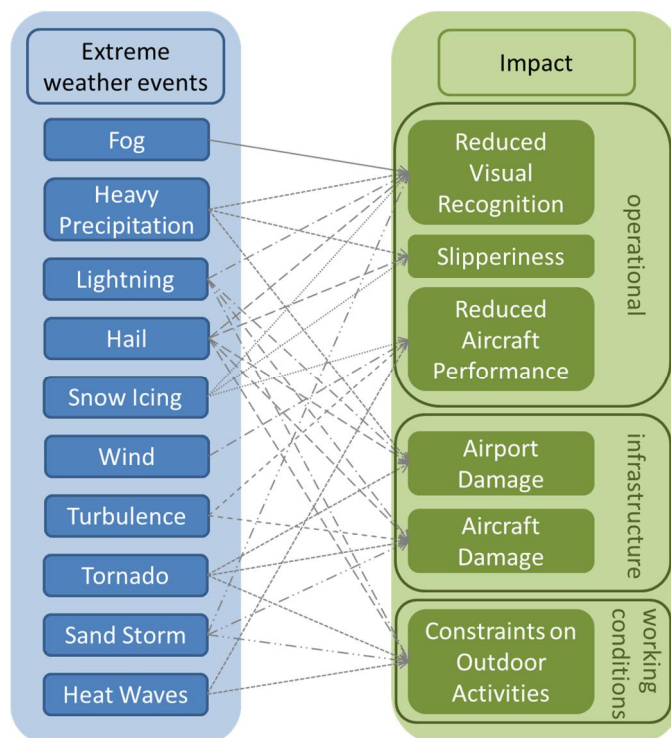
#### Aviation Weather Influence Assessment

As documented by the monthly reports of the European Organisation for the Safety of Air Navigation EUROCONTROL, weather is among the main contributors for delay depending on the time of the year. The European Aviation Safety Agency (EASA) registers weather as contributing but not as causal factor for incidents or accidents. The reason for these facts can be explained by the high safety standards in aviation, which come immediately into action when weather events with hazard potential appear. As a safety response to weather events changes in operational procedures are initiated, which finally lead to delays or even cancellations.

To assess the impact of adverse weather events on the European aviation network, important parameters are – besides duration, type, and intensity of weather events – related to the affected sectors and airports. Bottlenecks of the recent ATM system are especially congested airports operating on or beyond their airside capacity limit. This can be seen at the international and European hub airports rather than at secondary ones. Even minor weather events can lead to disruptions in the flight plan. Adverse weather events at these congested airports will result in limitations of the airside capacity, delays, or re-routings due to increased separation minima and

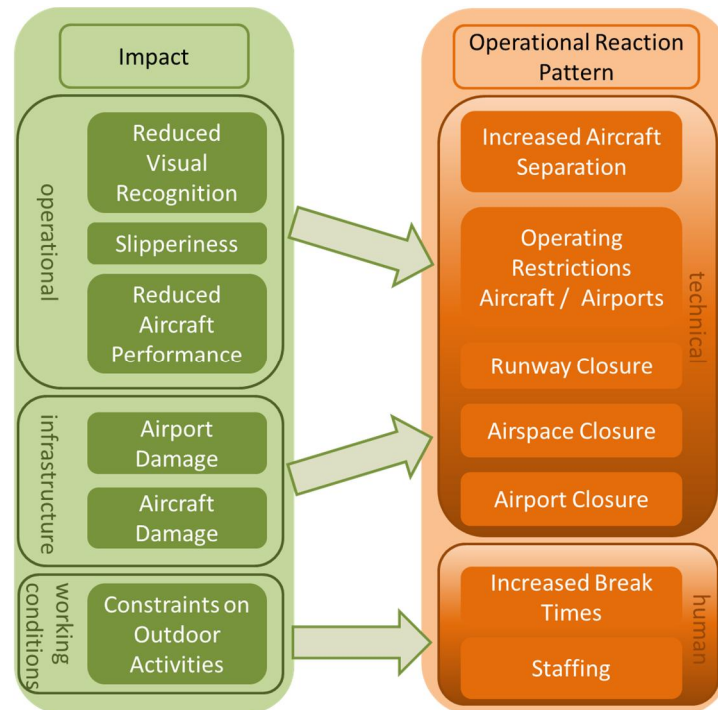
reduced runway conditions. In this context, the SESAR (Single European Sky ATM Research) program of the European Commission aims to provide better technology and harmonise procedures in order to meet future capacity and air safety needs. Although increasing resilience was not the main idea of SESAR, some of the developed technologies and procedures intend to keep capacity as high as possible in usually disruptive conditions.

From our point of view, special attention has to be given to adverse weather events that threaten the European aviation system such as long-lasting snow fall, freezing rain, or thunderstorms. All airports, independent of their size, can be hit by these events that may both disrupt connections to other modes of transport and lead to a partial or complete shutdown of an airport. An important factor is the areal extent of adverse weather events. A first step towards higher resilience of airports and the air traffic network is the understanding of the particular influence of weather events and the propagation of disruptions within the air traffic network. Figure 7 provides a short overview of the most important weather types and their impact on aviation. These impacts lead to different operational reaction patterns as illustrated in Figure 8. The reaction patterns are usually local measures that often have an impact on the aviation network.



**Figure 7: Weather events and impact on aviation**

Large-scale weather related disruptions are of great importance for the whole aviation industry as the problems occurring at hub airports may even have an impact on airports that have not been directly affected by these weather events so far. The number and size (in terms of passengers as well as physical aircraft size) of redirected aircraft will have an impact on alternate airports. Especially the airline network over central Europe with its high density of important international hub airports seems to be prone to large-scale weather related events in particular.



**Figure 8 Impact of weather events and operational reaction patterns**

Each airport has its own experience in applying suitable response measures. By intensifying the exchange among airports and stakeholders best practices can be shared and preparation for events that might become more frequent due to climate change could be fostered.

### 2. Summary of Recommendations

This section summarises actions described in the aviation guidebook that we recommend to take into account for further developments. Some more general aspects are extended by examples in order to improve understanding of these ideas.

#### Recommendations for European and national policy

- Research efforts related to the analysis of disruptive effects to the aviation sector shall be encouraged. To allow an estimation of the influence of weather related disruptions, the network influence and propagation of delays have to be understood.
- The development of a measurement system to assess and compare the vulnerability of airports and airspace areas would allow the establishment of priorities for research activities. New performance measures may be

Learn from best practices  
Sharing information and documentation of disruptions, measures taken and system reaction fosters understanding of the influence of weather events on the ATM system as well as identifying best practices for response strategies.



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developed that are able to assess performance for future scenarios under changing climatic conditions.

- More transparency in the comparison of the impacts of disruptive events shall be fostered, thereby addressing imprecision in the definition and assignment of codes and terms as e.g., when to assign which IATA delay code or the definition of consistent statistical evaluation procedures. The aim is to allow a correlation of disruptions to the original cause. Precise definitions and consistent recording of influences is the necessary basis for comparative analysis.

### Recommendations for the aviation sector

- More passenger oriented approaches shall be fostered, as e.g. the use of customer profiles to provide customer-specific alternative travel solutions in case of disruptions.
- A closer cooperation among stakeholders (meteorological service providers, airlines, airports, and air navigation service providers) helps to generate a common problem understanding. Documenting measures and impacts examined in such cooperation may help other stakeholder groups to identify and learn from best practices for disruptive events. Such best practice guidebooks may especially help aviation stakeholders that will be affected in future due to climate change.
- Climate change aspects shall be taken into account as one future aspect in ATM Master Plans. Besides the direct effects of changing climate addressed in the guidebook, geographical and seasonal demand redistributions should be taken into account for the longer term. Robustness and constraints of constructions and pavements as well as technical infrastructure (e.g. air conditioning of buildings) should be analysed with respect to temperature and precipitation changes.

#### Enhancing Resilience

The measures described in this document can contribute to enhance resilience for common events as well as in case of major disruptions. Applying measures to enhance resilience in case of regular operations will also help to deal with irregular operations.

### Recommendations for research and technical development

- Terms and definitions and their use shall be standardised on an international level in order to facilitate comparisons of impacts of disruptive events and enhance a common problem understanding.
- The activities to improve local weather and disruption forecasts shall be continued. Of special importance is the forecast of thunderstorms, snow, ice and icing, strong winds and wind shears as well as conditions of low visibility or low ceiling on an airport-specific basis. Forecasts with improved geographical and timely precision may help to reduce the disruptive impact.
- The inter-airline and intermodal cooperation shall be enhanced, e.g. through the generation of a new ticket category allowing intermodal flexibility (feasibility of shifting from one mode of transport to another one with one ticket, multimodal ticket use).
- Passenger and weather information services shall be developed to bring passengers into a more active role by enabling them to choose the alternative route and transport mode, respectively, which suits them best in case of disruptions.





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- Possibilities for information exchange among customers (esp. passengers) and travel providers (airlines, travel agencies) in order to use customised travel advices shall be assessed.
- It shall be assessed if and how shifts in traffic flows relocate disruptive problems or even may generate new disruptions, e.g. a measure similar to a Level of Service may be developed to denote areas affected by traffic flows and switches of traffic flows, respectively.

### Key findings of work package 5 (aviation)

<b>Organisational and decision making structures:</b> Long-term, strategic measures on policy level, issues on legislation, regulations, and standardisation, high level collaboration, roles and responsibilities for formulation of policies and strategies.
Consider climate change aspects in the ATM airport master plan.
Increase cooperation among stakeholders (meteorological service providers, airlines, airports, and air navigation service providers) to mitigate the impacts of disruptive effects.
Develop best practise guidelines for stakeholders that will be affected by climate change in future.
Assess how demand redistributions may relocate disruptive problems.
Encourage research efforts related to the analysis of disruptive weather effects to the aviation sector.
Harmonize the definition and assignment of codes and terms as e.g., when to assign which IATA delay code.
<b>Procedural and operational options to mitigate the risk:</b>
Managerial procedures, action plans, decision-making and responsibility assignments, adaptation of working modes, collaborative actions between stakeholders to mitigate risk – before, during, after a hazardous weather event
Define responsibility for travel rearrangements and additional costs for journeys in case of multi modal traffic chains.
Enhance inter-airline and intermodal cooperation in order to allow intermodal flexibility.
Foster the use of customer profiles to provide customer-specific alternative travel solutions in case of disruptions.
<b>Information flow, ICT support (e.g. monitoring by satellites) and passenger services:</b> Development & implementation of ICT technologies and services for passengers
Provide customized travel advices (smartphone apps, websites).
Develop passenger and weather information services offering passengers a more active role by enabling transport mode shifting.





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<b>Decision and risk models:</b>
Development of risk and decision-making models and impact assessment and evaluation procedures.
Develop a measurement system to assess and compare the vulnerability of airports and airspace.
Boost transparency in the comparison of the impacts of disruptive events (consistent statistical evaluation procedures)
Continue improvements of local weather and disruptions forecast (forecasts with improved geographical and timely precision may help to reduce the disruptive impact).

## 6. KEY FINDINGS OF WORK PACKAGE 6 (MARITIME AND INLAND WATERWAYS)

### **Guidebook for Enhancing Resilience of European Maritime Transport in Extreme Weather Events – Summary**

Maritime transport is globally heavily regulated by IMO, International Maritime Organization. IMO's jurisdiction defines ship types, navigation and ship deck equipment and these regulations are followed globally by all shipping companies. Technologically, changes into existing systems will require quite a significant process and stand alone products are not in general endorsed. This means that in principle good solutions for increased safety on board ships and in open sea operations are difficult to implement. There are many identified possibilities to do this, and even more potential through better utilisation of measurement data on board together with weather information from official forecasts. Current data transfer systems also enable information flow between ships of same shipping company or within certain geographical coverage but such systems are not in place. They would offer interesting opportunities for future safety improvements as technology and data costs are reduced.

Where the major changes can take place and safety and preparedness can be greatly enhanced is the coastal shipping and ports. Regarding technologies that can improve resilience against extreme weather these are the waters where IMO regulations do not offer guidance. The coastal waters leading to ports are challenging in navigation terms, when the extreme weather conditions take place. They will require specific equipment for monitoring the impacts, such as visibility, wave heights, wind direction and speed etc.

Surprisingly, this area of impact of extreme weather is not thoroughly covered by any particular process, not within EU or globally. This was one of the starting points of the safety analyses of extreme weather for the maritime transport part. Vaisala had collected



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lots of information of European ports weather equipment, both technical and locations, and based on this selected ports across Europe were visited for analyses of safety situation. The case study analyses revealed that there is no clear mechanism or even minimum requirement as to what port safety measures should entail for certain type or size of a port. In LNG ports there are very clear and strict procedural safety guidelines, in other ports visited the practices were depending on the port's internal management decisions.

As an example of LNG ports, National Grid Grain LNG is the UK's primary LNG terminal situated in relatively calm waters south east of London. Its approach to safety is second-to-none. Operational procedures are very strict to minimise any risk of accident. Vessels 100s of meters long have to manoeuvre to 1cm accuracy. Accurate knowledge of wind speed and direction is important. The terminal benefits from being situated such that the predominant south-westerly winds push its associated vessels into the terminal. Nevertheless if winds are likely to cross a maximum threshold, vessels are not allowed to proceed and are held out at sea.

### **Examples of European ports, their challenges and extreme weather preparedness**

#### Port of Odessa operations in the case of extreme weather events

Odessa is situated in an area which climate-wise poses a challenge for port operations. Winter conditions are below zero degrees and the presence of Danube River creates difficult ice conditions.

The port has a manual prepared for various external disruptions, which covers all weather conditions and provides the guidelines for companies which operate the various terminals and services in the port area. In addition, several companies that operate at the port each have specific equipment to deal with maintenance of port areas in the case of extreme weather events. They are used in a collaborative way between various operators, which makes their use effective and reduces need to have similar services available from all service providers for their own operations.

Regarding the weather information services, the port relies only on official daily forecasts from the service provider. The port authorities forward this information to companies operating in the port. In the case of special information this can be provided through a call



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or e-mail. No equipment exists at the port or coastal waters which could be used to provide additional weather information. The preparedness of the port to tackle with interruptions such as storms is therefore limited in terms of the foresight. In the case of storms, which can arise rapidly the port usually closes the operations but there is no preventive mechanism that could warn the cargo offloading services or ships entering the port at the time. This does pose a potential for hazardous situations and accidents. The port or the companies operating in the port area do not provide additional weather information to fishermen or other boats using the coastal waters. This means that there is no authority with responsibility of oversight of safety in the coastal area waters. This can also be a potential cause of accidents if conditions change suddenly.

The three most severe extreme weather events the Port of Odessa has to deal with are:

- Storms
- Ice
- Rain and wind combination

What is a particular concern at the Port of Odessa is the impact of the river, which in the winter time pushes ice to a thick frontier. The port is struggling to find ways in which the routes to port can be kept open with icebreakers as the wind changes making the ice move constantly, blocking recently opened routes. This is combination of wind changes and the flow of ice from river Danube. For other winter maintenance, including the port ground operations, salt, sand and chemicals are being used. Dedicated areas in the port are designated for vehicles and pedestrians and maintenance is planned accordingly.

Suggested areas of improvement for Port of Odessa:

- Management of ice situation at the port area
- On-time collection of weather-related information on ice situation, wind and storms.

The technologies to manage the information exist, at the moment the challenge is to define which actor should take a responsibility of the information collection and dissemination. This is related to the cost of investment to such systems, if their use is not mandatory, investment decisions should be weighed against gains in safety and accident reduction. In the view of the operations review it appears that such potential gains could be realised and they could be significant.

### Port of Limassol operations in the case of extreme weather events



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The port of Limassol is the main port hub of the Republic of Cyprus, situated in the Eastern Mediterranean. Extreme weather event challenges that the port faces include heat wave conditions during the summer months and low visibility due to fog/dust transport events.

The port of Limassol relies on the Cyprus meteorological service for the provision of official daily forecasts as well as warnings. The former is provided once a day. Furthermore, there is constant information flow through the Meteorological Service's web page as well as the possibility of further reception and clarification of information through telephone or email. However, the VTS office relies on some additional sources as well such as the Oceanographic Centre of Cyprus for provision of information on sea waves through their website or incoming ships. The dissemination of information is provided through the NAVTEX system and short wave radio.

Coastal waters information to fishermen is provided by the Cyprus Meteorological Service. The relevant information is provided three times per day for an 8-hour period along with warnings (when they exist) through uploads to a Voice Response System. Additional information is provided through telephone if asked.

The three most severe extreme weather events that exist in the port of Limassol are:

- Wind
- Fog/dust transport episodes
- Heat waves

Wind, as always, is the most crucial aspect of port operations. In the case of the Port of Limassol, the port closes and every crane activity stops when the wind gets 7 Beaufort or more. Fog and dust create problems about 3-4 times per year, the former especially during early summer in the early morning hours. Dust episodes, according to studies performed by the Meteorological Service of Cyprus present a positive trend for the area and might pose a significant problem in the future. Heat waves can also create problems. During the summer months the Department of Labour monitors the Discomfort Index and issues warnings when it considers this appropriate. When such a warning is issued, all activity within the Port area stops for a three-hour period. Trend studies performed by the Meteorological service of Cyprus also present positive trends for Heat discomfort episodes.

Suggested areas of improvement for Port of Limassol:

- Problems cited by the VTS office include the position of the port's meteorological station as well as the position of the VTS office itself. Both could be positioned on the end of breakwater to provide maximum optimal performance: the former through



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correct and relevant measurements, the latter through increased sea visibility for the officer in charge. Another problem cited by the VTS office is the lack of sufficient personnel; the office is considered understaffed and many times only one VTS officer is present. Despite the problems VTS faces the port has an exceptionally good record considering accidents: within a timeframe of 8 years, no accidents have been reported.

- Interview with the senior pilot and the VTS officer on site revealed that there is a desire for accurate weather information both for better performance and for the sake of record keeping. Decisions made for the closure of the port or the advises given of whether a ship should enter the port is given through experience; however in case something goes wrong it is desirable to have more concrete evidence for the handling of decisions. The same goes with decision parameters: the senior pilot has cited different criteria and thresholds of weather conditions for each pilot that impact their decisions. A clear regulation that all should follow is deemed desirable.

### Southampton operations in the case of extreme weather events

Port of Southampton is the second busiest commercial port in the UK, the busiest cruise terminal and its waters are also home to many yachtsman and sailing events, not to mention the Royal Navy. It of course opens onto one of the world's busiest water motorways The English Channel. Situated half-way along the channel it also has to contend with a double-tide phenomenon.

With such a large number of shipping movements there is limitless experience and local knowledge to rely on. It is a good location to understand that despite this wealth of expertise, technology is an absolute requirement to keep the port operating safely and to its optimum.

With south-westerly winds prevailing across the UK some 70% of the time it is usually clear what approach is required. But the experts there know that when the wind changes direction it can be a game-changer. The Harbour Masters and Hydrography Officer work using three zones to facilitate changing conditions. They have had wind-mapping undertaken to understand the effects of the land situated to the north and east of the port, its associated microclimate experiencing different challenges to its other zones.

The port authorities have a number of maritime weather stations strategically placed to assist with commercial movements, three primary wind stations both onshore and on the water, plus additional stations whose information is available to yachtsmen and other





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recreational users to improve their safety. The port is currently upgrading its equipment and adding additional visibility sensors.

### **Maritime key conclusions:**

**Organisational and decision making structures:** Long-term, strategic measures on policy level, issues on legislation, regulations, and standardisation, high level collaboration, roles and responsibilities for formulation of policies and strategies.

Collaboration between weather services, oceanographic institutes and other shareholders could provide much needed experience and pooling of resources.

IMO's bureaucratic decision-making mechanisms require improvements. Slow response to actions needed causes delays and subsequent economic losses.

Standardisation and system requirements to help quicker adoption of technologies in ports by authorities and to create a way to enforce the implementation.

### **Technical options and possibilities to reduce risk:**

Operational level actions on physical infrastructure (repair, maintenance, installations) – before, during, after a hazardous weather event

### **Procedural and operational options to mitigate the risk:**

Managerial procedures, action plans, decision-making and responsibility assignments, adaptation of working modes, collaborative actions between stakeholders to mitigate risk – before, during, after a hazardous weather event

Identifying the potential safety issues in ports and working with stakeholders on how to overcome them.

Some national weather related safety instructions and commands concern also the operations of ports. As these instructions often come with a cost, it is necessary to consider who should pay for the investments required. Models of managing the safety investments need to be clarified in various port ownership situations.

**Information flow, ICT support (e.g. monitoring by satellites) and passenger services:** Development & implementation of ICT technologies and services for passenger and freight transport.

There is a gap in both effectiveness and efficiency in new technologies, sensors, weather forecasting etc.

### **Decision and risk models:**

Development of risk and decision-making models and impact assessment and evaluation procedures.

Improving the quality and reliability of wind forecasts by using WRF (Limited Area Model) down to a 2 km resolution



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Comparison of weather forecast model outputs against reliable observed data for the forecast location is needed. With empirical comparison available forecasts become more accurate, more effective. Decision makers increase in confidence and make more effective decisions, increasing the efficiency and safety of operations.

### **Guidebook for Enhancing Resilience of European Inland Waterway Transport in Extreme Weather Events – Summary**

Inland waterway transport (IWT) is a cost-efficient and environment-friendly mode of transport. It is associated with a high degree of reliability and safety, as well as the lowest noise emissions being reflected in the lowest external costs related to one ton (t) of cargo transported over one kilometre (km), compared with other modes of transport.

Extreme weather events relevant to inland waterway transport are low-water events (drought), high water events (floods) and ice occurrence. Of less importance are wind gusts and reduced visibility. There is no convincing evidence that low-water events will become significantly severer on the Rhine as well as the Upper Danube in the near future. On the Lower Danube some impact of drought in association with increased summer heat might appear, demanding however dedicated research. Related to high-water events no reliable statement with respect to increase of discharge and frequency of occurrence can be given. However, consideration of floods on inland waterways will remain important also in the future due to reasons related to flood protection.

In the Rhine-Main-Danube corridor no decrease in the performance of inland waterway transport due to extreme weather events is expected until 2050. As a consequence, inland waterway transport is expected to stay a reliable and cost-effective transport mode. For the more distant future (2071-2100), the costs of inland waterway transport are projected to increase more significantly in Danube and Rhine waterways due to adverse impacts of climate change.

Nevertheless, the implementation of short-term measures presented in the guidebook will improve the navigation conditions already today. The inland waterway transport sector will benefit from these measures immediately, not only in an uncertain future. Long-term climate change adaption strategies and related measures shall become part of an overall long-term European inland navigation policy. The adaptation needs in particular refer to the year 2050 and beyond when climate change is projected to change the discharge characteristics of the Rhine-Main-Danube corridor more significantly.

### **Adaptation Strategies**

Using the knowledge gained with respect to changes in hydrology and navigation conditions, the impact of climate change and extreme weather events on inland waterway transport could be evaluated and assessed.

Considering the European transport system, amongst others, the projects ECCONET, EWENT, WEATHER and Knowledge for Climate have recently been carried out. In line with the results of



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these projects and taking into account outcomes of other activities e.g. the ones of the International Commission for the Protection of the Danube River (ICPDR), MOWE IT proposes the following set of policy actions in order to meet the above mentioned impacts on inland waterway transport:

1. Continuous observation of climate change impacts on IWT and research
2. Development of strategies for adaptation of infrastructure
3. Development of strategies for sustainable waterway planning
4. Development of strategies for enhanced use of Information and Communication Technology (ICT)
5. Support the adaptation and modernization of the IWT fleet
6. Preparation of ports for efficient handling of adapted and modernized vessels
7. Stronger cooperation of waterway administrations and enhanced use of “Smart Waterways”
8. Permanent and pro-active cooperation of river commissions
9. Logistics management

### **Most Promising Adaptation Strategies**

Improving the inland waterway infrastructure by implementation of the respective TEN-T priority projects acknowledged by the European Commission as well as national activities will have a significant positive impact on the reduction of the vulnerability of inland waterway transport to extreme weather events today and in the future. The following two main aspects of inland waterway infrastructure development are to be taken into account:

- Economics of inland navigation, i.e. the connection between the existing waterway infrastructure and the efficiency of transport
- Ecological effects of infrastructure works, i.e. balancing environmental needs and the objectives of inland navigation (integrated planning)

A further measure with high potential comprises the development of customer oriented waterway management. In case of changing water discharge patterns (e.g. altered seasonality of low water periods) the fairway maintenance cycle (surveying, dredging and provision of information) shall be accordingly adapted on the time axis. This includes an optimal timing of the necessary dredging works during the year which takes into account changing temporal distributions of the river's water discharge. Improved utilisation of the fairway can be achieved by provision and usage of up-to-date comprehensive information on the fairway conditions as well as implementation of concepts like “fairway-in-the fairway”. For this purpose waterway administrations need to have sufficient and modern surveying equipment (i.e. surveying vessels and software for data processing and analysing). The purchase of such specialized equipment should be co-funded with the help of European funding schemes (e.g. TEN-T and Structural Funds).

The usage of ICT can contribute considerably to managing navigability by providing amongst others up-to-date on-line information on water depths and estimated time of arrival. A major challenge is to link the relevant information and systems, to provide all the parties concerned the necessary information that needs to be shared. Therefore, it is important to either create generally



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accepted ICT-systems or to make existing systems compatible. This cooperation can be at governmental level, like the development of River Information Services (RIS), but also by the cooperation of private organisations. Smart Waterways would aim at collecting, recording, visualizing and sharing information on water depths. Gains are expected in efficient sailing in times of low water levels from the reporting of up-to-the-minute water depths, water depth forecasts for the coming days and shipments of goods. The navigability monitoring and forecasting system may be based on the echo sounders that are normally mounted on ships plying the river, a data acquisition and processing system, a hydrological low-water forecast model, a morphological bed-topography forecast model and data-assimilation techniques to use measured data for updating real-time navigability forecasts. Therefore the use of these systems asks for strong promotion. Support is needed for the extension of functions and the integration of these systems. A bottleneck to enlarge usage and usability is the lack of budget and/or cooperation among (market) parties.

### **Inland waterways key conclusions**

**Organisational and decision making structures:** Long-term, strategic measures on policy level, issues on legislation, regulations, and standardisation, high level collaboration, roles and responsibilities for formulation of policies and strategies.

#### **Stronger cooperation of waterway administrations:**

development of a state-of-the-art waterway management system as well as on further standardisation and extension of waterway related information.

- Water level information including forecasts
- Actual information on critical / shallow sections
- Accurate information on bridges, ports, locks
- Identification of and access to responsible authorities

Increase of awareness of different stakeholders on climate change impacts on IWT and related industries.

Establishment of a joint “task force” for the purposes of rapid reaction in cases of severe disturbances in navigation caused by hydrological/meteorological phenomena

Communicating the need of secured long-term finance for infrastructure development and maintenance of the entire waterway network.

Operation of an integrated smart network of waterways across Europe.

Supporting the creation of a European river engineering and inland waterways transportation science partnership with the aim of establishing dialogue between the scientific community, the industry and policy makers.

#### **Permanent and pro-active cooperation of river commissions:**

Creating a strategy to alleviate the consequences of climate change in river systems

Enhancing professional qualifications in the sector to ensure availability of skilled personal and attractive job opportunities and to create a business environment of the highest safety standards



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Supporting international efforts to reduce adverse air pollution attributable to waterway transportation

Creating a European inland waterway space with minimal administrative barriers and with a maximally harmonised legislative and regulatory framework

Support to the development of a comprehensive inland waterways transport strategy for the next ten years with the overall target to improve the efficiency, competitiveness and environmental performance of inland waterway transportation in Europe

Support to the implementation of the Joint Statement of Environment & Inland Navigation Development by providing technical assistance

Issuing guidelines on the application of environmental legislation relevant to ports and waterways

Encouraging the formation of multi-sector clusters and promoting technological innovation for fleet modernisation, fleet operation, port & terminal infrastructure

### **Support the adaptation and modernization of the IWT fleet:**

Adequate legislation and creation of an efficient and harmonized regulatory framework

State-aid schemes which stimulate the transition to innovative, adapted, efficient and more environmentally friendly vessels.

### **Technical options and possibilities to reduce risk:**

Operational level actions on physical infrastructure (repair, maintenance, installations) – before, during, after a hazardous weather event

### **Preparation of ports for efficient handling of adapted/modernized vessels:**

Provision of adequate berths, anchorages and shore equipment to handle larger number of vessels due to increased convoy size.

Infrastructure adjustments/provision of vertical quays in order to accommodate transshipment even under extreme low water conditions.

Improved fairway maintenance in port areas (eg. optimized dredging).

Upgrade of transshipment facilities enabling transshipment under extreme low water conditions and providing cost-effective throughput capacity for alternating volumes.

Increase storage capacities for increased seasonal logistics buffers and additional value added services for logistics chain modifications.

Provision of adequate fendering systems (for vessels of higher damage sensitive lightweight structures).

### **Procedural and operational options to mitigate the risk:**

Managerial procedures, action plans, decision-making and responsibility assignments, adaptation of working modes, collaborative actions between stakeholders to mitigate risk – before, during, after a hazardous weather event





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Adaptation of working hours of ports & terminals for handling vessels adapted for continuous operations.

An improved infrastructure management by waterway administrations

- short-term adaptation measures addressing continuous waterway maintenance activities and strategy.
- continuous and differentiated monitoring and analysis of the development of the river's water discharge regime.
- structural modifications of river engineering works as an adequate response to more severe climatic changes.

### **Development of adaptation measures for infrastructure planning:**

Emphasis on economics of inland navigation, i.e. the connection between the existing waterway infrastructure and the efficiency of transport

Consideration of ecological effects of infrastructure works, i.e. balancing environmental needs and the objectives of inland navigation (integrated planning).

- Identification of integrated project objectives incorporating inland navigation aims, environmental needs and the objectives of other uses of the river reach such as nature protection, flood management and fisheries
- Integration of relevant stakeholders in the initial scoping phase of a project
- Implementation of an integrated planning process to translate inland navigation and environmental objectives into concrete project measures thereby creating win-win results
- Conduct of comprehensive environmental monitoring prior, during and after project works, thereby enabling an adaptive implementation of the project when necessary

**Information flow, ICT support (e.g. monitoring by satellites) and passenger services:** Development & implementation of ICT technologies and services for passenger and freight transport.

### **Enhanced use of Information and Communication Technology "smart waterways" :**

create generally accepted ICT-systems or to make existing systems compatible.

collect, record, visualize and share information on water depths.

support the extension of functions and the integration of the River Information Services (RIS) systems (current lack of budget and/or cooperation among (market) parties)

### **Decision and risk models:**

Development of risk and decision-making models and impact assessment and evaluation procedures.

### **Development of adaptation measures for infrastructure maintenance:**

Development of innovative methods for the improvement of river monitoring (shear stress, sediment transport, morphodynamics etc.).

Development and programming of numerical models (3D hydrodynamics, sediment transport and habitat modelling).

Development and optimisation of river engineering works in order to improve navigable conditions in line with



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the minimisation of river bed degradation, the optimisation of flood protection and maximisation of improvements in environmental conditions.

An improved infrastructure management by waterway administrations.

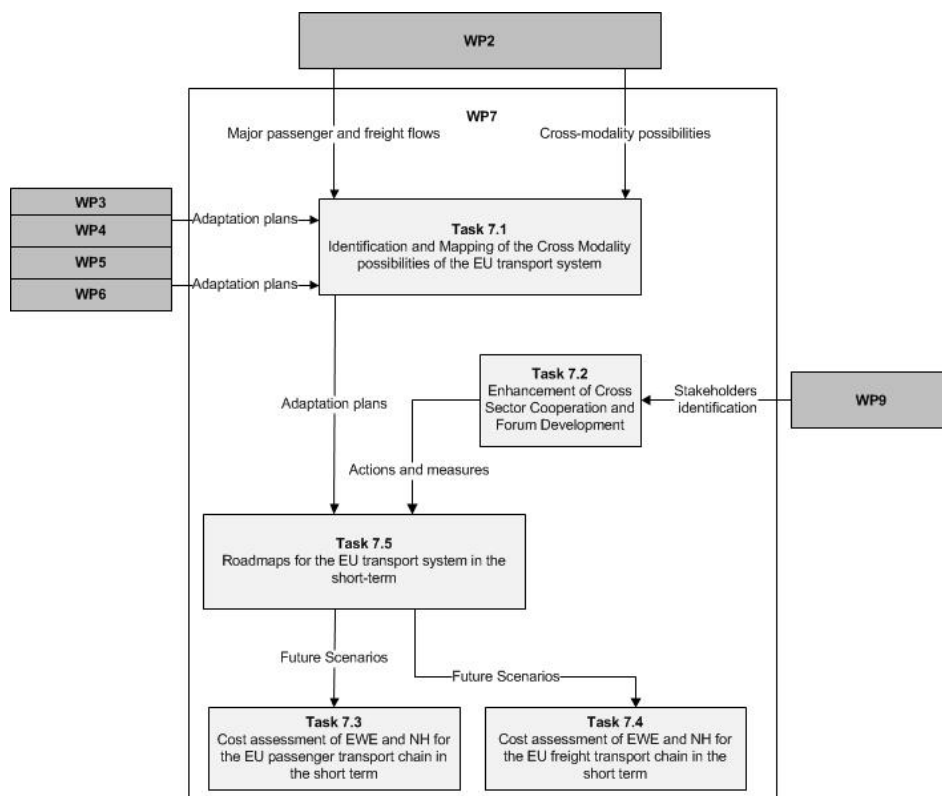
**Improved hydrological predictions**

**Logistic management:**

Development of risk strategies

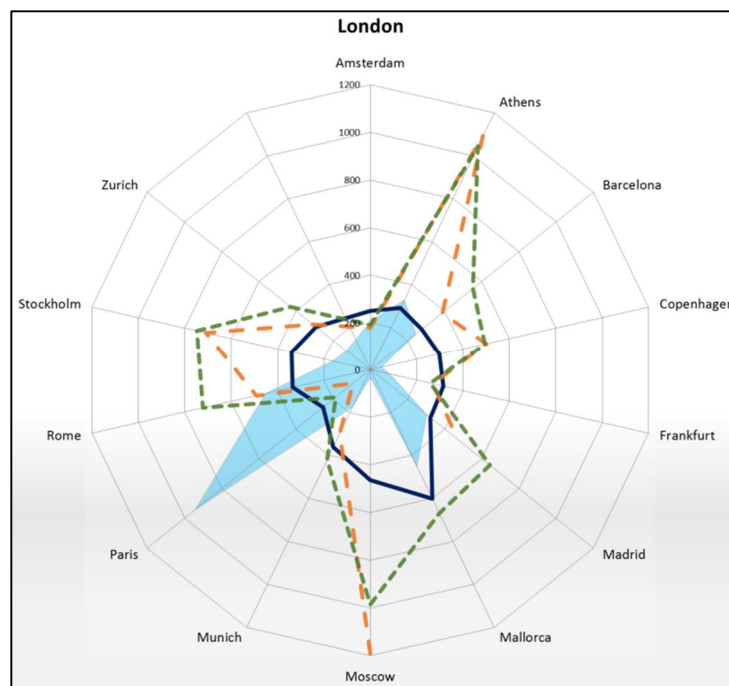
### 7. SUMMARY OF WORK PACKAGE 7 RESULTS (SHORT-TERM ADAPTATION)

WP7 of the MOWE-IT project had as a first and foremost objective to formulate roadmaps and guidelines of actions, measures, strategies and policies for the reduction of the vulnerability of the European Transport System in the short future (up to 2020). In an effort to achieve this, several side activities were conducted, each one contributing to the final output, as laid out in Figure 9.



**Figure 9: Workflow of WP7 and interactions with other WPs**

At first, results of previously concluded WPs were brought together and analyzed under Task 7.1, aiming at the identification of major passenger and freight flows in each examined transport mode (road, rail, air, maritime and inland waterway transport). In addition, current network characteristics for all modes were mapped at European level and gathered data information were correlated in order to identify the substitutability opportunities between modes. For the latter, cost (in €) and time (in hours) characteristics of trips between 14 major European hubs were combined in a generalized cost function, whose depiction revealed the cross-modal possibilities of substitution. Figure 10 presents an indicative output of this process.



**Figure 10: Substitutability opportunities**

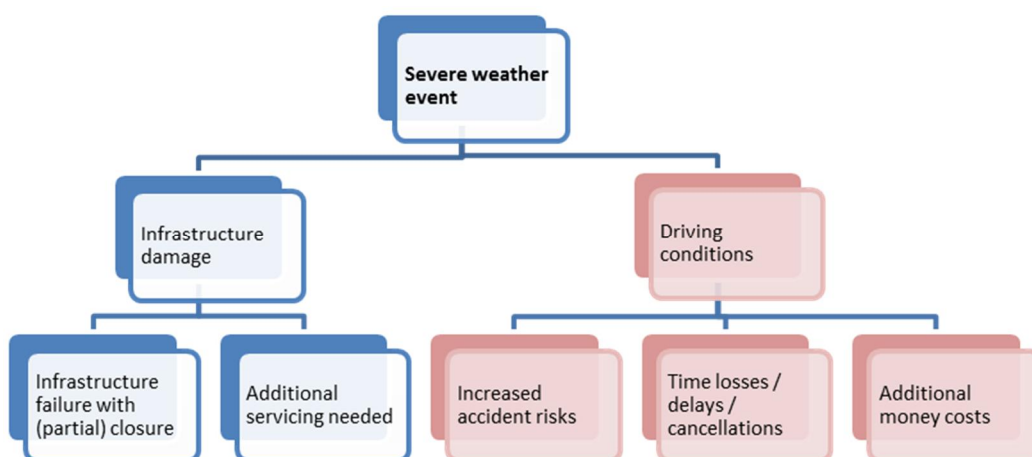
At the same time, a Transport Cross Modality Forum was set up, in an effort to bring all involved parties and stakeholders who are capable of promoting international cooperation and of alleviating procedural and legislative barriers for the promotion of transport resilience against climate change. Moreover, a questionnaire survey addressed to transport-related stakeholders was conducted, in order to identify the legislative and organizational barriers, the opportunities for cooperation and the technical options for the promotion of transport cross-modality and networks' resilience in regard to extreme weather events and natural hazards. The questionnaire was initially distributed to personal contacts (in a paper version), then produced in an online format available on the MOWE-It website to allow a larger number of participants. The questionnaire offered closed questions, and allowed participants to expand with their own comments. A total of 58 respondents replied to the questionnaire. Participants belonged to transport organizations and operators, decision makers, transport and passenger associations, and civil protection agencies. Responses



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highlighted the necessity to prioritize the resilience of rail, local roads and air transport systems, as those sectors appear more vulnerable than others. In the views of respondents, extreme weather events have an impact on the whole supply chain, with clear effects on the food chain of agricultural and perishable products, and on passengers. In the respondents' opinions, passengers should be more protected and safeguarded. They are often unable to take informed decisions before travelling, to switch from one transport mode to another if needed, and to monitor the transport situation while travelling. In general, the responses stressed that the transport system faces a very fragmented situation, because of the presence of national, regional and local authorities which, in some cases, are not harmonized and coordinated by a unique legislative framework. The lack of coordination is reflected also by transport operators and suppliers, who are incapable to exchange data and to establish inter-modality solutions that would protect passengers in case of emergencies. This fragmented scenario is accompanied by the need to update knowledge and studies on the impact of climate change and extreme weather events on transport, and therefore the necessity for policy makers to allocate additional funding and include transport resilience in their research agenda.

Shortly after, the vulnerability assessment of extreme events and natural hazards for the European passenger and freight transport chain was conducted. Impacts of extreme weather events (EWE) and natural hazards (NH) can impact transport flows directly through delays, accidents or by altering travel decisions. Indirect impacts can occur via damages to infrastructures or the enforcement of certain infrastructure operations blocking or reducing the capacity of transport networks. In front of this background, five dimensions of transport situations, user impacts and weather conditions were distinguished and elaborated in two steps: the estimation of clear weather costs and then the judgment of additional costs due to several degrees of severity of extreme weather events.



**Figure 11: Impacts of extreme weather events on transport flows**

Regarding the assessment of extreme events and natural hazards for the EU freight transport chain in the short-term, an extensive literature review was conducted in respect to the issue of



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vulnerability in freight transport, in an effort to highlight its various definitions, uses, applications and ways of quantifying. In addition, major freight routes that might be impacted from extreme weather events have been consolidated from previous research efforts (WEATHER and EWENT FP7 funded research projects) and a literature review was conducted on various extreme weather events and natural hazards affecting freight transport network operations at global, EU and regional/urban level. Finally, a specific case-study at regional/urban level has been selected for analyzing the impacts of extreme flooding on freight vehicle circulation (Attica flooding 2013) and the latter have been re-evaluated and re-assessed in light of the MOWE-IT developed roadmap of adaptation measures and policies addressing climate change – in the sense of how such an event would have impacted the freight transport networks, had a series of the suggested measures already been implemented.

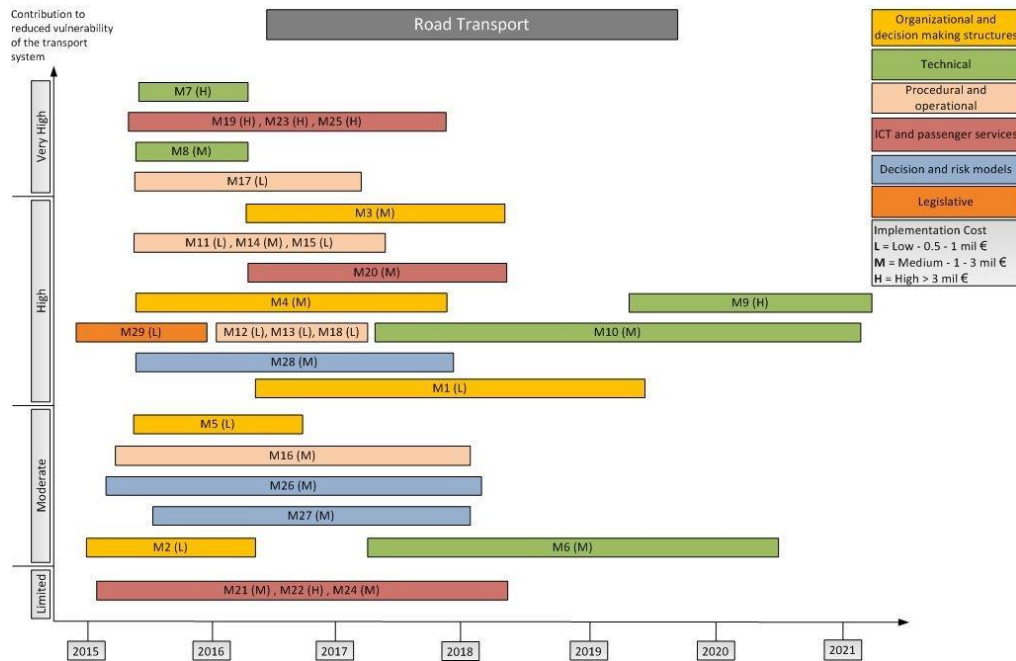
To improve the passengers' and goods' transport under the perspective of climate change, WP7 finally developed modal roadmaps for more resilient transport chains in passenger and freight transport. This contribution aimed at providing numerical estimates as well as discussions on the actual impact of severe weather events on passenger transport by modes, to support informed decisions on the transport sectors to be prioritized in terms of applying the roadmap. For the formulation of roadmaps, measures identified in the individual modal guidebooks were prioritized, based on a multi-criteria analysis. Each measure was assessed accordingly in the following areas:

1. Time needed for the implementation of the measure
2. When should the measure be implemented?
3. What is the extent of financial resources needed for the implementation of the measure?
4. What is the extent of the measure (size of population influenced/benefited from a potential application)
5. How well does the measure contribute in the protection of transport infrastructure?
6. How well does the measure contribute in the perseverance of transport network operations?

The prioritization of the measures was based on the development of questionnaire survey that was conducted within the MOWE-IT consortium. Partners were asked to fill in the questionnaire, by assessing each measure in the areas described above and the indicative layout of the roadmap of road transport is presented in Figure 12.



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**Figure 12: Roadmap of actions for road transport**



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## **8. LONG-TERM POLICY GUIDELINES WORK PACKAGE (WP8)**

Work package 8 started at the beginning of the second year of the project. The aim of the work package is to produce policy guidelines which help to enhance and secure resilience in European transport networks and in aviation in particular. Its output is condensed in two Deliverables, D8.1 and D8.2. D8.1 concerns a research agenda to support and enable improvement of transport system resilience, whereas D8.2 presents a review of resilience performance, implemented policies and recommendations for new policies and measures.

Results of the work package were presented in the regional dissemination conferences in September 2014. The very beneficial feedback and discussions during these conferences was used to finalize this Deliverables D82 and D81.

Deliverable 8.2 discusses first trends and causes of delays in aviation, and to a lesser extent in rail transport. Subsequently, it reviews the effectiveness of passenger protection regulation in the EU and comparable practices in the USA, China and Australia. It then proceeds with investigating the (theoretical) potential of inter-modal transfer of passengers in Europe, notably intra-aviation and aviation-HST/IC, in case of significant disruption. It concludes with a discussion and presentation of a collection of medium to long term policies and measures and the linked need for preparatory studies and more thorough R&D.

### **Key messages about delays in aviation and rail**

Delays can have multiple reasons. Often other stressors aggravate initial delays stemming from one cause and multiply the delays throughout the system. Weather is a significant initial source of delay, but the significance is in particular aggravated in systems operating near maximum capacity utilization. In Europe weather causes about 10% of the primary (initial) delays in aviation. Since the duration of delays caused by adverse weather is above the average of all delays, adverse weather is also a substantial contributor to reactionary delays in aviation (in combination with the utilization rate of airports and flight corridors). In Europe the share of weather caused daily delays is three to four times larger in winter (around a quarter of primary delays) as compared to summer months.

The total costs of delays in aviation in Europe amount to 1 to 1.4 billion Euro per year. This estimate does not include other delays outside the realm of air traffic flow management (ATFM), such as those caused by labour conflicts. Delays of more than 30 minutes represent only about 12% of all aviation delays, and yet this category represents about 60% of all (assessed) delay costs.



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**Table 1:** Comparison of punctuality performance across modes and their respective market sizes in the EU

	Air	Rail <sup>4</sup>	Ferry
Number of travellers <sup>1</sup>	1 400 000 000	5 000 000 000	200 000 000
% of trips <sup>2</sup> with delays (>5 min.)	~ 33%	~15%	few
% of delays > 30 min.	12 %	~5%	-
% of delays > 1 hour	4.5%	<2%	if delays occur, they last usually many hours
Cancellations (as % of all flights)	1.2%	less crucial thanks to high frequencies	in Greece <sup>3</sup> sometimes for consecutive days; elsewhere quite exceptional

1). Approximate number of recent years (sources: EUROCONTROL CODA database; CER/CIT 2012; TNS 2013; Eurostat 2013); 2) For rail the figure is based on table Q1.1, of which is assumed that at least once a week means 130 trips per year, several times per month means 40 trips per year, several times means 5 times per year; 3) meaning flights, train runs, ferry runs 3)) next to strikes, delays in pay-out of subsidies may cause suspensions of service; also storms may cause suspensions of one or several days. 4) only including regional (interurban), national (long distance) and international train services; 18% of international trains and 13% of the domestic long distance trains have over 5 minutes delay. 7% of international trains and 2% of the domestic long distance trains have over 30 minutes delay.

### Passenger protection regulation

Since 2005 passenger protection regulation has been implemented in EU Member States. First for aviation and later on for train, ferry, and bus services. It has been important for aviation services, entailing costs for airlines, while indicating a kind of minimum standard in the sector. The effectiveness of the regulation with respect to delay reduction in aviation seems however quite limited. The regulation is indeed more oriented towards ensuring rights to compensation for passengers in case of failures rather than primarily driving down delays. The regulation may have reduced delays to some extent, but even when using a favourable interpretation of the effects, corresponding to a delay reduction with a value of 250 – 350 million euro per year, these are still outweighed by the costs of 400 to 600 million euro + around 600 million euro compensation paid to affected travellers. Recently adopted amendments in the regulation will reduce the costs to some extent, but may likewise reduce the benefits somewhat.

Passenger protection regulation in the US offers a less generic coverage for delays than the EU regulation, but many major US airlines do offer facilities for costless rebooking, hotel and meal vouchers, etc. US has also set up a system of mutual assistance of airports



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(and airlines) by aviation region. All in all the regulations and voluntary arrangements are less costly than the EU regulation. The level of delays is somewhat higher in the US, notably due to more extreme weather events, but it does not differ crucially from European figures. The passenger protection level in Australia is by and large comparable to the level in the US.

### Exploiting spare and substitute capacity

The spare and substitute capacity in aviation distinguishes the following steps:

1. *rebooking* to later flights with the same destination of the same and other airlines while aiming to use all non-occupied seats;
2. *diversion* of arriving flights to (relatively) nearby airports and offering connecting flights or HST/IC trains to final destinations; if need be and possible – e.g. in case of long lasting diversions – also departures can be to some extent arranged from nearby substitute airports, however shift of departure airport is much more difficult for several reasons;
3. offering *modal switch* to stranded air travellers, notably HST and IC connections, offering them either to substitute the entire flight by train or to transfer them to another airport.

The daily passenger volume is larger in summer than in winter. On the other hand the risk for weather induced disruptions is 3 to 4 times larger in winter. A good part of the extreme weather types is affecting rail just as well. HST/IC trains are however not sensitive to fog and don't need defrost spraying during freezing periods and/or snowfall. Rush hours for aviation and rail travel largely coincide, which means that on working days HST/IC trains offer mostly little substitute capacity for stranded air passengers, neither may rebooking within aviation be of much help during rush hours. Outside rush hours and notably in winter time both the rebooking within aviation and the transfer to HST/IC services may be able to absorb appreciable shares of stranded passengers (e.g. 20% - 35%), provided the extreme weather conditions is not paralysing transport systems across the board.

**Table 2.** Summary overview of **tentative** substitute capacity as percentage of the possible maximum number of stranded passengers per hour

Substitute stage	Rush hour		Non-rush hour	
	Winter	Summer	Winter	Summer
Rebooking	0% ~ 10%	0% ~ 5%	5% ~ 25%	3% ~ 15%
Diversion	Due to the complicated logistic consequences diversion is preferably avoided by airlines. It is also costly, but it can be a mandatory choice for intercontinental flights and longer intra-Europe flights. Once chosen, it still would reduce delays and customer dissatisfaction, if relatively good alternatives can be offered at the			

	substitute airport. For this reason major hubs could develop cooperation with secondary airports in their neighbourhood (i.e. a radius of ~200 km or more depending on airport density)			
Modal switch to HST & IC	0% ~ 10%	5% ~ 15%	5% ~ 25%	5% ~ 35%

## Conclusions and recommendation for long term policy options

In principle the responsiveness of a transport system regarding impending disruptions owing to extreme (weather) events is largely steered by four main factors, being, (1) capacity, (2) Operational flexibility and information management, (3) Affordability of measures, and (4) Incentive structures. Furthermore, these main elements of resilience policy for transport systems are intersected by effects and drivers from (at least) four other policy areas, being:

- Resilience and crisis management strategies and protocols
- National, European and Global regulations on competition
- Environmental policies (incl. climate and sustainability policies)
- Social and regional equity policies

This results in a transport resilience policy field as summarized in the figure below.

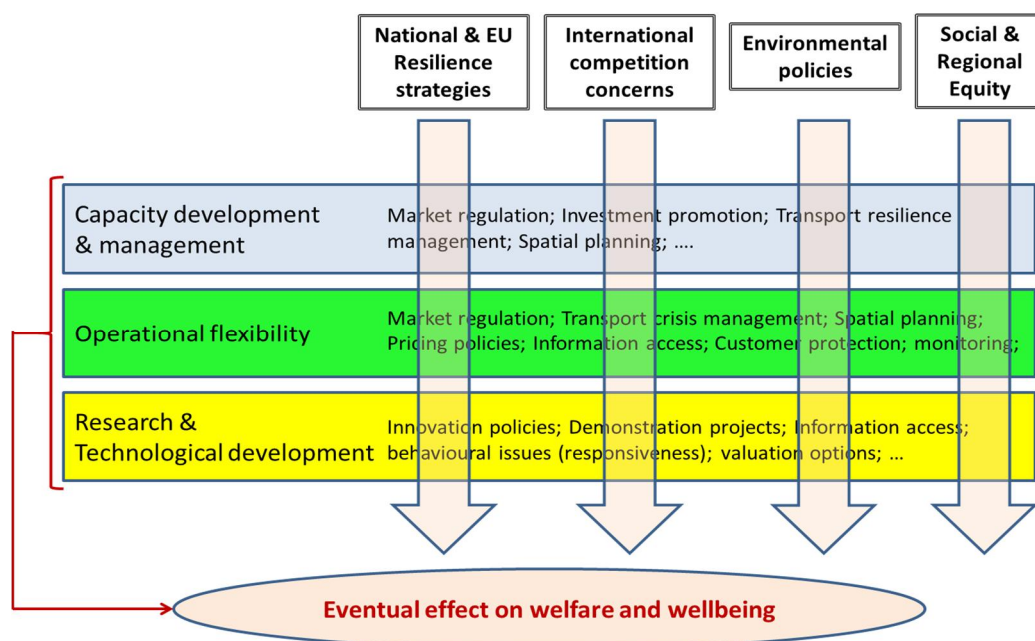


Figure 13. The overall policy field for transport resilience management





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Since air travel is projected to grow in Europe, albeit below the global average, the current level of policies and measures aimed at delay reduction will probably not succeed in maintaining delays at a constant absolute level. Additional policies and measures, supported by R&D are necessary if a reduction in absolute terms is desired. The extent to which an absolute reduction pays off in macro-economic terms cannot be straightaway answered. Very strong absolute reductions are probably not cost-effective, at least not for the foreseeable future. The various policies and measures, entailing incentive regulation, investments, and R&D support, are summarized below.

### **Policies and measures aimed at enhancing capacity**

1. Scan high speed rail networks and airports on bottlenecks and interconnectivity of the two systems throughout Europe and rank the capacity and access limitations in terms of resilience reduction effects (such as significant delay risks) and economic benefit-cost ratios of capacity investments; this option may need supporting R&D on adaptations in cost-benefit analysis (see research and innovation policy below)
2. Devise investment plans based on the priority rating of the above mentioned scan while drawing on resilience strategies and transport infrastructure strategies; review alternative funding approaches (PPP; life-cycle, etc.), a combination of national and European funding could be considered; based on the plans and funding reviews put up a joint EU-Member States investment plan to solve bottlenecks and improve interconnectivity;
3. Review the current HST service portfolio and assess whether extension of services (new destinations extending from current terminus points) without network extensions or upgrades would improve HST access and promote interoperability with airports; addition of extended HST services at the expense of local trains should be avoided though; scan options for jointly funding of service extension by bringing air and rail parties together (train service operators, (not yet) connected regions/cities, airports, airlines) – exact approach depends on national rail market regulations;
4. Promote further improvements in the agreements on the flexible use of airspace (FUA) – expand cooperation regarding military airspace so to ease swaps from military to civil airspace in congested flight areas, e.g. by offering military exercise airspace elsewhere (short to medium term action);
5. Review current business models of airports and identify to what extent the current incentive structure leads to an allocation of space and portfolio of services, which maximizes passenger expenditures rather than minimizes both passenger station time at the airport *and* airplane turnaround time; assess to what extent the currently prevailing business model raises the proneness for delays; depending on the outcomes of the review – devise viable business models with stronger incentives for



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minimization of both passenger station time at the airport *and* airplane turnaround time.

### **Policies and measures aimed at enhancing operational resilience**

6. In order to reduce some bottlenecks and improve operational resilience ensure timely implementation of the SESAR programme, among others by committing sufficient funding e.g. by committing the European Investment Bank (short to medium term action);
7. Include airports more broadly into the passenger protection regulation for aviation and introduce a benchmarking system for airports based on punctuality performance and gross travel time<sup>1</sup>; the benchmarking should be weighted and harmonized so as to compensate for climatic differences between airports and enable fair comparison; the benchmarking requires preparatory research; the benchmarking can be used as the basis for a sanction/reward system generated from payments by the airports – well rated airports receive more than they contributed, while poorly performing airports are losing; the benchmarking results should be public thereby also exerting influence on airport-client relations to match benchmark rating and charges;
8. Ensure completion and testing of the EUROCONTROL WX Resilience tool and incite coordinated application throughout Europe including protocols for capacity allocation in case of bad weather based projections of capacity limitations; the benchmarking of the airports (possibly combined with the sanction/reward system) may help to boost incitement for participation;
9. Alongside the WX Resilience tool for European aviation a similar tool could be developed for the European HST network and also used in a coordinated way by the European rail track organisations; eventually also a joint use of the system can be pursued so as to better judge actual available substitute capacity air – HST rail;
10. Consider a European coordination centre for cross-border HST and IC services comparable to EUROCONTROL, but much lighter given the smaller assignment;
11. Promote the introduction of intelligent information systems for travellers by supporting various demonstration programmes, focusing on various aspects such as: operability at different scales and in different countries, ease of use and access for vulnerable groups, etc. (this requires preceding R&D – see research and innovation policy below);
12. Facilitate different types of cooperation for transport sector actors in European, national and regional resilience strategy and management protocol development; the same goes for crisis management protocol development at European, national

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<sup>1</sup> Measured from the time the traveller has the ticket scanned before entering the security check until passing the customs at the destination airport.



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and regional level; make a best practice sharing programme at national and European level part of this cooperation.

### **Policies aimed at promoting necessary research, innovation and demonstration**

13. Promote a harmonized and complete coverage of punctuality measurement and reporting of all public modes in all Member States; promote transparency of the reporting and data access, e.g. by requiring it for access to some types of funding;
14. Promote fundamental research on modelling and prediction of extreme weather events – e.g. through the H2020 programme;
15. Promote innovation in dedicated weather services for specific transport sector user groups (aviation, maritime transport, road, multimode logistics, etc.) - e.g. through the H2020 programme and ERANET mechanism;
16. Ensure that weather service innovation is an acknowledged topic in the R&D programmes for intelligent roads;
17. Promote and fund EU (H2020) and national research on valuing of spare capacity of transport infrastructure and rolling stock in case hazard induced disruptions, under alternative market regulation schemes;
18. Promote research on the economic implications of alternative business models for airports and alternative governance and market regulation models for different transport modes, notably for aviation and rail services within the H2020 programme;
19. Promote R&D on intelligent information systems for travellers within the H2020 programme and ERANET mechanism with the specific aim to raise the resilience of the transport system(s);
20. Promote R&D on material and components in transport systems with the aim to extend the coping range in extreme weather conditions within the H2020 programme and beyond.

The main findings reported in D8.1 and D8.2 are the following:

- When compared to other large aviation markets, such as the USA and China, delays in European aviation are somewhat less in percentage terms (US) or even significantly less (compared to China);
- Mandatory arrangements regarding compensation and care of stranded passengers is by and large somewhat more favourable for travellers in the EU as compared to US and Australia;
- Next to aviation only for rail systematic statistics on punctuality performance can be found, even though punctuality statistics for rail services still lack standardization and compilation of statistics at one point (of web access); in absolute numbers the



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amount of travellers affected by delays in aviation and HST/IC services respectively is quite comparable;

- The instigated customer protection regulation for travellers in public transport in EU Member Countries has had limited effect on the reduction of delay occurrences. Punctuality in rail services is largely driven by national public service contracts for rail companies. The protection regulation for air travel may have had some effect on the reduction of delays, but it seems that the costs of the regulation outweigh the benefits.
- The customer protection regulation can be still somewhat enhanced, notably by involving airports more broadly in the regulation;
- Spare capacity within the aviation system and in HST/IC services can offer notable but by no means complete relief in case of disruptions of aviation services at major airports; a growing number of major airports in Europe has high quality rail links; to make good use of the spare capacity both preparatory research and development in ICT services and in the regulatory framework of air and rail are necessary;
- Improvement of nowcasting services in case of convective storms, further sharing of information among actors, a day-ahead capacity projection tool (related to weather and other factors) in combination with scarce capacity allocation protocols, and intelligent (2-way) travel information & advice apps for travellers would further enhance the resilience of the aviation sector; all these activities entail research, product development and demonstration;
- Other helpful measures are the flexible use of military airspace allowing for civil co-use, aiming for good minimum ATC standards for all significant airports in Europe, filling in missing links in the HST system and offering extended HST services;
- It is important to create harmonized punctuality and performance statistics, with coverage of all significant modes;
- The valuation of spare capacity in cost-benefit analysis (and related evaluation approaches) needs to be reassessed in the light of resilience policy objectives;
- Create intermodal and cross-sector databases on incidents and risks and improve the knowledge base on intra- and inter-modal resilience and co-operation options;

### **9. MAIN DISSEMINATION ACTIVITIES (WP9):**

The structure of the WP9 is characterized by four objectives, corresponding to the following four tasks:



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1. To develop and implement the plan for disseminating the results of the study (task 9.1 )
2. To co-ordinate the activities to transfer knowledge and results to policy makers, transport operators and citizens in the management of disaster recovery, mitigation strategies and optimal organizational and decision making structure (task 9.2)
3. To organize Regional dissemination Conferences (task 9.3)
4. Publish the key results in a peer-reviewed special issue of a leading scientific journal (task 9.4)

In turn, the following sections summarise the key findings related to each tasks.

### **Task 1: To develop and implement the plan for disseminating the results of the study**

This task has been the first one to be implemented, due to the fact that its primary objective was to set up the communication platform of MOWE-IT project. To fulfil this objective, the following steps have been carried out.

1. Identification of stakeholders. A long updated contact list of stakeholders has been set up, building on previous related EC research projects; namely WEATHER and EWENT. The contact list amounts to about 1,300 stakeholders spread across Europe, broadly classified in the following categories:

Type of stakeholder	Share (%)
Academia	20
Transport operators	25
Reserach Institutes	30
Institutions (Ministry, EC, associations, etc)	20
Industry	5
Total	100%

2. Construction of the MOWE-IT web site. The MOWE-It web site <http://www.mowe-it.eu/> was set up in month three (December 2012) and it is planned to be updated until two years after the end of the project lifetime (September 2014). It has been structured as to show the key results of the project, in particular through the sections on the MOWE-IT Regional Conferences and the MOWE-IT Knowledge Centre, in which the project Deliverables, the Guidebooks and other related material from other EC projects can be downloaded.





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3. The MOWE-IT Blog and Wiki tool. Hosted in the MOWE-IT Website, these two communication tools have been set up in order to convey post from newspaper, articles and other material connected with resilience transportation strategies to extreme weather events. Several articles on recent extreme weather events in Europe, their consequences and implications for policymakers and research have been hosted. Interviews to experts and policymakers have provided insights on national experience and case studies.
4. Dissemination plan for the media. The dissemination plan has been provided in month 2 (November). According to the plan, several dissemination activities as participation to Conferences, publishing of articles and public speeches have been carried out. The activity list, among the others, includes the participation through papers and posters to the following international conferences;
  - Participation to the World Conference on Transport Research (WCTR) 2013 (July 2013, Rio de Janeiro)
  - Participation to the Transportation Research Board (TRB) 2013 (Washington, D.C.) January
  - Participation to the Transport Research Arena (TRA) 2014 in Paris
  - Participation at the International Conference on Air Transport (INAIR) 2013 in Bratislava
5. Preparation and distribution of informative newsletters. Four issues of the MOWE-IT Newsletter have been carried out (in month 6, 12, 18, 24). Each Newsletter has informed the MOWE-IT stakeholders arena, reached via the MOWE-It stakeholders contact list, of the project outcomes and milestones.

### **Task 2: To co-ordinate the activities to transfer knowledge and results to policy makers**

This task has concerned with the organization of three Workshops and the establishment of the Transport Cross-Modality Forum (this last one, in close association with WP7 on short term solutions on transport resilience). Concerning the former task (the Workshops), they have been organized in collaboration with the WP3 (road), WP4 (rail) and Wp5 (aviation) leaders. The first two Workshops on road and rail have been organized in Brussels on 17-18 September, ensuring the participation of 30 stakeholders in total, among policymakers and transport operators, with an international overview of best practices and case studies. The proceedings of the two Workshops are available on the



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MOWE-IT website. The aviation Workshop was held on September 2013 in Braunschweig (Germany), organised by DLR.

The conclusions from the case studies discussed in the Workshops were considered applicable in most cases in other contexts. Promising areas for improving resilience are weather forecasts, equipment, infrastructure maintenance and design, stakeholders co-operation.

Concerning the set-up of the Transport Cross-Modality Forum, from November 2013 to March 2014, the MOWE-IT team distributed a questionnaire on “Short-term solutions assisting decision makers”.

The questionnaire, which was distributed on-line, aimed to address transport-related stakeholders in order to identify the legislative and organizational barriers, the opportunities for cooperation and the technical options for the promotion of transport cross-modality and networks' resilience in regard to extreme weather events and natural hazards.

The questionnaire was initially distributed to MOWE-IT personal contacts (in a paper version), then produced in an online format available on the MOWE-IT website to allow a larger number of participants. The questionnaire offered closed questions, and allowed participants to expand with their own comments.

A total of 58 respondents replied to the questionnaire. Participants were connected to transport organizations and operators, decision makers, transport and passenger associations, and civil protection agencies.

The MOWE-IT questionnaire highlighted the necessity to prioritize the resilience of rail, local roads and air transport systems, as those sectors appear more vulnerable than others. At the same time, all transport modes should be taken into consideration and should be strengthened, as they can be more or less vital for different geographic regions.

In the views of respondents, extreme weather events have an impact on the whole supply chain, with more pronounced impacts on the food chain of agricultural and perishable products, and on passengers.

In the respondents' opinions, passengers should be more protected and safeguarded. They are also considered in general unable to take informed decisions before travelling, to switch from one transport mode to another if needed, and to monitor the transport situation while travelling, when in presence of extreme weather disturbances.

### **Task 3: To organize Regional dissemination Conferences**



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This task has concerned with the organization of three Regional Conferences, aiming at discussing the Guidebooks on best practices improving the transport system resilience to extreme weather events. The three Conferences, held in September 2014 respectively in London (on 4<sup>th</sup>- 5<sup>th</sup>), Berlin (on 8<sup>th</sup> - 9<sup>th</sup>) and Thessaloniki (on 15<sup>th</sup> -16<sup>th</sup>) gathered about 60 stakeholders in total, among policymakers, transport operators and transport associations. The proceedings are available in the MOWE-IT website.

With the perspective to devise resilience strategies that may improve the transport system resilience to extreme weather events, the three Conferences stressed some relevant topics:

- the importance in improving information sharing across transport organisations and related public authorities;
- the crucial role of comprehensive resilience risk management systems;
- the significant role to be played by technology and infrastructure, e.g. monitoring systems, weather forecast tools (physical, asset management);
- the review of institutional frameworks, i.e. matching of responsibilities, mandates, resources, incentive structures.

### **Task 4: Publish the key results in a peer-reviewed special issue of a leading scientific journal**

Authors from the MOWE-IT consortium took part in several scientific publications. The table containing dissemination activities at the end of this report contains information of all published and forthcoming MOWE-IT related publications.

## **10. PROJECT MANAGEMENT DURING THE PERIOD**

### **Meetings and deliverables**

The following meetings took place during the first year:

- Project kick-off meeting, Brussels October 2012
- Work package 6 kick-off meeting, Odessa December 2012
- Work package 4 kick-off meeting, Frankfurt January 2013
- Work package 4 internal meeting, Frankfurt February 2013
- Work package 6 case study, Odessa July 2013



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- Work package 4 expert workshop, Brussels, September 17
- Work package 3 expert workshop, Brussels, September 18
- Work package 5 aviation expert meeting, Braunschweig, September 19-20, 2013
- Project interim meeting, Brussels, September 19-20, 2013

The following meetings took place during the second year of MOWE-IT project:

- WP6 case study, Port of Limassol, Cyprus, October 2013
- WP6 case study, UK ports, January 2014
- WP7 & WP8 kick-off meeting, Thessaloniki, March 2014
- WP2 visualisation tool meeting, Thessaloniki, May 2014

In addition, final regional conferences were arranged in three different locations:

London, September 4-5

Berlin, September 8-9

Thessaloniki, September 15-16

The reports from the regional conferences are available as D9.4 of the project and they are also publicly available from the project website.

The final consortium meeting was held in the connection of London conference on September 4. The purpose of the consortium meeting was to take stock of progress under the project, to discuss any outstanding workload and to provide guidance on reporting, both financial and the project outcomes.

The project has produced a number of deliverables, which with the exception of those related to project management have all been public and freely downloadable from MOWE-IT website. It was decided that since D9.6 provides an overview summary of WP7 and WP8 results, there was no need to publish D8.1. as a stand-alone product so it is included in D8.2.

Also, workshop reports were produced and they are available at MOWE-IT website. However, they have not been uploaded to Commission system as separate deliverables.

Del. no.	Deliverable name	WP no.	Nature	Dissemination level	Delivery date
D1.1	Risk and quality plan, including updated Dissemination Plan	1	R	RE	M3
D1.2	Cost statements and progress reports	1	R	RE	M12, M24
D2	Cross-modal substitutability in	2	R	PU	M18



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	European transport system to mitigate the impact of extreme weather and natural disasters				
D3	Guidebook and development of road map for enhanced resilience of the road transport and supply chains	3	R	PU	M16
D4	Guidebook and development of road map for enhanced resilience of the rail transport	4	R	PU	M16
D5	Guidebook and development of road map for enhanced resilience of the of air transportation	5	R	PU	M16
D6.1	Guidebook and development of road map for enhanced resilience of the of maritime transportation	6	R	PU	M16
D6.2	Guidebook and development of road map for enhanced resilience of the of inland waterways transportation	6	R	PU	M16
D7	Short-time solutions assisting decision-makers	7	R	PU	M22
<i>D8.1*</i>	<i>Research Agenda for Enhanced Cross-modal Transport Substitution and User Protection</i>	8	R	PU	M20
D8.2	Policy Guidelines for User Protection, Long-term Operational Resilience and Cross-modal Transferability between Air and Surface-based Transport Sectors	8	R	PU	M23
D9.1	MOWE-IT website	9	O	PU	M3
D9.2	MOWE-IT presentation leaflet	9	O	PU	M3
D9.3	Newsletters	9	O	PU	M6, M12, M18, M24
<i>D9.4**</i>	<i>Reports on workshops</i>	9	R	PU	M18
D9.5	Reports on regional conferences	9	R	PU	M24
D9.6	Preparation of the guidebook on the best options to reduce the vulnerability of European transport system to natural disasters and extreme weather	9	R	PU	M24

*Note: \*D8.1. is included in D8.2 and \*\*D9.4. workshop reports have been published on MOWE-IT website.*



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### Overall administrative issues

During the period there were no deviations from milestones or deliverables, as specified in the Part B or the work programme. However, preparation of some deliverables extended beyond the project deadline of September 30, 2014. These delays were communicated to Project Officer in the European Commission and she was made aware of the situation. These delays did not have any impact on the outcome of the project and were result of some key personnel being involved in other EU FP7 activities and organizational duties, which could not be avoided.

During the period there were no changes to legal status of any of the beneficiaries. However, VTT's organizational restructuring led to changes in signatory person responsible for scientific projects.

Project website was developed by the lead partner on dissemination, ISIS from Italy and it has been actively updated and has easy access and appealing features. Please see [www.mowe-it.eu](http://www.mowe-it.eu) for more details.

### Dissemination activities of the MOWE-IT project, updated October 2014

#### Peer-reviewed publications

Journal	Paper title	Author(s)
European Journal of Transport and Infrastructure Research; Special Issue Climate Adaptation and Infrastructures	Port safety now and in the future: Why and how to move to greater safety and resilience	<b>Marko Nokkala, Jussi Rönty (VTT), Paul Hutchinson (Vaisala), Vladimir Golikov (ONMA), Silas Michaelides, Matheos Papadakis, Spyros Athanasatos (CYMET)</b>
European Journal of Transport and Infrastructure Research; Special Issue Climate Adaptation and Infrastructures	Evaluation of aviation vulnerability with respect to climate change	<b>Michael Kreuz, Annette Temme, Thorsten Mühlhausen, Reinhard Schmitz (DLR)</b>
European Journal of Transport and Infrastructure Research; Special Issue Climate Adaptation and Infrastructures	Vulnerability of transport infrastructure to extreme weather events and natural hazards in small rural catchments (submitted)	<b>Evangelos Mitsakis, Iraklis Stamos (CERTH-HIT)</b>
Special issue on "Improving resilience of the European transport network against	Selected papers of the background work to be published as a special issue of	<b>Silas Michaelidas (CYMET)</b>





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extreme weather and natural disasters” 2014 – Date TBC	a leading meteorological journal	
International Journal of Environmental Science and Technology (DOI: 10.1007/s13762-014-0573-4)	Impacts of high intensity storms on urban transportation: Applying traffic flow control methodologies for quantifying the effects	<b>Mitsakis E., Stamos I., Diakakis M., Salanova Grau J.M. (CERTH-HIT)</b>
Disaster Prevention and Management – Emerald, Volume 23, Issue 4, pp. 329-342	Optimal allocation of emergency response services for managing disasters	<b>Mitsakis E., Stamos I., J.M. Salanova Grau, Aifadopoulou G. (CERTH-HIT)</b>
Cold Regions Science and Technology (The first version will be submitted before end of 2014.)	Optimization of winter road maintenance by using the sensor data from maintenance equipment fleet	<b>Hinkka, Ville; Mantsinen, Heikki (VTT); Pilli-Sihvola, Eetu (Finnish Transport Safety Agency)</b>
The Asian Journal of Shipping and Logistics		<b>Nokkala, Marko, Rönty Jussi (VTT)</b>

### Other publications

<b>Name of the publication</b>	<b>Title of the paper</b>	<b>Author(s)</b>
<b>WCTR 2013 proceedings</b>	IMPROVING RESILIENCE OF EUROPEAN TRANSPORT NETWORK TO NATURAL DISASTERS AND EXTREME WEATHER: CROSS-MODAL AND MODE-SPECIFIC METHODS	<b>Marko Nokkala, Pekka Leviäkangas (VTT)</b>
<b>WCTR 2013 proceedings</b>	EXTREME WEATHER EVENTS AND THE EUROPEAN AVIATION INDUSTRY – AN ECONOMIC PERSPECTIVE	<b>Michael Kreuz (DLR), Marko Nokkala (VTT)</b>
<b>On Course – PIANC E-Magazine 146, December 2012</b>	RESEARCH ON CLIMATE CHANGE IMPACTS ON THE TRANSPORTATION SYSTEM OF THE EUROPEAN UNION	<b>Juha Schweighofer (via donau)</b>
<b>ONMA Research Results 2014</b>	FEATURES OF EFFECTIVE USE OF METEOROLOGY INFORMATION DURING NAVIGATION UNDER EXTREME WEATHER CONDITIONS	<b>GOLIKOV V.V., NAZARENKO K.V., MARKO NOKKALA (VTT)</b>



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	ОСОБЕННОСТИ ИСПОЛЬЗОВАНИЯ И ЭФФЕКТИВНОГО ПРИМЕНЕНИЯ ИНФОРМАЦИИ О ПОГОДЕ ПРИ ПЛАВАНИИ В ЗОНАХ ДЕЙСТВИЯ ЭКСТРЕМАЛЬНЫХ ПОГОДНЫХ УСЛОВИЙ	
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**Presentations, conferences, posters, public speeches etc.**

<b>Event, venue, time</b>	<b>Name and type of presentation</b>	<b>Author(s)</b>
WCTR 2013 (July 2013, Rio de Janeiro)	IMPROVING RESILIENCE OF EUROPEAN TRANSPORT NETWORK TO NATURAL DISASTERS AND EXTREME WEATHER: CROSS-MODAL AND MODE-SPECIFIC METHODS	<b>Marko Nokkala, Pekka Leviäkangas (VTT)</b>
WCTR 2013 (July 2013, Rio de Janeiro)	EXTREME WEATHER EVENTS AND THE EUROPEAN AVIATION INDUSTRY – AN ECONOMIC PERSPECTIVE	<b>Michael Kreuz (DLR), Marko Nokkala (VTT)</b>
WCTR 2013 (July 2013, Rio de Janeiro)	PAPER ON WEATHER RESULTS WITH OUTLOOK ON THE MOWE-IT WORK	<b>Claus Doll</b>
TRB 2013 (Washington, D.C.) January	Determinants of Good Transport Crisis Management: Lessons from Tropical Storm Irene and 11 Cases Worldwide	<b>Claus Doll</b>
TRB 2013 (Washington, D.C.) January	Transportation Preparedness and Adaptation to Face Climate Change Challenges	<b>Claus Doll</b>
European Conference on Severe Storms (Helsinki, 3. – 7.6.2013)	Poster “The impact of thunderstorm activity on the European air traffic system	<b>Stephan Kral, Otto Hyvärinen, and Andrea Vajda (FMI)</b>
MOWE-IT Aviation expert workshop, Braunschweig, September 2013		<b>DLR</b>



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MOWE-IT Road expert workshop – ECTRI Brussels September 18, 2013		<b>Fraunhofer</b>
MOWE-IT Rail expert workshop – ECTRI Brussels September 19, 2013		<b>UoB</b>
Smart Rivers (September 2013, Liège (Belgium) and Maastricht (Netherlands))	Poster and Presentation on adaptation measures related to climate change and extreme weather impacts on inland waterway transport	<b>Nina Siedl (via donau)</b>
INAIR Conference 2013, Bratislava	Impact of climate change on aviation vulnerability	<b>Michael Kreuz, Annette Temme (DLR)</b>
German Climate Change workshop; 23.10.2013	Sharing results with experts from other domain	<b>Thorsten Mühlhausen (DLR)</b>
German Climate Change Workshop; 24.01.2014	Preparing a publication on climate change	<b>Thorsten Mühlhausen (DLR)</b>
TRB 2014 (January 2014, Washington D.C.)	Paper on cross-modal substitutability results, mode-specific papers (road, rail)	<b>Marko Nokkala (VTT), Claus Doll (FhG-ISI), Chris Baker (UoB), Adriaan Perrels (FMI)</b>
Transportation Research Board 93rd Annual Meeting, Washington, USA.	A data-driven method for assessing the resilience of the European passenger transport network during extreme weather events	<b>Mitsakis E., Stamos I., Kral S., Doll C., Nokkala M., Salanova Grau J.M., Aifadopoulou G. (CERTH-HIT)</b>
Transport Research Arena (TRA), Paris, 17 April 2014	Presentation of the MOWE-IT project Poster in the TRA Poster session	<b>Francesca Pietroni (ISIS) Alessandra D'Angelo (ISIS) Riccardo Enei (ISIS)</b>
Transport Research Arena (TRA), Paris, 17-18-19 April 2014	Projection of the MOWE-IT Power Point presentation in loop on the large LCD screen situated in the TRA institutional area. Guidebooks hardcopies available for consultation.	<b>Francesca Pietroni (ISIS) Alessandra D'Angelo (ISIS)</b>
17 <sup>th</sup> International Road Weather Conference La Massana, Andorra. 30 <sup>th</sup> January to 1 <sup>st</sup> February	Paper (+poster) on a case-study related to MOWE-IT WP3, entitled: Weather factors triggering the massive car crashes on 3 February 2012 in the Helsinki metropolitan area (article accepted).	<b>Ilkka Juga, Marjo Hippi, Pertti Nurmi, Virve Karsisto (FMI)</b>
Seminar/Workshop on climate change and transport, 20-21 March 2014, Ankara, Turkey	Invited speech/presentation on: a) Impacts of climate change on multimodal	<b>Evangelos Mitsakis (CERTH-HIT)</b>



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(organized by TAIEX)	transport systems, services and infrastructures b) Assessing climate change adaptation: methods and tools c) Data issues and data-driven approaches for estimating climate change impacts on transport system networks	
EUROPEAN GEOSCIENCES UNION (EGU) GENERAL ASSEMBLY VIENNA APRIL 2013	Overview of Best Practices in Mitigating the Impact of Natural Disasters and Extreme Weather Phenomena on European Aviation - The MOWE-IT Project by Thorsten Muehlhausen et al.	<b>Silas Michaelidas (CYMET)</b>
Cooperation with PIANC within the permanent taskgroup on climate change in the field of infrastructure adaptation	Networking and contribution to common knowledge	<b>Juha Schweighofer (via donau)</b>
Working Group meeting for Priority Area 1a - To improve mobility and multimodality: Inland waterways - of the EU Danube Region Strategy (EUSDR) EUDRS, November 2013	Impacts of extreme weather events on waterways (presentation by MOWE-IT project)	<b>Nina Siedl (via donau)</b>
World Weather Open Science Conference (WWOSC) 2014 User, Application and Social Science program, Montreal, Canada, August 2014	Moving towards a resilient transport network for the future: integrating meteorology, engineering and social perspectives	<b>Andrew Quinn (UoB)</b>
World Weather Open Science Conference (WWOSC) 2014 User, Application and Social Science program, Montreal, Canada, August 2014	Attenuating disruptive effects of bad weather on air travel – minimizing numbers of stranded travellers	<b>Adriaan Perrels, Atte Harjanne (FMI), Claus Doll (Fraunhofer), Mitsakis Evangelos, Iraklis Stamos (CERTH-HIT), David Jaroszewski (UoB), Michael Kreuz, Anne Temme (DLR) Kaisu Loikkanen, Anu Tuominen (VTT)</b>
12th International Conference on Meteorology, Climatology and Atmospheric Physics COMECAP 2014	Overview of Best Practices in Mitigating the Impact of Natural Disasters and Extreme Weather Phenomena on European Aviation - The MOWE-IT Project by Thorsten Muehlhausen et al.	<b>Silas Michaelidas (CYMET)</b>



MANAGEMENT OF **WEATHER** EVENTS IN THE **TRANSPORT** SYSTEM

ICAO/WMO Technical Conference, Aviation Meteorology – Building Blocks for the Future, Montreal 2014	Invited speech at the ICAO headquarters in Montreal ; Presentation about the impact of extreme weather events and climate changes on the aviation system	<b>Michael Kreuz (DLR)</b>
5th International Scientific Conference on "Energy and Climate Change", 11-12 October 2012, Athens (Greece)	A review on climate change adaptation policies for the transportation sector	<b>Stamos I., Mitsakis E. (CERTH-HIT)</b>
Nordic International Conference on Climate Change Adaptation, 26 – 28.8.2014 Copenhagen	Climate change adaptation in the transport sector: The Nordic experiences	<b>Molarius, R, Hanski, J., Tuominen, A., Nokkala, M. VTT</b>