WEATHER

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

Deliverable 3
Innovative emergency management strategies

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List of abbreviations

BCA - benefit-cost analysis
Car2X – car to - X
CB – citizen band radio
CCTV – closed circuit television
CSM - common safety method
DAB – digital audio broadcasting
DSCR – dedicated short range communication
DSL – digital subscriber line
DSS – decision support system
DVB – digital video broadcasting
EC - European commission
EM - emergency management
ETM - emergency transport management
ETSI – European Telecommunications Standards Institute
EWE - extreme weather event
FCD – floating car data
FM – frequency modulated
FTD – floating traveller data
GIS - geographical information system
GNSS – global satellite navigation system
GPRS – general packet radio service
GSM – Groupe Spéciale Mobile
HAR – highway advisory radio
HDTV – high-definition television
HiperMAN – high performance radio metropolitan area network
IT – information technology
ITS – intelligent transportation systems
ISDN – integrated services digital network
LASER – light amplification by stimulated emission of radiation
LED – light emitting diode
LiDAR – light detection and ranging
NMS - national meteorological service
PLC – power line communication
PSTN – public switched telephone network
RADAR – radio detection and ranging
RFID – radio frequency identification
RSS – really simple syndication
RWIS - road weather information system
RWS - road weather station
SDTV – standard definition television
SMS – short message service
SONAR – sound navigation and ranging
SSR – secondary surveillance RADAR
SWWS - severe weather warning system
TETRA – terrestrial trunked radio
TMC - transport management centre
TMC – traffic message channel
TPEG – transport protocol experts group
UMTS – universal mobile telecommunications system
VHF – very high frequency
VMS – variable message signs
VoIP – voice over internet protocol
WAP – wireless application protocol
WIS - weather information system
WiMAX – worldwide interoperability for microwave access
WLAN – wireless local area networks
EXECUTIVE SUMMARY

WP3 in the framework of the WEATHER project

WEATHER Project aims at adding to the current state of knowledge on the impacts of extreme weather events on economy and society in total and on European transport systems in particular. The project starts from the broad picture of climate scenarios and breaks them down to specific regions. Economic growth models are applied to study the impacts on economy and society and the inter-relations between transport and other sectors. The vulnerability of transport is assessed mode by mode including infrastructures, operations and intermodal issues. Best practices in emergency management are identified by studying the numerous damage cases world wide and options for adapting to more frequent and/or more extreme weather events are assessed. A particular focal point of the project is to quantify expected damage, emergency and adaptation costs and the benefits of improved emergency management and adaptation. Moreover, the project will try to identify policy options to implement the recommended measures and demonstrate the competitive potential and the innovation power of a European lead market for adaptation and emergency management technologies and policies.

Objective and structure of this report

Deliverable 3: “Crisis management and emergency strategies” addresses the objective how the negative impacts of extreme weather events can be eased by installing suitable crisis and emergency management systems and system recovery mechanisms. The conclusions are provided in the form of general policy guidelines, aiming at assisting policy makers as well as planners with the identification of the optimal crises and emergency management strategies.

The Deliverable is composed by three distinct Parts. PART A begins with a top down description of emergency management and its organization, aiming at linking emergency management operations and procedures with the role of transport networks in the case of Extreme Weather Events, PART B explores and analyzes in detail the key issues identified for the provision of ETM: the organisational and technological aspects and finally, PART C summarizes the key policy issues as drawn from the literature review and the analysis of the previous parts.

Emergency management: A top - down approach

The initial objective of this section is to accurately define the conceptual framework of emergency management (EM), serving as an introductory report for the ‘top down’ overview of EM issues and its connection with the function of the transport system. For this reason the detailed description of Emergency Management terminology is
undertaken, clarifying the main theoretical concepts of the term as well as the transformation of the context of the term during the recent years. Moreover it has been conducted an extensive literature review which identified the current and best practice of emergency management in the transport sector. The concept of Emergency Transport Management was introduced as well as its significance for maintaining the service function of transport networks.

Organisational and technological issues of EM in the transport sector

Organisational issues

The contribution focuses the organizational and informational aspects of weather-related emergency management especially in rail and road transport. The research followed a holistic approach, i.e. emergency management has been regarded as essential element of risk management. The likely benefits of weather-related emergency management structures regarding organization, information, and cooperation were identified. The work was based on a review of available studies, reports, guidelines, numerous expert interviews and the results of a workshop. The research framework included three main steps:

- **Organization**
  - Description of the four phases of EM planning and the basic activities of emergency transport management (ETM) with regard to extreme weather events
  - Identification of the characteristics of weather-induced emergencies and their implications for emergency management structures
  - Development of a framework in order to integrate meteorological risk into emergency transport management
  - Identification of relevant actors in emergency transport management
  - Discussion of barriers to the integration of meteorological risk and adequate strategies to overcome these barriers
  - Presentation of good practice examples

- **Information**
  - Identification of the benefits of meteorological information for emergency transport structures
WEATHER D3: Innovative emergency management strategies

- Availability and role of severe weather warnings in emergency transport management
- Cost and benefits of road weather information
- Description of the information flow and the roles of involved actors

• Cooperation
  - Inter-modal, trans-sectoral, and trans-regional cooperation
  - Transferability

Technological issues

This task concentrates on the identification, documentation, and proposals of implementing new technologies into emergency management in cases of weather-related events. The primary objective of this section was to provide an overview of innovative technological systems which are used in the transport sector. Firstly, a detailed description of all available technological ‘components’ (Satellite information and navigation technologies such as the upcoming use of Galileo, Decision Support Systems, new mobile communication technologies) is realized, emphasizing on the distinct role and functionality of each component in the provision of IT services in the transport sector. Next, a classification method for intelligent transport systems (ITS) is proposed in relation to the capabilities and the range of services that the system provides as well as to the level of automation. Different types of ITS systems are also described from different areas and capabilities pointing out the diversity and the broad spectrum of ITS uses.

Policy guidelines

The aim of this chapter is to summarize the results and conclusions drawn from the previous sections in a form of policy guidelines. The initial findings and theoretical conclusions of WP3 indicate that there are two main categories of aspects when considering the enhancement of emergency management strategies in the transport sector for coping with extreme weather events: the organisational and the technological aspects. Moreover, a short note on policy issues in general as well as a brief discussion on the different ‘levels’ of policy making is provided in the last section in order to throw some light on the linkages of the various policy elements. The main policy guidelines for the national as well as for the local level are provided herein.

Policies for Emergency Transport Management in the national level

1. Include disaster response to extreme weather events as part of all transportation planning procedures (local, regional, national, transit, etc.). Consider the
entire range of possible extremes weather impacts on the transport system and consider the widest range of possible solutions.

2. Identify and allocate the roles and tasks during extreme weather event emergencies. Coordinate regionally so that there is a clear chain of command concerning transportation issues during extreme weather events.

3. Update emergency transport response plans regularly, particularly their effectiveness after a disaster.

4. Establish a system to prioritize evacuations based on factors such as geographic location (evacuate the highest risk areas first) and individual need and ability.

5. Create communication and support networks that serve the most vulnerable people (people that experienced a catastrophe or a crisis). Establish a system to identify and contact vulnerable people, provide individualized directions for their care and evacuation and establish a chain of responsibility for caregivers.

6. Coordinate vehicle rentals and fuel supplies as well as provide special services (information, water, food, washrooms, medical services, vehicle repairs, etc.) along evacuation routes.

7. Be ready to quickly deploy buses, vans and trains. This requires an inventory of such vehicles and their drivers and clearly established instructions for their use.

8. Give buses and other high-occupancy vehicles priority where critical resources (road space, ferry capacity, fuel, repair services, etc.) are limited.

9. Coordinate fuel, emergency repair and other support services.

10. Run regular practice drills to assess preparedness.

11. Train people to know what is required of them in case of an emergency. Make sure they are prepared psychologically as well as physically.

The main policy issues in the local level are presented in the following table.
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<table>
<thead>
<tr>
<th>Organisational aspects</th>
<th>Supporting Actions / Strategies</th>
<th>Cost</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment of hazard and vulnerability of transport systems (infrastructure and processes) to extreme weather events</td>
<td>Risk analysis of transport systems regarding extreme weather events</td>
<td>None</td>
<td>More effective allocation of personnel and equipment</td>
</tr>
<tr>
<td>Responsibility sharing in relation to the existing resources and needs</td>
<td>Organization and conduct of common exercises, negotiation techniques between authorities, role games/simulation, group dynamics</td>
<td>Insignificant</td>
<td>More effective emergency planning to extreme weather events and efficient response</td>
</tr>
<tr>
<td>Promotion of cooperation between local authorities</td>
<td>Sign of agreements, establish communication networks and a platform to exchange best practices in weather-related emergency transport management</td>
<td>Insignificant</td>
<td>More effective inter-modal coordination and wide-spread knowledge about best practices, integration of weather data in ETM</td>
</tr>
<tr>
<td>Enhancement of communication between the different types of authorities (weather, traffic, civil protection etc)</td>
<td>Common EU standards on e.g. the format and content (message standards) of weather information and traffic warnings</td>
<td>None</td>
<td>More easier and consistent inter-modal, trans-sectoral, and trans-regional communication and information</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technological aspects</th>
<th>Supporting Actions / Strategies</th>
<th>Cost</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determination of technological equipment needed for traffic management and control</td>
<td>Review and benchmarking of available technological ITS solutions</td>
<td>Implementation and maintenance</td>
<td>Improvement of traffic management, automation of services, integration of services</td>
</tr>
<tr>
<td>Explore technological developments for organisational purposes</td>
<td>Examine opportunities for resolving organisational barriers with the use of technology (robots, agents)</td>
<td>Unregistered</td>
<td>Easy and quick solution of organisational issues concerning responsibility sharing, cooperation etc</td>
</tr>
</tbody>
</table>

It must be stated at this point that the costs of supporting actions and/or strategies in the table above which are considered as ‘none’ or ‘insignificant’ is assumed that (in the majority of the cases) can be covered by the current employees, equipment and infrastructure of the respective organizations and public bodies. So, it is a matter of ‘better organization’ and efficient resource management and planning rather than investing in new assets and this is the reason that these costs are considered to be low.
1 Setting the scene

1.1 Introduction to the WEATHER project

The WEATHER Project starts from the broad picture of climate scenarios and breaks them down to specific regions. Economic growth models are applied to study the impacts on economy and society and the inter-relations between transport and other sectors. There has been much work in the recent years on possible costs of climate change on economy and society. However, due to the long life time of most climate gases in the atmosphere, the complex system of weather and climate interactions and the manifold reaction schemes within the long time intervals over which climate change happens, the predictions of scenarios and effects differ widely.

The motivation for the WEATHER Project emerges from the great and still growing attention paid to the long term impacts of climate change and from the still large uncertainties on social and economic impacts and on options to ease their severity. Little knowledge has so far been developed on the economic costs of climate and extreme weather driven damages to transport, and even less evidence is available on the options, costs and benefits of adaptation measures. National adaptation programs of EU Member States, the US, Canada, New Zealand and the 4th assessment report of the IPCC provide only indicative measures and global fields of action. Thus there is a need for European studies addressing local conditions.

The third branch of WEATHER research is concerned with the role of transport systems for crisis/disaster management. In the transport literature, the term "emergency operations" spans a number of topics including the use of intelligent transport systems, traffic planning and institutional issues. The major task under these topics is to keep infrastructures and critical facilities working under extreme (weather) conditions. Transport infrastructures and services take a particular role in this context as transport facilities are required for supply, rescue and maintenance operations. The overall objective would be to identify the optimal adaptation measures in relation to different geographical areas for coping with the negative impacts of extreme weather events on the transport sector.

1.2 Project objectives and work plan

In front of this background the WEATHER project aims at analysing the economic costs of more frequent and more extreme weather events on transport and on the wider economy and explores the benefits and costs of suitable adaptation and emergency management strategies for reducing them in the context of sustainable policy design. The research is carried out by an international team of eight European insti-
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tutes, lead by the Fraunhofer-Institute for Systems and Innovation Research (ISI). The project runs for 30 months from November 2009 until April 2012. The weather project is funded by the 7th RTD framework program of the European Commission and is supervised by the Directorate General for Research.

The project work plan is broken down in two work packages for management and dissemination and seven work packages on research:

- WP1: Weather trends and economy-wide impacts
- WP2: Vulnerability of transport systems
- WP3: Crisis management and emergency strategies
- WP4: Adaptation options and strategies
- WP5: Governance, incentives and innovation
- WP6: Case studies
- WP7: Policy conclusions and final conference

The WEATHER work packages are closely interlinked as sound adaptation and crises prevention strategies require the simultaneous consideration of various aspects of weather trends, transport economics and policy design. Of utmost importance for the weather research are contacts to transport operators and the public sector (administrative agencies). For this reason each of the core work packages organises workshops to discuss the project findings with transport professionals and academia.

1.3 Position of WP3 in the framework of the WEATHER project

Emergency management denotes all activities taken to rescue and supply people who are suffering from extreme weather events, such as storms, storm surges, heavy precipitation, sudden ice or heat periods. Emergency management embraces also all activities undertaken to keep infrastructures and critical facilities working under such conditions. Transport infrastructures and services take a particular role in this context as transport facilities are required for supply, rescue and maintenance operations.

Accordingly, WP3 aims to provide a current situation analysis regarding advances and implementation issues of emergency management systems and to assess the organizational and technological challenges related to the reduction of the negative impacts of extreme weather events on transport networks. The activities in this WP will entail the identification and analysis of related cases and literature review, the identification of organization aspects related to emergency management procedures.
and Information Technologies needed. The possibilities of implementing new technologies in the area of crisis management will also be considered. All above are going to be supplemented by the organization of a workshop where invited stakeholders are going to share their experiences, best-practices and their know-how with the consortium members.

1.4 Objective of Deliverable 3

Deliverable 3: “Crisis management and emergency strategies” addresses the objective how the negative impacts of extreme weather events can be eased by installing suitable crisis and emergency management systems and system recovery mechanisms. Based on the experiences made in past disasters, best practice strategies to handle peoples' food, water supply and health services through keeping transport systems working will be collected and analyzed. Through literature reviews and a targeted workshop the understanding of the inter-relationship between policy structure, new and innovative technologies and transport system characteristics will be deepened. Outputs are a report on methods and findings and policy guidelines on the transferability of best practice crises management strategies.

1.5 Structure of Deliverable 3

The present deliverable is structured on the basis of the complex theoretical background underlying the role of emergency management operations to cope with the impacts of extreme weather events on the transport system. The Deliverable is composed by three distinct Parts:

Firstly, PART A of the Deliverable begins with a top down description of emergency management and its organization, aiming at linking emergency management operations and procedures with the role of transport networks in the case of extreme weather events. This Part ends with the definition of Emergency Transport Management (ETM) and some key considerations for its provision.

PART B explores and analyzes in detail the key issues identified for the provision of ETM: the organisational and technological aspects. These aspects are thoroughly examined, providing a complete picture on the organization and incorporation of Emergency Management into current transport operations. PART B concludes with the main results from the second Workshop of the WEATHER Project, conducted in the framework of WP3.

Finally, PART C summarizes the key policy issues as drawn from the literature review and the analysis of the previous parts. The conclusions are provided in the form
of general policy guidelines, aiming at assisting policy makers as well as planners with the identification of the optimal crises and emergency management strategies.
PART A: EMERGENCY MANAGEMENT: A TOP-DOWN APPROACH
2 Introduction

Over the past 30 years, a major shift has occurred in the way emergency situations and crises are managed. The World Health Organization (WHO) in the report ‘Risk Reduction and Emergency Preparedness’, points out the fact that in the past more emphasis used to be placed on humanitarian response and relief activities at national or international level, while little attention was given to strategies and actions in place prior to disasters that could mitigate the effects of these events on communities and preserve lives and assets. Moreover it notes that is becoming increasingly clear that while humanitarian efforts remain important and require continuous attention, community-based risk reduction and emergency preparedness programs are critical for reducing the effects of emergencies, disasters and other crises and thus essential for the attainment and protection of sustainable development.

The same report highlights the fact that Emergency preparedness has traditionally focused on stockpiling relief goods and providing urgent services to meet the public’s basic needs. In most countries political commitment and financial and human resources are concentrated overwhelmingly on these short-term emergency contingencies. While building up capacities for humanitarian response continues to be a priority for all countries, it is now widely believed (perhaps influenced by the severity and frequency of disasters and conflicts in the past decade) that more actions should be taken in order to reduce the social, economic and human consequences of these emergencies. This fact results to a need for placing greater attention on the implementation of proactive strategies and a call for a more comprehensive approach to building national capacities in emergency preparedness and response as well as in risk reduction, focusing on those communities most at risk.

Preparedness is essential in securing the right to life with dignity. States bear the primary responsibility for protecting their citizens and ensuring a dignified life. However, the modern approaches to preparedness extend well beyond those traditionally involved in relief efforts, such as civil protection agencies, emergency units and humanitarian organizations. Communities are now aiming at achieving close cooperation with local authorities, public organizations and the related private sector companies, in order to strengthen their own capacities to prepare for and manage the consequences of various risks. These efforts mark a reconsideration of the term ‘emergency management’, by broadening its perspectives and redefining its objectives.

The challenges focus on putting in place systematic capacities such as legislation, plans, coordination mechanisms and procedures, institutional capacities and budgets, skilled personnel, information, and public awareness and participation that can measurably reduce future risks and losses. The present document tries to provide
contributions towards this direction by underlying the main attributes of ‘emergency management’ and by pointing out the new challenges that emerge in respect to coping with emergency situations and crises, while placing special emphasis on extreme weather events.

Thus, the initial objective of this section is to accurately define the conceptual framework of Emergency Management, serving as an introductory report for the ‘top down’ overview of EM issues and its connection with the function of the transport system. For this reason the detailed description of Emergency Management terminology is undertaken, clarifying the main theoretical concepts of the term.
3 Basic concepts

Emergency Management (EM) is one of a number of terms which, since the end of the Cold War, have largely replaced Civil Defense, whose original focus was protecting civilians from military attack. Modern thinking focuses on a more general intent to protect the civilian population in times of peace as well as in times of war. Another current term, Civil Protection is widely used within the European Union (Wikipedia, 2008) and refers to government-approved systems and resources whose task is to protect the civilian population, primarily in the event of natural and human-made disasters. Within EU countries is also met the term Crisis Management, which emphasizes on the political and security dimension rather than on measures to satisfy the immediate needs of the civilian population. An academic trend is towards using the term disaster risk reduction, particularly for emergency management in a development management context (Wikipedia, 2008). This focuses on the mitigation and preparedness aspects of the emergency cycle (described below in the document).

A number of definitions of ‘emergency’ and ‘disaster’ have been proposed over time, many of them focussing on some measure of the cost of the event in terms of loss of life or damage. However, the Emergency Management Australia Report (Boon, C. B. / Cluett, C., 2002) underlines that the focus of concern with emergencies and disasters has moved towards consideration of the situation created by such phenomena rather than simply of the origin, nature, size, speed of onset and other physical attributes of the hazard, which results in the event itself. To some extent, the report recognizes that this change of focus has been brought by the recognition of the limited capability for controlling such attributes, in the case of natural hazards in particular. But it has also stemmed from the realisation that the consequences of many different types of events —the situation that the impact of such events, whether natural or man-made, may create in terms of social, economic, environmental, developmental and political consequences for the communities— can be remarkably similar. Importantly, the report concludes that it is now common ground that emergencies and disasters occur in a social context and have social consequences.

Moreover, the same report (Boon, C. B. / Cluett, C., 2002) acknowledges the need to expand our understanding regarding the situations caused (e.g. by defining different ‘scenarios’) of the hazards to which communities may be subject, in order to find ways to prevent emergencies or disasters occurring and to reduce their impacts. It is necessary to learn more about how situations created by the impacts of those hazards that cannot be prevented, can be manageable. This requires the development of a more detailed understanding of the factors that lead to such situations occurring, and how such factors may be managed.
The first step in order to understand the nature of critical incidents and organize emergency plans is to agree on a common terminology. Multiple organizations and personnel need to agree on the use and meaning of emergency management terms and phrases; a rather difficult task considering the complexity and the multi-dimensional character of such events. Common definitions need to be established in order to develop a mutual communication language (‘protocol’) for the cooperative and effective response to emergency events.

The process of developing definitions can be highly instructive for the public authorities and the emergency managers, focusing discussion and raising awareness in order to determine which types of impacts and consequences can be managed through Standard Operating Procedures (SOPs) and which require the activation of an Emergency Plan and emergency procedures.

Fundamental emergency terms such as emergency, disaster, crisis, are often used to refer to a number of circumstances that disrupt transport services and demand action, without specific references, prerequisites or conditions. For this reason, the definition along with a brief analysis of all the key terms regarding emergency management operations, is attempted herein.

The fundamental key terms of the emergency management procedure are:

- **Community** (Boon, C. B. / Cluett, C., 2002): A group of people with a commonality of association and generally defined by location, shared experience or function.

- **Event / incident** (Boon, C. B. / Cluett, C., 2002): A situation, which occurs in a particular place during a particular interval of time.

- **Crisis** (WHO, 2007): Crisis is an event or series of events representing a critical threat to the health, safety, security or well-being of a community, usually over a wide area. Public health dangers, natural disasters, environmental emergencies and other major harmful events may involve or lead to a crisis.

- **Disaster** (WHO, 2007): A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses that exceed the ability of the affected community or society to cope using its own resources. A disaster is a function of the risk process. It results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk.
WEATHER D3: Innovative emergency management strategies

- **Emergency** (WHO, 2007): An event, actual or imminent, which endangers or threatens to endanger life, property or the environment, and which requires a significant and coordinated response.

- **Civil protection** (Bankoff et al., 2004): According to is an effort to prepare non-combatants for military attack. It uses the principles of emergency operations: prevention, mitigation, preparation, response, or emergency evacuation, and recovery. Since the end of the Cold War, the focus of civil protection has largely shifted from military attack to emergencies and disasters in general.

- **Hazard** (Boon, C. B. / Cluett, C., 2002): A source of potential harm, or a situation with a potential to cause loss.

- **Vulnerability** (WEATHER Project D2, 2011; WHO, 2007): Vulnerability indicates the potential negative effects in cases where a system element is getting hit or affected by a hazard or threat. The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards. Vulnerability research covers a complex, multidisciplinary field including development and poverty studies, public health, climate studies, security studies, engineering, geography, political ecology, and disaster and risk management. In relation to hazards and disasters, vulnerability is a concept that links the relationship that people have with their environment to social forces and institutions and the cultural values that sustain and contest them. Therefore it indicates the degree of the consequences of a possible event.

- **Elements at risk** (Boon, C. B. / Cluett, C., 2002): Constitute the community-society that includes the population, buildings and civil engineering works, economic activities, public services and infrastructure etc. exposed to sources of risk.

- **Risk** (WEATHER Project D2, 2011; Boon, C. B. / Cluett, C., 2002): The chance of something happening that will have an impact upon objectives, measured in terms of consequences and likelihood. In emergency management, it is more particularly described as ‘a concept used to describe the likelihood of harmful consequences arising from the interaction of hazards, the community and the environment’.

Thus risk includes a probability indicator, and namely the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihood, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerabilities. The hazard-
specific Risk ($R_h$) combines both the probability and the level of impact of a specific hazard, as follows (Schulz, C., 2007):

$$R_h = H \times V_h,$$

where

- $R_h$ is the risk of a specific hazard,
- $H$ is the probability of the hazard occurring,
- $V_h$ is the vulnerability of the specific area (community).

The equation below states that the hazard multiplied by the populations’ vulnerability to that hazard produces a risk. Catastrophe modeling. The higher the risk, the more urgent the hazard specific vulnerabilities must be targeted by mitigation and preparedness efforts. However, if there is no vulnerability there will be no risk, e.g. an earthquake occurring in a desert where nobody lives.

Risk is defined as the product of a hazard (probability of an event with certain intensity) and its consequences. The following figure gives a visual demonstration of the definition of risk (Schulz, C., 2007).

Source: Schulz, C., 2007

Figure 1: Risk representation

**Emergency (or Disaster) management** (FEMA, 2007): Emergency management is the managerial function charged with creating the framework within which communities reduce vulnerability to hazards and cope with disasters. Emergency management protects communities by coordinating and integrating all activities necessary to build, sustain, and improve the capability to mitigate against, prepare for, respond to, and recover from threatened or actual natural disasters, acts of terrorism, or other man-made disasters.

It is a discipline that involves preparing for disaster before it occurs, disaster response (e.g., emergency evacuation, quarantine, mass decontamination, etc.), and supporting, and rebuilding society after natural or human-made disasters have occurred. In general, any Emergency management is the continuous
process by which all individuals, groups, and communities manage hazards in an effort to avoid or ameliorate the impact of disasters resulting from the hazards. Actions taken depend in part on perceptions of risk of those exposed (Federal Transit Administration, 2008). Effective emergency management relies on thorough integration of emergency plans at all levels of government and non-government involvement. Activities at each level (individual, group, community) affect the other levels. It is common to place the responsibility for governmental emergency management with the institutions for civil defense or within the conventional structure of the emergency services. However, emergency management actually starts at the lowest level and only increases to the next higher organizational level after the current levels resources have been exhausted. In the private sector, emergency management is sometimes referred to as business continuity planning.

Emergency management is often compared or confused with crisis management or risk management. Within EU countries the term Crisis Management emphasises on the political and security dimension aspects and mainly involves dealing with threats after they have occurred. On the other hand risk management focuses in the identification, assessment, and prioritization of risks followed by coordinated actions for their elimination. It can be concluded that the term EM is broader and cover the crisis, as well as the risk management aspects.

- **Disaster Risk Reduction (DRR):** The ‘Mainstreaming disaster risk reduction’ report by Tearfund Organization (Tearfund, 2005) defines Disaster Risk Reduction as the conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development.

According to this report, DRR is a systematic approach to identifying, assessing and reducing the risks of disaster. It aims to reduce socio-economic vulnerabilities to disaster as well as dealing with the environmental and other hazards that trigger them: here it has been strongly influenced by the mass of research on vulnerability that has appeared in print since the mid-1970s. It is the responsibility of development and relief agencies alike and it should be an integral part of the way such organisations do their work, not an add-on or one-off action. The expression ‘disaster risk reduction’ is now widely used as a term that encompasses the two aspects of a disaster reduction strategy: ‘mitigation’ and ‘preparedness’ (see below).
**Preparedness measures (concerning emergency management):** These measures have operational character and concern methods, techniques, strategies used in order to enhance the operational effectiveness and determine the most efficient ways to respond to an extreme event and an emergency situation in general.

**Mitigation measures (concerning emergency management):** These measures concern actions, policies, procedures developed for decreasing the possible impacts of an extreme event, independently of the type of response. These measures are not related to operational procedures but rather constitute ‘external’ measures (usually policy measures) that help to decrease the effects of a possible event (e.g. creating adequate building blocks and land-use planning in case of an earthquake).
4 Emergency Management context

The Australian Emergency Management Authority (EMA) (Boon, C. B. / Cluett, C., 2002) supports that risks dealt are likely to have adverse consequences for the communities and their community safety and sustainable development objectives. In this context, hazards by themselves are only one part of the risk equation. The second part of the definition - 'a concept used to describe the likelihood of harmful consequences arising from the interaction of hazards, the community and the environment' - recognises this reality.

The same report considers that hazards are the primary sources of risk in the emergency management context, but they need to interact with elements at risk in the community and its environment in order to lead to the situations that we identify as emergencies or disasters. Those elements include the built, physical and social elements which surround or interact with the community.

The extent to which any of these community and environment elements at risk may interact with a hazard (a source of risk) to create the possibility of an emergency or disaster can be measured in terms of that element's vulnerability to the particular hazard— theoretically, somewhere along a continuum from complete susceptibility to such an interaction (where any interaction can lead to the loss of the element or to its irreparable damage) to complete resilience to an interaction (where no interaction, however severe, will lead to loss or damage to the element).

So, from the emergency management perspective, the risk to a safer, sustainable community from emergencies and disasters lies in the potential and actual interactions between the hazards to which that community is exposed and the vulnerability of that community's elements at risk to such exposure (Boon, C. B. / Cluett, C., 2002).

Vulnerability is a hypothetical concept, but one that nevertheless does not lack reality. It is simply not tangible: in the same way that in the physical world friction only comes into being when it is mobilized, so vulnerability only becomes manifest when it manifests itself as impact. This is one reason why the concept is difficult to measure. Confirmation of the existence of vulnerability is obtained post hoc by measuring the impact of disaster, or at least by inferring that past impacts will be diagnostic of future events. Vulnerability is thus a latent or inherent property. One of the great achievements of disaster studies in the second half of the twentieth century was to establish that vulnerability is the principal component of risk (Boon, C. B. / Cluett, C., 2002).
In this concept, the Australian report considers that the aforementioned concepts and applications of EM must be designed to develop a safer, more sustainable community (Boon, C. B. / Cluett, C., 2002):

- **by limiting the potential for such interactions** - eliminating or mitigating the hazards to which a community is exposed, reducing the exposure of the community and its environment to those hazards, and increasing the resilience of the community’s elements at risk; and

- **by managing emergencies and disasters**, which result from those interactions which do occur.
The transformation of the Emergency Management concept

While the functions of emergency management have been performed for many decades by government and private organizations, it was only recently that the broader ideas about managing emergencies discussed in the present report were developed. During the recent years Emergency Management process has been transformed to include procedures that cover the whole spectrum of an event or a crisis, from the early phases of preparedness for an event (planning level) until the phase of recovery (restoration actions after the event). The promotion of this holistic consideration of the EM concept is based on a twofold approach (Boon, C. B. / Cluett, C., 2002): the comprehensive and the integrated approach of the emergency management procedure.

5.1 Comprehensive Emergency Management

The concept used for handling disasters (emergencies or/and events), as well as their consequences is called Comprehensive Emergency Management (CEM). This approach was institutionalized in 1979 with the creation of the Federal Emergency Management Agency (FEMA) in USA. FEMA resulted from the consolidation of five Federal agencies that dealt with many types of emergencies. Since that time, many state and local organizations have accepted this approach and changed the names of their organizations to include the words "emergency management" (FEMA, 1992).

The name change was an indication of a change in orientation away from specialized preparedness for single hazards or narrowly defined categories of hazards and toward an all-hazards approach to potential threats to life and property. This was not the only change brought about by the development of the concept of Comprehensive Emergency Management. The term "comprehensive" broadened the scope of emergency management by introducing the concept of Phases. Phases come from the idea that disasters have a lifecycle. Although hazards may always be present, it takes some event or accident to turn it into a disaster. As a result, one of the basic principles of CEM is that measures can be taken both before and after a hazardous situation occurs (FEMA, 1992).

In the past, emergency management has focused primarily on response. Being able to respond, however, is only one phase of CEM. A community also must address emergencies before they occur and must share in the responsibility to aid recovery. CEM asserts that there are four integrated phases of emergency management that aid in protecting a community. As a result, current thinking defines the following four
phases of CEM: Preparedness, Mitigation, Response, and Recovery. The four phases of comprehensive emergency management are visualized as having a circular relationship (Figure 2). Each phase results from the previous one and establishes the requirements of the next one. Activities in one phase may overlap those in the previous one. At this point, a brief description of the EM phases is given (Federal Transit Administration, 1998), as well as a description of the actions taken in each phase.

![Diagram of Emergency Management Phases](image)

Figure 2: Representation of Emergency Management Phases

**Preparedness phase**

Preparedness can be considered as a continuous effort of planning, organizing, training, equipping, exercising, evaluation and improvement activities to ensure effective coordination and enhancement of capabilities to prevent, protect against, respond to, recover from, and mitigate against natural disasters, acts of terrorism, and other man-made disasters.

The goal of the preparedness phase is to provide a uniform basis for operating policies and procedures for mobilizing authorities and other public safety resources to assure rapid, controlled, and predictable responses to various types of emergencies. Preparedness means being ready in advance to react promptly and effectively in the event of a crisis.

For some crises, such as a flood or hurricane, early warning may provide several hours to act; however, in many cases, crises will occur with no prior warning. Public authorities confronting the devastation of an explosion, major fires, weather events or
accidents without a sufficient level of preparedness will likely be overwhelmed by events, unable to coordinate effectively with other agencies, and incapable of deploying available resources to resolve the incident quickly (Federal Transit Administration, 1998).

Public authorities’ preparedness directly influences the magnitude of danger in an emergency situation. Preparedness is emphasized in the following areas (Federal Transit Administration, 1998):

- Understanding roles and responsibilities
- Coordination with local, Regional, and National agencies
- Emergency plans
- Emergency procedures
- Emergency training.

**Mitigation phase**

Mitigation refers to activities which eliminate or reduce the chance of occurrence or which limit the effects of an emergency or disaster. The actions, activities or measures of this phase are policy orientated in comparison to preparedness phase which are focused on more operational attributes. Activities performed in Mitigation phase have the following characteristics (FEMA, 1992):

- Include engineering or physical steps as well as situational or procedural measures (such as changing work practices or educating passengers on self-protection measures)
- Promote the application of special technical and managerial skills to the systematic identification and control of hazards throughout the lifecycle of a facility, vehicle, or program
- Ensure the safety and security of citizens during day-to-day operations
- Limit Public authorities' vulnerability to the consequences of natural and human-caused crises.

Mitigation is generally a form of crisis management, though it is often most neglected. Since mitigation measures are proactive, they frequently are more difficult to be justified to Management than activities which occur after a serious incident. Mitigation measures, however, are proven to be cost effective. For example, based on exten-
sive research and cost modelling, the following measures have been required by the Federal Government of the USA to prevent hazardous materials spills, and to reduce the severity of those spills that do occur (FEMA, 1992):

- Speed limits
- Container structure codes
- Corporate licensing
- Restricted routing.

Such common-sense measures have reduced hazardous materials incidents, saving lives, protecting the environment, and reducing both public and private sector liability.

In many ways, mitigation is the most complex phase of emergency management. Mitigation measures are designed and preserved by professionals — engineers, architects, planners, managers, operators, and maintenance personnel. As such, responsibility for mitigation activities is often divided, with no clear oversight to ensure that essential mitigation measures are implemented and maintained. Especially for a transport Emergency Manager, many mitigation efforts may be the responsibility of other departments, local government, or even private vendors who service the system. This shared responsibility requires mitigation programs to provide extensive coordination and monitoring (FEMA, 1992).

**Response phase**

Response phase includes those activities that address the short-term, direct effects of an incident (FEMA, 1992). Response includes immediate actions to save lives, protect property, and meet basic human needs. Moreover, includes the execution of emergency operations plans and of mitigation activities designed to limit the loss of life, personal injury, property damage, and other unfavorable outcomes. As indicated by the situation, response activities include applying intelligence and other information to lessen the effects or consequences of an incident; increased security operations; continuing investigations into the nature and source of the threat; ongoing public health and agricultural surveillance and testing processes; immunizations, isolation, or quarantine; and specific law enforcement operations aimed at preempting, interdicting, or disrupting illegal activity, apprehending actual perpetrators, and bringing them to justice.

Since response phase includes the mobilization of the necessary emergency services and first responders in the disaster area. This phase deals with the real time man-
agement of a crisis or a disaster, and thus refers to the short term and/or real time measures. This is likely to include a first wave of core emergency services, such as firefighters, police and ambulance crews, evacuation techniques, dynamic traffic assignment etc. They may be supported by a number of secondary emergency services, such as specialist rescue teams.

Responding to an emergency or disaster in any environment conceals a number of threats. Public authorities actions must be characterized by physical and operational features that increase their effectiveness, including:

- obtaining and communicating accurate situational data for evaluating and coordinating appropriate response during and after the event;
- effectively blending active involvement of top leadership in unified incident command and control with decentralized decision making authority that encourages innovative approaches to effective response;
- clearly understood roles and responsibilities prior to and in response to the event;
- effective communication and coordination;
- ability to identify, draw on, and effectively deploy resources from other governmental, nonprofit, and private entities for effective response.

**Recovery phase**

The aim of the recovery phase is to restore the affected area to its previous state. It differs from the response phase in its focus; recovery efforts are concerned with issues and decisions that must be made after immediate needs are addressed. Recovery initiatives, which begin during the response phase, become the primary activity once the incident scene has been successfully stabilized. During this time, control over the scene may be returned to the transit agency, and all transit agency efforts can be focused on repairing the damage and re-establishing service. Recovery efforts are most successful when they are based on realistic planning. Prudent and efficient restoration of service requires preparation—documented procedures that are fully understood by the authorities. More specifically, and from the transport perspective, eight basic steps for restoring normal operations in terms of a transport provision organization are (Wikipedia, 2008):

1) Determine critical services and prioritize needs
2) Assess damage and determine required resources
3) Communicate to appropriate authorities
4) Implement critical services
5) Assess feasibility of restoring normal operations
6) Perform trial runs of normal operations
7) Communicate with employees
8) Resume all scheduled service on all routes

A detailed Emergency Management Circle is represented below, that includes all phases, in correspondence to the actions taken in each phase, as well as to the time horizon of an event.

![Emergency Management Circle](image)

Figure 3: *Emergency (or Disaster) Management Circle (David Alexander)*
5.2 Integrated Emergency Management

The concept of an all-hazards (integrated) approach to emergency management, as outlined in CEM, has been implemented by FEMA in its Integrated Emergency Management System (IEMS). The implementation of IEMS is used to minimize, prepare for, and react to hazards in the transit environment, in accord with the four phases of CEM (FEMA, 1992).

IEMS is a long-term, all-hazard concept for improving the program implementation and development of emergency management capabilities at the state and local levels. It is a process for applying comprehensive emergency management concepts to "real world" emergency plans and capabilities. It formally recognizes the roles of emergency forces responding to the full range of emergencies at the local level. Its specific objectives are to:

- Save lives and protect property threatened by hazards
- Reduce duplication of efforts and resources
- Increase jurisdictional flexibility in upgrading the capacity to handle potential hazards
- Integrate support and objectives of all national and local operational requirements.

The IEMS approach recognizes that there are certain characteristics and requirements, which are common across the full spectrum of emergencies including evacuation, sheltering, and provision of food and medical supplies. Emergency programs which are using the IEMS approach to assist national and local officials in building capabilities in these areas as a basic foundation for planning, response, recovery, and mitigation of hazards whether they are related to natural or technological disasters, resources, resource shortages, or war-related national security situations.

The IEMS has been introduced to a nationwide network of emergency management organizations representing thousands of jurisdictions, not all confronted by the same hazards, and not all having or requiring the same capabilities. Employing the IEMS process, therefore, will require different levels of effort by each jurisdiction and will result in the identification of different functional areas requiring attention. The process, however, is logical and applicable to all jurisdictions regardless of their size, level of sophistication, potential hazards, or current capabilities.

The goal of IEMS is to develop and maintain a credible emergency management capability nationwide by integrating activities along functional lines at all levels of government and, to the fullest extent possible, across all hazards. It should be kept in
mind that the IEMS process is a means of improving capability and is not an end in itself. The various steps in the IEMS process are intended to serve management at each level of government by providing basic information upon which reasonable and justifiable plans can be made and effective action taken to increase emergency management capability nationwide. Governments can begin to implement IEMS by:

- Determining the hazards and magnitude of risk in a logical, consistent manner
- Assessing the existing and required capability with respect to those hazards
- Establishing realistic local and national-tailored plans that lay out necessary actions for closing the gap between existing and required levels of capability.

Operationally, IEMS provides the framework to support the development of emergency management capabilities based on functions that are required for all hazards. The above mentioned efforts are related and must be undertaken sequentially. The identification of hazards forms the basis for assessing capability and determining the capability shortfall. The shortfall, in turn, leads to preparation of a multi-year development plan. These initial steps are the starting points for integrating emergency management activities on a multi-hazard, functional basis.

The various steps in the IEMS process are intended to serve management at each level of government by providing basic information upon which reasonable and justifiable plans can be made and effective action can be taken to increase emergency management capability nationwide. The comprehensive and integrated approach of EM leads to the definition of a specific bundle of measures/actions for all phases.

While preparedness and response activities and measures are closely related and sequential, recovery follows the impact of an event; the comprehensive approach to emergency management requires that programs must be effectively integrated.

This can be most clearly demonstrated in emergency management planning at local government level, where consideration is being given to the hazards specific to a geographic area and to the particular vulnerabilities of communities within that area to those hazards.

Emergency programs at local government level, therefore, need to be subject to effective oversight arrangements to ensure the integrated ‘best use’ of available systems and resources. The adoption of an appropriate community emergency management/risk management process will help to ensure this outcome.

More specifically, the concept of integrated emergency management addressed to a transport authority (e.g. Transportation Management Centre - TMC) in relation to weather extreme events would lead to covering all aspects in order to achieve opti-
mal performance of the TMC in managing the transportation system (before and) during weather and emergency events in support of the public needs (Federal Highway Administration, 2006). The following diagram (Figure 4) represents the necessary procedures that should be developed from a Transport Management Centre (TMC) perspective for achieving Integrated Emergency Management operations in relation to extreme weather events (Federal Highway Administration, 2006).

![Conceptual Framework: Integration Determinants and Outcomes](image)

**Figure 4: Conceptual Framework: Integration Determinants and Outcomes**

The figure above underlines the main liabilities of a transport operator in case that is involved with emergency management procedures from the perspective of Integrated Emergency Management. In the following paragraph, the exact relation between
transport operations and emergency management procedures is thoroughly described and examined.
6 Linking Emergency Management procedures with the transport sector

6.1 The role of transport networks in EM operations - Towards Emergency Transport Management

During major emergencies, public transportation systems can provide specific functions and services that are identified in local emergency operations plans (EOPs) and detailed in transportation system plans and procedures. The functions may include:

- Emergency evacuation of citizens from affected area(s), coordinated with local law enforcement and other public safety agencies
- Identification and transportation of citizens with disabilities, with other forms of reduced mobility and other citizens who are often dependent on public transportation and who may be unable to reach an evacuation staging area;
- Temporary/in-place sheltering of evacuated citizens in air-conditioned/heated vehicles and stations;
- Transportation, in-facility transfer, or evacuation of populations in hospitals, nursing homes, hospices, and other community and private facilities;
- Transportation of meals, goods, and supplies to an affected area for victims, for emergency responders, or to support recovery operations;
- Provision of respite facilities and vehicles for emergency workers;
- Communications support for emergency responders (using hand-held and on-board vehicle radios, alphanumeric pagers and personal digital assistants [PDAs], cell phones, transportation dispatch facilities, and transportation communications infrastructure);
- Identification of routes and schedules to support the safe transportation of emergency responders, public utilities and support personnel, and essential personnel to an incident site or staging area;
- Provision of vehicles and equipment to support emergency operations and incident stabilization;
- Provision of estimates and information on the application of available resources to the movement of people or supplies;

Besides disadvantageous weather conditions affecting not only road traffic but all modes of transport, extreme weather events may cause traffic and or information infrastructure closures. In order to ensure a safe and efficient mobility, it is necessary to monitor the states of traffic, weather and infrastructure at a high quality and to enable all stakeholders to access relevant information.
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The Table below attempts to summarize all the operations - functions of ‘emergency transport management - ETM’ and identify the main barriers and solutions that arise before and during the operations.

Table 1: The framework of ETM operation

<table>
<thead>
<tr>
<th>Extreme weather event</th>
<th>Impact to transport network</th>
<th>Emergency strategies</th>
<th>Actions</th>
<th>Implementation tools</th>
<th>Strategic Emergency Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the event</td>
<td>Surpass predefined vulnerability thresholds</td>
<td>Activation of alarming systems</td>
<td>Provide real time information to authorities</td>
<td>Weather and traffic sensors, RWIS</td>
<td>Technological issues</td>
</tr>
<tr>
<td>During and after the event</td>
<td>Overload of transport network</td>
<td>Network management</td>
<td>Traffic management, control, provision of information</td>
<td>Provide real time information for alternative solutions /paths</td>
<td>ITS, GPS, GIS, VMS, Car2X, ATIS, DTA models</td>
</tr>
<tr>
<td></td>
<td>Overload + infrastructure failures</td>
<td>Infrastructure repair</td>
<td>Building efficient and innovative mechanisms and structures, information flow</td>
<td>Standards for cooperation and coordination between authorities</td>
<td>Organizational issues</td>
</tr>
<tr>
<td></td>
<td>Assign Emergency (transport) actions</td>
<td>Set up and execute EM plans</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.2 Further discussion

Conclusively, it must be stated that there are two types of aspects that influence Emergency Transport Management operations:

Technological aspects: The use of Intelligent Transport Systems (ITS) makes it possible either to devise new strategies for network operations or to improve existing strategies. ITS also provide a greater quantity and diversity of information, thus allowing users (motorists, commercial operators and public transport customers) to make informed travel decisions based on such factors as traffic conditions, road maintenance or construction work that potentially impact their travel time, and weather conditions that affect the road network and safety. This information is becoming increasingly available through traditional media like radio and television and, more recently, online over Internet dedicated tools.
Organizational aspects: Network operations can be characterised by the involvement of many partners in the delivery of services. Different organisations are involved in road network operations depending on the network hierarchy (expressways, highways, urban roadways, etc), transport mode (roadways, public transport, railways, etc) or the type of service (safety, information, etc). Effective road network operations require functional, organisational, and inter-jurisdictional coordination, cooperation, integration and interoperability within a geographic region.

Part B will explore in detail the organizational and technological aspects of Emergency Transport Management.
PART B: ORGANIZATIONAL AND TECHNOLOGICAL ISSUES OF EMERGENCY MANAGEMENT IN THE TRANSPORT SECTOR
FIRST SECTION: ORGANIZATIONAL ISSUES
WEATHER D3: Innovative emergency management strategies

7 Meteorological risk and emergency transport management (ETM)

The first section of Part B deals with ‘Organizational issues’ of ETM. Through the detailed description of two of the main organizational aspects that concern current ETM, namely the integration of meteorological risk into ETM procedures and the structure of information flow before and during ETM operations, the whole framework of organizational issues is thoroughly explored, such as the actors involved, the activities undertaken, the role of the actors etc. It must be noted that both these organizational aspects (integration of risk and information flow) are examined in relation to all phases of Emergency Management operations in order that the respective procedures of each phase are clearly specified.

The present chapter comprises the organizational aspects of emergency management (EM) in transport related to extreme weather events (EWEs). Therefore the most relevant research issue is how an EWE influences ETM. Furthermore the conducted research follows a holistic approach, i.e. emergency management will be regarded as essential element of risk management. Therefore issues of risk management required by ETM related to EWEs will be discussed as well.

A general framework to identify and assess the organizational aspects related to ETM is given by the four phases of emergency management (Alexander, 2002):

- Mitigation,
- Preparedness,
- Response,
- Recovery.

Furthermore emergency management in transport is based on six principles (PIARC, 2005):

- Organisation,
- Command and control,
- Coordination of support,
- Information management,
- Timely activation,
- Effective emergency plans.
In contrast to the propagated all-hazard approach (TRB, 2005; Lindell/Prater/Perry, 2006) the conducted research considers in accordance with the overall issue of the WEATHER project only meteorological hazards for transport infrastructures and processes especially for rail and road transport. The initial focus on rail and road transport can be justified by the fact that both modes of transport are most relevant. Aviation for instance is already concerned with issues arising from EWEs in a comprehensive manner. Furthermore the proposed innovative ETM strategies related to EWEs are mainly adaptable to transport infrastructure operators (especially rail and road) on the regional and national level. The empirical part of the research will focus two examples of good practices of risk management considering meteorological hazards in ETM. Furthermore a recently published regulation of the EC regarding a common safety method on risk evaluation and assessment in the railway sector will be presented. The work is based on a review of available studies, reports, guidelines, numerous expert interviews and the results of a workshop.

7.1 Integrating meteorological risk into ETM

Due to the growing relevance of climate change induced events and the extent of impacts on transport a systematic integration of meteorological risk in emergency transport management is instrumental. Since extreme weather is part of the global climate and meteorology it must be emphasized that meteorological risk for (continuously operating) transport systems is not avoidable (Beroggi, 2011). Therefore within the risk management EWEs should be accepted as recurring irregular shocks and not as individual isolated events. An overview of the system is depicted in Figure 5. In the following the most important elements of emergency transport management (ETM) sensitive to meteorological risk will be presented and described.

Risk analysis

In general risk analysis is distinguished into four steps: Identification, Analysis, Evaluation and Treatment (PIARC, 2005). Risk identification considers all meteorological hazards and the possible impacts on transport infrastructure and processes with help of e.g. brainstorming, expert judgment, experiences and records. In the next step the analysis assess the level of the identified risks in terms of e.g. low, medium or high. Finally risk evaluation compares the level of risks with the help of certain criteria e.g. operational, technical, financial, social, legal and environmental. The result of the process is a prioritised list of risks in order to determine the appropriate treatment (PIARC, 2005).

The meteorological risk of a transport system is the result of the merger of meteorological hazard and the exposure as well as the vulnerability of transport infrastructure
elements and processes. Concerning the risk analysis relevant meteorological events will be integrated in terms of their intensity and frequency. To conduct such a comprehensive analysis meteorological data for a sufficient time period and for the affected area is needed. High-impact but rare events can be described with probability of occurrence of $10^{-3}$ or $10^{-4}$ per year (PIARC, 2005). In addition the transport system itself represented by infrastructure, processes and interdependencies is also an essential input for an appropriate risk assessment.

In that context a detailed overview of the system is crucial. One of the most challenging aspects of the risk analysis is to find appropriate indicators or characteristics describing the exposure and vulnerability of transport infrastructure, processes and interdependencies. Liable sources of information may include e.g. past records, experiences and judgment by experts, transport practice or computer simulation (PIARC, 2005). In order to support decisions concerning precautionary measures (e.g. capacity building and resource allocation) a geographical information system (GIS) mapping the different categories of vulnerability is useful.

Table 2: Attributes of transport systems as input for the risk analysis

<table>
<thead>
<tr>
<th>Infrastructure</th>
<th>Processes</th>
<th>Interdependencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of certain infrastructure elements (e.g. stations, railroad switches, vehicles, links)</td>
<td>Operation (e.g. traffic load)</td>
<td>Interlinkages with other modes of transport</td>
</tr>
<tr>
<td>Geographical spread and location of the transport infrastructure elements</td>
<td>Maintenance (e.g. winter service)</td>
<td>Critical links (e.g. bridges, tunnels, operators)</td>
</tr>
<tr>
<td>Redundancies and emergency capabilities within the transport infrastructure</td>
<td>Transport services (e.g. lines)</td>
<td>Stakeholders (e.g. passengers, public authorities)</td>
</tr>
</tbody>
</table>

Finally the meteorological hazard, the exposed and vulnerable infrastructure as well as processes will be merged to identify the overall risk of meteorological induced emergencies in transport and the probable impacts (Boyd/Caton, 1998). Ideally the derived risk is also financially assessed to facilitate the evaluation or comparison (e.g. through benefit-cost analysis (BCA)) of potential EM measures.

Policy framework

Policy making with regard to ETM needs to find a solution for the trade-off between the aspired performance of transport systems and the required level of safety. Therefore the main task of the policy framework concerning ETM is to set the values which determine the level of risk acceptance, i.e. to define the socially and economically acceptable extent of impacts on transport (e.g. in terms of annual delay minutes or number of re-routings caused by adverse weather events). Thus the level of risk ac-
Risk acceptance defines what impacts on transport related to a certain EWE will be perceived as adverse. The level of risk acceptance is essential to decide on whether ETM should be implemented and which measures should be applied (Beroggi, 2011).

The policy framework is set by the legal mandates, the culture of the organisations involved, the available resources/capabilities, and the priorities. The essential parts of legal mandates are responsibilities and administrative structure. Culture means the different mentalities (e.g. strict hierarchical line of control and command) and main focuses of the involved emergency organisations (e.g. ambulance, fire brigade, police, and voluntaries) (Timmermans/Beroggi, 2000). The main elements of resources are the available personnel and equipment for emergency operations at the different administrative levels. Furthermore the priorities concerning ETM are determined at the different administrative levels as well.

**Emergency management**

With the help of the result of the risk analysis and the influence of the policy framework the strategy related to weather emergencies will be defined. The key questions concerning the strategy are on what, when and how ETM should respond to. Furthermore the setting of emergency operation targets (e.g. protect infrastructure, reduce duplication of efforts and resources) and the planning of emergency measures especially in terms of capacity building and resource allocation in the mitigation and preparedness phase are influenced by the mapped vulnerabilities (Boyd/Caton, 1998).

In that context it should be emphasized that all ETM actors need to trust and support each of the planned EM measures (Timmermans/Beroggi, 2000). Ideally the risk analysis provides quantitative thresholds for relevant meteorological variables related to the impacts of EWEs on transport which can be integrated into the emergency planning in order to initiate certain measures within the preparedness and response phase.
The main task of the information system is to monitor, in particular with the help of forecasting and nowcasting solutions, the current traffic and the meteorological situation in order to evaluate hazards that might arise rapidly. Whereas very short-range weather forecasts (usually for the next 6 to 12 hours) covering only a very specific geographic area are also known as nowcasting. Within that time range accurate forecasts on features too small to be resolved by a computer model such as separate convective events are possible. The accurate analysis is enabled by the latest radar, satellite and observational data (MHEST, 1999). The information system should provide information on the probability of upcoming developments and early warnings in case of pre-defined meteorological thresholds which have already been or will be exceeded in order to initiate the appropriate and pre-planned emergency measures. It is important to note that pre-defined thresholds are in general part of the Standard Operation Procedures (SOPs). Furthermore information on the current traffic situation is needed to make a comprehensive decision on the extent of certain emergency measures. The information system should continue providing information on the current situation also during the response and recovery phase to support the planning and effectiveness of applied emergency measures.


**Evaluation**

To ensure the improvement of the emergency management on the whole and the emergency measures in detail a systematic evaluation needs to be implemented as well. First of all evaluation means that in the aftermath of a weather emergency the performance mainly of response measures will be analyzed in order to identify weaknesses and demand for improvement.

But evaluation means also that all measures applied in the other emergency management phases needs to be reviewed regularly. The issues of the evaluation are directly determined by the emergency strategy, the targets and the emergency operations. The evaluation can be carried out by e.g. scenario-based exercises, benchmarking indicators, checklists or workshops. Finally the results of the evaluation will be used for the feedback (e.g. risk communication, sanctions, and incentives) in order to adapt the emergency management.

### 7.2 Barriers and strategies

In order to integrate meteorological risk into an ETM framework several barriers must be overcome. In general the organization as well as the ETM should be aware of meteorological hazards and their potential impacts on transport. In general sensitizing the transport organization for its meteorological risk is the basic step. In case that specific meteorological hazards are confirmed and assessed by the risk analysis the organization should integrate meteorological risk as formalized program into the ETM framework.

Table 3: Barriers and strategies to implement meteorological risk into ETM

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Basic strategies implied</th>
<th>Institutions and leadership strategies</th>
<th>Operations and technology strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>No awareness to the full range of impacts and emergencies due to meteorological hazards</td>
<td>Develop a structured ETM approach related to meteorological hazards with joint protocols, procedures, and with full regard for the range of objectives while minimizing transport disruptions</td>
<td>Develop (inter)organizational preparations for complete array of emergencies, reporting, organization, and with senior responsibilities</td>
<td>Carry out proactive preparations (protocols, procedure coordination, training, and exercises) within and across the organizations related to the meteorological risk</td>
</tr>
<tr>
<td>No systematic gathering and assessment of EWE impacts on transport</td>
<td>Develop a structured assessment framework and joint protocols to gather relevant data</td>
<td>Establish a framework and routine to collect data related to EWE impacts</td>
<td>Develop and implement joint protocols, a data selection and collection process as well as a database</td>
</tr>
</tbody>
</table>
WEATHER D3: Innovative emergency management strategies

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Basic strategies implied</th>
<th>Institutions and leadership strategies</th>
<th>Operations and technology strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>No specific WIS applied for the majority of transport modes</td>
<td>Understand the basic demands for WIS in the transport organization</td>
<td>Establish a framework for using meteorological service solutions within the transport organization</td>
<td>Develop and implement a WIS</td>
</tr>
<tr>
<td>Absence of effective evaluation approaches/performance measures for EWE emergencies</td>
<td>Measure performance in EWE emergencies to provide the basis for continuous improvement</td>
<td>Establish targets with related performance measures and accountability</td>
<td>Measure and benchmark performance against best practice</td>
</tr>
<tr>
<td>Informal, fragmented activities</td>
<td>Formalize meteorological risk as a program with appropriate policies, authorization, organization, structure, and resources</td>
<td>Develop policy, laws, regulations and (inter)organizational agreements</td>
<td></td>
</tr>
</tbody>
</table>

[adapted from TRB, 2005]

The awareness can be improved with the help of strategies concerned with different levels of action. One strategy regarding operations and technology is to implement and carry out proactive preparations (e.g. protocols, procedure cooperation, training and exercises) related to the meteorological risk.

Another important barrier to overcome is the absence of effective evaluation approaches or performance measures in order to compare EWE emergencies in transport and eventually improve the applied emergency measures. In that context performance measures (e.g. quantitative and qualitative indicators) related to the specific EWE emergency management targets needs to be specified. Furthermore the most fundamental precondition for analysing the risk induced by meteorological events is the systematic gathering of data related to the impacts of EWEs on transport infrastructure and processes. To realize that precondition joint protocols capturing the relevant variables of EWE impacts, a structured data selection and collection process as well as a comprehensive database are essential.

7.3 Good practices

In the following two examples of good practices from Austria (Österreichische Bundesbahnen AG) and Switzerland (Schweizerische Bundesbahnen SBB) will be presented. Both examples should illustrate how natural hazards are integrated into the emergency management of transport operators in rail transport. In addition the
new Commission Regulation (EC) No 352/2009 on the adoption of a common safety method on risk evaluation and assessment will be presented as a general and easily adoptable framework.

7.3.1 Natural hazard management at OEBB AG

In general the railway network of Austria is compared to e.g. Germany proportionally more prone to natural hazards. Due to the Alps as highest mountain range in Europe there are larger temperature gradients at different altitudes and especially more amounts of water coming from the mountains in the form of snow avalanches, torrents and fast rising floods. In addition debris flows mostly on steep mountainsides are caused by EWEs. The OEBB AG (Oesterreichische Bundesbahnen AG) - the operator of the Austrian railway infrastructure - follows different approaches to mitigate the impacts of EWEs by the help of precautionary measures (Rachoy et al., 2010).

One third of the 6000 km railway tracks in Austria are located within deeply incised alpine valleys and is taking course over several high alpine passes. Consequently the railway infrastructure is exposed to several natural hazards such as:

- Single rock-fall events,
- Snow-avalanches,
- Rock-avalanches,
- Debris flows,
- Flooding,
- Rock- and soil-slides.

The inner alpine railway network is highly relevant to cargo and passenger transportation. In addition its importance to the inhabitants and the economy of the alpine region is growing fast. Considering the increasing number of catastrophic meteorological events due to climate change maintaining and improving the reliability as well as the availability of the railway system is more and more a challenging task (Rachoy et al., 2010).

Methodological approach

A three step analysis was established to identify vulnerable for the entire railway network. Vulnerable sections of the railway infrastructure were defined by track identity and a kilometre mark. The three successive levels of analysis are characterized by the increase of scale or geographical resolution. In the first step (level I) an over-
view of homogeneous sections of endangerment was conducted on a scale of 1:25,000. The geomorphologic processes were distinguished into nival, fluvial and gravitational processes. Furthermore the hazardous potential was derived from the observed geomorphologic process activity and the usage of protective structures and evaluated on the basis of four categories of relevance (Rachoy et al., 2010):

A) High relevance: Sections where in the near past losses related to EWEs occurred and which are not adequately secured.

B) Medium relevance: Sections with existing but at the present stage inactive geomorphologic processes (e.g. avalanche zones covered with trees) and a lack of sufficient protective structures was found.

C) Minor relevance: Sections where fossil, overprinted forms or no evidence for process activity was found. But with regard to the existing topography and the morphological inventory the possibility of future hazardous processes can not be excluded. In addition the combination of recent process activity and the existence of sufficient protective structures is assigned to this category.

D) No relevance: Absence of any relevant process.

All in all 75 % of the entire railway infrastructure in Austria are not exposed to geomorphologic processes or are sufficiently protected. 10 % show a minor and 13.1 % a medium relevance. Only 1.9 % was characterized by highly relevance.

In the second step (level II) the sections identified in level I with relevant endangerment were subject to a more accurate and specific assessment. The level II analysis was conducted on a scale of 1:5,000. In level II only sections with high and medium relevance were analysed. Due to the scale of 1:5,000 every single hazardous process can be described in detail. The exposition of the railway infrastructure and the capability of the retaining measures was analysed on site. Furthermore geospatial data was surveyed and analysed as well as qualitatively interpreted in order to ensure the consistency of the dataset in terms of high-priority areas.

In level II the sections of endangerment and the entire areas of active processes were mapped to evaluate the hazardous potential of geomorphologic processes comprehensively. The process areas were distinguished into starting zone, transport zone and deposition zone. In addition evidences for geomorphologic process activities within every zone were described. Finally process activity, exposure of the railway track and usability of existing protective structure were mapped and assessed with the help of five defined classes. The protection deficit for homogenous sections as final outcome and measure for the necessity of further structural risk reduction was derived by allocating process activity, exposure of the railway track and usability
of existing protective structures (Rachoy et al., 2010). Figure 7 depicts an exemplary level II investigation for the Semmering pass section.

![Map of railway network Level I with relevance classes](image)

**Figure 6: Investigated railway network Level I - colour coded for relevance classes [Rachoy et al., 2010]**

Level III represents the final step. Based on the quantification (e.g. numerical modelling) of the dynamic processes the dimensions of organisational and structural means were derived at the design-scale. So far level III was only conducted for a pilot project (Semmering pass).

The OEBB AG is planning to combine a rapid alert system with the map of natural hazards and meteorological data. The so called INFRA.weather system is a meteorological information and warning system provided by UBIMET GmbH customised to the OEBB railway network. The system provides a polygon-based map of the Austrian railway system with the most important upcoming weather events in terms of storm, flood, and snowfall (ARISCC, 2010). Furthermore the implementation of a real-time monitoring system for the highly relevant sections and the integration of numerical models in order to predict the impacts of natural hazards on railway infrastructure are also planned (Rachoy et al., 2010).
Like Austria the railway infrastructure in Switzerland is due to the topography of the Alps very prone to natural hazards. Due to the fact that an unmanageable amount of reports and information on relevant events for the railway infrastructure of SBB is available in different archives and databases a central nation-wide web-based system was implemented in January 2008 in order to improve the spatial and temporal monitoring of natural hazards.

Figure 8: Structure and issues link portal SBB natural hazards [Meier, 2010]
The system consists of DERI NR (Derangements to the Infrastructure - Natural Risk) and WebGIS NR (Geographical Information System - Natural Risk). With the help of DERI NR all natural events relevant to the Swiss railway infrastructure will be gathered, processed and documented. Since DERI NR is a web-based solution occurred events and the corresponding attributes (e.g. insured losses, category, intensity) can be directly entered into the system and forwarded to the responsible person. Furthermore the geographical aspect of the natural event is based on attributes such as track identity or kilometre mark of the affected section within the railway network of SBB as well as the GIS coordinates.

The GIS NR represents the spatial event data and additional data layers such as hazard maps, potential damage in terms of number of trains and passengers, measuring points (weather conditions in general, snow) and protective structures. The precise positions of natural events recorded in DERI NR were projected on the SBB railway network by dynamic segmentation. GIS NR is capable of depicting the event attributes within the map. Conversely, events selected in DERI NR can be localised by GIS NR (Meier, 2010).

### 7.3.3 Common safety method (CSM) on risk evaluation and assessment

The Commission Regulation (EC) No 352/2009 of 24 April 2009 defines a CSM on risk evaluation and assessment for the railway sector. The aim is to harmonize the methods used for identifying and managing risks among the different actors involved in the development and operation of the railway system (EC, 2009).

The EC identified the absence of a CSM for specifying and demonstrating compliance with safety levels and requirements of the railway system as one of the main obstacles to the liberalisation of the Community’s railway market (EC, 2009). In that context an initial step is to harmonize the risk management process of railway operators.

The EC will cover that basic element of railway safety management with the help of the approach that is presented by the Regulation. Since a formalised risk-based approach is relatively new to the railway systems of some Member States, the CSM risk evaluation and assessment should remain voluntary until 1 July 2012 (EC, 2009).
**Purpose**

The purpose of the CSM is to maintain and improve the level of safety on the Community’s railways. Furthermore the access to the market for rail transport services shall be facilitated through harmonisation of (EC, 2009):

- The risk management processes used to assess the safety levels and the compliance with safety requirements,
- The exchange of safety-relevant information between different actors within the rail sector in order to manage safety across the different interfaces which may exist within this sector,
- The evidence resulting from the application of a risk management process.

**Scope**

The CSM can be applied to any alteration of the railway infrastructure and operation in a Member State. Changes of railway system can refer to all aspects of operation conditions, new materials and technologies which impose the evolvement of risks on the infrastructure or on operations (EC, 2004). In that context the evolvement of more frequent and intense EWEs as consequence of climate change can be regarded as change of operation conditions.

Although meteorological or any other specific hazards were not the initial reason to establish a CSM on risk evaluation and assessment for the national railway systems still represents an adoptable and applicable framework for issues relevant to ETM and EWEs.

It is important to mention that the EC defines a system as any part of the railway system which is subject to a change or exposed to EWEs. According to that definition a system could be e.g. elements of the railway infrastructure and a process or operation. Furthermore safety measures are a set of actions either reducing the rate of occurrence of a hazard or mitigating its consequences in order to achieve and/or maintain an acceptable level of risk (EC, 2009). Thus each emergency management phase and the corresponding measures can be regarded as safety measures.

**Risk management process**

The risk management process will be carried out by the railway undertakings or the infrastructure managers who decide about the different actors’ tasks and risk management activities. The risk management process shall be evaluated by an independent assessment body. The entire risk management process is depicted in Figure 9.
**System definition**

The risk management process is initiated by the definition of the assessed system and includes the following activities (EC, 2009):

- The risk assessment process, which shall identify the hazards, the risks, the associated safety measures and the resulting safety requirements to be fulfilled by the system under assessment,

- Demonstration of the compliance of the system with the identified safety requirements, and

- Management of all identified hazards and the associated safety measures.

- According to the Regulation the system definition should at least address the following issues (EC, 2009):
  - System objective, e.g. intended purpose,
  - System functions and elements, where relevant (including e.g. human, technical and operational elements),
  - System boundary including other interacting systems,
  - Physical (i.e. interacting systems) and functional (i.e. functional input and output) interfaces,
  - System environment,
  - Existing safety measures and, after iterations, definition of the safety requirements identified by the risk assessment process,
  - Assumptions which shall determine the limits for the risk assessment.

**Hazard identification and classification**

The railway undertakings or the infrastructure managers will systematically identify, using a wide range of sources, expertise, and methods, all reasonably foreseeable hazards for the whole system, its functions and its interfaces. In order to focus the risk assessment efforts upon the most important risks, the hazards shall be classified according to the estimated risk arising from them. Hazards associated with a broadly acceptable risk need not be analysed further but shall be registered in the hazard record. The level of the hazard classification (e.g. acceptable risk vs. not acceptable risk) shall be justified comprehensively in order to allow independent assessment by an assessment body. It should be also taken into account that the contribution of all
the broadly acceptable risks does not exceed a defined proportion of the overall risk (EC, 2009).

**Risk evaluation**

Acceptance principles are used to evaluate the risk acceptability. The principles presented in Table 4 are aiming at the identification of:

- Relevant codes of practice, or
- A similar system that could be taken as a reference system, or
- Explicit risk estimation.

The overall purpose is to apply the principle which covers the hazard in the most appropriate way. In case that the hazard cannot be made acceptable by the application of one of the three acceptance principles, possible additional safety measures must be identified or developed applying one of the two other risk acceptance principles. The safety measures selected to control the risk become the safety requirements to be fulfilled by the system. The compliance with the safety requirements resulting from the risk assessment phase needs to be demonstrated comprehensively (EC, 2009).

**Hazard record**

Furthermore the Regulation requires that all identified hazards as well as the relevant safety measures must be registered in the hazard record (EC, 2009). The hazard record includes all hazards, together with all related safety measures and system assumptions identified during the risk assessment process. In particular, it shall contain a clear reference to the origin and to the selected risk acceptance principles and shall clearly identify the actor(s) in charge of controlling each hazard.

**Table 4: Acceptance principles and requirements**

<table>
<thead>
<tr>
<th>Risk acceptance principle</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Codes of practice = a written set of rules that, when correctly applied, can be used to control one or more specific hazards</td>
<td>widely acknowledged in the railway domain relevant for the control of the considered hazards publicly available for all actors</td>
</tr>
<tr>
<td>Comparison with similar or reference systems = a system proven in use to have an acceptable safety level and against which the acceptability of the risks from a system under assessment can be evaluated by comparison</td>
<td>the reference system already been proven in-use to have an acceptable safety level and would still qualify for approval in the Member State where the change is to be introduced it has similar functions and interfaces as the system under assessment it is used under similar operational conditions as the system under assessment</td>
</tr>
</tbody>
</table>
**Risk acceptance principle**

<table>
<thead>
<tr>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>it is used under similar environmental conditions as the system under assessment</td>
</tr>
<tr>
<td>the methods used for explicit risk estimation shall reflect correctly the system under assessment and its parameters (including all operational modes)</td>
</tr>
<tr>
<td>the results shall be sufficiently accurate to serve as robust decision support, i.e. minor changes in input assumptions or prerequisites shall not result in significantly different requirements</td>
</tr>
<tr>
<td>The acceptability of the estimated risks shall be evaluated using risk acceptance criteria either derived from or based on legal requirements stated in Community legislation or in notified national rules.</td>
</tr>
</tbody>
</table>

[adapted from EC, 2009]

**Hazard management process**

Hazard record(s) shall be created or updated (where they already exist) by the railway undertakings or the infrastructure managers during the design and the implementation and till the acceptance of the change or the delivery of the safety assessment report (EC, 2009).

The hazard record shall track the progress in monitoring risks associated with the identified hazards. Once the system has been accepted and is operated, the hazard record shall be further maintained by the infrastructure manager or the railway undertaking in charge with the operation of the system under assessment as an integrated part of its safety management system (EC, 2009).

**Exchange of information**

All hazards and related safety requirements which cannot be controlled by one actor alone shall be communicated to another relevant actor in order to find jointly an adequate solution. The hazards registered in the hazard record of the actor who transfers them shall only be ‘controlled’ when the evaluation of the risks associated with these hazards is made by the other actor and the solution is agreed by all concerned (EC, 2009).

**Transferability**

The described CSM could provide a general framework for a standardised risk and safety assessment in order to harmonize the specification and demonstration of compliance with safety levels and requirements for actors of other transport systems than railway transport.
Figure 9: Risk management framework [EC, 2009]
8 Meteorological information

The second part of the work deals with the role of information for ETM. Especially the importance and benefits of meteorological information will be investigated in detail. For ETM severe weather warning systems implemented by the majority of national meteorological services (NMS) are in principle useful precautionary tools. Many of the latest updated information related to the occurrence and intensity of EWEs are now available on the websites of the NMS and EUMETNET (Network of European Meteorological Services). However, many of the online information are not detailed enough for mode-specific ETM or certain transport infrastructures and processes/operations (especially road and rail transport). Therefore the application of mode-specific weather information system (WIS) will be discussed. The current WIS already used for the different modes of transport in each EU-member state will be surveyed as well.

8.1 Severe weather warnings and Emergency Transport Management

In general the integration of meteorological information into ETM serves to improve the decision support and has several objectives:

- Reducing lives lost,
- Reducing (economic) impacts on transport infrastructure and processes/operations,
- Ensure the continuity of supply chains and transportation of passengers,
- Reducing costs of emergency response (e.g. avoiding false alarm), and
- Improving safety in transport.

The conducted expert interviews confirmed that severe weather warnings issued by the NMS are in fact the most common tool to derive information on EWEs with regard to ETM. All NMS in the EU are issuing severe weather warnings regularly on their websites for at least 0 to 48 hours and for different adverse weather events. The warning system of each NMS depends on the geographical and topographical exposure to certain EWEs. For instance no warning concerning avalanches is useful for Malta whereas Austria and Luxembourg are not issuing warnings on coastal events.

The number of warning levels implemented by the NMS (e.g. the German NMS (Deutscher Wetterdienst)) is using a 5-level-colour-system instead of the usual 4-level-system) on the predicted intensity of upcoming phenomena may differ. In this
regard the quantitative thresholds used for each warning level are different as well. Another important fact is that the scale of the warnings can differ.

In general all these conditions must be considered in pre-planning ETM with respect to predicted EWEs especially for international road and rail transport. For a more detailed investigation of the main differences between the NMS warning pages and the official coherent European system METEOALARM concerning scale and considered types of EWEs see Table 5.
Table 5: Severe weather warnings in Europe

<table>
<thead>
<tr>
<th>EU 27</th>
<th>National Meteorological Service</th>
<th>METEOALARM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wind/Storm</td>
<td>Snow/ice</td>
</tr>
<tr>
<td>Austria</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Belgium</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cyprus</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Denmark</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Estonia</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Finland</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>France</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>EU 27</td>
<td>National Meteorological Service</td>
<td>METEOALARM</td>
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</tr>
<tr>
<td></td>
<td>Wind/Storm</td>
<td>Snow/Ice</td>
</tr>
<tr>
<td>Germany</td>
<td>X X X X</td>
<td>X</td>
</tr>
<tr>
<td>Greece</td>
<td>X X X X</td>
<td>X</td>
</tr>
<tr>
<td>Hungary</td>
<td>X X X X</td>
<td>X</td>
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<tr>
<td>Ireland</td>
<td>X X X X</td>
<td>X</td>
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<tr>
<td>Italy</td>
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<tr>
<td>Latvia</td>
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<tr>
<td>Lithuania</td>
<td>X X X</td>
<td>X</td>
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<tr>
<td>Luxembourg</td>
<td>X X X</td>
<td>X</td>
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<tr>
<td>Malta</td>
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<tr>
<td>Netherlands</td>
<td>X X X X</td>
<td>X</td>
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<tr>
<td>Poland</td>
<td>X X X X</td>
<td>X</td>
</tr>
</tbody>
</table>

WEATHER D3: Innovative emergency management strategies
## WEATHER D3: Innovative emergency management strategies

<table>
<thead>
<tr>
<th>EU 27</th>
<th>National Meteorological Service</th>
<th>METEOALARM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>Wind/Storm Snow/Ice Thunderstorm Fog Extreme high temperature Extreme low temperature Coastal event Forestire Avalanches Rain/Precipitation Flooding Lightnings Thaw Tornado Scale of warnings</td>
<td>Wind/Storm Snow/Ice Thunderstorm Fog Extreme high temperature Extreme low temperature Coastal event Forestire Avalanches Rain/Precipitation Flooding Lightnings Thaw Tornado Scale of warnings</td>
</tr>
<tr>
<td>Romania</td>
<td>X X X X X X X</td>
<td>X</td>
</tr>
<tr>
<td>Slovakia</td>
<td>X X X X X X</td>
<td>X X</td>
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<tr>
<td>Slovenia</td>
<td>X X X</td>
<td>X X X X</td>
</tr>
<tr>
<td>Spain</td>
<td>X X X X X X X</td>
<td>X X</td>
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<tr>
<td>Sweden</td>
<td>X X X</td>
<td>X</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>X X X X X</td>
<td>X</td>
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</tbody>
</table>

Nuts 3
In some cases the information provided by the NMS warning pages are more specific compared to METEOALARM (e.g. Germany and Netherlands). In addition some countries implemented different to the common Nomenclature of Territorial Units for Statistics (NUTS) a divergent geographical resolution for the severe weather warnings (e.g. Finland, Sweden, Slovakia, and Slovenia). Severe weather warnings for Germany are only available on METEOALARM for the NUTS 1 level (Laender) whereas the NMS (Deutscher Wetterdienst) presents warnings for the NUTS 3 level (Kreise).

Nevertheless METEOALARM is the first system that presents coherent warnings on EWEs at the European level. The presented information is instrumental for preparing international transport activities and should be integrated as well as the NMS warnings into the individual ETM process.

**METEOALARM**

METEOALARM was launched in 2007 by EUMETNET – The Network of European Meteorological Services. Meteoalarm.eu is the official website for severe weather warnings in Europe. The initiative includes the NMS of 30 countries. The website presents on the first layer (European level) current severe weather warnings for each participating country. The time horizon of the issued warnings extends 0 to 48 hours. The colours assigned are related to the impact and damage expected by the EWE which is represented by a symbol.

The warning levels with their corresponding colours are following one coherent and consistent pattern on all layers. Furthermore the thresholds for each warning level are different with respect to the regional conditions. For instance continuous heavy snowfall in alpine regions is less adverse than in Mediterranean regions (METEOALARM, 2010).

Table 6: Warning levels METEOALARM

<table>
<thead>
<tr>
<th>Warning level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Missing, insufficient, outdated or suspicious data.</td>
</tr>
<tr>
<td>Green</td>
<td>No particular awareness of the weather is required.</td>
</tr>
<tr>
<td>Yellow</td>
<td>The weather is potentially dangerous. The weather phenomena that have been forecast are not unusual, but be attentive if you intend to practice activities exposed to meteorological risks. Keep informed about the expected meteorological conditions and do not take any avoidable risk.</td>
</tr>
<tr>
<td>Orange</td>
<td>The weather is dangerous. Unusual meteorological phenomena have been forecast. Damage and casualties are likely to happen. Be very vigilant and keep regularly informed about the detailed expected meteorological condi-</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Warning level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>The weather is very dangerous. Exceptionally intense meteorological phenomena have been forecast. Major damage and accidents are likely, in many cases with threat to life and limb, over a wide area. Keep frequently informed about detailed expected meteorological conditions and risks. Follow orders and any advice given by your authorities under all circumstances, be prepared for extraordinary measures.</td>
</tr>
</tbody>
</table>

[METEOALARM, 2010]

The second layer (Country level) comprises detailed information about the awareness situation for each participating country. The map will present the regions of the country and the related awareness levels for these regions. The specific regional information concerning the EWE is shown on the third layer (Regional level). The specific regional information consists of a “timeline” showing the period in which the event is expected to happen and some countries may add intensity information on this regional level, such as wind speed, snow- or rainfall amounts or density of the fog. Again the parameter and awareness colour is visible (METEOALARM, 2010).

Furthermore, links to the warning pages of the NMS are included in order to provide more specific national information. Examples of first and second layer maps are depicted in Figure 10 and Figure 11.

[METEOALARM, 2010]
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Figure 10: METEOALARM severe weather warnings (European level)

Figure 11: METEOALARM severe weather warnings (Regional level)

**Alternative severe weather warning system**

In addition to the NMS and METEOALARM the swiss Meteomedia AG provides severe weather warnings for several European countries (Belgium, Denmark, France, Germany, Luxembourg, Netherlands, and Switzerland). The issued severe weather warnings are based on an alternative forecasting concept. The issued warnings are produced with the help of polygons (Meteomedia AG, 2010).

The measurement and warnings are not longer based on the usual forecasting grid namely geopolitical boundaries, such as countries, states, and counties (Waters et al., 2005). The severe weather warning is now based on a geographic polygon that focuses the predicted location of the EWE (Waters, 2007). Due to the use of GIS the coordinates (numeric latitude and longitude points) of individual geospatial elements (e.g. highways, railway lines, airports, and railway stations) can be combined with the predicted intensity, movement, and location of the EWE (Ferree et al., 2007). Accordingly the forecasts are not covering only whole areas (e.g. towns) or geopolitical units (e.g. countries) but also very small areas of greater meteorological threat (Ferree et al., 2007; Meteomedia AG, 2010). Weather warnings based on polygons enables each transport operator to customise the monitoring/management of meteorological
risk on an individual level and to consider coherently transport infrastructures crossing geopolitical boundaries, such as roads and railway lines. Currently several NMS are planning to integrate polygon-based warnings into their warning systems by the end of 2011. The weather warning system INFRA.weather of the OEBB AG (Oesterreichische Bundesbahnen AG) - the operator of the Austrian railway infrastructure - is already based on polygons.

Figure 12 shows a severe weather warning including the radar tracking, the predicted path (yellow box) and the polygons with the highest threat (red and orange). Compared to Figure 11 it is obvious that the scale of the warning is more detailed. In fact only small parts of the depicted Dallas/Fort Worth metroplex will be affected and relevant to emergency management, e.g. activation of the siren system (Ferree et al., 2007).

Figure 12: Storm-based tornado warning [Ferree et al., 2007]

8.2 Information flow process during emergencies

In the following the flow of information during EWE induced emergencies in transport will be focussed in detail. The presented (see Figure 17) general scheme is based on the results of expert interviews and past ETM experiences with mainly local and regional EWEs in Germany. Concerning the EWE information is usually provided through severe weather warning systems (SWWS) issued by the NMS based on meteorological forecasts. Most relevant to ETM is information concerning scale, intensity, and probability of certain EWEs. In addition a WIS especially in road transport is used to nowcast conditions on roads and highways. The transport management cen-
TMC or transport operators are informing public authorities, such as police or fire brigade about emergencies within the transport system (e.g. derailed trains). On the other hand public authorities should inform the transport operator about the current overall situation. Together the information on evolving emergencies, direct/indirect impacts, scale and intensity of an EWE are forming the situational data.

In addition media reports can also be a source of information related to the current situation. The latest situation report is in principle the basic input for decisions concerning the steps in ETM. The report on the current situation needs to be updated regularly. With regard to the situation, information on upcoming developments and the available EM resources (personnel and equipment) public authorities, such as police, fire brigade or civil protection authority as well as transport operators are planning and apply specific measures within each EM phase. Usually the transport operators are using in most cases following means to communicate with public authorities and each other:

- Telephone,
- Telefax,
- Electronic mail.

In addition most persons in charge of emergency management in transport (transport operators and public authorities) on the local/regional level are known to each other due to several annual meetings, such as combined exercises or workshops. Beside the formal mandatory structure of EM informal local/regional networks of responsible persons from different stakeholders are highly relevant to an effective crisis communication and to form mutual trust among the different EM actors. The involved stakeholders of ETM are depicted in Figure 13. Moreover the level of the relevant stakeholder (local, regional or national authorities) is determined by the scale of the EWE and the impacts in particular.
Applied measures of ETM are targeting mainly the safety of drivers, passengers, freight, and transport infrastructure/processes. Constant feedback should be given by the emergency service teams at the scene concerning the success of ETM and to complete situational reports.

Especially for the current users of transport networks (e.g. drivers and passengers) additional pre-trip information concerning the current situation provided by the media (e.g. radio, television, online-newspapers, RWIS website, and NMS website) play a significant role to plan alternative routes or to postpone travels. Furthermore users of transport networks, in particular drivers and passengers, are nowadays in a position to (e.g. via mobile internet, text messages) provide relevant information directly to the media. The described general information flow is presented in Figure 14.

**Figure 13: Stakeholders of ETM [adapted from Beroggi, 2011]**

**Figure 14: Information flow during an EWE**
8.3 Road weather information system (RWIS)

Castle Rock Consultants defines Road Weather Information System (RWIS) as a combination of technologies and decision making techniques that uses detailed, historical and real-time road and weather information to improve the efficiency of highway maintenance operations and distribute effective real-time information to travelers (Castle Rock Consultants, 1998). An RWIS consists of the three main elements: environmental sensor stations (ESS), forecasts, and information dissemination and display (Castle Rock Consultants, 2002).

**Components of RWIS**

In general an environmental sensor station (ESS) consists of an array of environmental sensors and the remote processing unit (RPU). The RPU is generally a microprocessor that resides in the field nearby the environmental sensors. Due to the limited processing power of the RPU, the data is sent from the RPU to a Central Processing Unit (CPU). The central server is typically located in a highway maintenance facility. The CPU will comprise a database and other applications used for collecting, disseminating and archiving RWIS data (Castle Rock Consultants, 2002).

![RWIS components](image)

*Figure 15: RWIS components [adapted from Castle Rock Consultants, 2002]*

The information generated and provided by an RWIS is mainly used by road maintenance authorities to aid and improve decisions related to winter maintenance operations. RWIS is a system of pavement and atmospheric sensors integrated with prediction and monitoring functions that employs real-time environmental sensor data, historical weather patterns, and computer models to forecast specific adverse pavement conditions (MTO, 2005).
Table 7: RWIS components

<table>
<thead>
<tr>
<th>RWIS components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Stations</td>
</tr>
<tr>
<td>Communication Network</td>
</tr>
<tr>
<td>Weather and Pavement Temperature Modeling</td>
</tr>
<tr>
<td>Tailored Weather and Pavement Temperature Forecasts</td>
</tr>
<tr>
<td>Traveler Information</td>
</tr>
<tr>
<td>Winter Maintenance Decision Support Systems</td>
</tr>
</tbody>
</table>

[Boon/Cluett, 2002]

The real-time data can be helpful in reducing the need/dependency for road patrolling in specific road sections and locations prone to critical winter conditions by providing timely and spatially accurate information to the local winter maintenance manager (MTO, 2005). Usually an RWIS processes and provides the in Table 10 enlisted weather and surface data.

Table 8: RWIS data

<table>
<thead>
<tr>
<th>Weather data</th>
<th>Surface data</th>
</tr>
</thead>
<tbody>
<tr>
<td>air temperature</td>
<td>pavement temperature</td>
</tr>
<tr>
<td>amount and type of precipitation</td>
<td>subsurface temperature</td>
</tr>
<tr>
<td>visibility</td>
<td>surface condition (dry, wet, frozen)</td>
</tr>
<tr>
<td>dew point</td>
<td>amount of deicing chemical on the roadway</td>
</tr>
<tr>
<td>relative humidity</td>
<td>freezing point of the road surface</td>
</tr>
<tr>
<td>wind speed and direction</td>
<td></td>
</tr>
</tbody>
</table>

[Castle Rock Consultants, 2002]

**Practices enabled by RWIS**

According to Boon/Cluett winter maintenance decisions without detailed, tailored and targeted weather forecasts must be based on current weather conditions. Traditionally highway maintenance organizations have just reacted to current winter conditions, or at best to weather forecasts in the media. Patrols are sent to check conditions, and supervisors are notified that roads have become icy or snow has begun to accumulate. Crews are sent out to attack the problems as they occur and stay on the job until the problems have subsided (Boon/Cluett, 2002). With regard to time, personnel, and materials this kind of operation can be costly (Boselly, 1993). Due to the information available from a fully deployed RWIS it is possible to adopt new, proactive ways of doing business that can more efficiently and cost-effectively provide
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safer conditions for the travelling public (Boon/Cluett, 2002). Therefore Boon/Cluett identified in their case study on winter maintenance service in Washington State beneficial winter maintenance practices that are enabled by RWIS.

Table 9: RWIS-Enabled Practices and associated benefits

<table>
<thead>
<tr>
<th>RWIS-Enabled Practice</th>
<th>Associated Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower material costs</td>
</tr>
<tr>
<td></td>
<td>Lower labor costs</td>
</tr>
<tr>
<td></td>
<td>Higher level of service (improved road conditions), travel time savings, and improved mobility</td>
</tr>
<tr>
<td></td>
<td>Improved safety (fewer crashes, injuries, fatalities, property damage)</td>
</tr>
<tr>
<td></td>
<td>Reduced equipment use hours and cost</td>
</tr>
<tr>
<td></td>
<td>Reduced sand cleanup required</td>
</tr>
<tr>
<td></td>
<td>Less environmental impact (reduced sand runoff, improved air quality)</td>
</tr>
<tr>
<td></td>
<td>Road surfaces returned to bare and wet more quickly</td>
</tr>
<tr>
<td></td>
<td>Safe and reliable access, improved mobility</td>
</tr>
<tr>
<td>Anti-icing</td>
<td>Reduced equipment use hours and cost</td>
</tr>
<tr>
<td></td>
<td>Improved labor productivity</td>
</tr>
<tr>
<td>Reduced Use of Routine Patrols</td>
<td>Increased labor productivity</td>
</tr>
<tr>
<td></td>
<td>Reduced weekend and night shift work</td>
</tr>
<tr>
<td></td>
<td>Improved employee satisfaction</td>
</tr>
<tr>
<td></td>
<td>Reduced maintenance backlog</td>
</tr>
<tr>
<td></td>
<td>More timely road maintenance</td>
</tr>
<tr>
<td></td>
<td>Reduced labor pay hours</td>
</tr>
<tr>
<td></td>
<td>Overall higher level of service</td>
</tr>
<tr>
<td></td>
<td>More effective labor assignments</td>
</tr>
<tr>
<td>Cost-Effective Allocation of Resources</td>
<td>Better prepared drivers</td>
</tr>
<tr>
<td></td>
<td>Safer travel behavior</td>
</tr>
<tr>
<td></td>
<td>Reduced travel during poor conditions</td>
</tr>
<tr>
<td></td>
<td>Fewer crashes, injuries, fatalities and property damage</td>
</tr>
<tr>
<td></td>
<td>Increased customer satisfaction &amp; political support road maintenance authority</td>
</tr>
<tr>
<td></td>
<td>Improved mobility</td>
</tr>
<tr>
<td></td>
<td>Safer, more reliable access</td>
</tr>
<tr>
<td>Provide Travelers better Information</td>
<td>Higher labor productivity</td>
</tr>
<tr>
<td>Cost-Effective Summer Maintenance Scheduling</td>
<td>Improved roadway surface</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>RWIS-Enabled Practice</th>
<th>Associated Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share Weather Data</td>
<td>Improved weather forecasts</td>
</tr>
</tbody>
</table>

[Boon/Cluett, 2002]

**Costs and benefits of RWIS**

Table 10 represents a summary of benefit-cost analysis (BCA) conducted in order to assess the value of road weather information for road maintenance management. The studies were mainly conducted in the US and Canada. European forerunners in evaluating RWIS are Finland and Sweden. Sweden for instance already implemented RWIS in the 1970s (MTO, 2005). Based on their research review Leviäkangas/Hietajärvi concluded that road weather information service must be connected and justified by its business value. That means road weather services offered on the market to the different actors within the road management value chain must include a socio-economic component (Leviäkangas/Hietajärvi, 2010).

Table 10: Costs and benefits of RWIS

<table>
<thead>
<tr>
<th>Theme/aspect</th>
<th>References</th>
<th>Results/identified impacts</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter road management, maintenance and operations</td>
<td>Boselly (2001)</td>
<td>Road weather information systems are profitable investments (B/C = 5)</td>
<td>Safety and service level impacts probably dominate the benefits</td>
</tr>
<tr>
<td></td>
<td>Wass (1990), Thornes (1989)</td>
<td>Improved weather information will reduce winter maintenance cost for 5%-30%</td>
<td>Note that external environmental costs (reduced pollution of ground waters due to less salting) are not included</td>
</tr>
<tr>
<td></td>
<td>Kempe (1990)</td>
<td>50% less salt for de-icing with more advanced road weather information systems</td>
<td>Pilot project in Sweden</td>
</tr>
<tr>
<td></td>
<td>Lähesmaa (1997)</td>
<td>Investments in weather-controlled winter road management systems not easily profitable (B/C = 0.5)</td>
<td>Time costs due to reduced speeds eat up accident savings; operational savings in maintenance not significant</td>
</tr>
<tr>
<td></td>
<td>Pilli-Sihvola (1993)</td>
<td>Road weather service is beneficial (B/C = 5)</td>
<td>A system level assessment based on mainly expertise and inside observation on pilot projects in Finland</td>
</tr>
<tr>
<td>Theme/aspect</td>
<td>References</td>
<td>Results/identified impacts</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>----------------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Other road management, maintenance and other operations</td>
<td>Skarpness et al. (2003)</td>
<td>Weather information portal found very useful by road management personnel and road users. Howevon, low willingness-to-pay.</td>
<td>USA</td>
</tr>
<tr>
<td></td>
<td>WTI (2009)</td>
<td>B/C New Hampshire = 7.11, 8.67 B/C Minnesota = 6.4, 2.75 B/C Colorado = 2.25, 1.33</td>
<td>BCA of Maintenance Decision Support System is USA; based on two Scenarios (Same condition vs. Same resources)</td>
</tr>
<tr>
<td>Safety effects in winter conditions</td>
<td>Rämä (2001)</td>
<td>VMSs reduce speeds (1.2 km/h on average) and result in accident savings</td>
<td>Increased time not taken into account and no benefit-cost analysis performed</td>
</tr>
<tr>
<td></td>
<td>Schirokoff et al. (2005)</td>
<td>A wide-scale adoption of VMSs would enhance safety impacts and aggregate system would have a B/C=1.4</td>
<td>Finnish main road network</td>
</tr>
<tr>
<td>Safety effects in general</td>
<td>Cooper and Sawyer (1993)</td>
<td>Fog warnings by VMSs reduce speeds and improve safety</td>
<td>4.8 million observations on vehicle speeds in London for 1990-1992</td>
</tr>
<tr>
<td></td>
<td>Kyte et al. (2001)</td>
<td>VMSs warning drivers on poor road weather conditions had an additional marginal impact on driver behaviour reducing speeds</td>
<td>Sweden</td>
</tr>
<tr>
<td></td>
<td>Thornes and Davies (2002); Smith (1990)</td>
<td>Weather impacts significant on rail operations (schedule, safety, reliability), but not quantified</td>
<td>UK</td>
</tr>
<tr>
<td></td>
<td>Motte et al. (1994)</td>
<td>Weather information used for waterborne vessel routing did not improve significantly performance</td>
<td>USA</td>
</tr>
<tr>
<td>Other transport modes</td>
<td>Sonnininen (2007)</td>
<td>When efficiently utilising weather information, significant impacts on boating safety, vessel operations and oil combating efficiency</td>
<td>Sonnininen’s analysis utilised extensively other prior studies and statistics</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Theme/aspect</th>
<th>References</th>
<th>Results/identified impacts</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hautala (2007)</td>
<td>More efficient utilisation has great potential in improving pedestrian and light traffic safety especially in winter conditions</td>
<td>Hautala's study synthesised extensively different prior research results and statistics</td>
</tr>
</tbody>
</table>

[adapted from Leviäkangas/Hietajärvi, 2010]

Road weather information proofed to be beneficial especially in terms of less salt for gritting, less environmental burden on e.g. ground waters, improved safety, more efficient and better targeted de-icing operations (Leviäkangas/Hietajärvi, 2010). In addition Leviäkangas/Hietajärvi emphasizes that there will be in future a clear distinction between day-to-day weather information (serving the operational purposes) provided mainly by commercial or private entities and strategic, long-perspective weather information (serving the public sector) in order to deal with infrastructure placement and climate impact mitigation/adaptation. That distinction is reflected by the business value of the information: day-to-day information is cash valued and long-perspective information is of socio-economic value (Leviäkangas/Hietajärvi, 2010).

8.3.1 RWIS in Europe

As already mentioned RWIS are used mainly by countries to support winter maintenance operations (snow and ice control). In the following several aspects of RWIS in Europe, such as standardisation and access to data will be discussed.

Standards

Considering the requirements for RWIS a number of countries already developed standards. But according to PIARC 2008 very few current standards are international. Several standards related to RWIS need to be established in future (PIARC, 2008):

- Technical characteristics of sensors,
- Site installation recommendations/criteria,
- Common criteria on selecting appropriate sites for road weather stations (RWS),
- Communication standards (especially for information available to the general public),
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- Metadata standards,
- Training for (closed) user-groups,
- Message standards: on variable message signs, on websites, in vehicles, on SMS/RSS feeds.

International or European standards can be useful in order to facilitate data sharing for (PIARC, 2008):

- Road administration operations centres that might be interested in regions that border on their own road network or that compile data for an inter-regional or national system.
- Public or private organizations, such as contractors, who can use the data to provide higher quality service; municipalities, who can use them to create a denser and more seamless information system between rural and urban areas; traffic managers, who can better inform the public or manage traffic problems; the police, who can better manage incidents and emergencies; and forecasters, who can improve their product by anticipating road weather events.
- Road administrations in other countries, which view the alliance as an opportunity to provide drivers with continuous information pertaining to road conditions and certain road weather details.

**RWS equipment**

Concerning the equipment of RWS in Europe two types of sensors can be distinguished (PIARC, 2008):

- General sensors, which measure key road weather factors such as air temperature, relative humidity, road surface temperature, wind direction and speed, and the occurrence of precipitation.
- More specialized sensors, including video cameras, which generate more specific data, such as visibility, road depth temperature, road surface conditions (state), road surface freezing point, radiation, type of precipitation (classification), dew point, snow depth on the road surface, and the intensity of precipitation.

This division reflects the attempt of road maintenance authorities to collect complete information from multiple points of the road network and to have as many observation points as possible (with less information) simultaneously (PIARC, 2008). Consequently the gathered road weather information covers not all meteorological factors for the whole road network. That must be considered for factors that already vary
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significantly on a local level and that are conclusive in terms of making roadway maintenance decisions (PIARC, 2008).

![Graph showing sensor usage](image)

**Figure 16: Sensors of RWS [PIARC, 2008]**

In Europe the numbers of RWS vary from country to country and are determined by several factors, e.g. topography, geography, length and location of the road network, as well as exposure of road sections to severe winter conditions. In Finland for instance RWS are mainly located along relevant roads in the economically active and densely populated areas of the south (see Figure 17).

![Map showing RWS locations](image)

**Figure 17: Locations of RWS in Finland [PIARC, 2010]**
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The current number of RWS used in Europe is shown in Table 11 and was derived mainly from PIARC, 2010.

Table 11: Number of RWS

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of RWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>370</td>
</tr>
<tr>
<td>Belgium</td>
<td>99</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>300</td>
</tr>
<tr>
<td>Denmark</td>
<td>300</td>
</tr>
<tr>
<td>Estonia</td>
<td>50</td>
</tr>
<tr>
<td>Finland</td>
<td>350</td>
</tr>
<tr>
<td>France</td>
<td>800</td>
</tr>
<tr>
<td>Germany</td>
<td>1200</td>
</tr>
<tr>
<td>Ireland</td>
<td>62</td>
</tr>
<tr>
<td>Latvia</td>
<td>30</td>
</tr>
<tr>
<td>Lithuania</td>
<td>38</td>
</tr>
<tr>
<td>Netherlands</td>
<td>319</td>
</tr>
<tr>
<td>Poland</td>
<td>170</td>
</tr>
<tr>
<td>Sweden</td>
<td>700</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>200</td>
</tr>
</tbody>
</table>

[adapted from PIARC, 2010; Karkowski/Winiecki, 2003]
9 Improvement through cooperation

Referring to ETM and EWE cooperation is one of the promising strategies to promote improvements. Whereas cooperation can be distinguished into:

- **Inter-modal**: cooperation between modes of transport and affiliated actors (e.g. operators, undertakings, infrastructure managers)
- **Trans-sectoral**: cooperation between sectors (e.g. public authorities, NMS, industry), and
- **Trans-regional**: cooperation between regions and across political boundaries.

Accepting the growing risk of adverse weather events in transport is an important issue in an inter-modal, trans-sectoral as well as trans-regional context. In contrast the establishment of a platform to exchange or develop best practices is primarily useful in an inter-modal context. As explained before one of the most important steps is to initiate a structured gathering of data concerning the impacts of EWE on transport. Since the impacts of EWE are typically not restricted to one mode or sector it is useful to follow a holistic approach in order to derive a complete impact pattern and analysis of interdependencies between different modes of transport and sectors.

Furthermore the effectiveness of ETM operations related to EWE can be improved by integrating already existing systems of other modes (e.g. online traffic monitoring systems and route planning systems) and sectors (e.g. WIS and SWWS).

A good example of an already existing system that reunites different information is www.truckinfo.ch. The system established by the Swiss federal roads authority (ASTRA) incorporates and represents current data on roadwork, congestions, accidents, driving bans, routing, general weather, weather situation for alpine transit, intermodal/rail transport service, and additional information (e.g. toll and transport restrictions). Whereas road data is provided by Viasuisse AG, weather information by Meteo SF DRS, and rail service data by Hupac Intermodal AG and RAlpin AG (Truckinfo, 2011).

Another issue of cooperation is the development of common and efficient methods concerning safety and risk management across the different modes of transport as well as on a sufficient political level (e.g. EU). The implementation of standards is also important to WIS and its infrastructure. Common standards on a European level should be developed in an inter-modal, trans-sectoral and trans-regional context in order to include the different requirements for sharing WIS data.

The growing commercialization of meteorological services and the further development of e.g. polygon-based fore- and nowcasting could stimulate the integration of
customised service solutions within the ETM of more transport operators and modes of transport.

Table 12: Steps of improvement and forms of cooperation

<table>
<thead>
<tr>
<th>Step</th>
<th>Inter-modal</th>
<th>Trans-sectoral</th>
<th>Trans-regional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accepting EWE as risk</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Consideration of EWE in ETM processes</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Establishment of a platform to exchange best practices</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiation structured gathering of EWE impacts</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Development of a common safety method</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Involving other modes of transport and sectors threatened by domino-effects</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Integrating systems</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Involving NMS</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrating WIS in ETM</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Promoting customised/mode-specific forecast and nowcasting solutions</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enabling access for the general public to EWE information</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Sharing of meteorological data</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Development and implementation of common standards for WIS</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Funding of weather stations</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**Transferability**

Information provided by either national or commercial meteorological services can basically be incorporated into ETM operations of all modes of transport. The most attractive solution to ETM is of course the provision of free weather information via online systems. Ideally the critical ETM-related weather data identified within the risk assessment process can be derived from available SWWS or WIS in a sufficiently detailed and regularly updated format. Usually particular information systems (e.g. RWIS) were implemented especially in road transport to meet the mode-specific requirements. Besides road transport (see 1.15 Road weather information system (RWIS)) information on EWEs and weather in general is also widely used for aviation and inland waterways.

In Germany for instance the ELWIS - Elektronischer Wasserstraßen-Informationsservice (electronic waterway information service) provides current data on ice, flood, and according closures of inland waterway links (ELWIS, 2011). An-
other RIS (River Information Service) is the Austrian DoRIS (Donau River Information Services). The different RISs (like RWISs) in the EU-member states are currently characterized by the incompatibility of information systems, standards, and installations. In order to guarantee the efficiency and safety of inland waterway transport the setting of standards (like for RWIS) on a European level is necessary (Transport Research Knowledge Centre, 2006).

Although it can be assumed that also railway undertakings and infrastructure managers are paying attention to SWWS and general weather forecasts, there still exists a lack of effective railway-related severe weather management systems. That lack was obvious again by the impacts of the 2010/11 winter on railway transport in central Europe (e.g. Germany, France, and Austria). Current activities (e.g. the EU projects ARISCC and WEATHER or the joint UNECE-UNCTAD Workshop: Climate Change Impacts on International Transport Networks in September 2010) are indicators for a growing sensitivity of the railway sector to EWE.

In the course of transferring severe weather management practices or systems (e.g. implementation of a mode-specific WIS) into other modes of transport following issues need to be considered:

Table 13: Issues of transferability

<table>
<thead>
<tr>
<th>Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>What will be the scale (European, national, or regional) of the system?</td>
</tr>
<tr>
<td>Will it be a common system for all actors within the mode or just an individual solution for one actor?</td>
</tr>
<tr>
<td>Are the intended users only sectoral actors or also e.g. fire brigades, police, or civil protection authorities?</td>
</tr>
<tr>
<td>Will it be a free or a commercial system?</td>
</tr>
<tr>
<td>Will it be available to the general public on the internet or only to a closed user group?</td>
</tr>
<tr>
<td>Who will provide the meteorological data (one individual NMS, or a network of NMSs)?</td>
</tr>
<tr>
<td>What other information/data or already existing systems should be incorporated?</td>
</tr>
<tr>
<td>Are there standards which must be met?</td>
</tr>
<tr>
<td>Who will maintain the system?</td>
</tr>
</tbody>
</table>

...
SECOND SECTION: Technological issues
Review of Technologies in the Transport Sector

10.1 Towards all embracing ITS

The usage of intelligent transportation systems (ITS) has increased in the last decades: advanced traffic signal control systems, dynamic traffic signs and ramp metering are only three examples of a broad range of applications. ITS can handle traffic incidents such as accidents, road closures and congestion and therefore provide tools to connect other cases of emergency with traffic management.

In the past, emergency managers and emergency management systems have failed to take advantage of new and emerging technologies to improve operations and enhance capabilities. Only during the last years, technological applications (e.g. geographic information systems (GIS) and global navigation satellite systems (GNSS)) have been part of the emergency management tool-kit, leading to an increased use of the various available capabilities (internet, communication networks etc). These technologies are already commonly used and emergency management personnel can leverage these tools to transmit and gather information. One example is the weather forecasting, where the usage of information technology (IT) has led to more precise warnings of natural hazards, such as wind storms and floods. “IT has the potential for even greater impact on enhancing disaster management practice across all of its phases – mitigation, preparedness, response, and recovery – provided it is used consistent with the knowledge of hazards, disasters, and emergency management practices” (Rao et. al., 2007). Thus, “IT provides capabilities that can help people grasp the dynamic realities of an emergency more clearly and help them formulate better decisions more quickly as well as can help keep better track of the myriad details involved in all phases of emergency management.”

Weather-Responsive Traffic Management

Regardless of the local climate, all traffic managers will need to address the challenges created by adverse weather conditions. The concept of operations for weather-related events should be based on the operational objectives and strategies of the traffic management centre (Cambridge Systematics, 2003). While specific response plans must be defined in order to maximize safety and respond effectively to weather events, these plans should reflect the overall priorities and objectives of the traffic management centre.

The type and severity of weather events varies widely by region. Moreover, not all locations with similar weather conditions have the same capability to collect and process data on weather conditions and the impact of weather events on traffic. Incident response capabilities will also vary between different metropolitan areas. Cities
in warmer regions that receive an occasional ice storm or snowstorm will have fewer maintenance vehicles and trained personnel available than cities in colder climates (Cambridge Systematics, 2003). Therefore, their response plans may emphasize a different mix of operational strategies; for example, demand management may be emphasized over freeway/traffic management. Traffic management centres need to develop appropriate response policies and procedures that align with their available resources. This process will also help agencies to set funding priorities by identifying the missing resources that are most needed (Cambridge Systematics, 2003).

10.2 Overview of Technologies

The management of extreme weather related effects on the transport sector may be facilitated by decision support systems (DSS) at various levels of automation. This chapter provides an overview of the main DSS components; the next chapter introduces whole decision support systems in practice.

The three tasks, in which the related processes for DSSs can be broadly divided into, are the following:

- Data Collection (raw data streams)
- Information Processing (gain information via data analysis, -mining, -fusion)
- Information Transmission (communications, signalling, alarming etc)

The following diagram provides a schematic overview.
Figure 18: Overview of the data collection, processing and transmission chain in extreme weather events management for transport
The data collection, information processing and information transmission technologies for the management of extreme weather related effects on the transport sector are summarized in the next three tables.

Table 14: Data collection related technologies

<table>
<thead>
<tr>
<th>DATA COLLECTION</th>
<th>TECHNOLOGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODES</td>
<td></td>
</tr>
<tr>
<td>Traffic</td>
<td>Intrusive detectors (road, rail): inductive loops, magnetic field, piezometer, pneumatic tubes, weight in motion</td>
</tr>
<tr>
<td></td>
<td>Non intrusive detectors (all modes): video, radar, passive/active infrared, LASER, ultrasound, beacon switches, optical, microphones, RADAR, LiDAR</td>
</tr>
<tr>
<td></td>
<td>Cooperative systems: Car2X, FCD, FTD, SSR (RADAR), RFID</td>
</tr>
<tr>
<td>Weather</td>
<td>Surface weather observation (stations, ships, buoy): anemometer (wind speed), wind vane (wind direction), barometer (pressure), rain gauges, thermometer (temperature), hygrometer (humidity), LiDAR</td>
</tr>
<tr>
<td></td>
<td>Observation of the upper atmosphere: planes, balloons with radiosonde, satellites</td>
</tr>
<tr>
<td>Environment</td>
<td>Scenery detectors:</td>
</tr>
<tr>
<td>Surveillance</td>
<td>Aerial imagery (quadrocopter, helicopter, planes), satellite imagery (visible light, infra red, radar), robots</td>
</tr>
<tr>
<td></td>
<td>Soil/(ground-) water detectors:</td>
</tr>
<tr>
<td></td>
<td>stream gauges, water sensors, piezometers (groundwater, landslide and subsidence), extensiometers, tiltmeters, creep meters, geodetic leveling and triangulation, LiDAR, triaxial testing of soil samples</td>
</tr>
<tr>
<td>Locating of own location, tracking and tracing of objects, navigation</td>
<td>Dead reckoning (physical forces): Inertial sensors, odometry</td>
</tr>
<tr>
<td></td>
<td>Round trip delay time or triangulation of electromagnetic and acoustic waves: GNSS, TETRA, WLAN positioning, GSM positioning, wireless sensor networks, SONAR, RADAR, SSR</td>
</tr>
</tbody>
</table>

Table 15: Information processing related technologies

<table>
<thead>
<tr>
<th>INFORMATION PROCESSING</th>
<th>TECHNOLOGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODES</td>
<td></td>
</tr>
<tr>
<td>Data Mining</td>
<td>Image/video processing, data fusion and data quality management, data mining techniques (statistics)</td>
</tr>
<tr>
<td>Modelling</td>
<td>Weather models, discharge models, GIS (incl. map matching), traffic models</td>
</tr>
<tr>
<td>Decision-Making</td>
<td>traffic management system including traffic light/sign control, catastrophe management system</td>
</tr>
</tbody>
</table>
Table 16: Information transmission related technologies

<table>
<thead>
<tr>
<th>INFORMATION TRANSMISSION</th>
<th>TECHNOLOGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODES</td>
<td></td>
</tr>
<tr>
<td>General communication media</td>
<td>General systems based on electromagnetic waves: VHF radio communications, SMS (GSM), e-mail, rss-feed, instant messaging, websites, UMTS, wide-band, cell-broadcast, telefon, telefax, tv, radio (FM, internet, DAB, DVB), video-text, dedicated short range communications (DSRC)</td>
</tr>
<tr>
<td></td>
<td>Traffic-related systems: over-road gantry-signs, traffic lights, dynamic traffic message signs, Car2X</td>
</tr>
<tr>
<td></td>
<td>Non-electric systems: Poster, newspaper</td>
</tr>
<tr>
<td>Alarming</td>
<td>Emergency call-up (computerized dialling for emergency call-up, paging networks), (indoor loud speakers), SatWaS, multiple alarm devices (EU-project CHORIST), Advanced Sirens systems, Car2X, common alerting protocol (CAP, EU-Project OASIS),</td>
</tr>
<tr>
<td>Information</td>
<td>Information platforms for information integration (traffic management systems, GIS platforms), public internet platforms (flood information, traffic information, weather information and warning)</td>
</tr>
</tbody>
</table>

10.3 Information Collection Technologies

Traffic detectors may be grouped into three classes: In-Pavement detectors for road traffic, non-intrusive detectors and cooperative systems (both latter types may be used for all modes of transport).

- **Intrusive detectors** are detectors which have to be buried in or under the road- or railway. While being relatively cheap and working at a defined place, such detectors require road/railway-closures for installation and repair, and they are exposed to mechanical and chemical forces degrading their life-time. They can be used to detect presence, information of the vehicle type (weight/size) and measure speeds when coupled in pairs, thus detecting presence at two places. Inductive loops on roads and trackside magnets on rail ways are the most common detector types.

- **Non-intrusive detectors** do not need a solid surface and can therefore be used with all modes of transport (road, rail, air, maritime). Used as road traffic detectors, they do not require road-closures; however, environmental influences may degrade the quality of measurement, e.g. rain, fog and snow combined with video sensors. They can also detect presence and vehicle type information. Additionally, only one device is needed to determine speeds as such devices cover larger parts
Cooperative systems rely on a communication between a vehicle and another object which may be another car or an infrastructure element (part of the road or mobile communication infrastructure).

Surface weather, that is lower atmosphere, is monitored by stations, ships and buoys which may be equipped with anemometers (wind speed), wind vanes (wind direction), barometers (pressure), rain gauges (rainfall), thermometers (temperature), hygrometers (humidity) and LiDAR (visibility/clouds).

When monitoring the upper atmosphere, flying objects can be used, such as balloons with radiosonde, planes, rockets and satellites. They measure amongst others temperature, pressure and dew-point.

Besides the atmosphere, other environmental factors have to be monitored, as they are directly influenced by extreme weather situations in the atmosphere.

The overall scenery can be monitored by aerial imagery (quadrocopter, helicopter, planes), satellite imagery (visible light, infra red, radar) and robots.

More in detail, water and groundwater as well as the soil have to be observed.

Two important aspects of drain measurement are the water level and the flow rate; stream gauges, Radar and ultrasound detectors can be used to determine water levels, whereas flow rates may be monitored via hydrometric vanes, electromagnetic-inductive stream sondes, ultrasound detectors and specific forms of river beds.

Ground water levels are observed with piezometer tubes and observation wells.

Danger of landslides and subsidence because of heavy rainfalls can only be estimated indirectly via sounding. Measuring instruments like piezometers (landslide and subsidence), extensiometers, tiltmeters, creep meters, geodetic leveling and triangulation, LiDAR, triaxial testing of soil samples, can aid this task. However, continuous measurements are difficult to execute.

Important information in case of emergency is the position of moving objects. Determining the own position or the position of other objects is called “locating”. Following the track of an object is called “tracking” and planning the route of an object is called “navigation”. Both latter processes are based on locating.

Locating may be:

- Autonomous: an object determines its position on its own (e.g. with dead reckoning) or the position of an object is determined without its help (e.g. a aircraft by primary radar), or

- Cooperative: an object determines its position by means of technical support (e.g. via GNSS by means of satellite signals) or the position of an object is de-
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termined with its help (e.g. with a SSR receiving additional transponder data from the aircraft)

Important locating techniques are:

- Dead reckoning (physical forces) via inertial sensors or odometers
- Round trip delay time measurement or triangulation of electromagnetic and acoustic waves: GNSS, TETRA, WLAN positioning, GSM positioning, wireless sensor networks, sonar, radar

10.4 Information Processing Technologies

Data are gathered in order to get information about the current situation, to make forecasts and to keep historical archive for future use. Thus, the amount of data is getting overwhelming and personal computers make it easy to save data otherwise deleted since multigigabyte disks store information that can later be decided whether and which is useful or not.

Data mining is an analytic process and refers to extracting or “mining” knowledge from large amounts of data (Han and Kamber, 2006). Classical techniques of data mining involve statistics, neighbourhoods and clustering and next generation techniques use trees, networks and rules. The ultimate goal of data mining is prediction and the process of data mining consists of three stages:

1. The initial exploration
2. The model building or pattern identification with validation/verification
3. The deployment, meaning the application of the model to new data in order to generate predictions

Before data mining algorithms can be used, a target data set must be assembled. As data mining can only uncover patterns already present in the data, the target dataset must be large enough to contain these patterns while remaining concise enough to be mined in an acceptable timeframe.

Moreover it is necessary to monitor the quality of the sources and to adopt the process of data fusion including data pre-processing (e.g. image processing), fault correction of each source, combination of sources, closing temporal and spatial gaps as well as smoothening/aggregation.

Data fusion is the use of techniques that combine data from multiple sources and gather the information in order to achieve inferences, which will be more efficient and potentially more accurate than if they were achieved by means of a single source. Data fusion processes are often categorized as low, intermediate or high, depending on the processing stage at which fusion takes place (Klein, 2004).
Pre-processing of the data is also essential to analyze the multivariate datasets before clustering or data mining and includes the removal any observations with noise and missing data.

Image/video processing is a form of signal processing where the input is an image, such as a photo or video streams and the output may be either another image or video or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it (Wikipedia, 2010).

Models are a system approach to study complex phenomena of environmental and technical systems and landscapes consisting of interconnected, complex, and functionally related components in order to estimate the current and future state of the situation.

For extreme weather related traffic situations, most important models are nature models (weather and discharge models), traffic models and GIS (topic-specific layered maps).

Nature models
Weather forecasting can be done in various ways, depending on the underlying model. The easiest model is to assume that the weather will stay at it is (persistence). With up to date observation – having a look at the sky, using a barometer or satellite measurements, such as radar pictures – humans can make reliable short time predictions. Long term predictions can be derived from computerised weather models. There are many types of weather models, such as:

- analog models, a pattern recognition model searching for similar weather events in the past,
- analytical models based on the solving of equations by means of algebra or calculus and
- numerical models, which solve equations with numerical methods and therefore producing approximations to the analytical problems.

Discharge models (rainfall-runoff or streamflow routing models) describe water levels of rivers and the soil due to rain or drought using real time and predicted precipitation and streamflow data.

Traffic Models
Traffic models are used to simulate the traffic conditions aiming at testing alternative traffic interventions/scenarios as well as forecasting the future traffic demand. A classification of traffic models is provided in the table that follows.

Table 17: Classification of Traffic Models

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Model Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Operation</td>
<td>Simulation Models</td>
</tr>
<tr>
<td></td>
<td>Analysis Models</td>
</tr>
<tr>
<td></td>
<td>Prediction Models</td>
</tr>
<tr>
<td></td>
<td>Conditional Prediction Models</td>
</tr>
<tr>
<td>Level of detail</td>
<td>Macroscopic</td>
</tr>
<tr>
<td></td>
<td>Mesoscopic</td>
</tr>
<tr>
<td></td>
<td>Microscopic</td>
</tr>
<tr>
<td>System approach</td>
<td>Deterministic</td>
</tr>
<tr>
<td></td>
<td>Stochastic or Probabilistic</td>
</tr>
<tr>
<td>Time approach</td>
<td>Dynamic</td>
</tr>
<tr>
<td></td>
<td>Static</td>
</tr>
<tr>
<td>Methodological approach</td>
<td>Parametric</td>
</tr>
<tr>
<td></td>
<td>Non-Parametric</td>
</tr>
</tbody>
</table>

**Simulation - Prediction models**

Traffic simulation models are tools needed to help in system description, analysis and explanation, simplifying the interactions that exist in systems. Moreover simulation models, determine values, difficult to measure, by other data easier to collect, avoiding costly investigations. Prediction models resemble simulation models; however, they are used to predict future traffic conditions using data elements related to present data, future traffic conditions, land uses etc. This data set is based on assumptions as rational as possible, taking into account events of great certainty to occur. Conditional prediction models are required in traffic impact analysis, identifying the impact of a specific exogenous to the system event on the system studied.

**Macroscopic – Mesoscopic – Microscopic Models**

A system can be modeled in different ways according to various approaches depending on the modeler's purposes. Traffic flows can be modeled macroscopically from an aggregated point of view based on a hydrodynamic analogy by regarding traffic flows as a particular fluid process whose state is characterized by aggregate macroscopic variables: density, volume, and speed. But they can also be modeled microscopically, that is, from a fully disaggregated point of view aimed at describing the fluid process from the dynamics of the individual particles (the vehicles) that compose it.
Mesoscopic models represent a third intermediate modeling alternative based on a simplification of vehicular dynamics (Barcelo, 2010).

Deterministic models are models where future events are determined to happen or not without examining the probability of the occurrence. A deterministic model assumes that an outcome is certain. Conversely in Stochastic or Probabilistic models randomness is present and the possibility the examined or predicted event is likely to occur is considered.

**Dynamic-Static Models**

A static model does not account for the element of time, while a dynamic model does. A static model is one that does not account for time. It identifies the before and after outcomes but does not trace the path that the model takes to move from one equilibrium position to another. In contrast, a dynamic model contains time as a variable, which can be used to trace how the model moves from one equilibrium position to the next.

**Parametric-Non-Parametric**

One of the major issues in traffic forecasting is the selection of the appropriate methodological approach. Current practice involves two separate modeling approaches: parametric and non-parametric techniques. In the vast category of statistical parametric techniques, several forms of algorithms have been applied with greater weight to historical average algorithms and smoothing techniques. Autoregressive linear processes such as the auto-regressive integrated moving average (ARIMA) family of models, provide an alternative approach based on the stochastic nature of traffic (Eleni Vlahogianni et al., 2004).

The process of decision-making may be aided (in case of information or proposition systems) or substituted completely (in case of control systems) by traffic or catastrophe management systems.

**10.5 Information Transmission Technologies**

Information can be transmitted via several communication channels with the form of audio, video and text. During the last century, the advances in telecommunication technologies have greatly altered communication by providing new “media” for long distance communication.

Primary communication media, such as speech and nonverbal communication have to be transformed when addressing a larger target group. Moreover, many times it seems efficient from energy-related and from bandwidth-related points of view to promote broadcast solutions. **Broadcasting** is the distribution of audio, video or text content to a dispersed audience via radio, television, or other, mostly digital trans-
mission media. Receiving parties may include the general public or a relatively large subset of thereof. So, the dissemination of traffic information may be broadcasted to all drivers or only to those using the infrastructure.

The different types of electronic **broadcasting solutions** include:

- Telephone broadcasting (Cell broadcast in wireless telephony systems)
- Radio broadcasting (FM, DAB, TMC, cable radio, satellite radio)
- Television broadcasting (SDTV, HDTV, DVB, video-text, satellite/terrestrial)
- Internet (RSS-feed, modern telegraphy: e-mail, instant messaging, web-sites)
- Webcasting of radio/television: offers a mix of traditional radio and television station broadcast programming with internet-dedicated webcast programming.

The technologies used for the various types of broadcasting are (Wikipedia, 2010):

**Digital audio broadcasting (DAB)** services are digital radio technologies for broadcasting radio stations, which are more capable broadcast systems providing free slots for digital data broadcast in their bandwidth, used in several countries, particularly in Europe. **Digital video broadcasting (DVB)** is a suite of internationally accepted open standards for digital television. DAB+ and DVB+ are upgraded versions of the systems more efficient that provide higher quality of transmission.

**Traffic Message Channel (TMC)** has been established many years ago and it is primarily used for highway-related traffic information. TMC is based on analogue FM radio and it is used in most car navigation systems, but due to capacity reasons it is not advisable to expand it for more data-extensive urban ITS applications.

**Standard-definition television (SDTV)** is a television system that has a resolution that meets standards. The term is usually used in reference to digital television, in particular when broadcasting at the same (or similar) resolution as analog systems.

**High-definition television (HDTV)** refers to video having resolution substantially higher than traditional television systems (SDTV). HDTV has one or two million pixels per frame; roughly five times that of SDTV.

**Videotext** is another name for Teletext which is a broadcast (one-way) information service used in television.

The second way is to use telecommunication including, telephony, telegraphy and television as well as radio communication (broadcast systems).

Amongst others, an important goal in case of emergency is **alarming**. Professional relief units are alarmed via emergency call-up (computerized dialling for emergency call-up, paging networks), (indoor loud speakers), whereas the general public may be
informed and alarmed via SatWaS, Advanced Sirens systems and Car2X. The European project CHORIST studied multiple alarm devices (EU-project CHORIST), and another EU-Project, OASIS, developed the common alerting protocol which allows transmitting public warnings on a standardised way over diverse warning systems and languages.

The possible transmission technologies used in the modern communication media can be either wired or wireless and include:

a) **Wired technologies**

Data can be transmitted using wired technologies such as

- **Public Switched Telephone Network (PSTN)** is the network of the world's public circuit-switched telephone networks. It consists of telephone lines, fiberoptic cables, microwave transmission links, cellular networks, communications satellites and undersea telephone cables all inter-connected by switching centers which allows any telephone in the world to communicate with any other.

- **Integrated Services Digital Network (ISDN)** is a set of communication standards for simultaneous digital transmission of voice, video, text and other network services over the traditional circuits of PSTN.

- **Digital Subscriber Line (DSL)** is a family of technologies that provides digital data transmission over the wires of a local telephone network.

- **Voice over Internet Protocol (Voice over IP, VoIP)** is a family of methodologies, communication protocols and transmission technologies for delivery of voice communications and multimedia sessions over Internet Protocol (IP) networks, such as the Internet.

- **Power Line Communication (PLC)** are systems for carrying data on a conductor also used for electric power transmission.

b) **Wireless Technologies**

Wireless communication may be used to transfer information over short distances or long distances (Williams, 2008).

1. Long distance wireless communication includes technologies such as:

- **GSM (Groupe Spécial Mobile)** is the world's most popular standard for mobile telephony systems. Both signalling and speech channels are digital. GSM provides also the implementation of the short message service (SMS), also called text messaging. The standard includes a worldwide emergency telephone number feature. Newer versions of the standard are the General Packet Radio
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Service (GPRS) and a higher speed data transmission using Enhanced Data Rates for GSM Evolution (EDGE).

- **Wireless Application Protocol (WAP)** is an open international standard, commonly used for web browsers of mobile devices such as cell phones.

- **Universal Mobile Telecommunications System (UMTS)** is one of the third-generation (3G) mobile telecommunications technologies, which is also being developed into a 4G technology.

- **WiMAX (Worldwide Interoperability for Microwave Access)** is a telecommunications protocol that provides fixed and fully mobile Internet access. The current WiMAX revision provides up to 40 Mbit/s and an update is expected to offer up to 1 Gbit/s fixed speeds.

- **Satellite telephony** uses a type of mobile phone that connects to satellites instead of terrestrial cells. They provide similar functionality to terrestrial mobile telephones. Depending on the architecture of a particular system, coverage may include the entire Earth, or only specific regions.

- **HiperMAN (High Performance Radio Metropolitan Area Network)** and is a standard created by the European Telecommunications Standards Institute (ETSI) Broadband Radio Access Networks group to provide a wireless network communication in the 2 – 11 GHz bands across Europe and other countries which follow the ETSI standard. HiperMAN is a European alternative to WiMAX.

2. Short and very short distance wireless communication includes technologies such as:

- A **Wireless Local Area Network (WLAN)** links two or more devices using some wireless distribution method and usually providing a connection through an access point to the internet. This gives users the ability to move around within a local coverage area and still be connected to the network.

- **Dedicated short-range communications** (Ghosh and Lee, 2000) are one or two-way short- to medium-range wireless communication channels specifically designed for automotive use and a corresponding set of protocols and standards. In October 1999, the United States Federal Communications Commission allocated in the USA 75MHz of spectrum in the 5.9GHz band for DSRC to be used in ITS. Also, in Europe in August 2008 ETSI allocated 30 MHz of spectrum in the 5.9GHz band for ITS. The decision to use the spectrum in the 5GHz range is due to its spectral environment and propagation characteristics, which are suited for vehicular environments - waves propagating in this spectrum can
offer high data rate communications for long distances (up to 1000 meters) with low weather dependence.

- **Bluetooth** is a wireless technology standard for exchanging data over short distances (using short wavelength radio transmissions) from fixed and mobile devices, creating personal area networks (PANs) with high levels of security.

**Traffic Related Communication Media**

The **Transport Protocol Experts Group (TPEG)** has developed a European open standard for the broadcast of multimodal traffic information. It is designed such that it can be delivered via any of the mentioned digital broadcasting systems as well as queried via WiFi or GPRS/UMTS. TPEG provides some general applications for traffic-related data transmission and it is open to create new applications for any application type.

In the transport sector, using the above mentioned technologies, information about the weather, the infrastructure, the traffic conditions etc, can be transmitted either through the infrastructure (**On-Roadway information**) or directly to the user (**In-Vehicle or Off-Roadway Information**).

Traveller information can also be divided into two categories, according to the time it is provided. The first refers to information provided before travelers make trips and the latter during the trips. The dissemination of the information can be transmitted to the users of the infrastructure using various technology systems. In the following diagram (Figure 21), some of the most common information transmission systems are presented according to their **pre-trip** or **en route** use.
Figure 19: Pre-Trip and En-Route Information Transmission Systems

The output devices used to disseminate travel information are:

**Variable Message Signs (VMS)** include variety of different types of signs that display changeable messages to give the users of the infrastructure real-time information on local conditions. VMS may be permanent or portable, placed over-road or by the side of the roadway, displaying text, signs, even video content. Information transmitted through VMS signs may refer to roadway surface conditions, traffic conditions, special events - incidents, speed advisory, adverse weather and environment conditions, traffic control, special use of lanes, etc.

**In-Vehicle Route Guidance Systems - Navigators** may be video display terminals mounted on the dashboard of a vehicle or portable devices that provide real-time route guidance and navigational information to the drivers (Gordon, 2009). The traffic information updates for these navigation systems may be provided by cellular telephone or by satellite radio. They can display information either on a map, which can highlight the recommended route, or by displaying text and simple symbolic signals (such as an arrow). This type of information may even be provided by voice. Moreover, surveillance information may be used to take current traffic conditions into account in the development of route guidance paths.

**Alphanumeric Pagers** are devices that can be used to obtain pre-trip or en route information (Gordon and Tighe, 2005). Drivers can receive for example hourly information on traffic and have various data sent to their pagers. **Personal Data Assistants (PDAs)** can be used in conjunction with radio frequency communications in order to receive real-time traffic information, allowing more detailed information than an alphanumeric pager.

**Mobile phones** are electronic devices used for two-way radio telecommunication over a cellular network of base stations. A mobile phone primarily allows its user to place and receive telephone calls. In addition to being a telephone, new generation mobile phones support additional services such as SMS messages, e-mail, internet access, radio, GPS, Bluetooth and infrared short range wireless communication. In the transport sector, mobile phones can are to access special hotlines or info services with route-specific traffic information using GPRS. Such services can also be acquired through SMS service. Moreover as a cellular system it has broadcast mechanisms, used directly for distributing information to multiple mobiles.

Commercial radio stations often include traffic reports. In addition, there are special radio stations such as the **Highway Advisory Radio (HAR)** (Gordon and Tighe, 2005) dedicated to providing information to travelers and primarily used for freeways. A HAR system, similarly to commercial radio, consists of a radio transmitter to transmit the information and signs informing drivers what radio station to tune to.
**Citizen-Band radios (CBs)** (Martin et. al., 2000) allow two-way communication between the users of the infrastructure and the i.e. Traffic Management Center, and are useful in a driver aid service. Although CB radios are not as popular as they once were, they are still found in a significant number of trucks and commercial vehicles.

In recent years, the **internet** has become one of the most important methods for information dissemination. As a result a computer, connected to the internet, can receive various types of pre-trip information. In addition, many areas have public agencies and private services that display real-time, route specific traffic information that can be accessed through the internet. The internet can also be used to access static information, such as bus schedules, route distance, etc. Internet technologies include:

- modern telegraphy: e-mail, instant messaging
- RSS-feed (news ticker)
- Internet platforms, Web-sites

Many commercial **television** stations provide traffic information, either as a scheduled part of their program, or by interrupting regular programming. Moreover broadcast information services such as Teletext are also provided.

**Information kiosks** may have video monitors mounted on a stand-alone cabinet, in a wall, or on a counter-top. They may have input devices such as keypads, trackballs, or touch-screen displays. Such kiosks may be located in places such as hotels, restaurants, airports, service stations and retail establishments aiming to inform drivers.

**Cooperative Systems (Car2X)** are systems where vehicles communicate either with other vehicles (Car2Car) or with the traffic infrastructure (Car2Infrastructure) based on WLAN, Bluetooth or other, in order to acquire various information.
11 Best practices: Emergency Management ITS

11.1 Classification of IT systems (based on their automation level)

In this chapter a classification of Intelligent Transport Systems (ITS) is undertaken, which aims at pointing out and highlighting the different operational characteristics and capabilities of various Information Technology (IT) systems used in the transport sector as well as corresponding them to certain ‘levels of emergency’ that appear in specific areas and regions. In this sense, and following the rationale of the previous chapter where core technological components were described, in the framework of the current chapter the term ‘intelligent transport system’ corresponds to combinations of various technological components, such as sensors, loops, simulation techniques, software, broadcasting technologies etc that are put together in order to form an integrated (complete) ‘system’ capable of delivering adequate services to the end users (citizens and/or authorities). Thus the Intelligent Transport Systems (ITS) described hereafter, are consisted of various technologies that cover all three phases analyzed in the previous chapter (data collection, processing and transmission), and in relation to the specific mix of technologies that use, present various capabilities and characteristics as well as offer a broad range of services. A question that arises is how these different ITS with different operational characteristics and capabilities could be categorized and matched with specific transport emergency conditions. The obvious answer is that ITS can be categorized with many different ways (in relation to different characteristics) such as the type of services provided, the computational ability, the accurate and updated information provided, the type of technologies used etc. However the purpose is to identify those characteristics that could categorize all types of ITS, and simultaneously, differentiate each application based on their distinct characteristics. For this reason, the classification of ITS is made with the use of three criteria: the type of ITS based on the provided services, the technological process (data collection, processing or transmission) and the automated (or manual) computation. Herein the three classification criteria are explained briefly.

According to Sumit Glosh and Tony Lee, the automated computation indicates whether the decision making process is conducted manually or automated decision-making computer systems are utilized to yield accurate information and achieve precise control and coordination (Sumit Glosh et al., 2000). Therefore a critical characteristic that can be used for the categorization of ITS is the ‘level of automation’. As a result, ITS with automated services could be implemented in locations where the hazard of an emergency is bigger, since the more automated the system is the more accurate and expensive will be.
The other two criteria regard the technological processes the system conducts (as defined in the previous paragraph) and the type of service that the ITS is capable to offer. Concerning the criterion ‘type of service’ three different types of ITS are proposed:

- Informing systems: Concern ITS which are providing information (traffic or/and weather) to the passengers or/and the authorities. These systems do not conduct optimization processes and are usually systems that simply receive information (collect data) and transmit it without further process.

- Systems that propose solutions: These systems differ from ‘Informing systems’ in what concerns the processing of information, which is conducted either automatically or by human intervention. Obviously the systems that conduct the ‘processing data’ procedure automatically, are those utilized in cases with high possibility or/and major impacts of potential emergency events.

- Systems that manage conditions: These IT systems are able of giving information, optimize the data collected and propose ‘optimal’ solutions as well as manage the conditions of the transport network (traffic management). Again, whether traffic management is conducted automatically or by human intervention, the systems are differentiated concerning the ‘level of automation’

The above classification in relation to the three aforementioned criteria is depicted in the following ‘three-dimensional’ Table. Each one of the criteria is represented (and further analyzed) in the respective rows and columns. In relation to the ITS capabilities and characteristics, each system can be categorized on this basis. The green / red colour indicates whether the technological system is capable / incapable of providing the specific process respectively and the A or/and M symbol indicates whether the process is conducted automatically or in a manual way.
Table 18: Classification method of ITS

<table>
<thead>
<tr>
<th>Processes</th>
<th>A: Automatic process</th>
<th>M: Manual Process</th>
<th>A/M: Can be executed either automatically or manually</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weather</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment Surveillance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Mining</td>
<td>A</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Modeling</td>
<td>A</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Decision-Making</td>
<td>A/M</td>
<td>A/M</td>
<td></td>
</tr>
<tr>
<td>General communication</td>
<td>A/M</td>
<td>A/M</td>
<td></td>
</tr>
<tr>
<td>Alarming</td>
<td>A/M</td>
<td>A/M</td>
<td></td>
</tr>
<tr>
<td>Information</td>
<td>A/M</td>
<td>A/M</td>
<td></td>
</tr>
</tbody>
</table>

In the next paragraph, various types of ITS are described and categorized based on the proposed classification.

11.2 Applications and Use Cases

In this paragraph different types of ITS systems are described in order to point out and underline the distinct capabilities and use cases. Hereafter the descriptions of the IT systems are provided.

DISMA, TÜV Rheinland

DISMA is an emergency management data base system developed by TÜV Rheinland (TUV, 2001), which supports emergency planning, simulation and training during the phases of mitigation and preparation. In the phase of response and recovery all tools can be used as a means of preparing decisions.

DISMA has been developed since 1991. 150 implementations (valid for 2006): disaster protection authorities of the federal states Saxony, Mecklenburg-Western Pomerania, Saxony-Anhalt, big cities (Berlin, Duesseldorf, Mainz, Krefeld et al.) and rural districts as well as enterprises.
Data collection process

DISMA uses data bases for the registration and management of persons and objects. Weather information can be incorporated.

Data processing

DISMA assists managing all phases of emergency by means of:

- Calculation of scenarios and determination of dangerous area
- Development of emergency plans (alerting, warning, signalling, evacuation, information etc.)
- Preparation of exercises
- Controlling of protective measures in case of industrial accidents/disasters

Information transmission process

Outputs of DISMA are maps, emergency plans and extracts of data bases.

User Information System of Thessaloniki’s Ring Road

The Ring Road of Thessaloniki is a six lane (three lanes per direction) urban freeway with a total length of 22.5 km and 13 interchanges. Daily more than 100,000 vehicles, including heavy trucks, travel through the Ring Road and the annual rate of traffic increase is at around 5-7% over the last decade.

A system that allows traffic management of the ring road, informing road users before and during their journey, was considered to be an invaluable tool for the city, allowing citizens to make choices about their transportation using real time traffic data. The benefits of such a system are expected to be significant by saving lost man-hours during transportation, reducing fuel consumption and general operating vehicle costs and of course lowering environmental pollution.

The Users Information System of Thessaloniki’s Eastern Ring Road is an Intelligent Transport System (ITS) aiming to serve citizens by providing real-time information on traffic conditions, advanced detection and incident management. Currently the system covers a length of about 12.5 kilometers in each direction of the Eastern part of the Ring Road.

The system consists of the following modules:

- The Roadside Equipment that consists of 5 Variable Message Signs (VMS), Closed Circuit Television (CCTV) with 8 potentially rotating pan-tilt-zoom cameras and 9 fixed cameras linked to a specific Image Detection Equipment for recording traffic data.
• The Traffic Management Center (TMC) equipped with servers, workstations of the system and any necessary software. The software installed is NETworks © Advanced Traffic Management System and is used for all roadside telematics equipment management processes which are performed from experts (working shifts) and is also used to supply the internet web-platform with all collected data (images of cameras, message signs, incidents and traffic speeds).

• The Communications Subsystem using wireless communication protocols IEEE 802.11 (WiFi) and IEEE 802.16 (WiMAX) which link the cameras either directly to the control unit or via repeaters using similar wireless technology.

**Data collection process**

The data collection for the system is achieved through the CCTV cameras collecting images and various traffic data (traffic counts, travel speed, etc) using the appropriate image processing software.

![Figure 20: Images collected from the CCTV cameras](image)

**Data processing**

For the data processing, at the Traffic Management Center, experts evaluate the travel conditions of the road and manually provide adequate real-time information to the users.
Information transmission process

The system is providing users with real-time travel and weather information both through the infrastructure using VMS and through the Internet with appropriate web applications also accessible by appropriate mobile phones. Therefore the public interested about the traffic conditions of the Ring Road, can be informed either en route (VMS, mobile phones) or pre-trip (at home, at work or anywhere else they have internet access).

Figure 21: “Good Traffic Conditions on Ring Road” message transmitted to the driver through VMS1

The chain of data collection, processing and transmission processes of the Thessaloniki’s Ring-road Traffic Control Centre is schematically presented in the following diagram.

Figure 22: Processes chain for Thessaloniki’s Traffic Management Centre.

**Virginia’s Advanced Traffic Management System for Weather-Related Incident Detection**

**Data collection process**

The Virginia Department of Transportation operates an Advanced Traffic Management System (ATMS) to control the highway network in Northern Virginia. The ATMS
includes an Incident Detection subsystem and a Closed Circuit Television (CCTV) subsystem, which are used for traffic and road condition surveillance on 27 miles (43.4 kilometers) of Interstate 66 and nearly 29 miles (46.6 kilometers) of Interstate 395. Traffic managers are able to modify incident detection parameters based upon observed weather conditions.

The Incident Detection subsystem is comprised of inductive loop detectors, Type 170 controllers housed in roadside cabinets, and a central incident detection computer. Traffic flow data is collected at over 120 vehicle detection sites installed every half mile (0.8 kilometers) along the freeways. The CCTV subsystem includes over 50 cameras, video transmission devices, and three monitor walls for display of video images. Fiber optic cable and coaxial cable communication systems transmit data and video from the field to control computers in the Smart Traffic Center located in Arlington.

Data processing

Incident detection computer software contains statistical algorithms that continuously analyze field data to identify traffic flow disruptions caused by incidents. Traffic managers may select databases containing detection algorithms for “clear”, “rainy” or “snowy” conditions. When rain or snow events are observed on the monitor walls traffic managers access the incident detection computer and select the detection database most appropriate for prevailing conditions. The CCTV subsystem is also used to visually verify detected incidents and support incident management activities.

Information transmission process

The use of algorithms tailored to specific weather events improves roadway mobility and safety by facilitating incident detection under non-ideal conditions. Weather-related incident detection enhances mobility by minimizing response time and traffic delays associated with temporary capacity reductions. Safety is improved through expedited incident response and clearance, which reduce the risk of secondary crashes.

MOBIKAT, Fraunhofer IVI

The MobiKat system, developed by Fraunhofer IVI, is a decision support system, which enables relief units to efficiently plan and execute protection and rescue measures (FhG IVI, 2009). Main goal is to maintain mobility of all persons concerned, which also ensures rapid assistance in cases of emergency.

The MobiKat modules aided successfully serious situations of emergency as well as daily operations and emergency management trainings. For example, during the Elbe flooding 2006 MobiKat was used to visualize the situation and the current state of
crisis management, to monitor critical parts of the infrastructure with cameras, to analyse infrastructure and to produce maps for relief units.
Data collection process

MobiKat integrates data from various sources including permanent updating for emergency and traffic management; Included data material are for example the rail and road network, bridges, tunnels, on-going road construction sites, bodies of water, flood plains for two gauging sites, address coordinates with allocation of inhabitants, public transport routes and stops, outlines of buildings, parcel boundaries, critical infrastructure/critical objects, fire stations, rescue and police stations, emergency and disaster management equipment, hydrants, digital terrain model, climbing rocks and orthophotographs.

MobiKat provides a mobile autonomous camera system to monitor dangerous sites as well as mobile terminals for relief units.

It also allows data exchange with DISMA (described above).

Data processing

MobiKat executes planning and operative scheduling for both everyday operations and major damage cases as well as analyses and develops concepts for the evaluation of the road traffic infrastructure and maintaining mobility in major damage cases.

These functions are included:

- optimized selection and scheduling of resources for the fire brigade vehicles, rescue vehicles, etc.,
- scheduling and route planning under consideration of road networks and vehicle characteristics,
- calculation of long haul routes for fire and drinking water with pumping stations for freely selectable route, pressure and hose parameters,
- fire prevention demand planning and area accessibility for the fire brigade and rescue services, etc.,
- resource planning for high-priority emergency and disaster management objects, etc.

Information transmission process

MobiKat supports information flows in cases of emergency by following means:

- data exchange with DISMA,
- situation visualisation: depiction of infrastructure with a freely selectable zoom, detail and layer levels, directed search for objects,
solution visualisation for scheduling and planning.

VAMOS, TU Dresden

Dresden’s Traffic Management System VAMOS was created and developed during several research projects funded by the Federal Republic of Germany and the Free State of Saxony (e.g. "intermobil Region Dresden", 1999 - 2004).

Data collection process

The system links more than 1000 traffic detectors (e.g. inductive loops, infra red devices, video cameras), which are available in this region on urban roads and motorways, as well as floating car data of 500 taxi.

Data processing

Within VAMOS, traffic state estimation is done by means of data fusion and aggregation as well as extraction of traffic patterns.

Information transmission

Based on the determined traffic situation VAMOS actuates different traffic control systems automatically:

- Parking Information System using dynamic display showing names of suggested parking and number of free parking lots and allowing dynamic routing via pivot-mounted arrow
- Dynamic Routing System using trivision billboards
- Traffic dependent traffic light programmes
- Traffic Information system using freely programmable LED displays
- Variable LED Traffic signs

VAMOS also allocates information as a content-provider.

11.3 Further discussion

The primary objective of this section was to provide an overview of innovative technological systems which are used in the transport sector. Firstly, a detailed description of all available technological ‘components’ was realized, emphasizing on the distinct role and functionality of each component in the provision of IT services in the transport sector. Next, a classification method for Intelligent Transport Systems (ITS) was proposed in relation to the capabilities and the range of services that the system
provides as well as to the level of automation. Different types of ITS systems were also described from different areas and capabilities pointing out that each region should determine accurately its needs based on thorough risk analysis, before proceeding with (costly) investments in IT systems.
12 The second WEATHER Project Workshop: ‘Organizing Emergency Management strategies for the transport sector with the use of innovative IT systems’

12.1 General information

The second workshop of the WEATHER project has been carried out in the framework of WP3 ‘Crisis management and emergency strategies’, aiming at pointing out the interconnections and interrelationships between emergency management procedures in the transport sector with their technological advances and organizational challenges. The Workshop entitled ‘Organizing Emergency Management strategies for the transport sector with the use of innovative IT systems’, was carried out in 28 February 2010, in Brussels.

The following paragraphs provide a brief overview of the contents of the workshop. The respective presentations may be accessed through the weather website at www.weather-project.eu/weather/inhalte/proj-events.php.

12.2 Brief description of the Workshop concept

The general rationale behind the second WEATHER workshop was to constitute a ‘closed’, targeted workshop with a restricted number of selected experts, who would present their know-how on the research topics of the project as well as validate and complement the initial research endeavour of WP3.

The Workshop was comprised of two phases; in the first phase each of the selected key experts gave a presentation on a specific, predetermined thematology, while in the second phase a “Round Table” session was conducted with the participation of the key experts and the WEATHER researchers of WP3.

Four (4) key experts were selected to participate in the Workshop: Mr. Vangelis Katsaros from the University of Thessaly and the Greek train operator (TRAINOSE), Mr. Horst Hanke of the German Road Administration, Prof. Giampiero Beroggi from the Statistical Office Canton Zürich and Mrs. Gerlinde Angerhöfer from the Weather Forecast Service (Deutscher Wetterdienst).

The first phase of the Workshop included the following three research domains-thematologies:
WEATHER D3: Innovative emergency management strategies

1. Emergency management planning and operation
2. Organizational and administrative issues of EM in transport sector
3. Intelligent Transport Systems for coping with emergencies in the transport sector

These research domains corresponded to the distinct research directions of the different Tasks of WP3 of the WEATHER Project - concerning emergency management (EM), organizational issues in EM and technological issues in EM respectively. The initial idea concerning the organization of the Workshop was to address all research aspects of WP3 and specifically each research domain to be represented by one (or maximum 2) key expert(s), who would give a presentation related to their expertise.

The second phase of the Workshop, the “Round Table” session provided the chance for an ‘open dialogue’ among the WEATHER researchers and the experts. Each WEATHER researcher as well as key expert had the opportunity to raise important issues - questions to the other key experts regarding their research interests. The overall objective of this phase was to crosscheck the research directions and validate the initial results of the WP with the key experts, as well as decide and resolve on certain key methodological issues based on the experience and advice of the key experts.

A short summary of the presentations of the first phase along with the main discussions and conclusions of the second phase of the Workshop is provided in the next paragraph.

12.3 Workshop discussion and conclusions

*Brief overview of phase I (presentation phase)*

The first presentation entitled ‘Emergency planning and operation’ made by Mr. Katsaros, highlighted the main issues emerged from past disasters/ extreme events from the point of view of civil protection authorities and namely previous experiences from the Central Macedonia Region in Greece.

The key issues that were discussed concerned the following topics:

- Emergency facilities missing: The problem is often located in the lack of soft emergency measures, such as the emergency run pikes for emergency vehicles, emergency plans, and not in the lack of sufficient infrastructure.
• Weather Prediction: The need for having reliable, locally focused and real time information was underlined, in order to inform travelers as well as plan and implement the suitable measures/ actions. E.g. in special locations like high altitudes, snow forecasts should be provided.

• Emergency number calls (112 for Greece): The need for a wider awareness campaign was pointed out, which could lead to saving lives (finding location of people lost)

• Clear chain of responsibilities and sequence of actions: Need for focusing efforts on the most vulnerable areas and also to keep tracking the sequence of events; sometimes secondary impacts of an event affect neighbouring areas (e.g. the tornado in Chakidiki – holiday resort near Thessaloniki- was handled well, however the reaction of the drivers created traffic jam in the network of Thessaloniki).

• Informing Citizens/Tourists/Visitors: The issue of information provision to non natives highlighted as one of the most challenging since there is lack of adequate channels for spreading news and updates

• The role of Media was pointed out, underlining the fact that even though media could be used for information purposes, however the lack of responsibility concerning this cooperation from the authorities side entails irresolution.

• Educating Citizens / Professionals/ Volunteers: Sometimes ignorance and bad attitude leads to accidents, e.g. people ignoring public advice; signs and barriers of police in case of flooding or other events. Thus education on safety and security issues should be promoted.

• Local Risk Assessment/ Plans: Risk assessment and integrated local planning are totally missing in Greece. Single entities (police, fire brigades) operate well, but without any coordination or cooperation. There is the need to strengthen the organizational linkages and structures for enhancing cooperation among different entities.

In the framework of the research domain ‘Organizational and administrative issues of EM in transport sector’, Prof. Beroggi made the second key expert presentation entitled ‘Organizational Decision Making in Crisis Management’. The presentation explored the distinct roles and interrelationships of the involved organizations in emergency management operations and pointed out the key issues for enhancing the cooperation and reaching consensus concerning the responsibility sharing. Prof. Beroggi considered three distinct organizational levels in EM, the response, the strategic and the policy level. Through the examination of three cases studies, key strategies for each of these levels were identified for the improvement of crisis management decision making.
For the \textit{response level}, the Port of Rotterdam was examined as a case study of emergency management operations. The involved organizations in EM operations in the Port of Rotterdam are the Police Department (PD), the Fire Department (FD), the Chemical Advisor (CA), the Medical Officer (MO), and the Port Management (PM). The most crucial organizational issue acknowledged as the main challenge is the achievement of efficient cooperation between all these actors, which have different Standard Operation Procedures (SOP), support means, culture and hierarchical structure. In order to overcome the organizational and institutional restrictions, the concept of improvisation between the organizations was promoted by using groups’ dynamics exercises and implementing the actors into group decision support systems. The key conclusions that emerged from these training exercises are the need to complement SOP with improvisation techniques, the need for strict definition of improvisation when deviating from SOP and continuous promotion through common training exercises and trust building between the organizations, as well as the fact that certain legal issues must be addressed and resolved prior to deviating from SOP.

The second case study referred to the \textit{strategic level} and dealt with the achievement of consensus among safety experts concerning emergency management along transportation routes (during the transport planning phase). Specifically, the main challenge in this case is that safety experts from the involved organizations come to an agreement (consensus) concerning the introduction of emergency planning into the transportation planning process and the exact role and liabilities of each stakeholder in the planning process. The involved organizations (decision makers) in this case were the Fire Brigade, as well as authorities dealing with spatial planning, infrastructure planning and environmental planning. In order to come to a final decision for the selection of the most suitable alternative plan, multi-criteria techniques were used in which each organization representative has evaluated the alternative plans using qualitative scores to a certain set of predefined criteria/indicators (e.g. response time and needs, risks, life quality, costs). The alternative with the highest aggregated score constituted the optimal. The main conclusion emerged referred to the need that experts should only address aspects of safety for which they are qualified for and be free to propose and choose the safety indicators based on their experience and expertise. This way the overall objective of the process is served, which is to adopt an integral approach comprising multiple safety indicators and stakeholders, and thus contributing to a shared view of safety aspects for alternative line infrastructure plans.

At the \textit{policy level}, it was mentioned that many difficulties and problems arise when many actors are disputing over multiple issues concerning the ‘exchanging of power and control’. The case here was how to reach ‘Control-Equilibrium’ when planning Emergency Management for Regional Transportation. The main issues at stake re-
gard the combination of economic viability of the investments together with environmental protection and social sustainability and safety issues and as a result the organizations involved are national/regional public transportation authorities, the Police Department, associations representing small businesses and service providers, the Local Fire Department (in charge of approving construction permits), Local planning authority as well as the Environmental and Spatial Planning Department. In this case, an IT system was utilized to compute 'Equilibrium Control' status, by modeling the Interests, the Control and the Dependencies of each organization (as identified and proposed by them), using game theory and social choice exchange theory. The main conclusions drawn from this case are that trust between actors is a crucial factor and is built in small step negotiations/procedures in order to approach a stable solution. Moreover 'Equilibrium control' is a dynamic goal that changes as the process goes on and so one must keep track of shifting goals throughout the process.

The overall conclusions and key issues concerning IT-based Org-DM are that decision makers and group dynamics should not be under (or over-) estimated (models make suggestions, people make decisions), model results are mere suggestions and leave space for improvisation, wrong models can be good stimulators for communication and consensus reaching and finally Numerical & model sensitivity analysis is required.

The third research domain of the Workshop 'Intelligent Transport Systems for coping with emergencies in the transport sector' included the presentations of Mr. Hanke entitled 'Emergency Traffic Management In the Case of Severe Winter Conditions' and of Mrs. Angerhöfer entitled 'The Weather Information Systems (WIS) of the German Weather Service Provider (DWD): the Road WIS (SWIS) and the Fire brigade WIS (FeWIS)'.

Mr. Hanke discussed about the use and benefits of IT systems for optimizing the provided services of the Winter Maintenance Organization in Germany. Firstly he pointed out the major implications of the climate for the national road network in Germany, relating it with economic figures. The main problem of the German climate constitutes the alternating temperatures around zero as well as the strong variations of temperatures and precipitations over the years. The main effects of the weather conditions are the high reductions of the road network’s capacity (around 50%), significant increase of accident rates and injuries (6 times higher) and other important economical costs such as travel costs (fuel consumption), delay costs, accident costs (insurances) and other costs related to problems with the supply of the population and the industry (production costs).

Then, the role of German Winter Maintenance Organization was described and its means and capabilities for coping with heavy winter events. Winter maintenance (WM) Organization is equipped with modern truck and machinery equipment and
maintains a Winter Maintenance Management System which is connected to 750 local Maintenance Units for providing real time 24h the day strategic operational control (strategic optimized route planning, strategic salt stock provision) in cooperation with the regional Winter Maintenance Centres and the Road Weather Information Systems.

Considering the fact that most likely the winter problems in the transport network will increase, the role of Winter Maintenance (WM) is to identify the most cost-efficient ways for coping with the impacts of winter events in the national level, such as creating economies of scale with central disposition of machinery, having central salt stock provision and management and exploiting the capabilities of IT systems in the transport sector. Especially the role of IT systems was emphasized, which is considered to be the key solution to overcome the lack (or scarcity) of resources as well as the optimal way for the management and control of available resources. As a conclusion, three main areas were stressed for which IT systems support the German Road Administration and in particular the Winter Maintenance (WM) Unit by providing the respective services:

- **Weather Forecast and Detection:** Through the use of ice warning and road monitoring systems, WM is in position to conduct weather forecasts as well as micro-road weather forecasts (local level), informing and supporting the work of local authorities (winter road service, police, local ITS Traffic Centres, meteorological authority).

- **WM Planning and Operation Control:** IT systems provide support concerning the operation planning and on line recording, the monitoring of road surface conditions, the controlling of winter maintenance operations, the alerting staff and contractors. The example of winter 2010/2011 was discussed, in which the support of IT systems was underlined, mainly focusing on the distribution optimization and management of the salt stock capacity.

- **Traffic Guidance:** In cooperation with Traffic Centres, IT systems support WM providing traffic guidance through Variable Message Signs on the roads (VMS), lane blocking, speed limits, warning signs, route guidance, traffic Information by radio (TMC) and pre-trip information by internet and teletext.

Finally, the presentation of Mrs. Angerhöfer focused on the capabilities and services of two IT systems of the Weather Forecast Service (Deutscher Wetterdienst - DWD), namely the SWIS (Road Weather Information System) and the FeWIS (Fire brigades Weather Information System).

The main objective of the Road Weather Information System ‘SWIS’ is to provide weather information to maintenance staff. The utility of SWIS is that operates as a central system, collecting information from 120 Road Weather Systems (RWS) lo-
cated in 16 Federal States all over Germany, and providing this information to DWD in a structured format. By elaborating this information, DWD is in position to deliver a number of services such as:

- Special road weather forecasts - at a macroscopic (city) as well microscopic (point) level for all the RWS locations
- General weather information (weather reports, forecast charts)
- Data archive and exchange

The specific information that DWD (through SWIS) is capable of providing includes indicators for cloud amount, precipitation, wind as well as for road surface temperature and road conditions for major and minor roads and bridges in Germany. It is noteworthy that this information is provided to the road maintenance staff of the Federal States but not to the public. Conclusively, the role and contribution of SWIS to the Federal States (responsible for the Road Maintenance) involves the following attributes:

- Optimization procedures for maintenance staff
- Faster road clearing and gritting
- Less reduction of traffic in case of wintry conditions
- Better planning for transport companies (time needed, alternative routes)
- Reduction in costs of winter service

The second IT system described (FeWIS), aims at providing information to fire brigades for disaster management purposes. FeWIS supports a multi-level warning system, in which all spatial and temporal scales of warning information are closely connected. Following the German Disaster Management organizational structure, FeWIS provides information to local level (12 to 0 h ahead), regional level (24 h ahead) and national level (7 to 2 days ahead). Weather warnings are correlated to certain predefined and established criteria and thresholds, resulted from past weather experiences and operations. FeWIS has 27 different types of warnings, which are well defined and regularly evaluated in cooperation with disaster management. FeWIS services include among other the following:

- Individual composition of warning information
- Current weather and forecasts
- Webkonrad - Thunderstorm identification and prediction
- Forest fire danger index
WEATHER D3: Innovative emergency management strategies

- HEARTS - dispersion of toxic substances
- Flooding information (link)
- Basic climate information for regional risk analyses

The aforementioned services are provided to the interesting cooperating authorities (Fire Brigades, Relief Organisations, Police and Regional Emergency Centres) as well as to the public (through the internet). Conclusively, the role and contribution of SWIS to the Federal States (responsible for the Road Maintenance) involves the following functionalities:

- Supports optimizing disaster management operations
- Provides detailed storm warnings for rural districts
- Facilitates quick operational decisions
- Leads to the better organization of operations (in terms of time needed, alternative routes identification etc)
- Entails the reduction in costs of operation

Brief overview of phase II (round table phase)

The objective of this phase was to encourage an ‘open dialogue’ between the WEATHER Project researchers and the key experts as well as to clarify and validate certain methodological approaches and assumptions of WP3. The discussion was driven by a series of questions set by the participants, on which all experts had the chance to express and describe their personal view. In the following paragraphs, the main points of the discussion are summarized.

To begin with, it was mentioned that two important aspects of emergency operations are addressed in the framework of WP3: the holistic approach (all-hazards) of emergency management extended to the policy level, as well as the incorporation of risk analysis into emergency management as part of the operational strategy definition procedure. These two issues give room for further developments in EM operations, both in technological and organizational level.

Concerning the technological dimension of Emergency management in the transport sector, it was underlined that even though technological investments often prove their added value in terms of EM operational readiness, yet are often rejected for political reasons. Emphasis was given to the fact that willingness to pay from the side of politicians is highly related to the community’s (people) perception of the respective risks. A representative case constitutes the nuclear accident in Japan; it has changed
people’s perception concerning the risk of having nuclear plants near their location and thus a future investment of this type would require more controls and safety measures.

Another issue is that there are many costs even in cases of no risks (e.g. due to traffic delays because of snow-need for maintenance) and that these costs should be also taken into account if one is willing to invest in ITS. The main issues discussed concerning innovative components or procedures that could enhance current emergency management practice are:

- Standard messages via mobile phones before travelling (tourists - where to find them).
- Linking of data from different sources and companies / organisations. Example: open-gov by US government. Open source technology and data exchange via Schnittstellen, standard protocols could be an option.
- Different formats for different target groups. Customised information is important for acceptance of services. Innovation: integration of various different systems / data sources in a single user interface. Integration and customisation of systems. Problem: transfer of different formats.
- Develop and further connect existing systems. Good practice: truck-info from Switzerland. System includes road weather plus rail timetable. Maybe more easy there as drivers can be forced to use the rolling motorway.

Although there are certain difficulties for defining and investing in the optimal technological solutions for coping with EWE, it seems that the organizational issues are even greater. A main problem is the denial of different organizations to adopt a unified approach (guidelines) concerning operational procedures. The problem is intensified when moving from regional to national, cross border and international (e.g. European) level. An additional dissolving parameter towards this direction is the differentiation on cultural issues - different perception of risk between the different countries in a macro-level and between the different organizations in the micro-level.

Thus as a result, organizational issues surpass the technological barriers (given the availability and existence of technology). Main organizational issues are the culture (what we think is important as an organization) and the power (responsibility sharing) among the involved parties when cooperating (e.g. civil protection in Greece versus fire fighters in the Netherlands).

Additional organizational issues that were raised concerned:

- Cooperation problem concerning information exchange: Cooperating authorities maintain different information systems with distinct demands and outputs. In case of good cooperation (German Road Administration), each system de-
livers exactly the information required (e.g. weather information system to road maintenance and fire brigade platform).

- EM Organizations is important to work under emergency (and not normal) conditions, in order to be able to surpass the difficulty to move from day-to-day procedures to emergency case procedures. It was also stated that it would be useful to have a distinct (trained) body assigned only with the operational part of EM. Another argument towards this direction is the fact that many bodies (e.g. DB) do not have or operate under any risk management system and thus in these cases an external operational organization should be designated to step in and take over decision in emergency cases.

- There are certain cases in transport systems failures which could constitute win-win cases for all the actors involved (different transport systems as well as passengers). However, lack of responsibility as well as lack of a dedicated person creates operational and cooperation gaps because nobody is willing to take decisions and move the procedure. E.g. even though the Italian railways could earn money from other modes with service provision problems, they did not increase their capacity.

- Regarding best practices in EM: IT-Based information is one of the most innovative and rapidly changing fields. It was argued that there is no point at looking back to technological best practices of the past 2 years, as they are already outdated. The value of IT systems and platforms in EM is in their use and not only their technology.

- Intermodality: Intermodality is an important aspect and would be useful in cases of emergency. However, it is purely an organizational issue which the different involved parties (or the state) have to promote and resolve it in order to work and support EM operations. An important issue (barrier) that arises is the responsibility of coordination in joined operations.

- Participation of the Private sector in EM operations: In cases where private companies operate in competitive environment could efficiently support (or replace) public bodies in emergency operations. On the other hand, where monopolistic private companies are in charge, do not provide the desired level of services.

- Methodological focus in the road sector: The most dominant and challenging sector of EM operations is the road sector since it is self-organised and thus presents more necessity for direction. Air and maritime transport are naturally dealing with safety due to excessive air safety instructions. On the contrary the road sector is self-responsible for safety and furthermore what differentiates road is the number and type of users. Although in all other transport sec-
tors professionals / experts are in charge of the navigation, in the road sector all users decide and operate on their own. Thus, road sector and the road transport system is expected to receive the attention when dealing with organizing and optimizing emergency management operations.
PART C: POLICY GUIDELINES
13 Overall conclusions

13.1 General remarks

The main objective of the current report was to link the impacts of extreme weather events (EWE) on the transport sector (and particular in the road) with emergency management strategies. This has proven to be a rather difficult task since there are different interactions and implications between those three attributes: The implications on the transport system, the emergency management planning and organization and the various types of extreme weather events.

The aim of this chapter is to summarize the results and conclusions drawn from the previous sections in a form of policy guidelines. The initial findings and theoretical conclusions of WP3 indicated that there are two main categories of aspects when considering the enhancement of emergency management strategies in the transport sector for coping with extreme weather events: the organisational and the technological aspects. However before proceeding with the more detailed and targeted policy considerations concerning the technological and organisational issues of Emergency Transport Management, it is important to provide a short note on policy issues in general as well as a brief discussion on the different 'levels' of policy making.

13.2 Policy issues and priorities

Policy development is usually a "top-down" process, in that the central authority will prepare policy, and further decentralized policies may then be required. Policy is required to ensure that common goals are pursued within and across organizations, and that common practices are followed. Without agreed policies, efforts are fragmented, leading to lack of coordination and poor results.

Policy may also be created at all administrative levels of an organization or country, and be developed in consultation with those who are required to implement it. This ensures that a policy is realistic and achievable, and gains the commitment of those responsible for its implementation. Even though policies between different administrative levels are common, it is often a necessity to further particularize the policies (along with their actions) when going from the strategic (national, international) to the local level. Below, different sets of policy guidelines are provided, in respect to the different administrative levels (international - national and regional - local).

General policy guidelines for Emergency Transport Management in the national level

Comprehensive and integrated emergency management is a shared responsibility between all levels of governments, the private sector, non-governmental organizations and individual citizens. Threats and risks have become more complex, which
has led many governments to increase their focus on emergency management issues. Herein are given a set of high-level policy guidelines for emergency management addressed to national level:

1. Identify the risks that are within areas of responsibilities and base emergency management plans on the assessment of risks, including those related to critical infrastructure.

2. Develop emergency management plans that address, where appropriate, the risks and interdependencies to strengthen the resiliency and the protection of critical infrastructure within or related to the areas of responsibility.

3. Include in the emergency management plans facilitation of collaboration, both within and across sectors, through sector networks and other relevant sub-sector networks, if responsible for a critical infrastructure sector.

4. Include in emergency management plans any measures to assist provincial and territorial governments and, through the provincial, territorial governments, local authorities.

5. Establish internal structures to provide governance for departmental emergency management activities and make those consistent and interoperable with government-wide emergency management structures.

6. Address each function of emergency management in the emergency management planning process, and where appropriate be responsible for:

   **Mitigation/Prevention:** Conduct mandate-specific risk assessments, including those affecting critical infrastructure, within or related to their area of responsibility, based on all-hazards risk analysis and risk assessment methodology.

   **Preparedness:** Conduct or participate in exercises to test and implement emergency management plans and participate in training with respect to emergency management planning.

   **Response:** Align event specific and departmental plans with the Federal Emergency Response Plan in order to contribute, when requested, to an integrated Government of Canada response.

   **Recovery:** Undertake post-recovery analysis and incorporate lessons learned and best practices into emergency management plans.

The issue that is raised at this point is how these general emergency planning principles are transferred to the transport sector and incorporated in the framework of Emergency Transport Management (ETM), which constitutes a part of the Strategic Emergency Management in the national level. Referring to ETM and extreme
weather events, cooperation constitutes the key issue for promoting promising emergency transport strategies. Whereas cooperation can be distinguished into:

- Inter-modal: cooperation between modes of transport and affiliated actors (e.g. operators, undertakings, infrastructure managers)
- Trans-sectoral: cooperation between sectors (e.g. public authorities, NMS, industry), and
- Trans-regional: cooperation between regions and across political boundaries.

Taking into account the aforementioned herein is given a list of recommendations for effective emergency transportation plans in relation to extreme weather events. The list below constitutes a roadmap with general policy guidelines and best practices for transportation professionals and policy makers dealing with the organization of Emergency Transport Management in cases of extreme events:

12. Include disaster response to extreme weather events as part of all transportation planning procedures (local, regional, national, transit, etc.). Consider the entire range of possible extremes weather impacts on the transport system and consider the widest range of possible solutions.

13. Identify and allocate the roles and tasks during extreme weather event emergencies. Coordinate regionally so that there is a clear chain of command concerning transportation issues during extreme weather events.

14. Update emergency transport response plans regularly, particularly after a disaster tests its effectiveness.

15. Establish a system to prioritize evacuations based on factors such as geographic location (evacuate the highest risk areas first) and individual need and ability.

16. Create communication and support networks that serve the most vulnerable people. Establish a system to identify and contact vulnerable people, provide individualized directions for their care and evacuation and establish a chain of responsibility for caregivers.

17. Coordinate vehicle rentals and fuel supplies as well as provide special services (information, water, food, washrooms, medical services, vehicle repairs, etc.) along evacuation routes.

18. Be ready to quickly deploy buses, vans and trains. This requires an inventory of such vehicles and their drivers and clearly established instructions for their use.
19. Give buses and other high-occupancy vehicles priority where critical resources (road space, ferry capacity, fuel, repair services, etc.) are limited.

20. Coordinate fuel, emergency repair and other support services.


22. Train employees to know what is required of them in the event of an emergency. Make sure they are prepared psychologically as well as physically.

These general policy principles can be applied to any country or region. However, local communities often present particularities and in these cases the strategic policies must be adjusted to the local conditions and circumstances.

**General policy guidelines for Emergency Transport Management in the local level**

Policy making with regard to Emergency Transport Management (ETM) in the local level has to take into account certain facts and realities of the area under examination. The major issues that are concerned belong to the broad categories of organisational and technological aspects. More specifically the organisational aspects refer to cooperation issues between the different authorities, responsibility sharing as well as the assessment of risk analysis for identifying the suitable technological investments and manage more effectively the recourses. These issues have to be resolved and balanced taking into account the ‘culture’ of the local community. Specifically, policy making with regard to Emergency Transport Management (ETM) in the local level needs to find a solution for the trade-off between the aspired performance of transport systems and the required level of safety in the local community. Therefore the main task of the policy framework concerning ETM is to set the values which determine the level of risk acceptance, i.e. to define the socially and economically acceptable extent of impacts on transport (e.g. in terms of annual delay minutes or number of re-routings caused by adverse weather events). Thus the level of risk acceptance defines what impacts on transport related to a certain extreme weather event will be perceived as adverse. The level of risk acceptance is essential to decide on whether ETM should be implemented and which measures should be applied (Beroggi 2011).

Table 19 summarizes the main policy issues in the local level, along with the respective (more targeted) strategies and their relative costs and implications.
Table 19: Main Policy issues in the local level

<table>
<thead>
<tr>
<th>POLICY ISSUES</th>
<th>Supporting Actions / Strategies</th>
<th>Cost</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational aspects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment of hazard and vulnerability of transport systems (infrastructure and processes) to extreme weather events</td>
<td>Risk analysis of transport systems regarding extreme weather events</td>
<td>None</td>
<td>More effective allocation of personnel and equipment</td>
</tr>
<tr>
<td>Responsibility sharing in relation to the existing resources and needs</td>
<td>Organization and conduction of common exercises, negotiation techniques between authorities, role games/simulation, group dynamics</td>
<td>Insignificant</td>
<td>More effective emergency planning to extreme weather events and efficient response</td>
</tr>
<tr>
<td>Promotion of cooperation between local authorities</td>
<td>Sign of agreements, establish communication networks and a platform to exchange best practices in weather-related emergency transport management</td>
<td>Insignificant</td>
<td>More effective inter-modal coordination and wide-spread knowledge about best practices, integration of weather data in ETM</td>
</tr>
<tr>
<td>Enhancement of communication between the different types of authorities (weather, traffic, civil protection etc)</td>
<td>Common EU standards on e.g. the format and content (message standards) of weather information and traffic warnings</td>
<td>None</td>
<td>More easier and consistent inter-modal, trans-sectoral, and trans-regional communication and information</td>
</tr>
<tr>
<td>Technological aspects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determination of technological equipment needed for traffic management and control</td>
<td>Review and benchmarking of available technological ITS solutions</td>
<td>Implementation and maintenance</td>
<td>Improvement of traffic management, automation of services, integration of services</td>
</tr>
<tr>
<td>Explore technological developments for organisational purposes</td>
<td>Examine opportunities for resolving organisational barriers with the use of technology (robots, agents)</td>
<td>Unregistered</td>
<td>Easy and quick solution of organisational issues concerning responsibility sharing, cooperation etc</td>
</tr>
</tbody>
</table>
It is noteworthy the rising research interest during the recent years on exploring technological developments for organisational purposes. As it has already been mentioned, the vast majority of barriers in organizing Emergency Transport Management concern organisational issues. Thus, in the near future, new research trends such as the utilization of robots and agents for resolving negotiation issues in responsibility sharing as well as communication and standardization procedures, constitute an interesting and promising venture.
Outlook of WEATHER Project Deliverable 3: Innovative Emergency Management Strategies

Thessaloniki, 28.4.2011

14.1 Comparison of objectives and results

The following table compares the objectives of WP3 “Crisis management and emergency strategies”, as indicated in the WEATHER Technical Annex, and the results of the Deliverable 3 "Innovative Emergency Management Strategies", which has been specifically designed to address the objectives of the WP3. It is noteworthy that Deliverable 3 has also tackled additional issues, beyond the scope of WEATHER Technical Annex description of work. These issues are briefly discussed after the ‘original’ objectives of WP3.

**Objective 1: Work out efficient and innovative mechanisms of managing disastrous events with particular emphasis on maintaining the service function of transport networks in an intermodal context**

This objective as explained in the Technical Annex of the WEATHER Project is motivated from the failures and success stories observed in past natural catastrophes. It has been conducted an extensive literature review which identified the current and best practice of emergency management in the transport sector. The concept of Emergency Transport Management was introduced as well as its significance for was maintaining the service function of transport networks is discussed together with proposed targeted policy recommendations.

**Objective 2: Quantify costs and likely benefits of efficient emergency management structures**

The activities in this WP will entail the identification and analysis of related cases and literature review, the identification of organization aspects related to emergency management procedures and Information Technologies needed.

The contribution focuses the organizational and informational aspects of weather-related emergency management especially in rail and road transport. The research followed a holistic approach, i.e. emergency management has been regarded as essential element of risk management. The likely benefits of weather-related emergency management structures regarding organization, information, and cooperation were identified. The work was based on a review of available studies, reports, guidelines, numerous expert interviews and the results of a workshop. The research framework included three main steps:

- **Organization**
Weathervane D: Innovative emergency management strategies

- Description of the four phases and the basic activities of emergency transport management with regard to extreme weather events
- Identification of the characteristics of weather-induced emergencies and their implications for emergency management structures
- Development of a framework in order to integrate meteorological risk into emergency transport management
- Identification of relevant actors in emergency transport management
- Discussion of barriers to the integration of meteorological risk and adequate strategies to overcome these barriers
- Presentation of good practice examples

- **Information**
  - Identification of the benefits of meteorological information for emergency transport structures
  - Availability and role of severe weather warnings in emergency transport management
  - Cost and benefits of road weather information
  - Description of the information flow and the roles of involved actors

- **Cooperation**
  - Inter-modal, trans-sectoral, and trans-regional cooperation
  - Transferability

The respective costs and benefits of efficient emergency management structures are illustrated in the Table below.

**Table:** Representation of the costs and benefits of the various efficient emergency management structures

<table>
<thead>
<tr>
<th>Efficient emergency management structures</th>
<th>Brief description of the structure/strategies or issues concerned</th>
<th>Costs</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment of hazard and vulnerability of transportation systems (infrastructure and processes) to extreme weather events</td>
<td>Risk analysis of transport systems regarding extreme weather events</td>
<td>None</td>
<td>More effective allocation of personnel and equipment</td>
</tr>
<tr>
<td>Gathering of weather-related impact data</td>
<td>Systematic gathering of direct and indirect impacts of extreme weather events on</td>
<td>None</td>
<td>More effective emergency capacity building to extreme weather</td>
</tr>
</tbody>
</table>
Objective 3: To deepen the insight into the new organisational and technological challenges of emergency management in the transport sector for coping with extreme weather events, a WP3 Workshop with inviting transport professionals and aid organisations in crisis and emergency management will be organised. The participants will be encouraged to discuss on experiences, risks threats, best practices and emerging opportunities in Europe and worldwide.

The second workshop of the WEATHER project has been carried out in the framework of WP3 ‘Crisis management and emergency strategies’, aiming at pointing out the interconnections and interrelationships between emergency management procedures in the transport sector with their technological advances and organizational challenges. The Workshop entitled ‘Organizing Emergency Management strategies for the transport sector with the use of innovative IT systems’, was carried out in 28 February 2010, in Brussels.

The Workshop was comprised of two phases; in the first phase each of the selected key experts gave a presentation on a specific, predetermined thematology, while in the second phase a “Round Table” session was conducted with the participation of the key experts and the WEATHER researchers of WP3.

Four (4) key experts were selected to participate in the Workshop: Mr. Vangelis Katsaros from the University of Thessaly and the Greek train operator (TRAINOSE), Mr. Horst Hanke of the German Road Administration, Prof. Giampiero Beroggi from the Statistical Office Canton Zürich and Mrs. Gerlinde Angerhöfer from the Weather Forecast Service (Deutscher Wetterdienst).

The first presentation entitled ‘Emergency planning and operation’ made by Mr. Katsaros, highlighted the main issues emerged from past disasters/ extreme events
from the point of view of civil protection authorities and namely previous experiences from the Central Macedonia Region in Greece. The presentation highlighted the main organisational and technological challenges that the Civil Protection Authorities need to tackle for setting up an efficient emergency management system.

Prof. Beroggi made the second key expert presentation entitled ‘Organizational Decision Making in Crisis Management’. The presentation explored the distinct roles and interrelationships of the involved organizations in emergency management operations and pointed out the key issues for enhancing the cooperation and reaching consensus concerning the responsibility sharing.

Dr. Hanke made the third key expert presentation entitled ‘Emergency Traffic Management In the Case of Severe Winter Conditions’. The presentation discussed about the use and benefits of IT systems for optimizing the provided services of the Winter Maintenance Organization in Germany.

Mrs. Angerhöfer made the last key expert presentation entitled ‘The Weather Information Systems (WIS) of the German Weather Service Provider (DWD)’. Mrs. Angerhöfer focused on the capabilities and services of two IT systems of the DWD, namely the SWIS (Road Weather Information System) and the FeWIS (Fire brigades Weather Information System).

Finally, the second phase of the Workshop, the “Round Table” session provided the chance for an ‘open dialogue’ among the WEATHER researchers and the experts as originally planned in WP Technical Annex. Each WEATHER researcher as well as key expert had the opportunity to raise important issues - questions to the other key experts regarding their research interests. The overall objective of this phase was to crosscheck the research directions and validate the initial results of the WP with the key experts, as well as decide and resolve on certain key methodological issues based on the experience and advice of the key experts. Significant conclusions have been emerged, which contributed and reinforced the initial research directions and results of WP3. A more detailed description is provided in chapter 12 of D3.

**Objective 4: Enhancing the understanding of the inter-relationship between policy structure, new and innovative technologies and transport system characteristics will be deepened.**

This is an additional objective that has been placed in order to better demonstrate the work conducted in the framework of WP3. Even though this was not stated as a primary objective of WP3 (only mentioned in the introductory description of WP3 in the Technical Annex), the relative information and analysis provided in D3 is considered of high importance.


14.2 Overall achievement

The comparison of planned and actually achieved results within this work package of the WEATHER project reveals that the goals have been met. All objectives were tackled as well as a few complementary (but important) issues. Furthermore, for the first time it has been linked in a clear way the concept of Emergency management with extreme weather events for the transport sector. The conclusions drawn from the literature review as well as the targeted Workshop concerning the significance of the organisational issues and the role of technological developments in EM provide genuine added value to the research endeavour of the WEATHER Project.

Nevertheless, the issues examined were not fully balanced, as not all modes have been looked at with equal intensity. This fact can be justified with two reasons:

1. The first reason is that WP3 as well as the entire WEATHER Project initially aimed at the identification of emergency management structures (and adaptation measures in general) for all transport modes in relation to all extreme weather events. As the research was moving forward, certain assumptions and restrictions had to be introduced in order to safeguard a useful research output for the transport modes analyzed.

2. The second and more crucial reason (as it turned out to be) was that the significance and importance of enhancing the emergency management procedures differ from mode to mode. This can be partly explained due to the fact that each transport mode presents a different degree of level of automation (ITS use), established standards as well as organisational structures. It was pointed out that the road sector constitutes the more ‘uncontrolled’ sector and that the main focus should be given in this sector in order to reach the (already established) emergency management strategies of the other sectors (aviation, maritime and railway sector). Another reason that justifies the focus of D3 in the road sector apart from the fact that constitutes the more ‘autonomous’ sector, meaning that drivers act in an, is that constitutes the sector which is affected the most by extreme weather events (in terms of accidents and number of people involved) as well as provides the greater accessibility (to local communities and dispersed areas) in cases of emergency.

Finally it must be mentioned that subsequent work in this project in the framework of WP4 (with the examination of adaptation measures for all transport modes), as well as parallel research in this area currently funded by DG-RTD and DG-MOVE should help closing gaps and deepening the analyses initiated by this study.
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