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**Approval of this report:** MSG, European Commission

**Summary of this report:** This deliverable presents a review of occurrence of delay in air travel, of the role of weather, and of policy guidelines to reduce delays, notably when caused by adverse weather. Furthermore, the EU is compared to the US, China and Australia.

**Keyword List:** Aviation, customer protection, transport delays, punctuality, rail, resilience,

**Dissemination level:** Public (PU)
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<td>UA</td>
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# Table of Contents

Executive Summary .................................................................................................................. 6

1. Introduction ....................................................................................................................... 9
   1.1. Purpose and structure of MOWE-IT ........................................................................... 9
   1.2. Purpose and structure of this deliverable ..................................................................... 10

2. Levels and causes of delays and cancellations .................................................................. 12
   2.1. Reported delays in aviation ....................................................................................... 12
   2.2. The role of weather .................................................................................................... 15
   2.3. Cost of delay .............................................................................................................. 17
   2.4. Massive, long lasting disruptions – The Ash Cloud incident ..................................... 18
   2.5. Weather services and delay reduction ....................................................................... 20
   2.6. Comparing delays for different modes ...................................................................... 22

3. Air freight market in EU .................................................................................................... 26
   3.1. Main features of air freight ......................................................................................... 26
   3.2. Trends and Intermodal issues for air cargo industry: ................................................ 28

4. Passenger protection – regulations and (mal)performance ............................................. 33
   4.1. Introduction ............................................................................................................... 33
   4.2. Summary review of current regulations ................................................................... 33
   4.3. The limitations of regulatory approaches – what next? ............................................ 37

5. Lessons from outside Europe for natural hazard contingency management .................. 39
   5.1. United States ............................................................................................................. 39
   5.2. People’s Republic of China ....................................................................................... 43
       5.2.1. Overall situation ................................................................................................. 43
   5.2.2. Air traffic management ......................................................................................... 43
   5.2.3. Delays and weather ............................................................................................. 44
   5.2.4. Passenger rights ................................................................................................. 45
   5.3. Australia .................................................................................................................... 46
       5.3.1. Air Passenger Rights ......................................................................................... 46
       5.3.2. Flight Delays and Cancellations ........................................................................ 47
       5.3.3. Compensation for Delays and Cancellation ..................................................... 48
       5.3.4. Complaint Handling Procedures ....................................................................... 49
       5.3.5. Airport Performance and Preparedness ............................................................ 50
       5.3.6. Conclusions and Future Actions ...................................................................... 51

6. Towards integrated customer friendly natural hazard contingency management .......... 53
   6.1. Introduction .............................................................................................................. 53
6.2. Estimates of stranded passenger accumulation and air rerouting capacity..................................................53
6.2.1. Rebooking........................................................................................................................................53
6.2.2. Diversion...........................................................................................................................................55
6.3. Substitution air - rail.................................................................................................................................60
6.3.1. Background.......................................................................................................................................60
6.3.2. Interfaces between airports and rail networks.....................................................................................61
6.3.3. Increasing network size and capacity..................................................................................................65
6.4. Review of long distance travel mode substitution potential in Europe between air and ferry transport.................................................................................................................................66
6.4.1. Ferry links: Finland (Helsinki) – Sweden (Stockholm) and Finland (Helsinki) – Estonia
(Tallinn)......................................................................................................................................................67
6.4.2. Ferry link: Athens - Crete.....................................................................................................................68
6.4.3. Ferry links: UK – Continent................................................................................................................68
7. Lessons and prospects...................................................................................................................................71
7.1. Lessons....................................................................................................................................................71
7.1.1. Delays..................................................................................................................................................71
7.1.2. Climate change......................................................................................................................................71
7.1.3. Traveller protection regulation and other resilience enhancing policies............................................72
7.1.4. Spare and substitute capacity.............................................................................................................73
7.2. Response dimensions and resilience.........................................................................................................73
7.3. Prospects for improvements.......................................................................................................................75
7.4. Interaction with other policies...................................................................................................................78
8. Conclusions and recommendations...............................................................................................................81
Bibliography...................................................................................................................................................85
ANNEX 1: Regulations for passenger rights in various public transport modes ..................................................91
    Air Transport..............................................................................................................................................91
    Rail Transport...........................................................................................................................................93
    Maritime Transport.......................................................................................................................................94
ANNEX 2: Outline and example output from EUROCONTROL WX Risk Assessment Project & Tool......96
List of Figures

Figure 1: Work package structure of MOWE-IT ........................................................... 10
Figure 2: The logic and structure of this deliverable ..................................................... 11
Figure 3: Delayed flights and delays caused by weather 1997-2012 .................................. 13
Figure 4: Daily delay per flight and per delayed flight on European flights 2012 ............ 14
Figure 5: The share of delayed flights and delay minutes for delays of different lengths in Europe 2012 .......................................................... 15
Figure 6: Share of weather of delays in 2012 in Europe ................................................. 16
Figure 7: Monthly delay minutes caused by weather in Europe in 2012 ......................... 17
Figure 8: Impact of improved capacity .......................................................................... 22
Figure 9: Punctuality of train services in selected countries ........................................... 24
Figure 10: Cargo transport volume in tonnes at Schiphol airport for the years 2013 and 2012;........ 28
Figure 11: Schiphol airport freight volumes in tonnes by region March and December 2013, inbound and outbound .................................................................................... 29
Figure 12: Weather delays in the U.S. air system ............................................................. 40
Figure 13: Aviation market development in China 2008 - 2012 ........................................ 43
Figure 14: On time departure and arrival for participating domestic airlines in Australia since December 2008 ......................................................................................... 48
Figure 15: Cancellation rate for participating domestic airlines in Australia since December 2008 .......................................................... 48
Figure 16: Types of Complaints ....................................................................................... 49
Figure 17 Number of complaints per 100,000 passengers by airlines................................. 50
Figure 18: Passenger traffic volume and passenger load factor in Europe in 2012 ............... 54
Figure 19: The discussed case area. Figures in cursive are the distances from an airport to the associated city .............................................................................................. 56
Figure 20: Hourly estimates of substitution need and capacity at Frankfurt in January ........ 57
Figure 21 Hourly estimates of substitution need and capacity at Schiphol during July ........ 58
Figure 22: Maximum beeline speed of fastest railway connections between major European Metropolises ........................................................................................................... 65
Figure 23 Map of motorways of the sea ............................................................................. 66
Figure 24: International short sea passengers and Channel Tunnel passenger, 1957-2013 ....... 69
Figure 25. Development of delay cost with constant Figure 26. Development of delay cost with extra policy (costs in million Euro of 2014) policy (costs in million Euro of 2014) ........................................ 76
Figure 27 The overall policy field for transport resilience management ............................. 80
Executive Summary

This report aims in the first place at providing policy guidelines for user protection, long term resilience of operations, and cross-modal transferability for European air travel in case of disruptions. Furthermore, in conjunction with cross-modal transferability the report also pays attention to the resilience capabilities of other modes, notably (intercity) rail. The report also includes a review of these practices outside Europe.

Delays

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

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

The projected effects of climate change affect all modes. For aviation the effects seem to have mostly no large implications. Exceptions are airports in flood prone areas. For road systems occasionally reinforcement of infrastructure may be necessary, e.g. owing to growing flash flood risks. Railroads seem most prone to effects of climate change, which is possibly due a significant share of flood prone routes (river banks, sea side), which in turn relates to a combination of avoidance of steep gradients and of high tunnel costs. In addition heat waves may cause more interruptions due to buckling. For all types of infrastructure, and notably for road and rail networks, it is recommendable to enhance the asset management systems of these networks so as to better monitor and predict wear and tear, and optimize the timing for small and large maintenance.

Passenger protection regulation

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

Passenger protection regulation in the US offers a less generic coverage for delays than the EU regulation, but many major US airlines do offer facilities for costless rebooking, hotel and meal vouchers, etc. US has also set up a system of mutual assistance of airports (and airlines) by aviation region. All in all the regulations and voluntary arrangements are less costly than the EU regulation. The level of delays is
somewhat higher in the US, notably due to more extreme weather events, but it does not differ crucially from European figures. The passenger protection level in Australia is by and large comparable to the level in the US.

Delays are a more serious problem in China, with about 25% of all flights being at least 30 minutes late (as compared to about 7% and 10% in Europe and the US respectively). The continued strong growth in air travel causes chronic capacity shortages in China. China does have passenger protection guidelines, but these are non-binding. Major Chinese airlines do offer compensation for delays and occasionally for cancellations, but the amounts are appreciably smaller than in Europe.

Existing complementary policies for delay reduction in Europe are the further development of flexible use of military and civil air space, further enhancement of aviation weather services, and fitting the state-of-the-art equipment for guidance during approach and landing on significant airports lacking some of these devices (SESAR programme). In addition new policy approaches could be introduced which would promote exploitation of spare capacity, facilitate inter-modal substitution, and incite airports to optimize passenger flow handling and flight handling so as to minimize both turnaround times of airplanes and passengers’ station time. Two common features stand out for both existing and new policies options, being (1) boosting information sharing and cooperation, and (2) broadening the scope of actors addressed (not only airlines, but also airports, and possibly travellers).

Exploiting spare and substitute capacity

The spare and substitute capacity in aviation distinguishes following steps:

a) rebooking to later flights with the same destination of the same and other airlines while aiming to use all non-occupied seats;

b) diversion of arriving flights to (relatively) nearby airports and offering connecting flights or HST/IC trains to final destinations; if need be and possible – e.g. in case of long lasting diversions – also departures can be to some extent arranged from nearby substitute airports, however shift of departure airport is much more difficult for several reasons;

c) offering modal switch to stranded air travellers, notably HST and IC connections, offering them either to substitute the entire flight by train or to transfer them to another airport.

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

All in all we may conclude that the exploitation of spare and substitute capacity is not a panacea for solving disruptions in air traffic, but it has certainly significant relief capabilities that merit further review and development.

Prospects for improving transport resilience and reducing delays

Air passenger volumes in Europe are expected to almost double up to 2030. This means that to keep delays constant in absolute terms will already demand considerable extra effort on top of current policies. Some improvements of the current passenger protection regulation could be implemented, but the greater part
of delay reduction and resilience improvement will have to come from other policies and measures outside the passenger protection regulation.

The following sets of policies and measures are identified for medium to long term strategy implementation regarding resilience towards adverse weather. Deliverable 7.1 contains recommendations for the short term, whereas Deliverable 8.1 presents a research agenda. For a full description of the policies and measures see chapter 8.

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<td>9. Similar WX tool + protocols for (international) HST/IC services</td>
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<td>11. Intelligent traveller information system demonstrations</td>
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1. Introduction

1.1. Purpose and structure of MOWE-IT

Management of weather events in transport systems ("MOWE-IT") is a project focusing on understanding the impact of extreme weather events and natural disasters to transport systems and how to improve their resilience over time. These considerations need to be addressed in the context of the climate change agenda and the ways in which infrastructure needs to develop to improve the resilience from present.

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

Figure 1 below summarizes the structure of the MOWE-IT project. Work packages (WP) 3 to 6 reviewed best practices for reduction of vulnerability towards extreme weather events and development options and needs for adaptation to climate change for each mode separately (road, rail, air, waterborne), whereas WP2 had a cross-modal perspective and also assessed weather service improvement potentials (jointly with WP5). WP7 and WP8 deal with the policy needs that can be extracted from the reviews in the previous work packages and from dedicated assessments. WP7 deals with short to medium-term policy perspectives, whereas WP8 deals with medium to long-term policy perspectives and research and development needs. This report (D82) discusses the long-term policy perspectives. A concurrent report (D81) presents a research agenda. Identification of research needs is mentioned in this report, but more elaborately discussed in D82.

In WP8 and WP7 ‘short term’ is understood as a timeframe in which infrastructure can alter its capacity, technology, pricing, and institutional structure somewhat, but not dramatically, certainly not in various dimensions simultaneously. Long term means that more dramatic changes can indeed take place. In practice short to medium term means about four to seven years, whereas medium to long term looks beyond that duration up to (in this case) 15 ~ 20 years.
1.2. Purpose and structure of this deliverable

This report aims in the first place at providing policy guidelines for user protection, long term resilience of operations, and cross-modal transferability for European air travel in case of disruptions. Furthermore, in conjunction with cross-modal transferability the report also pays attention to the resilience capabilities of other modes, notably (intercity) rail. The report also includes a review of these practices outside Europe.

In order to provide arguments in favor of certain policy guidelines, the report provides first a review of delays in European civil aviation, causes, trends and costs. To some extent also similar figures are presented for European railways. This is covered in chapter 2. Airfreight is briefly reviewed in chapter 3, as it is closely related with passenger transport in aviation. Subsequently, in chapter 4, a review of the current customer protection regulation for aviation and other public modes in Europe is provided. The chapter also indicates what are the changes in the recently adopted revision of these guidelines, and what seem to be further policy options aiming at delay reduction in and beyond these guidelines. Chapter 5 presents the customer protection practices and current delay levels for aviation in the USA, China, and Australia. A stepwise assessment of the substitution possibilities and capacity is presented in chapter 6. It contains 3 steps: substitution within aviation (exploiting empty seats on still operated flights), deviation to nearby airports, and substitution to rail. Chapter 7 presents recommendations and conclusions. Figure 2 provides a summary of the report logic and structure.
Figure 2: The logic and structure of this deliverable
2. Levels and causes of delays and cancellations

2.1. Reported delays in aviation

Whenever a transport movement departs or arrives late, it has experienced delay. From the point of view of the passenger or the receiver of freight it is the delay in arrival that counts, but in the transport system also late departures can cause problems e.g. through airline slot allocation or rail capacity limitations. Whenever delay figures are analyzed or measured, it is important to pay attention to the exact delay definitions used. Different types of delay can be defined by the following categorization (based on Cook et al. (2004)):

- **Strategic delay** – Anticipated delay that is taken into account in the strategic planning. Such delay is manifested in the buffers airlines and other transport operators implement in their schedules to absorb inevitable disruptions in operations.
- **Tactical delay** – Actual delays that are encountered in operations.

Further on, delay can be categorized as primary delay or reactionary delay. Primary delay is the delay experienced by the movement originally affected by the disruption, whereas reactionary delay is delay caused by the delays of other movements through network effects. In aviation it is also useful to separate ground delay from airborne delay, since extended time in the air is in general much more costly than the delay on ground.

The level of strategic delay implemented in the transport system is challenging to measure, since it is embodied in the risk management decisions of individual airlines, airport, rail operations and even passengers. It could in theory be calculated as the difference between the theoretical maximum yet marketwise optimal transport offering and the actually implemented timetables. Such indicator would however be complicated to measure and have limited practical value. Bottom-up cost estimates for strategic delay factors have instead been presented (see EUROCONTROL (2013a)).

The measured and reported delay is then typically the tactical delay. For transport modes with planned and reported schedules such as air, rail and some of the coach services the level of delay is straightforward to measure and the data is mostly very accessible. In the EU, EUROCONTROL’s Central Office of Delay Analysis (CODA) gathers statistics on the performance of aviation. Rail punctuality data is not collected as systematically and in a concentrated way, but European level surveys have been conducted regularly (see European Commission (2013a) and Schade et al. (2006)).

Delay is endemic in air transport. In 2012, 34 % of all flights in Europe were delayed by at least 5 minutes in arrival and the average delay per delayed flight was 28 minutes (respective figures were 35,5 % and 27 minutes for departures) (EUROCONTROL, 2013b). 16 % of all the flights were delayed more than 15 minutes on departure. Figure 3 illustrates the historical development of delay. During the last 15 years, there has been slight improvement in the punctuality of European air traffic, although the share of long delays over 60 minutes has increased.
The level of delay varies among airports, airlines, month and time of day. In the most delay prone departure airport - Lisboa airport - over half of the departures were delayed in 2012, but the share of delayed departures is over 30 % in most of the main hubs and travel destinations in Europe (EUROCONTROL, 2013b). Causes of delay include chronic capacity issues and adverse weather conditions.

There are clear on-time performance differences among air carriers as well. The conditions under which the airlines operate however vary (national legislation, climate etc.) so distinguishing exact causes for these differences is challenging. Based on data from May 2013 and December 2013 (FlightStats, 2014) it seems that there are no major differences between the different types of European carriers, although traditional airlines seem to experience slightly more delay compared to regional and low-cost carriers. Flights by regional airlines seem to be canceled more often. Traditional airlines also might also be able to manage extreme, long-lasting disruptions better, at least based on the experiences from the volcanic ash incident in 2010 (EUROCONTROL, 2010).

Airport size effects how delay is distributed. Flight arriving late to a small or medium airport (less than 50 000 departures annually) is likely to be delayed 50 % longer than a flight to a large airport. This is attributed to the lack of advanced infrastructure to respond to peaks in demand. The share of volume of the small and medium airports of the total traffic is however small, so their share of total delay minutes is only around 6 %. (Wegner & Marsh, 2007)

Compared to delay data, cancellation data is more scarcely available for Europe. Cancellations differ from delays in that they are ultimately business decisions – whether to fly a certain movement or not. In extreme conditions cancellations are still inevitable, yet in some cases cancellation decision can be made solely based on economic reasoning on profitability. The exact definition in legislation between cancellation and extended delay does currently not exist in the EU. Unlike the U.S. the EU does not oblige air carriers to report the causes for cancellation.
Delay on the system level is very volatile, as figure 4 shows. Although the general level of delay follows the annual rhythm of flight activity, the daily variation is much more significant factor and is not explained by the amount of flights. Figure 4 shows how daily delay per flights operated and delay per delayed flights vary greatly on daily scale but there is no major fluctuation between different months.

![Figure 4: Daily delay per flight and per delayed flight on European flights 2012 (source: EUROCONTROL CODA database)](image)

Not all delays are the same, of course. Some flights get delayed only few minutes, whereas others can be delayed for hours. Based on CODA data from 2012 Figure 5 presents how different delay lengths were distributed (it should be noted that in official delay statistics, the threshold for delay is typically 5 minutes). While only 2.86 % of flights were delayed by more than an hour, these delay minutes accounted for 39 % of all delay. The delay distribution also seems to have a long tail, since for the delays over 60 minutes, the average delay is well over two hours, as Table 1 shows.

**Table 1:** Key figures on delay distribution in Europe 2012 (source: EUROCONTROL CODA database)

<table>
<thead>
<tr>
<th>Delay Duration</th>
<th>Share of all operated flights</th>
<th>Share of delayed flights</th>
<th>Share of total delay minutes</th>
<th>Average delay per delayed flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>On time or early</td>
<td>37.06 %</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Delay 1 to 4 min</td>
<td>27.52 %</td>
<td>43.72 %</td>
<td>2.98 %</td>
<td>1.04 min</td>
</tr>
<tr>
<td>Delay 5 to 15 min</td>
<td>19.66 %</td>
<td>31.23 %</td>
<td>18.65 %</td>
<td>9.14 min</td>
</tr>
<tr>
<td>Delay 16 to 30 min</td>
<td>8.26 %</td>
<td>13.12 %</td>
<td>18.89 %</td>
<td>22.05 min</td>
</tr>
<tr>
<td>Delay 31 to 60 min</td>
<td>4.65 %</td>
<td>7.39 %</td>
<td>20.47 %</td>
<td>42.41 min</td>
</tr>
<tr>
<td>Delay over 60 min</td>
<td>2.86 %</td>
<td>4.54 %</td>
<td>39.00 %</td>
<td>131.46 min</td>
</tr>
</tbody>
</table>
Figure 5: The share of delayed flights and delay minutes for delays of different lengths in Europe 2012 (source of data: EUROCONTROL CODA database)

The figures below are based on departure delays as compiled by CODA based on reports by participating airlines. They include both primary and reactionary delays. The magnitude of propagation (the ratio of reactionary delay induced by primary delay) depends on the length of delay and the topology of transport network. According to AhmadBeygi et al. (2008) the “delay multiplier” (as coined by Beatty et al. (1998)) is greater for long delays. When these system-wide propagation effects are taken into account, the significance of long delays is even larger than their relative share of delay minutes. Based on the CODA delay statistics and multipliers by AhmadBeygi et al. (2008) the total system-wide share of long delays of all delay when both primary and reactionary delay are accounted for could be as high as 62%. However the individual instances differ greatly, since according AhmadBeygi et al. (2008) even in the case of delays over three hours 40% of delayed flights cause no propagation effect at all. Delay multipliers also vary according to time of day (see Beatty et al. (1998)).

2.2. The role of weather

As stated above, many factors can result in delay. Weather is one of the usual factors, and can cause delay in different ways. There is the distinction between primary and reactionary delay, so that weather induced delays can propagate to flights not disrupted by the weather. The Federal Aviation Administration in the U.S. also distinguishes between extreme weather and National Aviation System weather delay. The former is for actual or forecast weather conditions that prevent flying whereas the latter is for weather that slows down operations and could be reduced with corrective actions by airports or the FAA (RITA, 2014a). The IATA weather codes used by EUROCONTROL make no such distinction, but are instead based on the affected operation or phase of flight (EUROCONTROL, 2013c). This results in challenges in comparing delay statistics between the regions. For the purposes of policy guidelines, the distinction between adverse weather (weather that impedes operations) and extreme weather (weather that prevents safe flying) is useful, since the response strategies might differ considerably.

Based on CODA data, 6.13% of flight delay minutes in Europe were directly accounted to weather in 2012. Taking out the share of reactionary delays, weather accounted for 10.27% of primary delays. For delays over 60 minutes, the shares were 7.70% and 13.34%, so weather delays seem to be slightly longer than
delays on average. These figures are based on airline reporting and do not show all weather effects – for example damage due to extreme weather is excluded. During the last ten years, the share of weather for all delays has varied between 10% and almost 16% (as shown in Figure 3).

The significance of weather as a delay cause varies heavily throughout the year, and weather delays are most common in the winter (Guest, 2007). This is also illustrated in Figure 6, which shows the share of weather of all delay minutes in 2012. This pattern is mainly resulting from the climate. The most challenging conditions such as heavy snow, freezing temperatures and blizzards occur in winter, and are also conditions that can result in sustained delays due to the need of snow and ice removal after the event itself. This conclusion is supported by the delay data gathered by CODA. The share of weather does not decrease in the warmer months e.g. due to operating closer to capacity limits. The level of weather delay is lower in absolute terms. And in the winter months, the amount of weather related delays is not only higher, but they also last longer as well. A long weather related delay in the summer months lasts on average a bit more than an hour and forty minutes, but in winter months the average long delay caused by weather is well over two hours. This is illustrated by Figure 7, which shows the delay minutes caused by weather related delays of different lengths. In 2011 there was also a pike during June, when high winds, thunderstorms and low visibility affect the major hubs of Heathrow, Munich and Frankfurt (EUROCONTROL, 2011). Again, there is major variation among the delay; in December 2010 the direct delay related to weather was approximately threefold compared to December 2012, the highest peak in the figure. The delay was mainly caused by heavy snowfall on multiple airports. The absolute increase of weather delays during winter is emphasized by the fact that there are considerably more flights during summer months.

![Figure 6: Share of weather of delays in 2012 in Europe (Source: EUROCONTROL CODA database)](image-url)
Figure 7: Monthly delay minutes caused by weather in Europe in 2012 (Source: EUROCONTROL CODA database)

In the US, weather accounted for 33.74% of delays in 2012 (RITA, 2014b). Extreme weather caused 2.6% of all delays and 4% of all delay minutes. This figure however accounts only for the primary delays. It still signals that the most significant weather impact on aviation comes from adverse yet not extreme phenomena. This could be even truer for Europe, where the climate lacks one of the most extreme weather phenomena – the hurricanes. Both the share of weather in general and extreme weather in the U.S. air traffic delay has decreased slightly during the last decade. This might not result from better adaptation but merely the fact that the share of reactionary delay has risen constantly.

A more detailed analysis of different weather phenomena and their impact on aviation is presented in the MOWE-IT Guidebook for Enhancing Resilience in European Air Traffic Passenger and Freight Transport (Temme et al., 2014). The guidebook also describes the anticipated changes in weather patterns caused by the climate change.

2.3. Cost of delay

Delay naturally comes with a cost. Keeping crews working or fuel burning and providing care or paying compensations for passengers create costs for the airlines directly. Time has value for the passengers, and the air freight is typically time critical as well. Several studies have been made on the systematic evaluation of the costs, and EUROCONTROL maintains updated values for delay and cancellation costs in the manual for standard figures of cost-benefit-analyses (EUROCONTROL, 2013a).

In 2002, a comprehensive study by EUROCONTROL concluded that the total cost of ATFM delay minutes in Europe was between 840 and 1200 million Euros (Cook et al., 2004). Based on the same calculation but with updated values EUROCONTROL estimates overall cost of 90.10 Euros to a minute of ground delay (with network effect) and 52.9 Euros (without network effect) per minute (EUROCONTROL, 2013a). This does not include any strategic delay cost, which has a lower figure. These figures however take into account passenger opportunity cost of 48.7 euros (with network effect) or 27.10 euros (without network effect),
which is representing the loss of potential future earnings for the airline. Thus, the loss to one airline will benefit another one and the cost disappears on a system level. But in order to include true cost for passenger for the lost time, some estimate for the passenger value of time (PVT) needs to be used. Such a figure is difficult to produce reliably, and there is naturally massive diversity in values in real life depending on the passenger, travel purpose and timing. The range recommended by EUROCONTROL is from 47 to 60 euro per hour, which is based on a study conducted in 2000. Figures proposed by other studies are slightly lower, ranging from 19 euros for private passengers to 35 euros for business travelers (EUROCONTROL, 2013a). In MOWE-IT deliverable D2 (Nokkala et al., 2014) figures ranging between 24 and 32 euros were used. In the delay compensation sums regulated by the EU the initial hourly compensation is between 83 and 150 euros, and decreases for longer delays (since the delay thresholds are 3 and 4 hours). These values can be used to analyze costs and benefits of policy changes and measures that may either reduce delay in general.

### 2.4. Massive, long lasting disruptions – The Ash Cloud incident

In a massive, long lasting disruption, such as the volcanic ash eruption in 2010, the dynamics of cost generation are likely to be different compared to typical disruptions. First there will be the ad hoc costs, but after the disruption remains the actors in the system start to adapt. Airlines redesign their flight plans and adjust crew shifts, passengers switch to subsidiary modes of travel or skip the trips entirely instead of waiting and public officials undertake measures to cope with the situation. Stranded passengers need to be transported too. The adaptive measures are mostly temporarily, but long disruptions may induce permanent changes as well. In many cases, the running costs can be tuned down (e.g. crew pays, aircraft maintenance) during such a disruption so that the standard cost estimates do not apply. In others, the costs may escalate or cause shutdowns in businesses dependent on steady cash flow or processes relying on time-critical air freight.

The volcanic ash cloud crisis in the spring of 2014 was perhaps the most severe peace-time transport system disruption ever to occur. Between April 15 and 22 around 104 000 flights were cancelled affecting around 10 million passengers. During the week, 48 % of all air traffic within EU27 countries was cancelled. Geographically the disruption was largest in Northern Europe and the British Isles, but central Europe suffered practically total air traffic shutdown as well when the disruption was at its largest (April 17 and 18). There were also differences between the different market segments and business models, as presented in Table 2. (EUROCONTROL, 2010)

**Table 2: The effect of the ash cloud incident in European Union (EUROCONTROL, 2010)**

<table>
<thead>
<tr>
<th>Business model / Market segment</th>
<th>% of flights cancelled between 15APR and 22APR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-cost scheduled</td>
<td>62 %</td>
</tr>
<tr>
<td>Traditional scheduled</td>
<td>51 %</td>
</tr>
<tr>
<td>All-cargo</td>
<td>43 %</td>
</tr>
<tr>
<td>Non-scheduled</td>
<td>40 %</td>
</tr>
<tr>
<td>Business aviation</td>
<td>33 %</td>
</tr>
</tbody>
</table>

It seems that unsurprisingly the more flexible forms of air transport suffered less, whereas the efficient operations of low-cost carriers are less resilient compared to traditional airlines. For cargo it should be noted that the majority of air freight is transported in the bellies of passenger planes, so the all-cargo figure might underestimate the impact on cargo transport.
The economic impact of such as major disruption is naturally enormous. Oxford Economics has estimated that the overall global impact was 4.7 billion US dollars with the share of Europe being 56%. Direct losses accounted for around a third of the total impact. These figures take into account estimated adaptive measures including modal shifts and transported consumption (e.g. revenues of hotels and restaurants from stranded passengers). It was estimated that because of these adaptive actions and induced consumption, the net economic impact of the disruption was only 31% of the potential losses in Europe. In other regions, where the possibilities to switch the route, mode or destination were lower, the net impact was closer to the potential impact. As an example, Oxford Economics estimated that the total amount of “stranded days” of passengers was 2.8 million days in Europe and 2.1 million days in North America, even though the impact on European airlines was much greater (IATA, 2010). (Oxford Economics, 2010)

Although the media coverage during the incident focused on passenger traffic disruptions, the problems of disrupted cargo transport were challenging as well. As shown above, the all-cargo flights suffered less cancellations compared to passenger transport. This may reflect the more flexible nature of cargo traffic, capable of utilizing alternative routes. Still, the economic consequences of air freight disruptions are extensive. While the volume of air cargo is small, its share of export and import value is significant. Nearly a quarter of the total value of trade between EU and the rest of the world was transported by air (European Commission, 2012). Many important intermediary products rely on air traffic. Nearly all of advanced electrical components and machine parts are imported to EU by air a large share of medical compounds and instruments as well (Lee et al., 2012). The length of disruption determines the scale of consequences, but the relation is not linear. In a survey by Chatham House (Lee et al., 2012) the respondents reported that returning to normal business took about a week. But they also stated that had the disruption continued for a few days longer, the recovery time would have been at least a month. The maximum tolerance of modern “just-in-time” global economy seems to be around one week (Lee et al., 2012). In this sense, the ash cloud incident was not as severe test of resilience as one might think.

Unexpected European-wide transport disruption was also a test for the regulatory framework. Problems occurred for example with the rigid flight restrictions, the passenger right regulation without time limits for extended disruptions and the limited options for financial aid for airlines. The absence of engine-specific safety limits for ash concentration was also a problem. Already during the incident the European Union reacted swiftly to enable more flexible flight restrictions and soon after the crisis instigated actions for improved future resilience. These included speeding up the Single European Sky development, review of passenger rights regulation and improving interstate and cross-modal co-operation and risk management in general. (European Commission, 2010)

During the incident the traffic switched to other modes mainly unguided and through available markets. While there no reports on the overall traffic flows or the temporary increase in road, rail and waterborne transport, media reports indicate that their capacity was quickly filled. The peak in demand likely led to utilization of any idle transport stock on the market as well, since even military capacity was put to use or prepared for it (BBC, 2010). Route changes also show up on statistics: in Santa Maria, Azores, the traffic increased 50% during the crisis (EUROCONTROL, 2010).

Role of information is crucial in a situation such as the volcanic ash incident where people need to decide whether to seek for optional modes or routes or to wait. Limited information about options, uncertainty about the length of the disruption and available compensation probably affected the responses of people and businesses. For these, there was no centralized source of information available and according to the Chatham House’s survey, the role of government officials in providing information was small; the messages were late and inconsistent (Lee et al., 2012). Instead, traditional mass media, online blogs and social media were relied on. Social media networks were used to organize shared travel solutions (Cellan-Jones, 2010).
In the event of volcanic eruption, the role of weather services is critical in the assessment of risks. Expert information needs to be delivered to decision-makers quickly and accurately. Globally, the ash hazard forecasts are the responsibility of the nine Volcanic Ash Advisory Centres. In Europe London VAAC is responsible for Eastern Atlantic airspace and Toulouse VAAC for the rest of the Europe. During the 2010 ash cloud the London VAAC was the responsible center. During an eruption providing the volcanic advisory information is centralized to VAACs. Based on VAAC input EUROCONTROL details safe flying zones. Still, the national aviation authorities remain responsible for declaring flight permissions, and they rely also on national weather services. This process was adopted during the ash cloud crisis and further refined by establishing European Aviation Crisis Coordination Cell (EACCC) after the incident (EUROCONTROL, 2014).

To summarize, the ash cloud event of 2010 provides an interesting view on the functioning of European transport system during a major disruption. Despite the significant costs, the recovery was relatively fast and resulted in no large structural changes. Without detailed information assessing the effectiveness of utilization of optional routes and modes is difficult. It seems however that the market reacted effectively and in general fairly. Although thousands of passengers remained stranded for days, the costs of reserve transport capacity adequate to cover such a peak demand would be large as well. Should a similar event take place, the impacts would probably be lower, mainly due to the new, more flexible and organized flight restrictions regarding ash and the more organized approach enabled by the EACCC. It is likely that also at least some businesses took the incident as a learning experience and reviewed their risk management processes and the vulnerability of their supply chain.

Had the ash cloud incident lasted for few days longer however, the scale of repercussions might have been different. A threshold of spatial and temporal disruption level under which the transport system starts to fail critically might exist. It is possible that the ash cloud incident of 2010 came close to it. Whether or not this is the case, the measures designed for local disruptions are might not enough in the face of such massive events. Regulation as well as response and communication strategies should be applicable for such situations as well. A separated approach identifying the special needs in a major, European wide disruption compared to smaller scale incidents may be justified. The EACCC is also formed to address aviation only, and similar entity with the viewpoint of the whole transport system is lacking.

2.5. Weather services and delay reduction

Weather services provide information on the upcoming and ongoing weather conditions. Since dangerous weather has the potential to cause severe accidents, weather services are critical for aviation. Airports, airlines and air traffic management are all thoroughly professional end-users of weather information and are typically very aware of weather conditions and predictions.

The accuracy of meteorological observations and predictions has risen steadily in the past. Still, the share of weather related delays (direct + follow-up effects) has remained high. Arguably, there are various reasons why the development of weather services seems not to have improved the weather resilience of air transport. One is that aviation is safety-driven. Flight rules typically don’t allow for adjusting flights according to exact, real-time information. Instead rigid thresholds are applied. The improved weather awareness perhaps augments safety, but hardly punctuality. The priority of safety can actually lead to a kind of asymmetry, where increased awareness of weather conditions can also lead to increased delays, as more risks can be identified. Efficient responses require flexible traffic management on both airline and system level. The SESAR plans (SESARJU, 2014) aim to create a more flexible and resilient air traffic management system for Europe in the future and more possibilities to proactively utilize weather information may then emerge.
Another reason why more precise and detailed weather services do not so much translate into delay reduction is that effects of adverse weather mix in with other stress factors (Kreuz 2014; Faber 2014), such as airports and flight corridors which are at (almost) full capacity utilization, and disruptions at the land side connections of airports (inter alia caused by weather). Adverse weather usually means that the number of arrivals and departures per hour is reduced. Extreme weather can lead to closure of an airport for some time ranging from one hour to a day. If prior to the onset of the adverse weather an airport is operating at (almost) full capacity, even small initial delays can easily proliferate and cause several (departing) planes to be reallocated to slots appreciably later than the original slot. Conversely arriving planes may be forced to deviate to nearby airports. Growth of the number of flights in Europe moves more and more airports and some flight corridors towards their capacity limits, thereby making the overall system more prone to delays. Simultaneously congestion has also aggravated on road systems in more densely populated regions in Europe (where the major airports tend to be). Consequently delay risks prior to flight departure have been rising for crews, supporting personnel and passengers, especially when congestion gets aggravated by adverse weather condition at the land side of the airport.

The effects of some of the adverse weather conditions can be attenuated through adequate preparedness (adequate equipment, trained (and sufficient) personnel, clear protocols). Examples are snow ploughing and de-icing treatment of airplanes just before take-off. Similarly, airlines could decide to have crew substitutes at their hub airports. Airports that are not so often exposed to such winterly circumstances are tempted to save on costly preparedness (such as adequate snow clearing capacity), as the savings can be retained whereas disruption cost are mostly accruing to other parties in the aviation sector. Similar considerations can be applied to airport security services (scanning luggage and passenger). Lack of responsiveness to peaks in passenger flows may save costs (and hence may keep airport surcharges in ticket cost moderate), but it would raise risks of delays due to passengers appearing late at the gates. In this respect the entire business model of airports could be reviewed with respect to its incentives regarding transport system resilience.

There are several ways to respond to adverse weather in the air transport system. Some of them depend on timely weather information, whereas others are more general measures to improve resilience.

- **Strategic delay**: Implementing buffer in the flight schedules does not reduce primary delay caused by weather effectively, but can help in reducing the reactionary delay. Schedule planning is usually done months in advance, when information on weather is not available. Climatological information can be used to anticipate higher weather related delays based on the time of year and region.

- **Avoidance**: In many cases the only way to response to possibly dangerous weather is to avoid flying in it. It is notably less costly to delay aircraft on the ground than on air, so in the case of high chance of adverse weather in the destination airport it is probably better to delay the departure instead of taking the risk of airborne delay. In such a case weather information does not necessarily reduce the delay but can help to lower the costs.

- **Rerouting**: Instead of delaying or cancelling the flight, an option is to change the destination. This option creates or modifies the need for follow-up transport and creates especially problems for passengers with connecting flights at the original destination. This option is more relevant for intercontinental flights. On the one hand the long flight duration raises the probability that (weather) conditions change in the neighborhood of the destination, whereas the relative disturbance is smaller than for flights within Europe.

- **Modal shift**: Depending on the weather phenomena, other transport modes could be available and used for the transportation. Excluding the long lasting, major disruptions, road and rail are the
alternatives to aviation (and ferries in a few specific cases). More in particular high speed rail services
can offer alternatives that approach (or even match) the total travel time (i.e. door to door).

- **Preparation:** Airports can’t avoid weather, so they need to prepare for it. While there are weather
  conditions that inevitably force the suspension of flying or the increase of safety margins (thereby
  reducing capacity/hour), proper preparations can help the normalization of operations e.g. in the case
  of snowfall, thus reducing the following delay. Preparations often rely on investments (such as snow-
  removal equipment or staff training) that are difficult or impossible to implement in the timescale of
  weather information.

- **Damage prevention:** Extreme events such as thunderstorms, high winds and hail can damage
  infrastructure and ground equipment. Early warning can enable timely actions to take protective
  measures, preventing the damage and the resulting delays caused by it.

Strategic delay, avoidance, rerouting and modal shift rely mainly on the decisions of air carriers (or
passengers), preparation and damage prevention take place on airports. Extensive rerouting and modal
shift would require changes in the current practices and markets and are discussed in more detail in
chapter 5.

Even if weather information could be utilized to reduce weather related delay, it might not result in
reduced delay in general. The level of delay in summertime in Europe does not decrease proportionally to
the decrease in occurrence of adverse weather. The reason is that the volume of traffic increases, causing
capacity issues and higher reactionary delays. In general, improved capacity can be used to decrease delay
or increase traffic as illustrated in Figure 8. Currently and historically there has been demand for additional
capacity in Europe, so the gains have mostly gone to increased traffic. The demand is likely to remain high
enough (EUROCONTROL, 2012a) for this trend to continue if the incentive structure remains the same.

![Figure 8: Impact of improved capacity (Modified from Holzäpfel, 2008)](image)

**2.6. Comparing delays for different modes**

Unlike the detailed and comprehensive statistics compiled by EUROCONTROL on delays and cancellations in
the European airspace, there is no such a regular set of statistics available for railways. Many EU Member
States mandate monitoring of punctuality in railways services within their countries, but there are no annual harmonized statistics available which cover all or at least most of the EU. Yet, occasionally a study document is available (e.g. European Commission, 2013a; TNS 2013) on satisfaction with rail services. For (maritime) ferry services and intercity bus services statistics are even harder to get by. Furthermore, various railway companies and rail track companies do provide on-line information on punctuality in recent years as well as the current year. Yet, in different countries different train categories are used, and to some extent also the categories of delay duration are not defined in the same way.

From table 4 can be inferred that long distance international trains are clearly less punctual than national long distance trains. Probably this has more to do with the larger number of organizations involved than with – possibly – longer average routes of international trains. All in all the share of long distance trains arriving more than 15 minutes late at their final destination is about 6% (approximate average of domestic and international trains), which is appreciably less than the almost 16% share for comparable delays in aviation (table 1). Please note however, that for trains the delay reported here is based on the arrival time at the final destination. Some countries (e.g. Belgium) produce also train delay figures weighted for the performance over the entire route, but that seems to affect the indicator results only slightly (i.e. 1% point or less).

Table 3: Average punctuality of train services in Europe in 2011 by delay duration and type of train service (source: CER/CIT – 2012)

<table>
<thead>
<tr>
<th>Type of Train Service</th>
<th>Punctuality using a threshold of up to 5 minutes</th>
<th>Punctuality using a threshold of up to 10 minutes</th>
<th>Punctuality using a threshold of up to 15 minutes</th>
<th>Punctuality using a threshold of up to 30 minutes</th>
<th>Punctuality using a threshold of up to 60 minutes</th>
<th>Punctuality using a threshold of up to 120 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL SERVICES</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>99%</td>
<td>97%</td>
<td>98%</td>
</tr>
<tr>
<td>INTERNATIONAL Long-Distance Services</td>
<td>99%</td>
<td>97%</td>
<td>93%</td>
<td>90%</td>
<td>87%</td>
<td>81%</td>
</tr>
<tr>
<td>Long-Distance DOMESTIC Services</td>
<td>100%</td>
<td>100%</td>
<td>98%</td>
<td>92%</td>
<td>92%</td>
<td>86%</td>
</tr>
<tr>
<td>REGIONAL-LOCAL-SUBURBAN-URBAN (PSO)</td>
<td>100%</td>
<td>100%</td>
<td>99%</td>
<td>97%</td>
<td>97%</td>
<td>94%</td>
</tr>
</tbody>
</table>

Figure 9 provides an impression at country level for selected countries for a series of recent years. Lack of harmonization implies however that one should be cautious when comparing countries. For example, the German and French figures do not contain suburban train services or at least not the greater part of it. On the other hand – for the years shown – such services are included in the other countries. The more detailed country specific punctuality statistics confirm the overall European picture (table 3) that long distance train services (intercity and HST) are more subject to delays than regional and local trains. The dip for VR (Finnish railways) in 2010 and 2011 relates to winters with extreme snowfall and blizzards. Similarly, the German railways (DB) dip in 2013 is related to the flooding events, which crippled some stretches of the network. Probably also the low rating of NMBS (Belgium) in 2010 relates to winter conditions. Another observation is that institutional organization (degree of separation of track and train services; number of train companies competing for track space) cannot be very straightforwardly associated with good or bad punctuality.
performance. Strong separation and extensive competition can be found in the UK and the Netherlands, which rate neither best nor worst. Another element is the intensity of network utilization, which is the highest in Switzerland and the Netherlands, followed by Belgium. Similar to aviation, this factor seems to matter more than the institutional organization, but it would require more dedicated analysis to provide more pertinent answers.

![Figure 9: Punctuality of train services in selected countries](image)

By combining several sources at least an indication can be provided of the relative size of the travel volumes and the occurrence of delays. This is summarized in table 4 below. The figures for rail are based on a European survey on traveler satisfaction regarding rail services (TNS, 2013) to which assumptions are added regarding annual ridership per category use intensity. If only longer distance rail travel would be considered, the travel volumes of air and rail will get approximately the same size. Maritime ferry services have a much smaller overall traveler volume, but in some parts of Europe – such as in Greece and between Finland and its EU neighbors – the role is significant. Furthermore, ferries usually fulfill also a very important goods transport function. Intercity bus services have not been included owing to lack of data. Statistics on intercity bus transport are scant and patchy, and no punctuality figures were found for intercity bus services. Considering that the intercity bus services are usually significantly slower than trains or private cars, customers seem to favor buses mainly due to low prices or because of lack of alternatives (rural areas). In turn this means that delays are less of a concern in this market. Therefore we do not pay further attention to intercity bus services in this report.

In relative terms delays seem more prominent in air travel than in rail travel. In terms of absolute number of delayed trips – without further distinction by the amount delay – air and rail seem quite close to each other. However, when delays are weighted by their duration and by the value of travel time of air and rail travelers respectively, it seems that delays in air travel constitute a larger cost to society. This overall picture should not be confused with the economic significance of punctuality and reliability at local levels and/or with respect to specific sectors. Even though punctuality in percentages terms is weaker in aviation than in rail services, the number of rail travelers is much larger causing similar or even higher numbers of
affected people. On the other hand considering the higher ticket prices the economic value of delays in aviation might be larger than the corresponding value of rail travel delays.

Compared to aviation it is harder to ascertain trends in punctuality performance of railways. For some countries the occurrence of delays shows a downward trend, whereas for some other countries the occurrence of delays seems to increase. Also, for many countries lack of observations precludes the establishment of trends. Also for rail extreme winter conditions are a reason for reduced punctuality. The drivers for reduction of delays in rail services are more depending on the national public service contracts than on the European regulation regarding passenger rights.

Table 4: Comparison of punctuality performance across modes and their respective market sizes

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

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

3.1. Main features of air freight

Volume

Around 13.5 million tonnes (in another Eurostat source 14.5 million tonnes) of air freight was carried out by EU-27 in the year 2011. Air freight accounts for only 0,1% of freight transport within intra-EU (in billion tonne-kilometres) (European Commission, 2012). On global level, the share of air freight is less than one percent of all goods transported in the world, however, yet in terms of value the share is much higher. The estimated total value of air cargo of 4.3 trillion US$ (IATA) compares to about 35% of the total value of global trade\(^1\). Thus, air freight has substantial economic significance, especially in international trade where fast and safe transportation with global coverage for high-value shipments is needed.

Expected growth and main airports

Boeing forecasts that world air cargo traffic will grow 5.2% per year over the next 20 years. However, as a mature market, intra-Europe will grow on a lower than average growth rate. Intra-Europe air cargo market is forecasted by Boeing to expand at an annual rate of 2,4% per year up to 2031, which is lower than the 3,7% historical growth trend in world air cargo shipments during 20 year period from 1991 to 2011. The biggest growth for European air freight market is estimated to take place on inter-continental flights. This is depicted in table 5.

Table 5: Historical and forecast air cargo growth rates for Europe

<table>
<thead>
<tr>
<th>Historical and forecast air cargo growth rates</th>
<th>2001-2011 annual growth %</th>
<th>Forecast 2011-2031 annual growth %</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>3,7</td>
<td>5,2</td>
</tr>
<tr>
<td>Intra-Europe</td>
<td>1,6</td>
<td>2,4</td>
</tr>
<tr>
<td>Latin America- Europe</td>
<td>3,2</td>
<td>5,3</td>
</tr>
<tr>
<td>Europe- North America</td>
<td>1,5</td>
<td>3,5</td>
</tr>
<tr>
<td>Middle-East – Europe</td>
<td>9,5</td>
<td>5,7</td>
</tr>
<tr>
<td>Africa – Europe</td>
<td>3,2</td>
<td>4,8</td>
</tr>
<tr>
<td>Europe – Asia</td>
<td>6,2</td>
<td>5,7</td>
</tr>
<tr>
<td>South Asia- Europe</td>
<td>6,1</td>
<td>5,8</td>
</tr>
</tbody>
</table>

Source: Boeing, World Air Cargo Forecast 2012-2013, p. 3

In EU, the biggest airports are the main hubs for air freight and mail. The four major EU airports for air freight are Frankfurt (Main), London /Heathrow, Amsterdam/Schipol and Paris/Charles de Gaulle. Figures for volumes for the 10 biggest EU airports for air freight for 2008, 2009 and 2010 are found in table 6. From the table it can be seen how air freight decreased between 2008 and 2009 and rebounded in 2010. This development depicts air freight’s dependency on global economic activity - the economic crisis in 2008 was followed by a collapse in world trade which hit substantially air freight industry the following year.

\(^1\) Air freight services also include domestic trade flows, especially in the USA. Therefore the comparison provides an idea of the significance, even though it does not really represent a share.
### Table 6: Top-ten EU airports for air freight (cargo and mail loaded and unloaded)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Airport</th>
<th>Country</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Change % 2009/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Frankfurt (Main)</td>
<td>Germany</td>
<td>2104.3</td>
<td>1882.7</td>
<td>2270.2</td>
<td>20.6</td>
</tr>
<tr>
<td>2</td>
<td>London / Heathrow</td>
<td>UK</td>
<td>1482.7</td>
<td>1348.9</td>
<td>1551.3</td>
<td>15.0</td>
</tr>
<tr>
<td>3</td>
<td>Amsterdam / Schipol</td>
<td>Netherlands</td>
<td>1592.5</td>
<td>1316.8</td>
<td>1538.0</td>
<td>16.8</td>
</tr>
<tr>
<td>4</td>
<td>Paris / Charles de Gaulle</td>
<td>France</td>
<td>1392.1</td>
<td>1202.3</td>
<td>1292.5</td>
<td>7.5</td>
</tr>
<tr>
<td>5</td>
<td>Luxembourg</td>
<td>Luxembourg</td>
<td>788.2</td>
<td>627.3</td>
<td>705.8</td>
<td>12.5</td>
</tr>
<tr>
<td>6</td>
<td>Köln / Bonn</td>
<td>Germany</td>
<td>574.1</td>
<td>549.0</td>
<td>638.2</td>
<td>16.2</td>
</tr>
<tr>
<td>7</td>
<td>Leipzig-Halle</td>
<td>Germany</td>
<td>430.2</td>
<td>508.8</td>
<td>637.8</td>
<td>25.4</td>
</tr>
<tr>
<td>8</td>
<td>Liège / Bierset</td>
<td>Belgium</td>
<td>381.6</td>
<td>401.8</td>
<td>508.5</td>
<td>26.6</td>
</tr>
<tr>
<td>9</td>
<td>Milano / Malpensa</td>
<td>Italy</td>
<td>414.1</td>
<td>343.6</td>
<td>432.7</td>
<td>25.9</td>
</tr>
<tr>
<td>10</td>
<td>Madrid / Barajas</td>
<td>Spain</td>
<td>355.0</td>
<td>330.2</td>
<td>400.5</td>
<td>21.3</td>
</tr>
</tbody>
</table>

Note: Figures from airport websites are not always fully comparable with those collected by Eurostat.

Source: EU Transport in figures, Statistical Pocketbook 2012, European Commission (p. 60)
(European Commission, 2012)

Rising fuel prices is a threat to the growth of air freight traffic as high oil prices will affect air transportation most. During the past years there has been some modal switch from air freight to sea transportation.

**Types of goods shipped**

Air freight is considered as a fast, reliable and safe transportation mode with a global reach. It is suitable for *time-critical and high-value shipments*, such as medical equipment and supplies, perishable goods and spare parts. Rapid distribution is also needed for products, which have short shelf lives, high obsolescence rates and cyclical sales patterns (for example consumer electronics and fashion goods). Air cargo, or other fast enough distribution mode, is also being used by companies to avoid inventory costs for high-value shipments when transportation costs are relatively lower to carrying costs. Air freight can create competitive advantage for companies by enabling just-in-time production and fast customer service. Sometimes *air freight may be the only means to provide the needed transportation conditions*, e.g. cold chain storage. Developments in technology may change this to favour other modes of transportation.

**Types of cargo shipments**

Air cargo traffic can be split into three categories within Europe: scheduled freight, mail and express. Volume of scheduled air freight (37.6% share in 2011) and mail (8.1%) have been relatively stable for many years, whereas, express traffic (54.3) has been growing on a faster rate and today carrying more than half of air cargo within Europe (Boeing, p27). Four integrators (DHL, FedEx, TNT and UPS) together account for more than half of the market share of the international express market. Express carriers are often referred to as integrators because of their role of combining the work of broker, haulier, freight forwarder, ground handler and aircraft. Express carriers are typically chosen for high-value added, time-critical shipments.

Air freight shipments are transported by both passenger and all-cargo aircrafts. Passenger air crafts carry freight in the belly of the aircraft and they account for around 60% of world air cargo traffic. (see e.g. GACAG, 2014). Air cargo can also be transported by road the whole journey. In these cases the load is designated as “air freight” and the involved trucks may have assigned flight numbers. *Truck transport is typical for short distances and 500 km is usually considered as a limit for transporting air freight by truck.*

*Air freight trucking* has become a complement, or a replacement, for short distances.
Air freight shipments are usually delivered from door-to-door. This means that air shipments are inherently multimodal as they typically involve trucks to pick shipments from shipper or manufacturer to the airport of departure and from the destination airport to the consignee.

3.2. Trends and Intermodal issues for air cargo industry:

Rise of e-commerce

eCommerce has been growing fast and is expected to continue growing. In 2010 Europe surpassed USA as the largest B2C e-commerce market in the world and rapid growth within Europe is expected to continue. (Ecommerce in Europe). In business-to-consumer (B2C) direct deliveries to end customers mean a large number of small consignments with demand for fast and accurate deliveries. Time will be important when choosing distribution model for a delivery. Seamless, time-critical inter-modal transportation solutions will be needed on European and global level. Information and communication is in key role in developing solutions to transport network.

This type of industry requires completed new demand for custom-made delivery solutions, which to some extent can utilise the existing distribution chains. However, combining individual small size consignments with air cargo packaging creates pressure to distribution chains. Most of parcels within continental Europe tend to travel on trucks, but positioning of logistics hubs must also take into consideration the air cargo possibilities.

The real possibilities for air cargo development are on the intercontinental shipments, where production logistics lead to necessity to move goods long distances, especially when they are parts of importance for other processes or high-value goods. Figure 10 below gives an indication of air cargo volumes transported at Amsterdam Schiphol airport in 2013 and 2012.

Looking at the volumes of inbound and outbound air cargo from Schiphol Airport, Amsterdam, shows that Asia has clear dominance in cargo volume (figure 11). This is a clear indication of the types of goods shipped by air cargo. Also, the relative modest volume in European skies indicates that distances in Europe would make use of trucks still an option worth utilising. This has definitely an impact on transport costs of the goods.

![Figure 10: Cargo transport volume in tonnes at Schiphol airport for the years 2013 and 2012; Source: Schiphol airport freight statistics.](image-url)
Technology developments

Technological developments can either favour air cargo or other cargo transportation modes:

- online tracking, electronic tags: to track location and condition of high-value, time-critical or other important shipments, increased visibility => add attractiveness of air cargo
- development in storage technologies can increase attractiveness of sea shipping (or other modes)
- transition to biofuels (potential to make aircraft carbon neutral)
- electronic documentation (to enhance security, efficiency and sustainability), IATA’s Multilateral Air Waybill (e-AWB) removed need for bilateral e-AWB agreements between airlines and freight forwarders.

Fuel prices

- rising fuel prices are a threat to air cargo, some has already been lost to (short) sea shipping
- yet, instead of steady rises fuel prices may also fluctuate, whereas exchange rates kick in as well
- however in as far as the effective fuel price may not rise as much as expected in real price terms, there will be adjacent climate policies which effectively mean that –over time – the use of fossil fuels will get more expensive one way or the other
- will also be subject to regional disparities and fluctuations, as refuelling of planes at different costs forces airlines (and airports) to optimize pricing decisions to minimize decisions.
Use of regional airports

Regional airports are popular for avoiding congestion and delays typical of major airports. Movement from plane to cargo facility may be faster and less time required for tendering. From table 6 can indeed be seen immediately that ranking airports by freight volumes means that some of the large passenger airports appear less important, whereas some specific freight hubs come clearly forward (Luxembourg, Liege, Leipzig). Nevertheless the four largest European passenger airports are also by far the four largest air cargo airports in Europe.

Luxembourg airport is a good example of a successful freight hub strategy. According to the airport website the advantages of the airport at glance are (http://www.lux-airport.lu/en/Business/Cargocenter.32.html):

- Located right in the heart of 27 Nation European Economic Community
- **Any European city within easy reach in less than 24 hours by road**
- Over 1 Million ton/year handling capacity
- Shipment transit time (avg): 8 hours
- Cargocenter and customs at the airport open 24 hours
- Experienced staff on duty 24/24 7/7
- **A Cargocenter optimized for Cargo-only aircraft and accommodated for 8 wide-body jets**
- **No air congestion by passenger traffic**

The factors marked in bold, reach of European cities by road in 24 hours and no passenger traffic congestion in particular indicate that the airport is aware of its strategic location and uses it as a marketing strategy. With 900,000 tonnes of air freight reached already in 2007, the airport volumes is not significantly lower than that of nearby Schiphol, yet compared to passenger stats of 2 million per year at Luxembourg and 22 million at Schiphol the balance is quite different. Apart from local cargo companies the airport hosts a number of Asian and African cargo carriers, making it a freight hub in central European airspace.

Security issues

- air cargo most secure transportation mode
- costs associated with security ("Costs associated with security today are 10 times more than in 2001, reports Lufthansa")

It has to be remembered that (quite) some of the cargo is shipped with passenger carriers as well. However, at major airports the freight carriers are a factor that needs to be addressed, as many cargo
planes are of size which is not suitable for use of regional airports. Figure 12 below shows the monthly volume of full freighter planes. Whilst these planes do operate on regional schedules, most air cargo companies also plan their routing according to both seasonal and regional demand factors. This means that their slot times are not as fixed as those of passenger carriers, which operate with regular schedules. Management of these slot times is therefore also a challenge at times of disruptions, as their predictability in slot management is more difficult. On the other hand various carriers seem to reduce the dedicated cargo fleet, concentrating more on cargo capacity of passenger flights (e.g. KLM will reduce its cargo fleet (Lloyds Loading List.com 5 September 2014)

Restrictions on night flights (for example, Frankfurt Airport) hits air cargo carriers

Policy aspects / measures
- Harmonising requirements among countries, for example, US and EU have signed an accord to recognize each other’s airfreight security regulations.
- improve coordination among air traffic control authorities in Europe
- EU: Emission Trading Scheme (ETS) – see fuel prices above

Intermodal issues
- the entire trip for air cargo has to be seen as a whole (ideally multiple-mode single-bill shipments),
- total transit time through the supply chain is the critical issue
- air shipments already multimodal (first and last part of journey by trucks)
- trucking has to some extent already replaced air cargo for short distances
- substitution to railway (studied by UoB)
- for intercontinental transport there are usually only two transport modes to choose from: air or maritime shipments. Air transport is fast and more reliable, whereas, maritime transport can compete with low cost.

Weather-related issues
Severe consequences to aviation cargo transport were particularly investigated for the cases of volcanic ash cloud eruptions. The case study “Volcano 2010” shows that air cargo services and other supply chains in the European Union were affected for several weeks. On 18.04.2010, more than 75% of the European airport network was closed. Economic damage to airlines in a two-week time frame was estimated by IATA to be between 0.85 - 1.3 Billion €. Countries out of Europe were affected by over-flight constraints and by the impossibility to buy or deliver goods. Press releases stated major losses in African countries that could not deliver goods to European customers. For instance, one million roses for the European market rotted in Kenya, Africa. Several companies could not transport up to twenty per cent of the aviation cargo volume (Alexander, 2013).

European authorities closed most of the northern Europe airspace after the eruptions. The main reason for this measure was the possibility of severe aviation accidents due to the risk of engine breakdowns. The air cargo network over Europe broke down by the closure of most of the European airspace. However, no major shortage of consumer goods occurred although some just in time productions had to be stopped and
high value goods could not be delivered. According to Eurocontrol 43 per cent of all cargo flights were cancelled (see table 2 in chapter 2).

It has to be noticed that a good part of air cargo in Europe is carried out as road transport. This explains the largely non-affected supply of consumer goods despite the massive drop in operated flights. Besides that, for many goods there were sufficient stocks available in case of supply shortages. Some non-delivery of spare parts caused – locally – considerable cost, but such deliveries are overall not decisive for the air cargo sector. All international transport routes (that pass the European airspace) were hit. The biggest economic loss occurred on the routes between the UK and the USA. Germany, France and the UK suffered also significant losses. Shortly after the main crisis, air cargo traffic returned to scheduled flight plan (Eurocontrol, 2010). This is shown in cargo stats from Amsterdam Schiphol airport, presented in table 8 below. No major drop in monthly volume of flights was observed despite the week long disruption.

**Table 8: Amsterdam airport cargo flights March and April 2009 and 2010**

<table>
<thead>
<tr>
<th>Month</th>
<th>2009</th>
<th>2010</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>1207</td>
<td>1312</td>
<td>8.7</td>
</tr>
<tr>
<td>April</td>
<td>1048</td>
<td>1059</td>
<td>1.0</td>
</tr>
</tbody>
</table>

All in all air cargo seems relatively volatile to ups and downs in world trade and critical cost factors such as fuel and airport handling cost and efficiency. On the other hand the wide use of trucking in Europe and the availability of less congestion prone specialized freight hubs seem to make air cargo quite resilient. Apparently only a fairly limited share of the air freight has really high time cost thereby giving the sector more flexibility than the passenger side. Obviously making aviation services less sensitive to adverse weather, e.g. advanced tailored weather prediction and by better use of air space, is still economically attractive for the sector.
4. Passenger protection – regulations and (mal)performance

4.1. Introduction

Changes in air travel markets, entailing increased competition, and growing travel volumes have driven the need for better passenger protection legislation, which developed since 2004 in Europe. It started with EU Regulation 261/2004, which aims at consumer protection of air travelers regarding delays, cancellations, denial of boarding, and a few other forms of significant shortfall in service delivery. The protection can take the form of monetary compensation as well as food and hotel service. It obliges airlines to inform travelers timely, including timely updates in case of long lasting delays, and to offer alternatives in case of cancellations and if delays exceed certain time thresholds. The regulation is quite detailed and complex owing to all kinds of exemptions, conditions, and limitations. At the same time the regulation is not always very pertinent and neither is the supervision on compliance (Steer Davies Gleave 2011). Between 2007 and 2010 comparable regulation came into force for train services, bus services, and ferry and cruise services.

From the point of view of the MOWE-IT study it has to be realized that passenger or customer protection is typically based on legislative protection of consumers with respect to their well-being (product safety) and with respect to their economic interests and vulnerability (fair prices, adequate product information, rights to repair and compensation in case of faulty products). Such regulation can be helpful to create minimum standard and to raise general awareness. If the regulation gets more detailed, usually reducing flexibility, the approach not necessarily leads to the highest possible welfare, inter alia due a possible strong increase in transaction cost and reduced opportunities for situation specific trade-offs. Similarly, it may promote safety and resilience of various systems less than hoped for, since it may incentivize suppliers more to be defensive than to reduce underlying causes of faulty delivery.

Since customer protection regulation in transport is currently nevertheless the cornerstone of policies aimed at attenuation of disruptions, this chapter will first present a summary of the current regulation and its upcoming revisions, as well as the performance of the regulation (more information is provided in Annex A). Subsequently, limitations of this approach will be discussed, including questions pertaining to the need for some minimum level of spare capacity in relation to relief of disruptions. This is meant as step up to chapter 5 where is investigated how the ability to attenuate disruptions can be improved with other types of measures aimed at better utilization of the capacity as w hole.

4.2. Summary review of current regulations

Passenger protection regulation at EU level started with Regulation 261/2004, which aims at consumer protection of air travelers regarding delays, cancellations, denial of boarding, and a few other forms of significant shortfall in service delivery. A revision of this regulation is in the making and has already passed various review stages. In this report is assumed that most proposed amendments will be accepted, albeit sometimes with amendments.

Several years after the adoption of the consumer protection regulation for air travelers similar regulation was adopted for rail travel (2007), maritime travel (2010), and intercity bus travel (2011). Table 9 presents a summary of the regulation features for air and rail travel. Maritime travel appears to be a smaller market (see section 2.6 table 4) and is usually operating at a different time scale (from several hours to a day or longer). Furthermore, it usually does not operate in a tightly knit network structure as aviation and rail services do. We therefore concentrate on air and rail, but admit that for some links, such Sweden – Finland and between Mainland Greece and the archipelagos, ferries can be a relevant alternative in case of disrupted air traffic.
Table 9: Punctuality performance and main features of EU passenger protection regulation for air and rail travel

<table>
<thead>
<tr>
<th></th>
<th><strong>Air</strong></th>
<th><strong>Rail</strong>¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Which actors addressed?</strong></td>
<td>• Airlines primarily</td>
<td>• Train service providers</td>
</tr>
<tr>
<td></td>
<td>• Airports (in the revision: contingency plan obligation)</td>
<td>• Travellers</td>
</tr>
<tr>
<td><strong>Compensation if</strong></td>
<td>• Cancellation while no alternative offered /possible (reimbursement)</td>
<td>• Cancellation (also of parts) while no alternative offered /possible (reimbursement)</td>
</tr>
<tr>
<td></td>
<td>• Delay &gt; 3h (5h) / 9h (12h)²</td>
<td>• Delays:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o End point reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Experiences by traveller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 1h-2h: 25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- &gt;2h: 50%</td>
</tr>
<tr>
<td><strong>Exemptions</strong></td>
<td>short flights; small airplanes; force majeure (unavoidable circumstances, i.e. adverse weather)</td>
<td>force majeure (unavoidable circumstances, incl. adverse weather effects); passenger’s own doing</td>
</tr>
<tr>
<td><strong>effects of rules?</strong></td>
<td>• Major airlines will usually fulfil minimum requirements, but will avoid (&amp; game) if possible;</td>
<td>• Developments in accuracy mixed, but in most countries on balance positive;</td>
</tr>
<tr>
<td></td>
<td>• at best modest reduction in delays</td>
<td>• Incentives come however primarily from national mechanisms such as public service contracts</td>
</tr>
<tr>
<td><strong>Costs of regulation</strong></td>
<td>~800 – 1300 million € per year ³</td>
<td>?</td>
</tr>
<tr>
<td><strong>Paid compensation</strong></td>
<td>~ 600 million € per year ³</td>
<td>?</td>
</tr>
<tr>
<td><strong>Information obligations?</strong></td>
<td>YES, including specifications for timeliness and offering choices.</td>
<td>YES, including specifications for timeliness and offering choices. Altogether less elaborate than for aviation as rail travellers are usually less captive than air travellers.</td>
</tr>
<tr>
<td><strong>Enforcement ?</strong></td>
<td>Surveillance of compliance and handling of complaints is usually allocated to an aviation agency or to a generic transport agency, but in some Nordic and Baltic countries and Romania to a consumer protection agency. In most Member States enforcing bodies tend to be cautious in putting much pressure on airlines. In some Member States enforcement bodies have started to increase pressure somewhat (e.g. issuing more sanctions).</td>
<td>Surveillance of compliance and handling of complaints is usually allocated to a rail agency or to a generic transport surveillance agency, but in some Nordic and Baltic countries and Romania to a consumer protection agency. Enforcement seems to be even more restraint than for aviation.</td>
</tr>
</tbody>
</table>

¹) see footnote table 4; 2) figures between brackets are new duration thresholds of the revised regulation ; 3) source: Steer Davies Gleave (2011)
The actual regulation is much more complicated than may be understood from table 9. More information is provided in Annex 1. Also the report by Steer Davies Gleave (2011) provides more detailed understanding of the various implications and leeway for alternative interpretations of various rules.

The revision of the regulation (which is approved by the European Parliament – European Commission 2014) brings several changes of which the most important are:

- **Requirement for unambiguous definitions of extraordinary circumstances.** Extraordinary circumstances can be a ground for exemption of meeting certain passenger rights. For example extremely bad weather conditions, natural disasters, and volcanic ash clouds can cause quite sweeping flight prohibitions and thereby make it impossible to offer alternative flights or routes. Disambiguation of the definitions can reduce the number of disputes and improve the willingness of actors to be proactive (as there are opportunities for gaming).
- **The thresholds for entitlement to flight compensation are increased:** for flights within Europe from three to five hours and for long (intercontinental) flights to nine or twelve hours. This will probably reduce the total amount of paid compensation to stranded travellers.
- **Obligations to timely and properly passengers have somewhat tightened:** carriers must provide an explanation to travellers no later than 30 minutes after the scheduled departure time.
- **Airlines are obliged to use other options of other carriers for rerouting travellers, if these have been detained for more than 12 hours or if airlines cannot reasonably guarantee rerouting within 12 hours; alternatives may also include other modes (in practice HST).**
- **National enforcement bodies will be coerced by the European Commission to more international cooperation, with respect to exchanging experiences and comparability of treatment of airlines and travellers. They are also expected to get more proactive and monitor and report on compliance by airlines.**
- **National law may not restrict the air carriers’ right to seek compensation from responsible third parties (such as airport authorities, baggage handling contractors, etc.).**
- **Airports will be required to develop contingency plans for large-scale disruptions**
- **There are several other measures implying limitations on obligations for provision of compensation, accommodation or care. All of these will imply some decrease in costs of compliance for airlines.**

Essential for this report is however that the regulation’s overall effect on reduction of delays and disruptions in aviation seems to be rather modest at best. From figure 3 (section 2.1) can be inferred that after a year or so of hesitation the airlines seem to get the delay trend bending down as compared to the traffic volume, even though the trend does not seem very steady yet. New punctuality figures of EUROCONTROL for 2014 (not in figure 3, but shown during a MOWE-IT regional conference in Berlin) hint at a rise in delays as compared to 2013. During the period 2005-2012 the tentative reduction in the share of delayed flights is 7%-10% points, but a part of that may has to do with other measures, such as improved aviation weather services, increased capacities at some airports, and progress in the implementation of the EU regulation on Flexible Use of Airspace (e.g. enabling use of military airspace by civil aviation). Furthermore, after the upsurge in truly long delays (> 1 hour) in 2009/2010 the share of long delays has not returned to the very low pre-2009 level. In other words the delay reduction has been relatively strong in the more moderate categories of delays. This inference gets further support by the fact that the regulation offers options to invoke force majeure arguments in case of extreme circumstances. It should be realized that a relatively large share of total travel time loss is concentrated in the long delay segment (see figure 5 section 2.1).
On the other hand if the costs of the regulation are considered (800 to 1300 million euro per year) and compared to the costs of delays and cancellations (approx. 1 – 1.4 billion euro), it gets obvious that the estimated reduction in delays represents a value of 200 million to 350 million Euro. So the annual cost of the regulation significantly outstrip the benefits (of which the extent of attribution to the regulation is unsure). A significant part of the costs are borne by compensation payments to travellers. From a societal point of view this is rather a transfer than a societal cost. If these compensations are left out, the regulation is nevertheless still not cost effective at the macro-level. Furthermore, it has to be realized that eventually travellers are paying for the cost of regulation (and tax payers in as far as the incurred costs for airlines invoke loss compensation mechanisms for taxation). It is fair to add that the cost per traveller per flight remain altogether quite modest, i.e. around 85 Eurocents.

The amendments to the original regulation may be expected to reduce the compliance costs of the regulation to a moderate extent. The amendments imply both moderate increases and decreases in incentives to reduce delays and cancellations, so it is hard to judge possible net changes at the benefit side owing to the amendments. Please note that the evaluation by Steer Davies Gleave (2011) typically focuses on compliance cost, much less so on benefit effects.

So, all in all the regulation incurs cost to all travellers together to an amount of 800 to 1300 million Euro per year, of which a small group of travellers which suffered delays liable to compensation, receives about 600 million Euro, while all travellers to some extent benefit from the reduced number of delays, but nevertheless on balance experience a small welfare loss as a consequence of the regulation. The proposed revision will not alter this picture essentially (see also Steer Davies Gleave (2011)).

For comparison, the total amount of compensations paid to rail travellers seems to be substantially smaller than for air travellers. For example, in the Netherlands it amounted to 6.5 million Euro in 2010, having been growing gradually over the years (also because of ticket price rises). In Germany in 2013 DB paid out a record sum of about 40 million Euro, but 2013 was a top year due to major flooding events. So 30 million would be a more normal figure. By relating these compensation cost to the total rail travel performance in the Netherlands and Germany respectively the corresponding figure for the whole of Europe (EU28 + EFTA) would be around 130 million Euro (+/- 30 million).

A striking feature of the consumer protection regulation is its focus on one type of service provider only, i.e. airlines and train service operators, instead of addressing all main actors that can exert significant influence on delay generating factors. In particular the absence of airport authorities and rail network companies is remarkable. However, owing to national policies in many EU Members States rail network companies have a co-responsibility for punctuality shared with trains service operators. Rail network companies and sometimes also train service operators are also obliged to monitor and report on punctuality. For airports there does not exist such a national supplementary policy framework. Decisions on maintenance of facilities, snow clearing, slot allocation procedures, and pricing are typically made by the airport and/or local air traffic management, whereas such decisions have large consequences for operational response options and effectiveness of airlines. The EC regulation could for example include benchmarked performance indicators for airports (weighted for local inescapable circumstances).

It should also be realized that airports and also major train stations are ever more managed as a real estate investment, which should have a reasonable return on investment, whereas at the same time surcharges on tickets (such as for landing charges, nuisance taxes, etc.) are preferably kept moderate so as keep up demand for air travel. This means that shopping options and business service facilities are expanded, whereas unproductive services such as passenger and luggage safety checks are tuned to a just acceptable level. Especially at larger airports this raises the risks of passengers getting wound up somewhere instead of timely moving to the gate. Summarizing, the currently prevailing business model of airports does not seem
optimal from a resilience management point of view. By introducing benchmarks regarding punctuality factors, which e.g. could affect allowable charges, the business model could get better aligned with resilience management objectives. The proposed revision introduces an obligation for airports to prepare contingency plans in case of large scale disruptions (and possible evacuation needs), but otherwise no incentives for other actors than airlines have been added.

4.3. The limitations of regulatory approaches – what next?

The current regulation has limited effect on delay reduction. On the other hand it should be acknowledged that the civil aviation sector in Europe is subject to international competitive pressures and the profitability of the sector tends to be low (Annual Analysis of the Air Transport Market 2011), while options for government support are ever more limited due to competition legislation. This makes airline companies prone to takeovers and bankruptcy. As a consequence additional European regulation has only limited leeway for broader or stricter policies regarding consumer protection.

As was identified in the preceding section, inclusion of more actors, notably airports, seems still an option that has some potential. Also the traveler itself could be held more responsible for some types of delays, but in practice it may be difficult and costly to prove the actual accountability of such travelers. Otherwise the proposed revisions of the regulation are partly even a relaxation of current guidelines, which is to some extent instigated by the relatively weak financial position of airlines. All in all it seems that the consumer protection regulation does not offer much effective scope for extension, apart from a benchmarking based guidance of airports, and on the other hand may have anyhow limited potential for promoting delay reduction.

This means that further improvement of the resilience and reduction of delays should be sought via other approaches, such as (1) affordable forms of spare capacity, (2) better sharing of information across actors, (3) transparent information and decision support facilities for travelers, and last but not least (4) price differentiation in relation to risks and risk avoidance (guarantees).

Ad.1: Spare capacity easily risks to cause extra capital costs, while not or scantly raising extra revenues. This effect can be attenuated by trying to develop spare capacity with multiple purposes or by increasing the flexibility of existing capacity (e.g. variable lane assignment on motorways in congestion prone areas). Efficient and flexible use of spare capacity ties in with the third approach, information provision, meaning that better and timely informed actors enable a more efficient use of capacity.

The value of spare capacity during disruptions is much higher as compared to normal operations. This value bonus effect of spare capacity is usually not accounted for in cost-benefit analysis of transport infrastructure investments. Similarly, in pricing approaches for infrastructure capacity this bonus effect is usually not accounted for, unless the infrastructure use is based on capacity utilization sensitive bidding mechanisms, such as is the case in wholesale electricity markets. Correcting these misrepresentations may be expected to generate some spare capacity.

In chapter 6 will be explored how much spare capacity can be found within the current systems. For a meaningful exploitation of the theoretical spare capacity also the other types of solutions (information tools; price differentiation) will be necessary.

Ad.2: Recently ever more infrastructure companies and crisis management authorities have identified that sharing of information across actors and competitors is still poorly developed (Fjäder 2014a, 2014b; CEPS 2010; UK Cabinet office 2011 ) even though it can bring savings for all in disruptive situations. Partly the challenges are technical, related to data formats, etc. partly it is a matter of creating mutual trust and partly it is a matter of being creative in finding management structures and approaches fit for overarching
joint but mutually sensitive data systems. Again benchmarking may help here comparing regional cooperation in one areas with that of others. Furthermore, this approach also needs support for R&D and demonstration / piloting. Laplace et al (2014) discuss an example of collaborative decision making on French airports as a means to raise resilience.

Ad.3: Another important element of information is transparency for travelers. Mobile applications assisting travelers to find alternative routes and providers can be very helpful. However, in case of large scale disruptions a massive use of such tools may only result in a transfer of the problem from air to rail. This means that such applications should be interactive and be frequently updated on the evolving situation so as to have a (near) real time assessment of still available capacity of the original mode and the alternatives. This requires cooperative rather than a competitive approach from involved actors, i.e. also here information sharing is very important.

Ad.4: Already now airlines apply price differentiation in terms of the extent it is allowed to still change (features of) a ticket after its purchase. Furthermore, frequent flyers and business passengers will often get preferential treatment in case of cancellations, serious delays and other disruptions. Yet, overall possibilities to sell different levels of rebooking guarantees for air travelers are not very well developed. Neither are ticket prices related to weather and seasonal climate risks. Some airlines (e.g. Lufthansa, Air France) have developed cooperation with train service operators, e.g. to have seamless connections between HST services and flights, including check in and luggage handling already at the rail side. In principle this type of cooperation is based on a mixture of reducing unprofitable feeder flights (while retaining the customers) and improvement of the catchment area thanks to the elaborate HST network. This type of cooperation could be elaborated for resilience purposes. Furthermore, somewhat similar to air cargo by road, airlines could systematically offer HST services as an alternative so as to relieve busy flight connections.

More cooperation in multimode service provision will also need more cooperation in information provision, while at various nodes possibly some extra capacity or bypasses have to be built. This exemplifies that often the four approaches will have to work together.

The attempts to increase resilience of transport systems, notably aviation and rail, are embedded in an institutional setting which is facing conflicting goals. On the one hand ease of travel and affordable travel are regarded as cornerstones for economic development, in particular by gains from trade and mobility of labour. The structure of the aviation and rail transport makes profitability of operators in these sectors precarious, in turn this means that new obligations are hard to impose. On the other hand environmental policies, create new cost challenges – notably for aviation. Furthermore, these policies may also lead to tendencies to curtail (the growth in) demand. The tendency of airport authorities (companies) to run airports primarily as a huge real estate project is related to these pressures as it is one of the few ways to raise more money, e.g. for resilience investments, without directly burdening ticket prices. However, by the end of the day the traveler still has to pay. From the point of resilience to natural hazards and other disturbances, but also from the point of view minimized travel time and smooth travel it seems to get relevant whether other more cooperative business models, with more active roles for travelers, would be better fitting the current and near future challenges of aviation. This question goes well beyond the remit of the MOWE-IT project, but merits to be recognized in relation to resilience promoting policies.

Regardless of the types of policies and measures it is important not to forget the ultimate purpose of increasing the resilience of transport systems and reducing delays, which is to contribute to societal welfare and wellbeing. Unaffordable and inefficient transport resilience policies and measures may achieve the opposite. The implication of this is that a truly resilient society should be able to sustain a very occasional – hard to avoid - disruption in the transport system.
5. Lessons from outside Europe for natural hazard contingency management

In comparison to the extent of delays and cancellations experienced in other aviation markets, the European air transport seems to fare reasonably well. According to data by FlightStats from 2013 presented in Table 10 the share of excessively delayed (over 45 minutes), cancelled or diverted flights is significantly lower compared to North America or Asia. An interesting detail is the share of diverted flights. In Europe, diversions seem to be very rare, whereas in North America rerouting to a new destination seems to be used as an alternative for delay or cancellation much more frequently. Different structure of the air transport market and network or the absence of strong political boundaries could offer an explanation (EU member states in comparison to states in the U.S. – in Asian market the high share of Chinese and Japanese domestic flights mean less boundaries too). In this sense, the North American air transport system seems more flexible compared to Europe.

Table 10: The share of excessive delays, cancellation and diversions in 2013 (source: FlightStats, 2013-2014)

<table>
<thead>
<tr>
<th>Region</th>
<th>Excessively delayed (over 45 minutes)</th>
<th>Cancelled</th>
<th>Diverted</th>
<th>Total E+C+D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>5,8 %</td>
<td>1,21 %</td>
<td>0,02 %</td>
<td>7,03 %</td>
</tr>
<tr>
<td>U.S.</td>
<td>8,8 %</td>
<td>1,58 %</td>
<td>0,17 %</td>
<td>10,54 %</td>
</tr>
<tr>
<td>Asia</td>
<td>16,56 %</td>
<td>1,9 %</td>
<td>0,10 %</td>
<td>18,56 %</td>
</tr>
</tbody>
</table>

5.1. United States

The transport system in the United States differs from Europe in its reliance on air and passenger car transport. The share of air of all passenger kilometers in the U.S. is 12 % compared to the 8 % in the EU, and the difference in the share of public transport (62 % compared to 33 %) is even clearer. The role of railways in intercity passenger transport is marginal, but it is one of the dominant modes in freight transport (European Commission, 2012). In absolute terms, the U.S. is the largest market of both passenger and freight transport by air (World Bank, 2014). Long geographic distances within the country and the lack of public investments in passenger rail transport are among the causes contributing to the composition of transport modes.

The air transport market in the U.S. is largely consolidated. The combined market share of the five largest carriers is over two thirds and the whole market is largely dominated by the ten leading carriers (RITA, 2014c). The market deregulation started decades earlier in the U.S. than on the European scale, and the current market structure is somewhat different as well. The share of so-called low cost carriers is significantly lower. The hub-and-spoke network structures of the leading carriers have significant impact on the flows and distribution of air transport, giving rise to major hubs such as Hartsfield-Jackson in Atlanta or O’Hare in Chicago. The U.S. system differs from Europe in that the major freight hubs and routes are different from the passenger hubs.

The level of air transport delays in the U.S is comparable to Europe. The threshold for the flight to be defined as delayed is 15 minutes. In 2013, 79.2 % of all flights were on-time (RITA, 2014b). The share of weather in delays is however more significant than in Europe. Extreme weather, meaning conditions that prohibit flying, accounted for 4.1 % of delay minutes in 2013. All weather related delay including primary delay and reactionary delay caused by weather accounted for 36.5 % of delay minutes in 2013. Based on the data provided by BTS, it can be estimated that around 33 % of all primary delay was weather related.
Although the differences in reporting make direct comparisons challenging, it seems clear that weather disrupts air traffic more frequently in the U.S. than in Europe. One reason could be more challenging meteorological conditions. Unlike in Europe, in the U.S. the share of weather delays has been in the decline for the last ten years as shown in figure 12. It thus seems that improvements in weather services have been more effectively utilized. Since the on-time performance in general has not drastically changed in the same period and the volume of traffic in terms of departures has actually decreased, not only the relative share but the absolute volume of weather induced delays has decreased.

![Figure 12: Weather delays in the U.S. air system (Source: RITA)](image)

The passenger rights regulation in the U.S. differs from the E.U. Besides responsibilities about baggage handling and ticket pricing it is focused on two issues: tarmac delays in which passengers have to wait in the airplane and involuntary bumping (i.e. denial of boarding in the case of overbooking). In the case of involuntary denied boarding, passengers are entitled for monetary compensation if the planned arrival of the alternative transportation is more than one hour later than the original arrival (DoT, 2011). For domestic flights, the compensation for delay between one hour and two hours is 200 % of the original one-way fee up to $650, and for delay over 2 hours 400 % up to $1300. For international flights the compensation amounts are the same, but the threshold for the higher compensation is 4 hours instead of 2 (DoT, 2011). If the airline arranges alternate transportation on another carrier, it has to cover all of the expenses of such transfer. When the passenger regulation was renewed to its current form in 2011, the officials assessed it to bring monetized net benefits of 14.3 million dollars in the following ten years. Most of the benefits were expected to result from improvements in the transparency of ticket pricing. The stricter contingency planning and bumping compensations were estimated to cause some monetized net costs (few million dollars) but to bring broad range of unquantifiable benefits to all stakeholders in the air transport system (DoT, 2011).
Regulation on the tarmac delays came about after incidents where the passengers were confined in the sitting airplane for hours with limited food, drinking and sanitation facilities. Current regulation states that an airline can keep passengers waiting in the airplane for maximum three hours (domestic flights) or four hours (international flights) and that the passengers need to be continuously informed about the situation. If the airline fails to do this, it is heavily fined by the Department of Transportation, but the passengers are not entitled to fixed compensation (DoT, 2011). The tarmac delay issue seems to be more in focus in the U.S. compared to the Europe. There are two likely factors involved: the use of diversion as a disruption response and the strict security practices. As discussed in Chapter 2, the diversion rates for flights in the U.S. are notably higher than in Europe. The strict security practices complicate letting passengers out of the plane after a diversion, as the resources might not be readily available at the changed destination. The new tarmac delay rules have forced the airlines to alter their disruption management procedures. It has been claimed by IATA that the likelihood of cancellation has risen 24% since the regulation was put to place (IATA, 2013).

In contrast to the tarmac delays and denied boarding, there is no regulation regarding passenger rights in general in delay or cancellation events. While there are no federal requirements, airlines have their own policies. The major airlines do not have fixed compensation rates, but the Department of Transportation guides passengers to ask for meal vouchers or possibility to switch to another airline instead of waiting. Examples of written policies include Delta Airlines providing hotel accommodation when passenger needs to wait overnight for available flight (Delta, 2014) and United Airlines (United Airlines, 2014) and Southwest Airlines (Southwest, 2014) offering to waive extra costs of ticket change if the original flight is delayed or cancelled. Fixed passenger compensation appears not have become a competitive advantage in the market.

Commercial airports in the U.S. are regulated and certified by Federal Aviation Administration, which requires certain levels of preparedness, such as e.g. weather detection systems and plans for snow and ice removal (FAA, 2014a). The airports are thus expected and legally required to obtain a high level self-sufficiency towards disaster management, but there are occasions in which mutual aid is necessary for rapid recovery. For the case of larger disruptions, such as natural disasters, there are mutual aid programs between airports in the U.S. These exist on different levels from one-on-one partnerships to regional arrangements. Two regional organizations that assist with airport mutual aid are Southeast Airports Disaster Operations Group (SEADOG) and Western Airports Disaster Operations Group (WESTDOG) (Transportation Research Board, 2012). SEADOG and WESTDOG are voluntary, informal organizations that assist and coordinate responses to disasters. Examples are supplying teams of volunteer airport staff and necessary equipment (SEADOG, 2014).

A FAA sponsored study in 2012 by Transportation Research Board (2012) concluded the following characteristics for successful mutual aid program (in descending order of perceived importance):

1. Voluntary participation
2. Limited to aviation functions
3. Continued control by receiving airport
4. No impact on the operational effectiveness of the responding airport
5. Restoration of operations at the affected airport as quickly as possible after an emergency
6. Effective communications
7. Precise matching of need and aid

In terms of policy design the voluntariness is an important aspect. According to the aforementioned study, a mandatory mutual aid program would not be effective and would not bring the benefits of rapid response and cost savings. The study also recognized the value of airlines as part of disaster response, but their
willingness to support is limited to certain emergencies and ways, so it seems that voluntariness is essential in involving airlines as well.

Similarly to the European SESAR undertaking, there is a major effort in the U.S. for the development of next generation of national airspace management, dubbed NextGEN. The goal of NextGEN is more flexible and safe traffic management enabling the growth of traffic while at the same time reducing congestion and environmental footprint as well as improving safety. Central aspects of NextGEN are automatic surveillance broadcasts, data communications, unified weather information system, single NAS voice system, new collaborative air traffic management technologies and system wide information management. The new weather service system, CSS-Wx, will provide the authorities and all users of the national airspace with unified aviation weather picture provided by NOAA and other weather services. The idea of CSS-Wx is to enable more flexible and proactive responses to present and expected weather conditions. CSS-Wx is currently being tested, and the timeframe of the whole NextGEN implementation is from 2012 to 2025. (FAA, 2014b)

The main enforcement body of passenger rights regulation is the Department of Transportation, which also handles official complaints by passengers towards airlines. The amount of complaints compared to traffic volume has been increasing during the last ten years, and now around two out of 100 000 passengers file a complaint (DoT, 2014a). The largest share of complaints (approx. 30 % in 2013) is related to “Flight problems” which include delays, cancellations and misconnections. It is followed by complaints on baggage handling, bumping and customer service. The impact of the complaints on flight problems is unknown but most likely result in no compensation, since the airlines are in general not liable for financial damages resulting from delays or cancellations and typically refuse to pay such losses (DoT, 2014b). For delays and cancellations the main measure of passenger protection is information. Department of Transport guides passengers to compare the on-time records of the airlines and airports, and the publication of this information is enforced. The DOT Office of Aviation Enforcement and Proceedings itself also publishes monthly records by airline and airport.

Interestingly, as an example the impact of the storm Sandy shows a clear rise in the complaints about denied boarding and customer service in October and November 2012 compared to year 2011, but the level of flight problem related complaints saw no similar major increase. This could indicate that in the face of such a major disruption the passengers have accepted the delays and cancellations but were not as satisfied on how the airlines handled the issue. In the denied boarding cases the passengers are also automatically entitled to the fixed compensations, so there is stronger motif to file a complaint in the case the airline has not acted as regulated.

The policy approach on air transport disruptions in the United States differs from the path taken in the EU. The emphasis is more on market mechanisms instead of regulation, although recent tarmac delay incidents pushed for more stringent legislation. The market efficiency is supported by detailed and open collection of performance data of the actors in the transport system. Measured by disruptions and delay, including those caused by weather incidents, the system performs poorer than in Europe, but the conditions are likely to be somewhat more challenging. There is also considerable improvement in reducing the impact of weather on air traffic, which could be the result of continuously implementing improved technology and procedures. The U.S. air transport system also seems more flexible in terms of rerouting the traffic in the face of adverse conditions, but there is practically no capacity for modal shift excluding the use of private cars. The enforcement of regulation is streamlined since there are only two main federal agencies (the Department of Transport and the Federal Aviation Administration) responsible for enforcing the regulation.
5.2. People’s Republic of China

5.2.1. Overall situation

China’s civil aviation sector is the world’s second-largest, after the United States. The market is still growing, with an average growth rate of 11% in the last five years, slowing down to 6% growth in 2012. According to information from the Civil Aviation Administration of China (CAAC, 2013), the market is likely to grow by up to 13.5% annually from now through 2020.

Figure 13: Aviation market development in China 2008 - 2012

Source: 2012 年民航行业发展统计公报 (CAAC, 2013)

In 2012 the total air passenger growth was 9.2% from the previous year with a total of 319 million passengers transported. In the same period, total air cargo and mail transportation showed a negative growth rate of -2% with 5.4 million tons. Compared to the air transport markets in the U.S. (more than 60 000 flights per day) and Europe (more than 50 000 flights per day) the Chinese market is rather small (around 10 000 flights per day) Want China Times (2013). But the market is growing strongly. According to the EUROCONTROL industry monitor EUROCONTROL (2014b) Hainan Airlines alone has ordered 28 new aircrafts (including B787 and A380).

The Chinese air transportation market is strongly controlled by the government. The main carriers are all state owned enterprises. The largest ones being Air China, China Eastern, China Southern and Hainan Airlines. The four airlines together account for 90.3% of air transportation in China. A total of 46 airline companies exist, out of which 36 are state-owned. 10 out of these 46 are only in the freight transportation; 14 out of all companies are joint ventures with foreign companies and 5 of all companies are listed companies Civil Aviation Administration of China (2013).

5.2.2. Air traffic management

Different to the US and Europe, China’s civil aviation industry is still very young. It was spun off from the nation’s military in March 1980, ending Air Force control of all civil aircraft. From then onwards civil aviation industry was supposed to operate independently and manage air space together with the Air Force. In 1986 the Air Traffic Control Commission was set up, but was still supervised by the military. The
commission today still approves all new civil air routes and emergency route change requests, the latter which also need Air Force to agree on it.

The Air Traffic Management Bureau of the Civil Aviation Administration of China was formed in 1994 and given charge of air route management. In June 2000, CAAC was full rights to supervise all civil aviation routes.

Again different to many industrialized countries, only 20% of the China’s airspace is allocated to civil aviation while the rest is reserved for military use. Other sources state, that civil aviation utilizes 34% of mainland skies, while the military uses 25%. No flights are reportedly allowed in the remaining 41 per cent of airspace eChina cities (2013).

5.2.3. Delays and weather

There is only one official statistic publicly available for the delays and there causes, which is issued in the annual report of CAAC for the civil aviation in China. The definition of delay seems to vary between China and the US: in the US more than 15 minutes later than the scheduled departure time are considered a delay, while in China a delay is more than 30 minutes after departure time eChina cities (2013).

The official average punctuality rate for 2.5 million flights in 2012 was 74.83%. According to data from US based FlightStats, Beijing Capital Airport has the most delays with 81.7% of all flights delayed and Shanghai with 71.3% of all flights (see also Want China Times (2013)). According to unofficial data Chinese airlines lose a minimum of 576 million Euros each year because of delays. The punctuality figures in Table 11 (percent of delayed flights and average delays in minutes) compare the punctuality of Chinese airports to other global destinations from and to London. The figures confirm the somewhat lower in-time performance of Beijing with an average punctuality rate in 2013 of 58% against a global average between 70% and 80%. However, the most frequently approached Chinese airport from London, Hong Kong, meets these international performance standards quite well, and also Beijing the 2010 figures are within a satisfactory range.

The above mentioned restrictions in civil air space in China has a significant impact also on weather related delays, as the limitations lead to a reduced flexibility in bad weather conditions.

Delays also happen in the summer month in China, when large thunderstorms occur frequently. Planes are not allowed to detour around storms as they would then enter restricted military areas, which force them to stay on the ground. Since 2010, flight delays have been mounting during the country’s thunderstorm-prone summer months, according to Caixin Media Market Reports Market Watch (2013). Storms were cited as the reason for 1,200 flight cancellations by the nation’s flagship carrier Air China in June 2013 alone. And on July 8, bad weather was blamed when Air China cancelled 230 domestic and international flights, and delayed another 118 for no less than four hours.

In July 2013 CAAC eased its controls on departures at eight airports including those serving Beijing, Shanghai, Guangzhou and Shenzhen in order to ease the delay situation in China. As a result, civil flights leaving these cities can no longer be delayed or barred by authorities in destination cities, unless for bad weather conditions or the military. Yet experts doubt that this will have any significant impact, as it will not solve the major issue of the very limited air space.

As most delays in China are due to congested air traffic routes and inefficient management on the airline and air traffic management side, these two are the most publicly debated topics. Not much is published with regards to the impact of bad weather on delays.
Table 11: Punctuality rates on selected flight routes from London to Asian airports 2010-2013

<table>
<thead>
<tr>
<th>Route (from / to London)</th>
<th>Flights annual 2013</th>
<th>Number of airlines 2013</th>
<th>Punctuality [% flight &lt;15 min. delay] 2013</th>
<th>Punctuality [% flight &lt;15 min. delay] 2010</th>
<th>Severity of delays [av. delays all flights, min.] 2013</th>
<th>Severity of delays [av. delays all flights, min.] 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>China</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beijing</td>
<td>1709</td>
<td>2</td>
<td>57,6</td>
<td>72,0</td>
<td>25,7</td>
<td>16,2</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>5407</td>
<td>3</td>
<td>74,3</td>
<td>72,7</td>
<td>15,3</td>
<td>17,5</td>
</tr>
<tr>
<td>Shanghai</td>
<td>1805</td>
<td>3</td>
<td>68,5</td>
<td>74,6</td>
<td>20,5</td>
<td>30,4</td>
</tr>
<tr>
<td><strong>Rest of Asia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>4601</td>
<td>3</td>
<td>75,5</td>
<td>75,5</td>
<td>16,0</td>
<td>15,1</td>
</tr>
<tr>
<td>Delhi</td>
<td>4333</td>
<td>4</td>
<td>76,6</td>
<td>60,1</td>
<td>14,7</td>
<td>27,0</td>
</tr>
<tr>
<td>Tokyo</td>
<td>3358</td>
<td>4</td>
<td>79,6</td>
<td>74,4</td>
<td>14,5</td>
<td>12,3</td>
</tr>
<tr>
<td>Seoul</td>
<td>2063</td>
<td>3</td>
<td>67,0</td>
<td>67,9</td>
<td>16,8</td>
<td>15,3</td>
</tr>
<tr>
<td><strong>Australia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sydney</td>
<td>2182</td>
<td>3</td>
<td>74,5</td>
<td>66,4</td>
<td>21,5</td>
<td>24,2</td>
</tr>
<tr>
<td><strong>N. America</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York</td>
<td>21326</td>
<td>6</td>
<td>76,4</td>
<td>67,1</td>
<td>13,9</td>
<td>20,4</td>
</tr>
<tr>
<td>Chicago</td>
<td>6387</td>
<td>4</td>
<td>74,2</td>
<td>67,1</td>
<td>15,8</td>
<td>19,0</td>
</tr>
<tr>
<td>Toronto</td>
<td>5367</td>
<td>3</td>
<td>68,1</td>
<td>62,8</td>
<td>20,6</td>
<td>26,6</td>
</tr>
<tr>
<td>Washington</td>
<td>5208</td>
<td>3</td>
<td>77,7</td>
<td>68,2</td>
<td>14,3</td>
<td>18,1</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>4579</td>
<td>4</td>
<td>71,7</td>
<td>59,4</td>
<td>18,5</td>
<td>23,8</td>
</tr>
<tr>
<td><strong>Europe</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amsterdam</td>
<td>30359</td>
<td>5</td>
<td>82,9</td>
<td>77,2</td>
<td>9,4</td>
<td>13,0</td>
</tr>
<tr>
<td>Geneva</td>
<td>19529</td>
<td>4</td>
<td>76,6</td>
<td>67,3</td>
<td>13,2</td>
<td>20,8</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>18379</td>
<td>5</td>
<td>79,2</td>
<td>67,8</td>
<td>10,0</td>
<td>16,9</td>
</tr>
<tr>
<td>Milan</td>
<td>17941</td>
<td>4</td>
<td>79,2</td>
<td>66,0</td>
<td>11,5</td>
<td>19,1</td>
</tr>
<tr>
<td>Barcelona</td>
<td>17826</td>
<td>7</td>
<td>77,5</td>
<td>63,5</td>
<td>12,3</td>
<td>22,7</td>
</tr>
</tbody>
</table>

Source: Flightontime.info (2014).

5.2.4. Passenger rights

The Civil Aviation Administration of China and the Civil Aviation Association issued guidelines on how to compensate passengers in 2004 and 2010 respectively. So far these guidelines are non-binding and have not been transferred into a law or binding regulation. This has resulted that each Chinese airline has their own set of rules and standards related to financial compensation.

Passengers who choose to buy insurance while booking tickets online, which normally costs 2.30€, are entitled to aviation accident insurance and delay insurance compensation eChinaCities (2013). According to the same source, 80% of passengers are unaware that they could buy delay insurance and more than 50% of those who are entitled to compensation do not claim it. Besides the rather low amount of compensation, those passengers who want to claim compensation for delayed flights must produce evidence of the delay (i.e. prove that the delay was caused by bad weather or traffic operations management etc.).

Table 12: Rules and standards for passenger compensation by Chinese airlines

<table>
<thead>
<tr>
<th>Airline</th>
<th>Delays on booked flights</th>
<th>Luggage delays</th>
<th>Cancellations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air China</td>
<td>300 RMB (35 €) for every four hours delayed (max. 600 RMB) (35 €)</td>
<td>500 RMB (60 €) for every eight hours delayed (max. 1000 RMB) (35 €)</td>
<td>300 RMB (35 €)</td>
</tr>
<tr>
<td>China Southern</td>
<td>300 RMB (35 €) for every four hours delayed</td>
<td>500 RMB (60 €) for every eight hours delayed</td>
<td>-</td>
</tr>
<tr>
<td>China Eastern</td>
<td>600 RMB (70 €) if delayed by more than four hours</td>
<td>1000 RMB (115 €) if delayed for over eight hours</td>
<td>-</td>
</tr>
</tbody>
</table>

5.3. Australia

Australia is a large island continent with a thriving resource-driven economy. An air transport system, which constitutes the airlines together with airports, air navigation and other essential grounds services, is thus vital to Australia’s economic growth and prosperity. Australia’s competitive disadvantage from the ‘tyranny of distance’ has to be tackled through an efficient air transport network to facilitate seamless flow of people and commodities nationally and globally. The enormous infrastructure costs, transport hub bottlenecks, limited economies of scale, inadequate modal integration and disruptions from extreme weather events are other key challenges underpinning the efficiency of the Australian air transport network.

Australia is a country subject to a vast array of climatic regimes. In recent years it has had continuous exposure to various weather events such as drought, prolonged periods of extreme temperatures (heat waves), bushfires, cyclones and floods. The intensity and likely frequency of these events is forecast to significantly increase over the next 20 to 50 years as a result of climate change (Chhetri et al, 2012). Queensland floods in 2011 is one such example that resulted in shutting down of Rockhampton airport for several weeks, disrupted 54 coal mines and 11 ports and damaged more than 9,100 km of state road network and approximately 4,700 km of the rail network (The World Bank, 2011). Since Australia is predominately a commodity export-driven country, any impact on the country’s transport infrastructure directly impacts GDP and living standards.

The aviation sector contributes $32 billion, which is 2.6 per cent of Australian GDP (Oxford Economics, 2011, p.4). 312,000 people are employed in the aviation sector, out of which 149,000 are directly employed. Air transport is the main transport carrier in Australia as more than 90 per cent of the visitors to or from Australia travel by air. There are 53 international airlines currently operating in Australia (BITRE 2014a).

The air transport sector carries over 78 million passengers (IATA, 2014) and 709,000 tonnes of air freight to, from and within Australia (Oxford Economics, 2011, p.5). There were more than 86,400 scheduled international flights departing from Australia every year, connecting 61 airports across 39 countries. Within Australia, there were more than 603,000 flights per year with a total capacity over 71.6 million seats available to passengers. Furthermore, a total of 31.34 million passenger movements from or to Australia from overseas were registered in 2013 (BITRE, 2014a). The overall percentage of seat utilisation has remained relatively high, though it has marginally declined from 77.6 per cent in 2012 to 76.7 per cent in 2013.

The volume of international air freight to Australia’s total merchandise trade is less than 0.1 per cent. But its value accounts for over 21 per cent of total trade, which was worth over $110 billion in 2011–12 (BITRE, 2014b)

5.3.1. Air Passenger Rights

Airlines in Australia are guided by IATA, which advocates for the protection of passenger rights, including the right of compensation for delays, denied boarding and cancellations, right of information for fares and ticketing, assistance for those with impaired mobility and efficient complaint handling procedures (IATA Press Release No.: 32 Date: 3 June 2013). Passengers are entitled for the provisioning of re-routing, refunds or care and assistance where circumstances are within the airlines’ control (ibid). Unlike Europe (Regulation 261/2004) and the United States (DoT Rules - 14 CFR Part 259), Australia has no explicit air passenger rights regulation to specifically deal with delayed, cancelled flights or tarmac delays. Air passengers, however, have access to the Australian Competition Consumer Commission (ACCC) or state
consumer affairs departments, which provide general consumer protection. As a government agency, the ACCC ensures “individuals and businesses comply with Australian competition, fair trading, and consumer protection laws - in particular the Competition and Consumer Act 2010”.

In Australia, there is currently no strong indication from the Commonwealth Government to legislate the Airline Passengers’ Bill of Rights (APBOR). In 2012, the airline industry voluntarily established an independent body, called the Airline Customer Advocate. The Airline Customer Advocate, as argued by commentators in the media, is an alternative to a legislated air passenger bill of rights in Australia. The key task for this agency is to handle unresolved complaints related to Australian domestic airlines. Thus, it acts like an ombudsman. The Australian Aviation Associations Forum, an industry body, however expressed the urgent need to expedite the regulatory reforms within the Australia’s aviation sector. The reforms are required to align with international best practices, key trading partners and the relevant international treaties. New regulations to internationally harmonized aviation policies, procedures and practices on issues around aircrew and passenger safety, particularly during a disrupted flight should be formulated through formal and informal consultation with industry and other stakeholders.

**Passenger’s Right to Information**

The European Commission recommended that passengers should have the right to information about their situation, 30 minutes after a scheduled departure time. All major airlines in Australia have documented the passenger’s right of information on their websites. For example, Qantas, the Australia's flagship carrier, will ensure that the passengers are informed “if a delay of 45 minutes or more is expected, or if the flight is cancelled, at least 2 hours ahead of the scheduled departure time”. Virgin Airline has the same timeframe for contacting passengers (i.e. at least 2 hours before the scheduled departure time); whilst Jetstar will advise passengers or travel agents via SMS or a phone call and leave a message, “if a delay of more than 30 minutes is expected before the day of departure, or of more than 45 minutes on the day of departure, or if a cancellation”. Tiger Airways is also committed to timely informing passengers if there is a delay by more than 30 minutes.

**5.3.2. Flight Delays and Cancellations**

There is currently no systematic procedure for recording weather-related disruptions, delays or cancellation in Australia. Some data related to on-time flight departure or arrival however are now available due to the intervention from the Federal Government in 2003, which requires all Australian trunk carriers to report departure delays in excess of 15 minutes (Bowran, 2004). On-time performance over all routes operated by participating airlines in Australia averaged 81 per cent for on-time departures and 79 per cent for on-time arrivals for 2013. In 2013, 1.8 per cent of all scheduled flights were cancelled. Figure 14 shows the on-time performance of participating airlines in Australia for both on-time departure and arrival since December 2008. It shows a gradual decline with substantial month-wise fluctuations. The graph also depicts an overall decrease in average on-time departure for the period after July 2010 as shown with dotted red lines in Figure 14.
Figure 14 On time departure and arrival for participating domestic airlines in Australia since December 2008 (source: BITRE, 2014c)

Figure 15 shows cancellation rates for all participating Australian domestic airlines. Cancellation rate seems to operate below 2 per cent since December 2008 with few exceptions. The cancellation rate drastically increased to 5.2 per cent in June 2011 due to the volcanic ash cloud disruptions in Chile.

5.3.3. Compensation for Delays and Cancellation

The provision for compensation for delays or cancellation is similar across all domestic airlines in Australia. All domestic airlines will make a reasonable attempt to re-book on an alternative flight at no additional cost to the passenger. Alternatively, a passenger will get a refund of the full fare or a fare credit for up to 6
months, as in the case of Tiger Airways. Overnight delays or cancellation, whether caused by technical or operational problems or by a weather-related disruption, a compensation for meals, accommodation and transfers away from the home port will be provided, as stated in the policy published by Qantas and the Virgin Airline. Similar policy is put in place by Jetstar and Tiger Airways to deal with overnight delays. There is however little information on tarmac delays published on internet in Australia. Virgin Airlines has put in place provision for supplying water, food and urgent medical requirements if such on-board delays occur. In general, the Australian Airlines offer generous passenger entitlements for flight delays or cancellations. The compensation mechanisms however vary to include an arrangement for an alternative flight, re-routing, refund of full fare or a fare credit, and accommodation and transfer.

5.3.4. Complaint Handling Procedures

The Airline Customer Advocate collates data gathered from the major Australian airlines on the number of complaints, flight delays and cancellations. Figure 16 shows various categories under which passenger complaints are reported. The data show that almost two-thirds of complaints received from passengers by airlines were resolved. For instance, there were 429 complaints registered in 2012, out of which 283 were directly resolved. The unresolved complaints were passed on to state consumer affairs departments. On an average, it takes about 14 days to successfully resolve a complaint, which is within the published 20 working days timeframe as set out by the participating airlines. It is also within a 2 month response time as recommended by the European Commission to the European Parliament to ensure that the passenger has a right to a response to their complaints (European Commission, 2014).

Booking cancellations and refund request accounted for 31 per cent of the total complaints between July and December in year 2012. This is followed by flight delays or cancellations (18%) and fees or charges (16%). A Flight delay, as defined by the Australian Bureau of Infrastructure, Transport and Regional Economics (BITRE), occurs when a flight failed to depart the gate within 15 minutes of the scheduled departure time, and a flight arrives at the gate after 15 minutes of the scheduled arrival time shown in the carrier’s schedule. Other forms of complaints are related to Website and Terms and Conditions.

![Figure 16 Types of Complaints (Data source: the Airline Customer Advocate, 2012)](image)

The data also show that the Tiger Airways has received, 6.5 complaints per hundred thousand passenger trips, which is the highest among all participating airlines. It is followed by Jetstar (3.2/100,000). Qantas (QF) has fewest complaints, i.e. 0.11 per 100,000. Virgin Australia and Qantas have both effectively restricted the figure within 0.5 complaints per hundred thousand passenger trips. Rex Airlines, a regional airline, has received the lowest number of complaints. Most complaints were related to booking cancellation/refund request or flight delays and cancellation as shown in Figure 17.
5.3.5. Airport Performance and Preparedness

Airports are vital transshipment nodes in Australian transport systems. Airports are also employment hubs and growth foci. Australian airports’ estimated economic contribution is about $17.3 billion – about 1.2 per cent of Gross Domestic Product (Deloitte Access Economics, 2012). Airports are often the most secured and fortified built infrastructure, yet they are equally exposed to threats from extreme weather events, terrorism or system failures.

Fog is one of the major causes of flight delay in Australia. There are numerous incidents when aircrafts were diverted to other airports. For example, 9 flights were diverted to Adelaide and 14 flights were delayed at the Melbourne airport on the 15th of June 2014. Virgin Australia 737 almost ran out of fuel in Mildura fog crisis on the 18th of July 2013. The aircraft had only 535 kilogram of fuel left in it tanks and had no other option but to land in a blinding fog. Qantas flights arriving from Asia were diverted from Perth due to thick fog shrouds the airport on the 1st of June, 2012. Similar difficulties were confronted by Cathay Pacific and Air Asia. By the end of 2014, Melbourne airport will be a ‘fog-proof airport’, meaning aircraft will be allowed to land in fog. Melbourne airport has implemented a “category III” instrument landing system and a ground-based system that use a combination of radio signals, high-intensity lighting and IT systems to support aircraft landing at Melbourne airport. The new system will enable the control tower to communicate with the pilot to guide the plane down where the pilot has no visibility.

Tropical cyclones also significantly disrupt key aeronautical services and operations. For example, the tropical cyclone Yasi – a maximum-force Category Five storm with winds of more than 250 km/h, had a major impact on airline and airport operations in Cairns, Townsville and Mount Isa in Northern Queensland (Australian Bureau of Meteorology, 2011). Aircraft can take off or land generally with only a low cross wind, usually up to strength of about 15 knots (28 km/h). Above that strength of wind, an aircraft may have to use another runway or divert to an alternative airport. Such weather events have caused flights diversion or aircraft re-routing. Volcanic ash has no significant aircraft disruption in Australia except in 2011. However, Volcanic Ash Advisory Centre has been proactively set-up by the Bureau of Meteorology in Darwin to monitor volcanic ash in the Asia-Pacific region and to provide advice to airlines on the likelihood of encountering ash. However, the decision to suspend operations due to disruption from volcanic ash sits with airlines.
On-time performance reporting on Australian airports shows substantial differences. For example, Port Lincoln Airport recorded the highest on-time departure (90.9 per cent), whilst Karratha Airport has the highest percentage of on-time arrivals (91.4 per cent). Port Macquarie Airport, on the other hand, recorded the lowest percentage of on-time departures (69.0 per cent) as well as the lowest percentage of on-time arrivals (68.4 per cent) (BITRE, 2014c). Often, smaller domestic airports tend to perform better than larger hub-like international airports. For example, Sydney (On-time departure 80.3 and on-time arrival 77.9 per cent), Melbourne (On-time departure 80.4 and on-time arrival 78.8 per cent) or Brisbane (On-time departure 80.0 and on-time arrival 72.5 per cent) all have relatively lower percentage of on-time departures and arrivals. The lower on-time performance of key international airports could be due to a large traffic volume, passenger transfer or consolidation or simply the passenger logistics complexity, in terms of custom and quarantine clearance, security, baggage handling and transfer and capacity constraints.

Overall, the Australian airports are generally well prepared to deliver essential emergency responses when disasters occur. Australia in comparison to the United States and Europe however experiences a lot less frequent weather-related disruptions to air transport. Bushfire is an exception, but its impact on air transport services is generally manageable. Most airports have deployed systems and mechanisms for prevention, preparedness, response and recovery operations. Airport authorities in Australia develop, test and review plans, procedures and resource management systems. They are required to comply with occupational health and safety laws and regulations. The Civil Aviation Safety Authority ensures that airport and airline staff are trained and technically competent to safely operate in extreme weather conditions.

5.3.6. Conclusions and Future Actions

Australian air transport system is generally robust and resilient to extreme weather events. Recent growth of the aviation sector, both in passenger and freight volumes, indicates the augmented capacity of the aviation sector to operate services even in harsh weather conditions. These weather perturbations, of course, result in flight delays, diversion or disruptions to aeronautical operations. Nonetheless, on-time departure and arrival statistics for airlines and airports show opportunities for improvement in performance.

The Australian airlines are relatively prompt in responding and resolving passenger complaints. Australian Airlines generally offer generous passenger entitlements to compensate for flight delays or cancellations. The compensation mechanisms include arranging for an alternative flight at no extra cost, re-routing, refund of full fare or fare credit and accommodation and transfer.

Most airlines in Australia agree and comply with providing timely information on lowest available airfare, notify passengers of known delays or cancellations and access to basic food or medical treatment on tarmac delays. Airlines also resolved majority of the complaints within the published 20 working days timeframe, which is within a 2 month response time as recommended by the European Commission (European Commission, 2014). A reasonably low level of complaints per hundred thousand passenger trips also attests the ability of airlines to efficiently address the passenger complaints.

There is currently no serious debate in the media that argues a case to support the legislation of the Airline Passengers’ Bill of Rights (APBOR) in Australia. Nonetheless, the legislative environment in Australia to deal with air passenger rights is still in the initial stage when comparing it with Europe and the United States. A review of the current aviation regulatory system is now called upon to harmonized aviation policies, procedures and practices to align with international best practices, consumer protection rights and the relevant international treaties.
Future actions in three key areas are recommended:

- Develop protocols for establishing standard compensation and complaint handling procedures and practices across all Australian airlines.
- Establish a data hub and a set of procedures to systematically collect, collate and share data on a standard template, detailing the occurrence of all types of airline operations and airport services disruption, including the extreme weather events, and actions executed to mitigate risks and impacts.
- Review the processes, procedures and policies to protect air passenger rights.
6. Towards integrated customer friendly natural hazard contingency management

6.1. Introduction
In this chapter we try to establish what is the theoretical potential for air passenger transfer in case of larger disruptions of aviation in a region in Europe. The potential is composed of several steps, which are in summary:
- rebooking of stranded passengers to other flights, including those of other airlines
- deviation of arriving planes to other (nearby) airports
- transfer of air passengers to another mode (notably HST and other wise IC)
- serious delay possibly including hotel accommodation
- cancellation
In this chapter we will first review and illustrate what is the order of magnitude of stranded air travelers accumulating in a hub in case of significant interruptions and what kind of capacities could be found from rerouting within the airline system and from reallocation to high-speed trains and intercity trains.

6.2. Estimates of stranded passenger accumulation and air rerouting capacity

6.2.1. Rebooking
In the face of transport disruption, the simplest solution is often to wait for the situation to resolve. If however the delay is extensive compared to the length of the trip or otherwise critical, or the movement is completely cancelled, a substitution is only option for cancelling the trip or cargo transportation. Typically the most straightforward and practical substitute to a flight is another flight. If the disruption is limited to one flight or airline, the natural option is a substitutive flight with the same departure and arrival destination. In the case a whole airport or region is disrupted, the route needs to be adjusted. Such a situation requires ground transportation either from the arrival point to the new arrival airport or from the changed destination airport to the final destination.

As regards rebooking of passengers there is quite some capacity left – at least in theory. The fraction of non-occupied seats on European flights varies from 12%~15% in July to 23%~28% in February (IATA Economics – market analysis for various years; see also figure 16 below). For popular connections the occupancy rates may get near to 100% in some months. As was illustrated in chapter 2 high utilization rates increase stress and risk for delays in the system. Furthermore, there are also competition and practical information sharing factors which reduce the actual share of non-occupancy that can be used for rebooking, at least in current operating conditions.

The system level of substitution potential comes into question especially when considering the larger disruptions. The European passenger air traffic has a seasonal cycle, with the largest traffic volume in the summer months (notably July and August). This trend is present at practically all major European airports, as shown in Figure 18, representing figures for 2012. Occupancy rates vary somewhat from year to year, but the pattern is the same. The medium airports with annual passenger volumes between 5 to 15 million follow a similar curve. Only the airports near popular winter tourism destinations such as Canary Islands and alpine ski resorts deviate from this, showing higher or equal traffic during the winter months.
Figure 18: Passenger traffic volume and passenger load factor in Europe in 2012 (Sources: www.anna.aero, www.aea.be)

Figure 18 illustrates how the passenger load factor (calculated as the ratio of available seat kilometers and passenger kilometers) fluctuated in 2012. Load factors are significantly lower in the winter months both for long-haul and inter-European flights. The airlines fly fewer flights in the winter, but this does not totally compensate the lack of demand. Airports and airlines are also likely to employ smaller staff and schedule (more) maintenance operations etc. in the quiet periods. Still, it seems that at least outside the peak months, there is available capacity on the system level in Europe. There is probably some excess capacity during peak periods as well. In the most congested airports (Düsseldorf, Frankfurt, Gatwick, Heathrow, Milan and Paris Orly) the demand exceeds capacity most or all day (Steer Davies Gleave, 2011). This is planned to be addressed mainly by market-based slot allocation and some airport expansions, but even so the regular congestion is likely to remain as a problem in the busiest airports.

Considering the air-to-air substitution capabilities, the seasonal cycle is favorable. As discussed in Chapter 2, the extensive delays are most likely during the winter months, when the conditions to arrange substitute transport seem to be best. With system level approach it seems that there is potential to alleviate disruptions caused by adverse (winter) weather by air-to-air substitution. The dynamics and practicalities of specific cases are then another issue.

It seems that there is technically more potential to intra-airport substitution than is currently practically feasible. The theme is also discussed in the MOWE-IT aviation guidebook (Temme et al., 2014). Key issues are open and early available information, flexibility of regulations and practices and solution oriented cooperation between all stakeholders within an airport.

For connections with a significant number of daily flights the rebooking of stranded passengers can be done in the first place by shifting travelers to next direct flights. However, for those that have to wait a long time for a direct flight rerouting via a multi-leg flight gets more attractive whereas the offering of such additional alternatives reduces the risk of surpassing critical compensation thresholds of the amended regulation. Especially if spare capacity of all relevant carriers for direct and indirect connections can be mobilized the absorption capacity of stranded passengers would grow substantially. In the amended regulation airlines
have to extend their offers to seats of competing airlines for delays accruing to more than 12 hours. Of course airlines are free to arrange wider scoped back-up agreements with shorter time thresholds.

Delays for different airlines on the same routes or for same destinations may be expected to be quite strongly correlated, which is another reasons why the actual absorption capacity of this rebooking option will quite often turn out to be appreciably smaller than the theoretical non-occupancy. EUROCONTROL is developing a tool which assists in predicting the next day’s flight capacity between each notable European airports on the basis of weather predictions, notification of restrictions on airports and in air corridors, etc. (Faber, 2014; Annex 2). Subsequently, such a projection would need to be accompanied by a procedure for flight allocation on connections where scheduled demand exceeds capacity. Considering the time necessary to find and offer viable alternatives to affected travelers, the procedure should be largely based on predictable mechanisms rather than case wise negotiations. Options could be simple rationing rules, such as ‘favour flights operated by large planes over those of small planes’, or ‘cancel departures from 1 airport for a certain destination if there are N preceding flights (with the same destination) within a time span of X hours’. The procedures could also make use of auctions, somewhat comparable to day ahead bidding for capacity in electricity markets. Please note that the bidding among airlines could be either organized as a fee payable for still being allowed to fly or a compensation receivable for sustaining a cancellation. Even though auctions can be very efficient in cases like these they raise new issues such as what to do with auction revenues, how to organize the auction authority, who should pay to whom, how the auction interferes with airport slot allocation mechanisms, etc.

Apart from systems to better project and allocate available capacity also the information provision and ways of offering choices to customers merits further development. In fact the protocols for deciding what flights to operate and which to cancel offer solutions for the wholesale market (competition for flight capacity between airlines). However, these wholesale market solutions should be accompanied by retail market solutions, that is the satisfactory provision of information and alternatives to the travelers. Also in this respect the experiences in the electricity market may help, as the initial strong focus on the wholesale markets was later on repaired by also paying more attention to the end-users of electricity in terms of pricing, contract options, supplier choice and complaint procedures.

6.2.2. Diversion

In the event that a whole airport is disrupted, the dynamics are different. In such a case the air-to-air substitution would be to reroute the flights to undisrupted nearby airports. For arrivals, this means redirecting the flights, which is operationally somewhat straightforward. For departures the situation is more complicated, if the departing planes cannot be moved from the disrupted airport. Transferring the passengers of these flights would not require only airport capacity, but extra planes as well.

Major disruption does not necessarily mean that the capacity is reduced to zero. For large hub airports a halving of the capacity for the whole day or greater part of the day would have already major repercussions for the entire European air travel system. The magnitude of the substitution need depends in the first place on the size of the airport disrupted, but also the duration and extent of the capacity cut are relevant. As discussed above, European air transport is very concentrated, as the busiest 25 of the airports count for half of all the passenger traffic. In essence, the passenger volume distribution of the European airports follows power law. The traffic flows of one of the major hubs would be challenging to accommodate on substitutive airports since the capacity of smaller airports is very low compared to the hubs. Then again, transferring flights from regional and smaller airports to hubs is challenging as well since it is the major hubs that are typically most congested.
A following case example illustrates the scale. Heavy winter storm in January forces the Frankfurt am Main airport to close its operations for a day. The full closure is decided in the previous night based on the available forecast. This creates a need to reroute over 75,000 arriving passengers and 600 flights. Based on distance and capacities, the best available substitutes are the two nearest international airports, Stuttgart and Cologne, and the auxiliary airport in Frankfurt area, Hahn. These are illustrated in Figure 19. For individual flights minor nearby airports (Nürnberg, Saarbrücken and Karlsruhe) and further major airports (e.g., Munich) could be a practical destination as well. Looking purely at the numbers, the diversion of all the traffic from Frankfurt to would result in over 300% increase in their passenger levels and from 187% to 257% increases in aircraft arrivals. While these figures may affect as quite high, these airports are typically not running close to their maximum capacity in January. Using summer peaks to estimate the factual capacity, it could be estimated that these three airports could handle even up to 40% of passenger volume and 24% of flights from the disrupted Frankfurt airport. With small international airports nearby these figures could be up to 49% and 31% and if Munich would be used as well then majority of passengers (even up to 80%) and nearly half of the flights (45%) could in theory be handled. This would however probably require extensive efforts to mobilize staff resources for baggage handling, customer service, aircraft maintenance etc. For airlines that would not typically fly to these substitute destinations there would be need for temporary service agreements with service providers at the airports. Furthermore, non-hub airports may have restrictions in terms of airplane models they can receive, either due to size or due to requirements for model specific technical service capacity.

Figure 19: The discussed case area. Figures in cursive are the distances from an airport to the associated city. Source: create with the aid of Google Maps

Hourly analysis illustrates the volume of the passenger flows in more detail. In Figure 20 the arrival traffic pattern of Frankfurt is imposed over the estimated substitute capacity of nearby airports. The estimations are based on the assumption that the airports could handle a level of daily traffic comparable to a busy summer day, and that the capacity is proportional to the existing patterns of arriving traffic. It might seem counter-intuitive that the capacity to absorb most extra traffic is assumed to be highest in the already
busiest hours. However, in regional airports the traffic typically fluctuates between bursts of arrivals and departures due to runway and terminal constraints, so assuming that there is capacity to manage extra arriving traffic in the seemingly quiet hours of arrival would be false.

![Figure 20](image)

**Figure 20:** Hourly estimates of substitution need and capacity at Frankfurt in January. Dashed lines show the maximum hourly arriving passenger levels based on 2012 statistics. (Sources (Röhner, 2009), CODA]

Depending on the assumed capability of the nearby airports to address higher passenger volumes, their substitute potential could be from 28 to 36 % of the arrivals. Of the rest, some could be diverted to other airports further away. Around 55 % of all the passengers at Frankfurt are transfer passengers (Fraport, 2014), who would not be much affected by substitution provided the continuing flight would depart at the substitute airport as well, while the substitution should not cause major extra delay. Especially for these flights Munich could be the preferred substitute option. Other European hubs could help to share the diversion load as well, since many of the final destinations of the passengers transferring through Frankfurt are outside Germany. In Frankfurt around half of all the flights are to or from Europe, while the share of domestic passengers is 11 %. If Munich could be used, it could in theory accommodate around half of demand. This part of the substitution would however have much larger disturbing impacts for the air traffic in general and would require much more complex management of passengers and aircraft fleet.

Applying a similar case approach to Schiphol airport in Amsterdam, another major hub in Europe, yields similar results. Should some weather event (e.g. thunderstorm or heavy precipitation) disrupt Schiphol during its peak summer season, the volume of traffic displacement would be large compared to available capacity nearby. Figure 21 illustrates the hourly arriving traffic at Schiphol compared to the available capacity at the nearby airports. These airports have been assumed to be able to absorb 30 % increase in incoming passengers compared to their normal hourly traffic. In this case, the overall substitution potential for one day would be 34 % of all the arriving traffic. Hourly figures deviate between 12 % and 63 %. The travel time from the included nearby airports to Amsterdam are around two hours by trains or buses. The smaller airports are not equipped to handle the largest jet planes such as A380, which also limits the substitution potential. However, Schiphol too is an airport where the share of transfer flights is significant (40 % (Schiphol Group, 2014)) and some of these flights could be diverted to substitute hubs elsewhere in Europe with limited consequences for the passengers.
Figure 21 Hourly estimates of substitution need and capacity at Schiphol during July. Dashed lines show the maximum hourly arriving passenger levels based on 2012 statistics. Sources [CODA]

The remaining challenge for the inter-air substation is that the last leg of the trip still requires ground transport for all but the transfer passengers (and even a part of those may have to be transferred). The flow of the passengers needing rail, bus or taxi service is measured in thousands, as figures 20 and 21 illustrate. The maximum hourly levels for the discussed airports are presented as well. While they are high enough to absorb the extra passengers in theory, the airports are unlikely to be able to sustain such levels of service, especially with such a short lead-time.

Besides transportation, the extra flows of diverted passengers require other ground services as well. Their baggage needs to be handled and security measures are necessary as well. Because of the exceptional situation, many would require personal help from the airline staff as well (e.g. about compensation or connecting flights). Looking at the annual figures, large airports typically employ around one person per 1000 passengers (Regeneris Consulting, 2013, Fraport, 2014) critical services (excluding activities such as retail or construction). The regular staff could probably handle temporarily a significant rise in passenger volumes, but smooth substitution would likely require extra resources and working overtime. Applying the 1 to 1000 rule, the disruption in Frankfurt would require between 20 and 70 extra employees at the substitute airports. This is probably an underestimation because of the potential bottlenecks. These estimates neither include staff operating the transportation between airports and cities.

The practical challenges should not be under-estimated. During the Christmas disruption at Gatwick in 2013, the operation of moving large amounts of flights and passengers from one terminal to another was already enough to cause major logistical problems (McMillan, 2014). Baggage for example complicates transfers of passengers. Check-in process is slow to reverse, and the practical solution can be separating the passengers and the baggage intentionally to different flights. Security screenings are another challenge and can quickly form a bottleneck for the substitution process if not staffed with sufficient resources.
As for the passengers the overall transport system needs to be flexible in order for them to be better off with this kind of substitute arrangements. For the shortest flights the benefits of substitution might not be justified compared to the costs in money, time and effort, but especially if high speed rail connections would be available, the nearest substitute destinations would provide competitive option for a delay of a day or half a day.

The substitution described above applies only for air traffic scheduled for arriving at Frankfurt or Schiphol. The air-to-air substitution for the flights scheduled for departure from these airports could follow the same logic, but would arguably be more challenging to arrange. Depending on the lead time for the closure and airline decisions most of the airplanes would be stuck on the disrupted airport. Even if the crews could be moved on the ground, extra aircrafts are likely to be scarce, though some of the deviated planes could be reassigned to transferred departures. Yet, in turn this would create other knock-on planning and information sharing challenges Therefore, the majority of the passengers would have to be accommodated on available free seats on scheduled flights at the substitute airports, which would reduce the substitution potential significantly. The hub nature of Frankfurt and Schiphol compared to the nearby airports means that many destinations flown from those hubs are normally not offered on the substitute airports. Early delivery of information to passengers would be critical as well in the case the passengers would have to get to another city to depart.

The example analysis above is very simplified. It ignores many key factors, but gives a sense of scale. Particularly important are the reactionary impacts caused to operational management of airlines, as the aircrafts and crews end up in unplanned airports. Estimating these would require a complex, detailed network model out of scope of this project. Still, depending on the time of the year the substitution capability of the airport network is likely to be significant but not enough to absorb all of the disrupted traffic. On the other hand winter conditions are likely to affect ground transport as well, which services are needed as well in relation to deviation of arrivals and (perhaps) of some departures. Geography matters too. The dense airport network in central Europe and British Isles allows for more substitution options. On the other hand, airports very near each other are more likely to be affected by the same adverse conditions so that they cannot alleviate each other’s disruptions. The substitution potential is also likely to be much lower during busy summer months, when the substitute airports can already be operating near their capacity limits. In the case of Frankfurt, the substitution potential of nearby airports would be only 12 % of arriving traffic in busiest summer months, if they are assumed to be able to handle 30 % rise in their passenger flows compared to normal levels.

However, when the substitution is arranged, its costs should not exceed those caused by the original disruption. According to the EUROCONTROL suggested values, the cost of cancelling a flight varies between € 3700 (narrow body, short haul) and € 81000 (wide body, intercontinental) depending on the flight distance and plane type (EUROCONTROL, 2013a). Valuing an average flight at € 17300, a single winter day redistribution at a major hub like Frankfurt would amount to cost of at least 20 million euros. This figure is probably an understatment since it does not include ground handling costs, missed connection compensation, denied boarding compensation and luggage delivery costs. Based on these figures it could be estimated that the cost of substitute transport should be few hundred euros per passenger at maximum, but this is case specific.

Since not all flights can be substituted, some prioritization is necessary. For flights, this is somewhat straightforward, since typically the longer the flight, the more expensive it will be to cancel it. Yet, also other rationing principles could be applied. The capacity limitation impact assessment tool under development by EUROCONTROL (see previous section) could be extended to be able to deal with deviation cases as well.
On the level of individual passengers the prioritization is more challenging task. Prioritization based on ticket class can be the first step, but within the same ticket class more difficult. More advance and inter-compatible ticket information systems could provide data for the basis of passenger sorting, or airlines could introduce new classes of priority tickets to passengers interested in higher guarantee to arrive in time.

There are examples of existing substitution practices. An example is Copenhagen, where the Malmö Sturup airport acts as a complement to Copenhagen airport where the traffic is diverted in case of disruptions. These two airports are in practice served by the same urban public transport system. This is often exceptional, although Paris and London are other examples of such a situation. The ground transport element is crucial to all air-to-air substitution arrangements except for transfer passengers. Thus availability of rail connections and coach capacity directly affects the potential for airport level substitution.

In the view of high-level numbers there is potential for increased air-to-air substitution. There seems to be some capacity, especially in wintertime, when the prolonged weather-induced disruptions are more likely as well. Comparing to other regions, flight diversion is rare. This indicates that the current regulation – which is the framework for the operational business decisions of airlines and airports – does not provide many incentives for air-to-air substitution.

6.3. Substitution air - rail

6.3.1. Background

One of the most notable extreme events which tested the rail system’s ability to substitute for air travel during extreme events was the April 2010 Eyjafjallajökull volcanic ash cloud event. The eruption caused vast quantities of ash to be sent into the atmosphere, closing the airspace of much of Europe between the 15th and 20th of April, affecting around 10 million travelers. Although Europe-wide statistics on travel behavior during this event are not available, analysis of the effects of the 2010 volcanic ash cloud on transport by Oxford Economics estimates that 15% of affected trips from the UK were taken at a later time, with 37% of these being taken by rail and ferry, although these are not disaggregated further. Although many of the planned journeys are likely to have been to destinations outside of Europe, the relatively low proportion of journeys which are rearranged does not necessarily indicate that there is a low demand. Rather, it may be indicative of the low number of substitutive options available and the lack of regulations and communication structures between modes and operators.

Rail, and particularly high-speed rail, is a potentially useful substitutive mode in the case of air travel disruption as it transport passengers over long-distances at speeds which, although slower than air travel, can be considered as an acceptable alternative for many journey types. There are three main ways in which rail can assist travelers during disruptive events. Firstly, rail can provide a direct link to the nearby city where accommodation and onward travel can be arranged, thus alleviating the strain on the airport during times of weather-related transport disruption. Secondly, rail can provide a means of transferring to unaffected airports within the same city or regions. This is only practical in regions with airports that are linked to the rail network with frequent services. Additionally, this is only feasible if a substitution flight with spare capacity is available at the alternative airport. However, as mentioned in the air-air substitution section, arranging additional flights from substitute airports can be difficult and involve the transfer of crews by ground. Again, it is also dependent on whether luggage has already been checked-in and loaded onto the plane. In some cities there are several large airports such as in London or Berlin, so it is possible that transfers can be made from one airport to another. However, this depends on the other airport being functional, which may not be the case during extreme weather events. Finally, high-speed rail can be used
to transport passengers over long distances during instances where air travel is disrupted over large regions and/or to relieve well connected hub airports from a part of their stranded passengers by overland rerouting.

It has to be remembered that the weather conditions that affect airports and air travel can cause simultaneous impacts on the rail network. For example, the June 28th 2012 extreme storm events in the UK caused flights to be diverted from Birmingham International Airport as well as the closure of the East and West Coast Mainlines, the primary rail links between England and Scotland. This event also caused localised flooding to the UK’s motorway network. Although the air travel disruption was quickly resolved, this event temporarily precluded travel between Birmingham and many parts of the UK. Additionally, during the 2010 ash cloud event ongoing strike action in French railways affected long distance trains and precluded some rail replacement options.

However, the main obstacle to providing a substitutive option during extreme events is the current coverage and connectedness of the European high-speed rail network. Creating a greater capacity for modal substitution to rail during extreme events is a goal which ties in with the wider EU aim of increasing the provision for rail for medium and long-distance journeys. This was outlined in the 2011 EU White Paper on Transport, which set the goal for a 50% modal share for rail for medium-long distance journeys by 2050. This section argues that there are three main steps which must be met to enhance the substitution potential for rail. Firstly, the capacity, coverage and speed of the railway network and rail services should be increased. This itself has three tiers; increasing the provision for rail transport between airports and nearby cities, improving the connections between airports within the same city and ensuring that the number of available destinations within Europe is similar to those available to air travelers and that these journeys can be undertaken in times that are not prohibitively long. As outlined in D7.1, the current level of service in terms of speed and frequency of trains is variable within Europe, with relatively few regions having the sufficient network coverage and high-speed services to offer a viable alternative to air travel between countries over medium-long distances. Secondly, the interchange between airports and the high-speed rail network must be as straightforward as possible. Ideally this is achieved through high-speed railway stations at the airport such as with Frankfurt and Paris Charles de Gaulle. Finally, more agreements must be made between airlines and rail operators to replace disrupted or cancelled air services with rail to ensure that passengers have the right to travel by alternate means and that they are assisted in doing so. The following subsections describe the current situation in each of these areas and outline how each of these could be improved to increase the substitutive capacity of rail.

6.3.2. Interfaces between airports and rail networks

Good rail connections between airports and cities with sufficient capacity, frequency and in some cases redundancy can be seen as the building block of rail based modal substitution during times of inclement weather. Links between airports and cities are important both for onward travel on the high-speed rail network, which is more often connected from the city than airports (see Table 13), and secondly to relieve an airport in cases where all flights become grounded due to a large spatial event such as the 2010 Eyjafjallajökull volcanic ash cloud. There is steadily increasing number of large and medium sized airports with some rail connection, and smaller but also growing number of airports with HST and IC connections to various destinations (Paris CdG, Frankfurt, Amsterdam, Zürich, Copenhagen, Düsseldorf).
<table>
<thead>
<tr>
<th>City</th>
<th>Airport</th>
<th>Country</th>
<th>Dedicated link from city to airport</th>
<th>Metro link from city to airport</th>
<th>Connections to regional trains</th>
<th>High speed train connections at airport</th>
<th>High speed connections available in city</th>
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Table 13. Indication of availability of different types of rail services at European airports and nearby cities.
Compared to North America, Europe is well-served for rail links between airports and cities. These generally consist of two types; dedicated rail lines between the city centre and airport and airport railway stations as part of a main line. Examples of dedicated rail links include Heathrow Express in London and Flytoget for Oslo Airport. These are often high-speed connections and benefit from not sharing carriage capacity with passengers with different destinations. They are also more likely to have stops at multiple terminals, reducing the interchange needed on arrival. Services often include the provision to check in luggage at the station. Current planned airport rail links include a new express service to Charles de Gaulle International Airport in Paris, to be operated by SNCF. This planned project will cut the journey time down to 20 minutes and deliver passengers to Gare de l'Est station. Dublin Airport is due to be connected to the Metro North, which would cut travel times to 18 minutes, although this development is currently on hold. Thessaloniki Airport is due to be connected to the local metro system, whilst Helsinki-Vantaa Airport is to be connected to the Ring Rail Line and service is planned to start in July 2015. This will greatly enhance connections to the city, which are currently primarily by bus.

For four airports, London Heathrow, Paris CdG, Frankfurt, and Amsterdam Schiphol, we reviewed what number of air passengers could be transferred by rail. The capacity per hour is based on all train connections stopping at the airport, and includes accounting for unused rail slots and for some degree for train length. This is summarized in table 14. The judgment whether the transferable amount is quite adequate (green) or tight (yellow) or totally insufficient (orange / red) depends on the average and maximum amount of stranded passengers on an airport. For London Heathrow and Paris CdG the assessment has concentrated on the link to the nearby large city. For Frankfurt and Amsterdam Schiphol also train services to the rest of the country and international destinations have been taken into account. The minimum figures for Frankfurt and Amsterdam represent approximate spare capacity during rush hours (which may still be overstated).

**Table 14.** Relief capacity of rail links between major European airports and nearby city (average passengers per hour during normal hours of operation)

<table>
<thead>
<tr>
<th>Airport</th>
<th>Relief capacity</th>
<th>rail access to nearby city/cities*</th>
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<tbody>
<tr>
<td></td>
<td>in N pass. per hour</td>
<td>Rating</td>
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<tr>
<td>London</td>
<td>≤1000 pass/h</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>1000 - 1999 pass/h</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>2000 - 2999 pass/h</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>≥3000 pass/h</td>
<td>Green</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>≤1000 pass/h</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>1000 - 1999 pass/h</td>
<td>Yellow</td>
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<td>≥3000 pass/h</td>
<td>Green</td>
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<td>Paris CDG</td>
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<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>≥3000 pass/h</td>
<td>Green</td>
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</tbody>
</table>
It is important to realize that peak hours at the airports largely coincide with the rush hours in national and local transport systems. Both in Frankfurt and Amsterdam Schiphol a part of the national and international trains do not have their terminus at the airport, implying the trains contain (quite some) passengers who only pass through the airport by train. Furthermore, for all airports counts that airport areas are also large concentrations of work places. For the considered airports the number of employed varies roughly between 70,000 and 100,000. In addition airports are also meeting places attracting local non-air travelers. So, as was experienced earlier with rebooking and diversion, the relevant substitution capacity of rail will be often much smaller than the maximum theoretical spare capacity. We reiterate that the figures in table 14 are only indicative.

Finally, there is scope for redistributing departures and arrivals for an urban region where there are several airports. Although it is likely that the airports will be subject to similar weather conditions, the way they react to these stressors may vary, so it is possible to envisage the situation where one airport is partially or completely closed where another remains operational. Such situations occurred during the cold and snowy periods in London during early and late 2010. As an example, the potential transfer capability of the links between London Heathrow and Gatwick can be examined. Gatwick is the second busiest airport in the UK and may have the potential to handle some of the flights from Heathrow in cases where this Airport is disrupted. Gatwick is connected to London Victoria and London Bridge stations by the Brighton Mainline, which provides several direct and non-direct services run by several different train operating companies. On average, there are 13 trains an hour between Victoria and London Bridge and Gatwick. If an average capacity per train of 325 is assumed (based on the different rolling stock and configurations), then approximately 4225 passengers would be able to travel between London and Gatwick. As the Heathrow-London rail and metro links can supply roughly 9500 passengers per hour into central London (corresponding to 10% of daily transfer passengers per hour), the Victoria-Gatwick figure falls short of the necessary relief capacity. The actual number of passengers who could be carried to Gatwick is likely to be fewer still, as the Brighton Mainline carries passengers to a number of different locations apart from Gatwick, so much of the capacity will already be used. Additionally, for this strategy to work, the flow of transfer passengers within the London Underground network must be managed, as passengers will have to change lines to reach London Victoria/London Bridge.

However, the potential for redistributing flights between airports depends not only on the rail links between airports, but also the level of operational cooperation, planning, runway and terminal capacity (Gatwick consists of a single runway), and the provision of staff and equipment to handle passengers and luggage at the airport. It is likely that these would require the greatest level of investment to ensure that this option is available during times of disruptive weather. In practice, the situation could however, be more flexible and dynamic than a simple two-way arrangement. Several other airports exist in the London area, including City Airport, Luton, Stanstead and Southend. Birmingham International Airport is also reachable from London Euston Station in under one hour and twenty minutes. Therefore, if the requisite cooperation between airports, rail and metro providers exists, there is the potential for a sophisticated and intelligent system of utilizing capacity during extreme events.

Based on Garcia (2010) and Suvanto (2004) the marginal cost of an extra train (IC or HST) is rated at 2.5 to 4 cent per passenger(seat)-kilometer. Based on these cost figures an incremental train service capable of transferring 1000 passengers over 200 km would cost between 5000 and 8000 Euro (assuming practically fully occupied trains). When comparing these figures with the flight preparation costs in section 6.2.2 on diversions (meaning extra and foregone flight preparation cost) it seems attractive to have preventive mode switching to HST and IC instead of cancelled or diverted flights.
6.3.3. Increasing network size and capacity

Generally the substitution option for air to rail is not as straightforward as with air to air. One of the most significant determinants of substitutive capacity between air and rail is the nature of the European rail system in terms of coverage, speed and frequency. As mentioned in D7.1, the 2013 report by Lütterdling and Gather on the level of service of European rail assessed the current network in terms of maximum beeline speed and frequency of services between major metropolises. Figure 22 shows the maximum speeds of rail connections between a subset of major European cities. This is useful for identifying potential routes where substitution between air travel and rail is feasible and where additional high-speed lines could improve the provision of substitution options.

![Figure 22: Maximum beeline speed of fastest railway connections between major European Metropolises (Lütterding and Gather, 2013)](image)

As can be seen, Spain, Germany and France have a relatively dense network of railway lines rated in the highest speed category. The United Kingdom, Benelux, Norway, Sweden and Italy also have relatively fast lines. Additionally, further analysis by Lütterdling and Gather reveals that these lines are generally rated in the highest categories for frequency of services (37-92 trains per day). However, the authors also observe that relatively few international high-speed/high-frequency train services exist, which currently serves as a barrier towards long-distance modal substitution. Examples of existing international HST connections include Madrid-Barcelona, Amsterdam-Brussels-Paris, Frankfurt-Paris, Paris-Brussels-Cologne, London-Lille, London-Paris, Zürich-Geneva-Lyon, and Helsinki-Sankt Petersburg. There are several easily identifiable gaps in the European high-speed rail network which should be prioritized to increase the modal substitution potential over longer distances. For instance, there is currently no high-speed connection between Spain and Portugal. New high speed rail lines should be built to cross over the current physical barriers such as the Alps. Much more investment must be made in high speed rail in Eastern Europe.

These airports include Frankfurt International, which was linked to the high speed rail network through the Frankfurt am Main Airport long-distance station in 1999 (with most services operating since 2002), Paris Charles-de-Gaulle Airport, Brussels National Airport and Amsterdam Schiphol. This connectedness is already acting to replace feeder flights with high speed rail services. Additionally, an extension of high
speed night trains could also act to increase the capacity of potential substitutive services as well as make substitution over greater distances more viable.

There is a long term objective to link all airports to the European high speed train network. The 2011 EU White Paper on transport states that by 2050 all core network airports should be connected to the rail network, preferably by high-speed rail. Again, the TEN-T objective of seamless passenger transport chains. To ensure these services are viable, the effective speed should be increased. It has been suggested that the best way of achieving this is to have underground stations below the terminal, potentially on a multilevel basis with intersecting lines. Additionally, there is an issue with luggage. Space must be given for luggage.

There are several general temporal trends in the potential substitution capacity of rail which should be considered in terms of network usage and spare capacity. In contrast to air travel, there appears to be no commonly available summary information on high speed rail throughout the course of the year. However, it seems fair to assume that there will be peaks in demand (and hence troughs in substitution potential) in the lead up to particular holidays such as Christmas. Furthermore, there is likely to be a trend in substitution capacity throughout the course of the day, with greater spare capacity outside of the rush hour periods. Likewise, there is also assumed to be a weekly trend, with workdays having different defined peaks to weekends, with a general increased spare capacity at the weekends. The diurnal variations in (net) available seat capacity has been taken into account in the Frankfurt and Amsterdam case reviews.

6.4. Review of long distance travel mode substitution potential in Europe between air and ferry transport

The potential for substitution has been assessed through three ferry link case studies. These ferry routes were chosen because they comprise parts of the EU concept “motorways of the sea” in different locations of the Europe. The “motorways of the sea” concept aims at introducing new intermodal maritime-based logistics chains in Europe, which should bring about a structural change in our transport organisation within the next years to come. These chains will be more sustainable, and should be commercially more efficient, than road-only transport. Motorways of the sea will thus improve access to markets throughout Europe, and bring relief to our over-stretched European road system. Four corridors have been designated for the setting up of projects of European interest (Figure 23).

The corridors are:
- Motorway of the Baltic Sea (linking the Baltic Sea Member States with Member States in Central and Western Europe, including the route through the North Sea/Baltic Sea canal) (by 2010);
- Motorway of the Sea of western Europe (leading from Portugal and Spain via the Atlantic Arc to the North Sea and the Irish Sea) (by 2010);

Figure 23. Map of motorways of the sea
• Motorway of the Sea of south-east Europe (connecting the Adriatic Sea to the Ionian Sea and the Eastern Mediterranean, including Cyprus) (by 2010);
• Motorway of the Sea of south-west Europe (western Mediterranean, connecting Spain, France, Italy and including Malta and linking with the Motorway of the Sea of south-east Europe and including links to the Black Sea) (by 2010)

The longer routes are mainly important for short sea shipping (goods), which tend to replace truck and train trips overland. The shorter routes are (also) relevant for passenger ferries, i.e. Finland-Sweden; Finland-Estonia; UK-Benelux/Channel coast; West-Mediterranean Islands – mainland; Greek island – Greek mainland.

6.4.1. Ferry links: Finland (Helsinki) – Sweden (Stockholm) and Finland (Helsinki) – Estonia (Tallinn)

Assessment of the need for substitution

The need for substitution both for freight and passenger transport is currently non-existent. During the past 5 years a ferry has been delayed only very few times and in those cases only for couple of hours. The delay has been due to difficult weather conditions, namely heavy ice cover.

Substitution potential

No substituting mode is needed because of the good service level of the ferries in all weather conditions. In case a delay would, however, occur in the future, the substitution potential is very small. For passenger transport this is due to the fact that most of the ferry passengers are cruise passengers and hence do not need or want to change modes. As regards freight transport, the main substitution mode would be road transport. The option doesn’t seem very realistic, since the delay for transporting the goods via the North or the East of Finland would probably take more time than the duration of the delay.

As a very long term option a tunnel connection between Helsinki and Tallinn could be mentioned. Currently a pre-feasibility study, commissioned jointly by the cities of Tallinn and Helsinki, is carried out (Helsinki City, 2014).

Impacts on the service level of the transportation²

Currently, three main threats for the service level of the Finnish short sea shipping are as follows:

1. The sulphur directive. In 2012 the European Parliament adopted the sulphur Directive 2012/33/EU to limit the sulphur content of marine fuels from one per cent to 0.1 per cent in the Baltic Sea, North Sea and English Channel. The sulphur directive will enter into force in 2015. The basic guidelines to limit marine pollution were agreed already in 2008 within the International Maritime Organization IMO. The Sulphur Directive may cause small shifts from short sea shipping to other transport modes, but this is quite unlikely. The most likely impact is the rise in costs of freight transportation within the emission control area.

2. The ice cover and ice-breaker capacity. The (hard) ice cover and simultaneous strong winds may cause delays in maritime freight transportation especially in the Gulf of Bothnia during the hard “ice winters” such as winter 2009-2010. Air or road transportation could provide a substituting mode in some cases, but basically substitutions have been few, since the freight is already on its way. In some critical cases totally new shipments with substitution mode have been made.

² Sources: Finnish Transport Agency, Confederation of Finnish Industries
3. Labour conflicts in harbours and on ferry ships. Striking in harbours has caused most of the delays to Finnish maritime transportation. As regards the substitutions, the case is much the same as with the winter delays (see the previous point).

6.4.2. Ferry link: Athens - Crete

Assessment of the need for substitution

Ferries between Athens (i.e. the port of Piraeus) and Crete (i.e. the ports of Iraklion, Rethimno, Hania) are cancelled at un-predefined periods of time (between 1 and 15 days) due to three main reasons, mainly extreme weather conditions, workforce strikes and uncovered costs (in terms of failure on behalf of the state to deposit subsidization costs necessary for the operation of certain lines). Cancellations due to the first reasons are more frequent during winter times, when extreme wind gusts prohibit the departure of passenger and freight ferries. Depending on the duration and intensity of such events, and taking into account the ageing ship vessels fleet, the Athens-Crete link can remain unserved up to 2 weeks’ time at most. Data availability is rather limited regarding the cost assessment of these cancelations and can only be estimated based on the time (ranging from hours to several days) a passenger has to wait for the link to be served. At the same notion, yet also considering the limited durability of certain goods, cost implications for freight transport are more complex to estimate.

Substitution potential

Substitution of services is neither possible nor applicable. This is due to the nature of the Athens-Crete link, as ships serve both goods and passengers at the same time. As such, passengers can choose to switch to air transport, yet covering the additional costs themselves. Usually goods remain stationed in the ports, and can only be transferred once the cause of cancelation/delay has been withdrawn.

Impacts on the service level of the transportation

Currently, ferry carriers do not offer any alternatives to their passengers when there is a prohibition on cruising. This means that passengers who can afford an airplane, and need to travel as soon as possible, will cover the cost of the air ticket themselves, while others will receive an open-date ticket, similar to the one they were holding when the prohibition was announced. Regarding freight transport, ferries that travel the Athens-Crete route, are in the majority of cases loaded both by passengers and goods. In that case, goods will remain at the port of Piraeus until sea conditions allow ferries/ships to travel again.

6.4.3. Ferry links: UK – Continent

Assessment of the need for substitution

From a passenger perspective, ferry travel is more regularly viewed as a substitutive mode of transport. This comes both from the general reduction in passengers crossing the English Channel by sea, the increase in crossings by the Channel Tunnel (Figure 24). Additionally, several instances in the past decade have demonstrated the strengths and weaknesses of ferries as a substitutive mode in extreme weather events. These include the extreme cold weather of late December 2009 and disruption caused by the Icelandic volcanic ash cloud of April 2010. The disruption to the Channel Tunnel services in late December began on the evening of Friday the 18th, which saw heavy snowfall in the Calais area (40cm in the afternoon and evening with further snowfall during the night). Temperatures during the night fell to -1.6C. On the English side (Kent) temperatures fell to -3.4C with a north-easterly breeze and light snow. The impacts of this event were dominated by the closure of the Eurotunnel and subsequent disruption following this event. Other
modes of transport coped relatively well in the conditions. However, the incident did have some implications for road transport. For example the M20 in England was virtually impassable due to the tailback of freight vehicles. These conditions remained until midday on Sunday the 20th.

Figure 24. International short sea passengers and Channel Tunnel passenger, 1957-2013 (Department for Transport, 2014)

In the evening of Friday the 18th five trains failed inside the tunnels. Before the trains entered the tunnels then collected large amounts of fine snow which was sucked in through powerful ventilation into the power car, and subsequently entered the electronic control cabinets and the electronic components of the common bloc and motor bloc. As conditions are warm and moist within the tunnel (around 25°C) this caused both melting of the snow and condensation of moisture in the tunnel atmosphere. The tunnel atmosphere also contained metallic dust from vehicle brakes which exacerbated the electronic component failure resulting from the melting and condensation. The affected trains were either towed back through the tunnel to their origins or evacuated with passengers being taken back by Eurotunnel shuttles. Services using the Channel Tunnel were suspended until Tuesday the 22nd. No information is given on knock on delays to other services. This event caused direct disruption between the cities of London, Paris and Brussels. Although trains were trialed on Saturday, these failed. Services resumed on Tuesday the 22nd, although there was a severe backlog in travel, with passengers initially due to depart on the weekend being prioritised for the first journeys. Although Eurostar reported that it had no reports of passengers failing to reach their destinations by Christmas, it is possible that many of them decided not to travel. Eurotunnel, SNCF, Network Rail, HS1 and IGC . First Line of Response (FLOR) are tasked with preparing measures for emergency situations. Additionally, P&O Ferries and Dover Harbour Board were involved in transporting passengers onwards following their cancelled trains.

In total, five ferries were chartered by Eurostar to transport checked-in passengers from London by ferry to Paris and Brussels. However, substitution by ferry was not offered to passengers at Gare Du Nord station in Paris. As well as the organised modal substitution from London to Europe, many passengers decided to travel by train to Dover Priory station to board ferries to Calais. However, these passengers were affected by disruption to Southeastern trains, although other routes were available. One of the main barriers to modal substitution mentioned in the independent report by the Institute of Civil and Protection and Emergency Management (2011) is that Dover and Calais are no longer set up to handle large numbers of foot passengers. Although capacity remains on the ferries themselves, the ports were not prepared from the sudden influx of passengers, with long queues forming at both ports. Modal interchange was also reported to be very poor between train station and ferry terminal in both locations, with passengers having
to walk up to an hour with luggage in adverse weather conditions. The report criticises Eurostar for not communicating the necessary information about onward travel. Over 700 passengers were stranded in Calais after arriving too late to take the last bus to Paris.

As incidents had occurred in almost every severe winter during its operation several measures were put in place to reduce the impact of weather. The response in terms of accommodation and onward travel was broadly criticised in the report. This was especially apparent on the British side, with little information being given to delayed passengers. Alternative arrangements were made to transport passengers by coach and ferry, although many passengers made their own arrangements. Difficulties included passengers being dropped by coach at Dover rail station rather than the ferry port, passengers making it to Calais only to be delayed as coach drivers had run out of working hours, and passengers being stranded at the ferry port overnight in freezing temperatures. When Eurotunnel services were resumed several queues formed spontaneously, which needed to be integrated into the main queue, leading to confusion and resentment among the passengers.

A total of 21 recommendations were made which fit into the following three broad categories

1. Train reliability
2. Evacuation and rescue
3. Managing disruption and improving communication

This case study demonstrates a situation where a known technical vulnerability has occurred at a time of high usage on the network. Although similar faults had been observed annually since the opening of the channel tunnel, it is obvious that such an extreme scenario had not been planned for. As much as the technical failure, this case study demonstrates that there are also critical times in the year where contingency in terms of both travel and accommodation may be stretched. This ‘worst case scenario’ should have been envisioned due to the obvious confluence of high demand and inclement weather during the second half of December. This example also highlights the interdependency of different transport infrastructure, with the response to the incident compromised due to the difficulty in mobilising personnel.
7. Lessons and prospects

In this chapter we will first summarize the lessons from the previous chapters and from other work packages. In a next section we discuss the four key factors around which resilience of a transport system is built. Subsequently, we review the prospects for improvement, while also accounting for the market prospects of aviation.

7.1. Lessons

7.1.1. Delays

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

The above average duration of weather caused delays in aviation suggests that the aggregate economic costs of weather caused delays is relatively high compared to the costs of other causes, and therefore differs from the simple share of all delays. The total costs of delays in aviation in Europe amount to 1 to 1.4 billion Euro per year, when correcting the estimate of 2002 (Cook et al., 2004) for the traffic growth since then. This estimate does not include other delays outside the realm of air traffic flow management (ATFM), such as those caused by labour conflicts. Costs accrue in particular when delays are long. Delays of more than 30 minutes represent only about 12% of all aviation delays, and yet this category represents about 60% of all (assessed) delay costs.

For high speed (HST) and intercity (IC) train services only 5% of all delays is exceeding the 30 minutes limit. The number of annual HST and IC travellers is about 3.5 times the number of annual air travellers in Europe, but the relevant ticket prices and especially the average time losses are clearly lower for train travellers. This suggests that the aggregate cost of delays in train services in Europe is of the same order of magnitude or possibly somewhat smaller than the aggregate cost of delays in aviation. Yet, coherent estimates of costs of delays of train services in Europe are not available, so these suppositions should be taken with caution.

Delay statistics for other public transport modes (ferries, intercity and international bus connections) are largely lacking. As regards ferries, delays seem to be mainly an issue in the Eastern Mediterranean, but the causes are often not related to weather.

7.1.2. Climate change

The projected effects of climate change affect all modes. Usually climate change means changes in either the frequency and/or the severity of extreme phenomena to which transport systems are already exposed. There are therefore no imminent threats, but climate change should be accounted for in the resilience planning and maintenance of transport systems. For aviation the effects seem to have mostly no large implications. Exceptions are airports in flood prone areas. For road systems occasionally reinforcement of infrastructure may be necessary, e.g. owing to growing flash flood risks. Railroads seem most prone to effects of climate change, which is possibly due a significant share of flood prone routes (river banks, sea side), which in turn relates to a combination of avoidance of steep gradients and of high tunnel costs. In addition heat waves may cause more interruptions due to buckling. For all types of infrastructure, and
notably for road and rail networks, it is recommendable to enhance the asset management systems of these networks so as to better monitor and predict wear and tear, and optimize the timing for small and large maintenance.

A general lesson for all types of infrastructure is that coordination and information sharing between actors should be further developed, both within one mode as well as across modes. This requirement does not stem from climate change only, but has a general significance for resilience and crisis management in transport infrastructure and – owing to cascading effects – indeed all critical infrastructure (UK Cabinet Office 2011; Australian Government 2010). Indeed case studies illustrate that infrastructure organisations and regions that have stepped up their resilience and crisis management coordination usually suffer from less disruption during more recent extreme events (e.g. MOWE-IT Guidebooks; Fjäder, 2014a, 2014b).

### 7.1.3. Traveller protection regulation and other resilience enhancing policies

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

For railways national regulation on delay reduction and accountability of railways seems much more important that the EU regulation on traveller protection. Still, for some Member States the EU regulation may have been more important for railways as well. Delay statistics for railways are available per country for a large selection of Member States, though not all of them. Neither are these statistics harmonized, thereby making international comparisons rather difficult. For other modes, ferries and inter-urban bus services, information on the compliance of the European regulations is scant, preventing the study from producing assessments and recommendations.

Traveller protection regulation in the US offers a less generic coverage for delays than the EU regulation, but many major US airlines do offer facilities for costless rebooking, hotel and meal vouchers, etc. US has also set up a system of mutual assistance of airports (and airlines) by aviation region. All in all the regulations and voluntary arrangements are less costly than the EU regulation. The level of delays is somewhat higher in the US, notably due to more extreme weather events, but it does not differ crucially from European figures.

Delays are a more serious problem in China, with about 25% of all flights being at least 30 minutes late (as compared to about 7% and 10% in Europe and the US respectively). The continued strong growth in air travel causes chronic capacity shortages in China. Furthermore, large tracts of military airspace severely limit flexibility of routing in civil aviation. Strong growth and capacity restraints are a more generic problem in Asia, but at least for international connections flights to and from China tend to have lower punctuality rates than other Asian destinations. China does have traveller protection guidelines, but these are non-binding. Major Chinese airlines do offer compensation for delays and occasionally for cancellations, but the amounts are appreciably smaller than in Europe. Awareness about traveller rights is low among Chinese travellers. On the other hand it is possible for travellers to buy a delay insurance alongside an air ticket,
which guarantees higher compensations, but requires strong proof by the traveller about the incurred delay.

Australian aviation has a somewhat higher delay percentage than Europe, but there is no crucial difference. Especially in Australia rail is not an alternative, neither have many airports another airport in the relative neighbourhood, which makes diversions difficult. In case of substantial delays or cancellations of domestic flights airlines usually provide rebooking, catering, hotels, refunds, etc. without charges. Otherwise no compensation (for lost time) is provided.

In Europe airlines have rather humble track records in terms of profitability (IATA Economics, 2014). In fact budget airlines tend to perform much better financially (Behrens, 2013). This means that the traveller protection regulation should have low cost impacts to European airlines in order not to threaten their continuity. In this light it is understandable that the recently approved revision of the regulation includes some relaxations, e.g. regarding time limits for delays beyond which compensation should be paid. The competition limitations in combination with limited effectiveness of the regulation point at the need to quite different approaches in addition to the traveller protection regulation. The current EU regulation is almost entirely concentrating on airlines only. Considering that airports also play a large role in prevention and attenuation of delays, it would be logic to include airport authorities also in the regulation. So far, they are only obliged to devise a contingency plan for dealing with very large disruptions and catastrophes.

Existing complementary policies for delay reduction are the further development of flexible use of military and civil air space, further enhancement of aviation weather services, and fitting the state-of-the-art equipment for guidance during approach and landing on significant airports lacking some of these devices. In addition new policy approaches could be introduced which would promote exploitation of spare capacity, facilitate inter-modal substitution, and incite airports to optimize passenger flow handling and flight handling so as to minimize both turnaround times of airplanes and passengers’ station time. New policy options will be further discussed below in section 7.3. Two common features stand out for both existing and new policies options, being (1) boosting information sharing and cooperation, and (2) a broadening the scope of actors addressed (not only airlines, but also airports, and possibly travellers).

7.1.4. Spare and substitute capacity

The analysis for spare and substitute capacity concentrates on relief options for stranded passengers in aviation. For HST and IC train passengers there is usually much more scope for rerouting and rebooking to later departures within the rail system, whereas corresponding connections by air often have much less capacity. For shorter distances buses can be used to replace train services. Yet, if the capacity to be substituted is large and the bus cycle time raises well over an hour, the demand for replacement buses quickly swells to large numbers and logistic problems grow accordingly.

Regarding spare and substitute capacity in aviation the following steps are distinguished:

d) rebooking to later flights with the same destination of the same and other airlines while aiming to use all non-occupied seats;

e) diversion of arriving flights to (relatively) nearby airports and offering connecting flights or HST/IC trains to final destinations; if need be and possible – e.g. in case of long lasting diversions – also departures can be to some extent arranged from nearby substitute airports, however shift of departure airport is much more difficult for several reasons;

f) offering modal switch to stranded air travellers, notably HST and IC connections, offering them either to substitute the entire flight by train or to transfer them to another airport (in principle for transfers to nearby airports buses can be used as well, but the same capacity limitations apply as
mentioned above for disruptions in HST connections); it should be noted that trains (and public transport in general) tends to have high occupancy rates in winter as compared to summer, whereas in aviation travel volumes in summer are larger than in winter; furthermore also trains are more prone to disturbances and disruptions in winter. For major airport hubs rush hours for aviation and rail roughly coincide, meaning that disruptions, which include rush hours, have much less leeway regarding substitution.

A summary of tentative estimates of relief capacity is presented in table 15. The presented figures attempt to correct for the fact that the theoretical substitute capacities presented in chapter 6 are typical upper limit estimates in ideal circumstances. Furthermore, the figures below also try to reflect that train connections or transfer by train to another airport is not attractive for all stranded passengers. For example, for a family with small children it may be more attractive to weather the storm in an airport hotel than to endeavour in a transfer. Also visa restrictions of transit passengers will be a point in case. On the other hand the percentages are related to the maximum numbers of stranded passengers per hour (6000 to 7000). Obviously in case of a partial shut-down of connections the relief effect of substitute capacity may rise considerably. The better and smoother inter-modal cooperation works, the better the relief effect will be.

**Table 15. Summary overview of tentative substitute capacity as percentage of the possible maximum number of stranded passengers per hour**

<table>
<thead>
<tr>
<th>Substitute stage</th>
<th>Rush hour</th>
<th>Non-rush hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Winter</td>
<td>Summer</td>
</tr>
<tr>
<td>Rebooking</td>
<td>0% ~ 10%</td>
<td>0% ~ 5%</td>
</tr>
<tr>
<td>Diversion</td>
<td>Due to the complicated logistic consequences diversion is preferably avoided by airlines. It is also costly, but it can be a mandatory choice for intercontinental flights and longer intra-Europe flights. Once chosen, it still would reduce delays and customer dissatisfaction, if relatively good alternatives can be offered at the substitute airport. For this reason major hubs could develop cooperation with secondary airports in their neighbourhood (i.e. a radius of ~200 km or more depending on airport density)</td>
<td></td>
</tr>
<tr>
<td>Modal switch to HST &amp; IC</td>
<td>0% ~ 10%</td>
<td>5% ~ 15%</td>
</tr>
</tbody>
</table>

If disruptions have a long duration or at least can be foreseen to have a long duration (e.g. over 8 hours), it may be possible that railways manage over the course of the day to offer some extra capacity, e.g. by extending train length. Outside rush hours there might also be some spare capacity for extra trains. Yet, for a more structural, reliable and maximized exploitation of this substitute option all kinds of structural measures are necessary, in terms of information sharing and information provision to travellers, joint ticketing, luggage handling, availability of suitable rolling stock, etc. This will be further discussed in section 7.2.

All in all we may conclude that the exploitation of spare and substitute capacity is not a panacea for solving disruptions in air traffic, but it has certainly significant relief capabilities that merit further review and development.
7.2. Response dimensions and resilience

All transport systems are prone to delays caused by adverse weather, but the vulnerability regarding specific weather events varies. This means that in some cases substitution to alternative transport systems is a viable solution, whereas quite often the alternative modes suffer from capacity restrictions as well. For disruptive events during which delays do generally not amount to more than four hours, alternatives have to be found within the same system by rebooking, diversion, and waiting. The revised EU regulation for protection of travellers stipulates that when delays extend beyond 12 hours, or can be foreseen to do so, airlines should also offer alternative flights of other airlines (including competitors).

In principle the responsiveness of a transport system regarding impending disruptions owing to extreme (weather) events is largely steered by four main factors, being

1. **Capacity**
   a) Capacity of links (no. of lanes, tracks) and of nodes (no. of gates, platforms, etc.), attainable speed (number of turns/runs/trips per hour);
   b) Amount of (spare) rolling stock (seats offered)

   Adding capacity is in principle expensive, and therefore adding capacity merely as back-up in case of disruptions is in most cases a very expensive and thereby non-affordable option. Sometimes multipurpose or shared capacity may be an option. On the other hand spare capacity in disruption situations may have a higher value than would be normally attributed to marginal capacity.

   Adding tracks, lanes, and tarmac is expensive, easily surpassing 1 million euro/km and often resulting in cost of tenths of millions Euros per extension case. If this is compared to the expected value of an avoided or attenuated significant disruption it turns out this will often not pay back. Exceptions may be short additional links that significantly raise the number of rerouting alternatives. Considering the marginal cost of extra trains and flights, designated (extra) spare train-sets at strategic locations may be cost effective in some cases, provided cooperation between the air and rail sectors enables seamless transfers of air passengers to rail. The value of spare capacity in crisis situations may be underrated in cost-benefit studies. This merits further research.

2. **Operational flexibility and information management**
   a) Ability to offer extra slots within a fairly short time span
   b) Extent and timeliness of sharing information with co-actors (airlines – airport – air control – weather & navigation services – support services (catering, luggage, security, cleaning, etc.) – land side connections – etc.)
   c) Improvement of mode specific weather services and other dedicated navigation services and their integration into shared information systems
   d) Information provision to and interaction with travellers; travel advice services including awareness raising regarding seasonal and actual delay risks per destination
   e) Ability to offer seamless multimode services to passengers, also ad-hoc arising demand situations (disruptions)

   Operational flexibility is to some extent preconditioned by the extent to which spare or substitute capacity is (easily) available. Yet, in addition organization structures, allocation of mandates, clarity of protocols, technical abilities to interact and share information, organization cultures, etc. can make a very large difference in actual performance and demonstrated flexibility.

3. **Affordability**
a) Create infrastructures of which the maintenance requirements and costs are affordable (in terms of costs and skills) for the society concerned
   - Flagship parts of a transport system risk to marginalize other parts if affordability is not properly assessed, thereby creating an unbalanced system
   - Oversized or otherwise unaffordable infrastructure will lead to deteriorating condition of the system leading in turn to more disruptions
b) Conduct scenario planning and seek for innovations to reduce costs and/or to raise revenues; also these actions pay off to share – at least partly – with other actors

4. Incentive structures
   a) Objectives and reward criteria should not cause de-prioritization of resilience in transport
   b) Objectives and criteria should be sufficiently inclusive in terms of actors and situations
   c) How are costs of delays and cancellations carried by different actors as compared to their contributions to causing and attenuating delays and cancellations
   d) Review business models with respect to their welfare creating potential, when (also) accounting for societal objectives such as high resilience regarding natural hazards and promotion of sustainability
   e) Ticket condition and price differentiation so as to reflect different levels of delay risks and of priority rebooking guarantees

7.3. Prospects for improvements

Even in Europe with an already more mature market and moderate GDP growth rates air traffic is projected to have annual growth rates of just over 4% up to 2030 (European Commission 2013a). This comes close to a doubling of travel volumes for aviation in Europe between 2015 and 2030. Assuming that the current (revised) traveller protection regulation remains in force until 2030 and remains equally effective in percentage terms, the amount of delays and their costs would continue to grow. This is illustrated in figure 25. The indicated trend is not exact but illustrative. In the report Flightpath 2050, made by the High Level Group on Aviation Research and published by the European Commission (2011a), a practically delay free aviation is formulated as a target, which is extremely ambitious. As illustration figure 26 shows the extra policy effort necessary to keep delays costs more or less constant at the current absolute level. Also this figure is illustrative and does not pretend to be an exact projection. Nevertheless, despite the uncertainty about the exact extra effort needed in the upcoming decades, it is obvious that a substantial extra policy effort is needed, mainly through other policies in addition to the traveller protection regulation.

![Figure 25. Development of delay cost with constant policy](image)

![Figure 26. Development of delay cost with extra policy](image)
In order to strengthen the EC regulation by some additions and mostly by other policies so as to boost the reduction of delays the following policies could be considered for air and for air and rail together.

**Air**

a. The EC regulation for traveller protection in aviation should strive for broader inclusion of airports in the regulation. In particular this could be done by introducing a (normalized) benchmarking system for airports regarding delay performance with repercussions for tariffs (as part of the regulation);

b. Fully implement the SESAR programme – actions are already going on for this option;

c. Further promote the flexible use of (military and civil) air space – actions are already going on for this option;

d. Further enhance the currently developed EUROCONTROL weather impact projection tool (part of the Network WX Resilience Roadmap – see Annex 2) into a real time crisis proof application and combine it with capacity adaptation protocols so as to timely respond to projected limitations of airports and flight corridors – considering the complexity of the (re)assignment problems under capacity and time constraints, it merits to consider auction mechanisms for assisting in the reassignment; a similar tool could also be devised for the European HST network, both as a valuable resilience management tool for rail transport as such and in order to support smooth interoperability between air and (high speed) rail in particular when projected temporary capacity limitations in aviation create an acute need for substitute transport;

e. Improve the cooperation between main actors – per airport and across airports, including land side organisations (railways, other transport infrastructure, police, civil protection organisations), as well as across Europe; including the improvement of inter airline rebooking possibilities; promotion of interactive (personalized) information and advice services for travellers (air and rail); promotion of the cooperation can be realized by means of benchmarking systems, and innovation and demonstration projects;

f. Promote research and innovation in weather services for aviation, as well as for other transport modes; based on calculations by Klein et al. (2009) for the U.S. air traffic the improved aviation weather forecast accuracy has the potential to reduce delays significantly, even up to 40%; a part of the innovations will need parallel or preceding (more) fundamental research;

g. Promote the emergence of cooperative real time travel information and advice portals for private travellers, e.g. by stipulating rights to data access for (specifically) this purpose; promotion of the emergence of such information systems can be realized by research, innovation and demonstration projects; research and innovation should certainly also include behavioural aspects.

h. Promote risk based pricing of airline tickets and ticket differentiation regarding travel time guarantees; in connection with such initiatives it would be important to make risks transparent for ticket buyers – for example by creating easy access information on seasonal variations in punctuality per airport and airline as well as on recent performance indicators (e.g. last quarter) per airport and airline; one step further would be to enable comparison of prices, travel times and delays risks between air and high speed rail.

i. Use the INSPIRE and PSI directives to convince Member States to (further) open their public data for third party access, e.g. for the purpose of developing traveller information and advice systems.

**Air / Rail**

a. Promote the extension of high speed train networks with respect to connecting major and other significant airports – yet, such extensions should pass minimum requirements regarding affordability and socio-economic benefits; promotion of HST network extensions can benefit from
appropriate funding schemes, supportive land use planning, and credible scenario studies; in turn these policies may need to some extent supporting economic and spatial research.

b. Promote cost efficient – often multi-purpose – redundancy investments in rail (short missing links, spare rolling stock) so as to bolster the quick and smooth transferability of passengers from air to rail; promotion of redundancy investments can benefit from integrated resilience management plans for transport, appropriate funding schemes, supportive land use planning, and research on the proper valuation of spare capacity under crisis conditions in cost-benefit analysis;

c. Promote the development of a weather impact projection tool for HST in Europe, similar to the system for air mentioned under Air-point d;

d. Develop seamless service provision for combined air and high speed rail travel throughout Europe – at least for significant air hubs, both for regular travel and in case of substitute travel needs during disruptions in aviation; for policies and measures promoting realization see above Air-points d/e/g/h;

e. promotion of interactive (personalized) information and advice services for travellers (air and rail), separately and in conjunction with the seamless service provision for combined air and high speed rail; for policies and measures promoting realization see above Air-points d/e/g/h;

f. Use the INSPIRE and PSI directives to convince Member States to (further) open their public data for third party access, e.g. for the purpose of developing traveller information and advice systems

Other modes
- exploration of the benefits of intelligent highways as a means to improve resilience for extreme weather in road transport; possibly similar applications are possible for rail systems
- see Guidebooks

7.4. Interaction with other policies

Some of the policy objectives within the transport sector are also driven – and sometimes predominantly – by other policies outside the realm of transport. An obvious example is environmental policy, e.g. leading to zoning, time windows, and admissible noise levels for airport approaches of airplanes.

Within the literature focusing on resilience, delay reduction and the role of weather for transport systems these interactions with other policy realms get relatively little attention. Implications from these policies are taken as given (and fixed) or are even not mentioned. At least the following policy areas merit to be mentioned:

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

Ad. 1. Resilience and crisis management

This policy area gets ever more attention at Member State and EU level. Starting from being able to adequately respond to a crisis, the field has expanded to raising preparedness, reducing vulnerability and precipitating full recovery regarding natural and manmade hazards. In the context of the European Programme for Critical Infrastructure Protection (EPCIP) Member States have started to develop resilience management strategies for critical infrastructure. The thinking expands now beyond extreme events as such, and includes also less visible processes, such as public budget discipline driven backlogs in maintenance as well as demographic and social-cultural processes that can increase vulnerability. Well
organized information sharing among actors is recommended as key building block in the recent resilience literature (CEPS 2010; European Commission 2013b). This concords with the findings in MOWE-IT. The cooperation and information sharing endeavours recommended in this report should indeed be sufficiently linked to overarching regional, national and European resilience strategies.

Ad. 2. National, European and Global regulations on competition

Airlines and trains service operators have often severe problems with maintaining profitability. On the other hand both current operators and potential entrants are keen on possible infringements of the market regulation in their sector as well as sensitive changes in the regulation that affects their vulnerable competitive position. Obviously new policy should be very careful for not being challenged to be retracted owing to market infringements.

On the other hand policy makers and experts may also need to ponder the very basics of current market regulation in the transport sector. The information available for this study did not clearly indicate whether full separation of tracks and train service operations leads to better or worse punctuality compared to soft separations within one overarching rail service organisation. Considering the history of rail transport re-regulations in the past 25 years, there is nevertheless reason to wonder to what extent economists tend to underestimate the coordination benefits of a not (fully) separated system as compared to the benefits of more open competition in a fully separated system. A revised approach to market regulation in the transport sector could aim for a better distinction of the common and private goods produced as well as the interaction between these private and common goods given the overarching aim of raising welfare and wellbeing. The result may be a new composite of largely competitive markets, yardstick competition and management of commons based on modern public choice theory.

Ad. 3. Environmental policies

Environmental polices tend to limit expansion alternative for transport infrastructure. Occasionally this may affect the resilience of a transport system if a strategically located redundancy element is missing. Similarly environmental policies may limit operational flexibility, such as in case of noise regulations around airports. Especially in conjunction with certain types of adverse weather this may have large impacts on delay risks. On the other hand it should be acknowledged that – for example – noise can cause true cost to society via health effects and reductions in labour productivity in the affected area. In such a case environmental policy makes hitherto hidden cost visible, and consequently it may be more effective to reconsider the location of the infrastructure or of the affected built-up area, rather than only driving the transport infrastructure interests. All in all this means that at the level of strategic transport resilience planning and related innovations the interaction with environmental policies and the actual environmental effects should be properly taken into account. In this respect it also merits to check whether a possible weakening of transport resilience raises the risk for pollution mishaps (e.g. owing to accidents).

Climate and sustainability policy are special – multi-faceted – policy areas. Climate change impact assessments and adaptation policies are helpful for a better risk assessment regarding disruption reduction in transport. Conversely, various transport resilience improving investments are often also making a system more climate proof. Furthermore, the promotion of better concerted aviation and high speed train services in Europe seems to be in line with climate and sustainability policies.

Ad. 4. Social and regional equity policies

In principle improved transport resilience has a positive social effect. If however the reduction of delays entails delay risk based product and price differentiation while it entails familiarization with new quite extensive travel information systems, social equity – in terms of ease of access to a mode for different
groups – may be affected in a mixed way. For example, the elderly may have harder times to exploit the potential benefits. The EC White Paper on transport (2011) stipulates good access for the elderly as an explicit objective. This means that in the innovation trajectories for the various envisaged information systems the effects on vulnerable groups (elderly and others) should be considered and access and usability of these information systems for these groups should be tested.

Regional equity has been always an important feature of many EU transport policies. Similar to the judgement for social equity the improvement of transport resilience is in principle good or at least OK for regional equity. Yet, also in this realm practical implementation may sometime lead to different results. For example, affordability requirements may mean that investments in non-central regions for HST connections or spare capacity will hardly ever be rated positively. Even though that may be wise in most cases, occasionally it may leave some regions quite vulnerable to disruptions.

The overall policy field for transport resilience management is depicted in figure 27 below. The eventual benefits of actions and policies to reduce adverse weather induced disruptions are generated in this context.

Figure 27. The overall policy field for transport resilience management
8. Conclusions and recommendations

Generic

- The significance of adverse weather induced delays and cancellations should be understood in the wider context of all factors causing or aggravating these disruptions. Lack of this understanding can easily lead to ineffective decision making and resourcing in transport resilience management.

- Strategic and operational policies and measures regarding reductions of delays and cancellations should be planned and implemented in close co-ordination. Delay reduction is very much a total quality control product, which is very sensitive to segmented approaches.

- Utopic low delay targets risk to demand too much resources and to result in very cost-ineffective situations. A truly resilient society should have the ability to sustain the very rare occasion of a temporarily disrupted transport system with modest socioeconomic effects.

- Resilience of the transport system regarding adverse and extreme weather is in the first place operationalized by indicators for delays and cancellations (of flights, train trips, etc.). In addition it would be good to also monitor the realized travel times for a representative collection of trips, as (change in) travel time is what eventually counts in the welfare evaluation of the traveller. Even though turn-around times of planes and trains may have gone down, passengers have often experienced increases in gross travel time due to longer ticketing and embarkation procedures.

The remit of this report is medium to long term policies aimed at passenger protection, operational resilience, and cross-modal transferability between and surface transport with the overall purpose of making the transport sector, an in particular aviation, more resilient towards adverse and extreme weather. In the previous chapters was shown that various structural measures may first need pre-studies and other initial measures, which means that long term and short term policies cannot be totally separated. The emphasis in the listing below will be however on the long (and medium) term, but if necessary preparatory actions will be mentioned. Table 16 shows an indicative timing of the policies and measures. For various policies is assumed that they remain active after a start-up phase (e.g. investment plan) in a continued implementation phase (e.g. national or sector wide resilience protocols).

Policies and measures aimed at enhancing capacity

1. Scan high speed rail networks and airports on bottlenecks and interconnectivity of the two systems throughout Europe and rank the capacity and access limitations in terms of resilience reduction effects (such as significant delay risks) and economic benefit-cost ratios of capacity investments; this option may need supporting R&D on adaptations in cost-benefit analysis (see research and innovation policy below)

2. Devise investment plans based on the priority rating of the above mentioned scan while drawing on resilience strategies and transport infrastructure strategies; review alternative funding approaches (PPP; life-cycle, etc.), a combination of national and European funding could be considered; based on the plans and funding reviews put up a joint EU-Member States investment plan to solve bottlenecks and improve interconnectivity;

3. Review the current HST service portfolio and assess whether extension of services (new destinations extending from current terminus points) without network extensions or upgrades would improve HST access and promote interoperability with airports; addition of extended HST services at the expense of local trains should be avoided though; scan options for jointly funding of service extension by bringing air and rail parties together (train service operators, (not yet)
connected regions/cities, airports, airlines) – exact approach depends on national rail market regulations;

4. Promote further improvements in the agreements on the flexible use of airspace (FUA) – expand cooperation regarding military airspace so to ease swaps from military to civil airspace in congested flight areas, e.g. by offering military exercise airspace elsewhere (short to medium term action);

5. Review current business models of airports and identify to what extent the current incentive structure leads to an allocation of space and portfolio of services, which maximizes passenger expenditures rather than minimizes both passenger station time at the airport and airplane turnaround time; assess to what extent the currently prevailing business model raises the proneness for delays; depending on the outcomes of the review – devise viable business models with stronger incentives for minimization of both passenger station time at the airport and airplane turnaround time.

Policies and measures aimed at enhancing operational resilience

6. In order to reduce some bottlenecks and improve operational resilience ensure timely implementation of the SESAR programme, among others by committing sufficient funding e.g. by committing the European Investment Bank (short to medium term action);

7. Include airports more broadly into the passenger protection regulation for aviation and introduce a benchmarking system for airports based on punctuality performance and gross travel time; the benchmarking should be weighted and harmonized so as to compensate for climatic differences between airports and enable fair comparison; the benchmarking requires preparatory research; the benchmarking can be used as the basis for a sanction/reward system generated from payments by the airports – well rated airports receive more than they contributed, while poorly performing airports are losing; the benchmarking results should be public thereby also exerting influence on airport-client relations to match benchmark rating and charges;

8. Ensure completion and testing of the EUROCONTROL WX Resilience tool and incite coordinated application throughout Europe including protocols for capacity allocation in case of bad weather based projections of capacity limitations; the benchmarking of the airports (possibly combined with the sanction/reward system) may help to boost incitement for participation;

9. Alongside the WX Resilience tool for European aviation a similar tool could be developed for the European HST network and also used in a coordinated way by the European rail track organisations; eventually also a joint use of the system can be pursued so as to better judge actual available substitute capacity air – HST rail;

10. Consider a European coordination centre for cross-border HST and IC services comparable to EUROCONTROL, but much lighter given the smaller assignment;

11. Promote the introduction of intelligent information systems for travellers by supporting various demonstration programmes, focusing on various aspects such as: operability at different scales and in different countries, ease of use and access for vulnerable groups, etc. (this requires preceding R&D – see research and innovation policy below);

12. Facilitate different types of cooperation for transport sector actors in European, national and regional resilience strategy and management protocol development; the same goes for crisis management protocol development at European, national and regional level; make a best practice sharing programme at national and European level part of this cooperation.

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3 Measured from the time the traveller has the ticket scanned before entering the security check until passing the customs at the destination airport.
Policies aimed at promoting necessary research, innovation and demonstration

13. Promote a harmonized and complete coverage of punctuality measurement and reporting of all public modes in all Member States; promote transparency of the reporting and data access, e.g. by requiring it for access to some types of funding;

14. Promote fundamental research on modelling and prediction of extreme weather events – e.g. through the H2020 programme;

15. Promote innovation in dedicated weather services for specific transport sector user groups (aviation, maritime transport, road, multimode logistics, etc.) - e.g. through the H2020 programme and ERANET mechanism;

16. Ensure that weather service innovation is an acknowledged topic in the R&D programmes for intelligent roads;

17. Promote and fund EU (H2020) and national research on valuing of spare capacity of transport infrastructure and rolling stock in case hazard induced disruptions, under alternative market regulation schemes;

18. Promote research on the economic implications of alternative business models for airports and alternative governance and market regulation models for different transport modes, notably for aviation and rail services within the H2020 programme;

19. Promote R&D on intelligent information systems for travellers within the H2020 programme and ERANET mechanism with the specific aim to raise the resilience of the transport system(s);

20. Promote R&D on material and components in transport systems with the aim to extend the coping range in extreme weather conditions within the H2020 programme and beyond.
## Table 16. Policies & measures time lines

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### Operational resilience

| 6        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| SESAR programme implementation |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 7        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| airports in pass, protection regulation + benchmarking |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 8        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Eurocontrol’s WX Resilience tool + limited capacity allocation protocols for air |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 9        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Similar WX tool + protocols for (international) HST/IC services |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 10       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Euro(HST)rail coordination |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 11       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| Intelligent traveller information system demonstrations |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 12       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| transport system actors - EU / MS / regional resilience strategies & protocols |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

### Research & Innovation

| 13       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| punctuality monitoring & reporting |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 14       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| (spare) capacity valuation in CBA |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 15       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| research on extreme weather modelling |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 16       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| weather service innovations |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 17       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| weather service & intelligent roads |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 18       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| economic implications of alternative business and regulation models |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 19       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| R&D on intelligent traveller information and advice systems materials & components |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 20       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| extreme weather coping range extension |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
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ANNEX 1: Regulations for passenger rights in various public transport modes

This section gives a summary of current regulations regarding passenger rights for the transport modes air, rail, maritime, and bus. The enforcements of the regulation are described in brief.

On December 12, 2011, the Commission issued a Communication on Passenger Rights in all transport modes. It summarises the rights and principles which apply to all transportation modes. The Communication also announces that the Commission’s main objective from this point on is to make these rules easily understandable and to consolidate their implementation and enforcement in all modes of transport. The current status of the revision of passenger rights regulations is also part of this section.

Air Transport

Growth of air transport, stimulated by the development of the single market, is giving rise to much dissatisfaction today in terms of the quality of service provided by airlines. The European Community has so far taken specific measures in an effort to disseminate passenger' rights information both to airline operators, airports and passenger themselves.

The action taken by the EU in the field of air transport aims, among other things, at ensuring a high level of protection for passengers. This Regulation establishes common rules on compensation and assistance to passengers in the event of denied boarding and of cancellation or long delay of flights (Regulation (EC) No 261/2004). This Regulation does not apply to passengers travelling free of charge or at a reduced fare not available directly or indirectly to the public.

The regulation went into effect in February 2005 and it introduced new rules on compensation and assistance for air passengers. It defines minimum level of protection and applies both to scheduled and non-scheduled flights, including that part of package tours. For effective application the regulation stipulates that obligations that it creates rest with the operating air carrier. However, this does not restrict air carrier from seeking compensation from any person, including third parties, in accordance with the law applicable. The regulation applies to any flight leaving an EU airport and any flight into the EU on an EU-based airline or airline from Iceland, Norway or Switzerland.

A requirement to apply the regulation is that the passengers have a confirmed reservation on the flight concerned and, except in the case of cancellation, present themselves for check-in at the time indicated in advance or, if no time is indicated, not later than 45 minutes before the published departure time.

According to the regulation air carriers are obliged to offer air passengers reimbursement or re-routing by operating air carrier in case of cancellation. When the flight is cancelled on a short notice passengers are entitled to adequate care such as refreshments, meals, telephone calls, accommodation, while awaiting a later flight. The level of assistance is available according to the length of delay and flight distance. A passenger may also be entitled to a flat-rate compensation up to EUR 600 depending on the flight distance. However, an air carrier has no obligation to pay compensation when the cancellation has been caused by extraordinary circumstances, which “could not have been avoided even if all reasonable measures had been taken” (Article 5(3)). Meteorological conditions incompatible with the operation of the flight concerned is deemed as such a circumstance.
In case of delay passengers should be able to cancel their flights with reimbursement when the flight has been delayed for a specified time. Passengers awaiting a later flight should also be adequately cared for within set time limits. In addition, the regulation states that passengers should be informed about their rights under Regulation when denied boarding or when flight is cancelled or delayed for a long time in order that passengers can exercise their rights.

**Enforcement Bodies**

The Regulation required Member States to set up National Enforcement Bodies (NEBs) to verify that transport operators treat all passengers in accordance with their rights. Majority of Member States (23) has one authority responsible of enforcement and complaint handling task. In most cases (18) this is the Civil Aviation Authority or relevant Government Ministry.

In three Member States (Hungary, UK, Sweden) the enforcement and complaint handling tasks are separated. In one Member State (Finland) there are three authorities with different duties in charge of implementing the Regulation.

When a passenger is dissatisfied on how an air carrier has dealt with his/her passenger rights, (s)he has a right to submit a complaint to the carrier, and if still dissatisfied, then turn to the National Enforcement Body for assistance.

**Revision of Air Passenger Rights**

In parallel with the Communication on Passenger Rights in all transport modes the Commission launched a public consultation on the possible revision of Regulation (EC) 261/2004. The consultation took place between 19 December 2011 and 11 March 2012. It brought together stakeholders’ views on the identification of possible shortcomings of the Regulation and their extent, and on the options to improve its application, either via non-legislative measures or via a revision of the Regulation.

The Commission staff working document on Impact assessment for the revision of the Air Regulation was published on March 13, 2013. It was accompanied by Commission proposal to amend the Regulation. The proposed regulation is aimed to clarify the existing Regulation (EC) 261/2004 and it introduces some new passenger rights.

The proposal has e.g. following changes:

- clarification on extraordinary circumstances: list of circumstances considered as extraordinary, e.g. natural disasters and meteorological conditions incompatible with flight safety
- flight compensation: the minimum delay for flight compensation to increase from three to five hours and for long, international flights to nine or twelve hours.
- information for passengers: carriers must inform travellers about delays and cancellations and they must provide an explanation no later than 30 minutes after the scheduled departure time.
- re-routing: airlines will be obliged to use other carriers to reroute travellers if they have been detained for more than 12 hours.
  - Multi-Modal Transport: “where the air carrier cannot ensure the rerouting within 12 hours of its own service, it must offer rerouting with other air carriers or other transport modes where available.”
- on role of NEBs: coordination and exchange of information among the NEBs with the support of the Commission to be reinforced. The NEBs must also take a more preventive role and proactively monitor airline policies and not just react to complaints.
• on accommodation: obligation to provide accommodation will be limited to three nights and EUR 100 per night and per passenger in exceptional circumstances. (Limitation not applying to passengers with reduced mobility, persons accompanying them, unaccompanied children, pregnant women and persons with specific medical needs.)

• regional operators: no obligation to provide accommodation to passengers of flights of less than 250 km and with aircraft with less than 80 seats. (Limitation not applying to defined groups of people)

• cost sharing: national law may not restrict the air carriers' right to seek compensation from responsible third parties.

• Airports will be required to develop contingency plans for large-scale disruptions

The proposal is subject to approval by member states and the European Parliament and should come into effect in 2014. Transport Committee (EU Parliament) is to vote on the amended text on 14 November 2013.

**Rail Transport**

The action taken by the EU in the field of rail transport aims, among other things, at ensuring a high level of protection for passengers. This Regulation establishes common rules on compensation and assistance to passengers and the obligations of railway undertakings in cases of delay or cancelation of journey trips (Regulation (EC) No 1371/2007).

In detail, in Chapter IV, Article 15, the regulations and obligations of rail carriers are described concerning delays, missed connections and cancelations. The carrier shall be liable to the passenger for loss or damage resulting from the fact that, by reason of cancellation, the late running of a train or a missed connection, his journey cannot be continued the same day, or that a continuation of the journey the same day could not reasonably be required because of given circumstances. The damages shall comprise the reasonable costs of accommodation as well as the reasonable costs occasioned by having to notify persons expecting the passenger. The carrier shall be relieved of this liability, when the cancelation, late running or missed connection is attributable to one of the following causes:

• circumstances not connected with the operation of the railway which the carrier, in spite of having taken the care required in the particular circumstances of the case, could not avoid and the consequences of which he was unable to prevent

• fault on the part of the passenger

• the behavior of a third party which the carrier, in spite of having taken the care required in the particular circumstances of the case, could not avoid and the consequences of which he was unable to prevent; another undertaking using the same railway infrastructure shall not be considered as a third party; the right of recourse shall not be affected.

In addition, Article 16 specifically describes the regulations governing reimbursement and re-routing for rail transport: Where it is reasonably to be expected that the delay in the arrival at the final destination under the transport contract will be more than 60 minutes, the passenger shall immediately have the choice between:

• reimbursement of the full cost of the ticket, under the conditions by which it was paid, for the part or parts of his or her journey not made and for the part or parts already made if the journey is no longer serving any purpose in relation to the passenger’s original travel plan, together with, when relevant, a return service to the first point of departure at the earliest opportunity. The payment of the reimbursement shall be made under the same conditions as the payment for compensation referred to in Article 17; or
• continuation or re-routing, under comparable transport conditions, to the final destination at the earliest opportunity; or
• continuation or re-routing, under comparable transport conditions, to the final destination at a later date at the passenger’s convenience.

Without losing the right of transport, a passenger may request compensation for delays from the railway undertaking if he or she is facing a delay between the places of departure and destination stated on the ticket for which the ticket has not been reimbursed in accordance with Article 16. The minimum compensations for delays shall be as follows:

(Art. 17):

• 25 % of the ticket price for a delay of 60 to 119 minutes,
• 50 % of the ticket price for a delay of 120 minutes or more.

Where the transport contract is for a return journey, compensation for delay on either the outward or the return leg shall be calculated in relation to half of the price paid for the ticket. In the same way the price for a delayed service under any other form of transport contract allowing travelling several subsequent legs shall be calculated in proportion to the full price. The calculation of the period of delay shall not take into account any delay that the railway undertaking can demonstrate as having occurred outside the territories in which the Treaty establishing the European Community is applied. The passenger shall not have any right to compensation if he is informed of a delay before he buys a ticket, or if a delay due to continuation on a different service or re-routing remains below 60 minutes.

Moreover, Article 26 states the overall regulation for personal security of passengers, as follows: In agreement with public authorities, railway undertakings, infrastructure managers and station managers shall take adequate measures in their respective fields of responsibility and adapt them to the level of security defined by the public authorities to ensure passengers’ personal security in railway stations and on trains and to manage risks. They shall cooperate and exchange information on best practices concerning the prevention of acts, which are likely to deteriorate the level of security

Maritime Transport

The Regulation on passenger rights in maritime and inland waterway transport was published on 17 December 2010 as Regulation 1177/2010. The Regulation applies in respect of passengers travelling:

• on passenger services where the port of embarkation is situated in the territory of a Member State;
• on passenger services where the port of embarkation is situated outside the territory of a Member State and the port of disembarkation is situated in the territory of a Member State, provided that the service is operated by a Union carrier;
• on a cruise where the port of embarkation is situated in the territory of a Member State.

However, the Regulation does not apply to passengers travelling on ships certified to carry up to 12 passengers, on ships with an operating crew of not more than three persons, or where the overall service is less than 500 meters, one way, on excursion and sightseeing tours or on ships propelled by non-mechanic means.

In detail, Article 17 states the following:
Where a carrier reasonably expects the departure of a passenger service or a cruise to be cancelled or delayed for more than 90 minutes beyond its scheduled time of departure, passengers departing from port terminals shall be offered free of charge snacks, meals or refreshments in reasonable relation to the waiting time, provided they are available or can reasonably be supplied.

In the case of a cancellation or a delay in departure where a stay of one or more nights or a stay additional to that intended by the passenger becomes necessary, where and when physically possible,

the carrier shall offer passengers departing from port terminals, free of charge, adequate accommodation on board, or ashore, and transport to and from the port terminal and place of accommodation in addition to the snacks, meals or refreshments provided for in paragraph 1. For each passenger, the carrier may limit the total cost of accommodation ashore, not including transport to and from the port terminal and place of accommodation, to EUR 80 per night, for a maximum of three nights.

Moreover, according to Article 18 regarding re-routing and reimbursement in the event of cancelled or delayed departures:

Where a carrier reasonably expects a passenger service to be cancelled or delayed in departure from a port terminal for more than 90 minutes, the passenger shall immediately be offered the choice between:

- re-routing to the final destination, under comparable conditions, as set out in the transport contract, at the earliest opportunity and at no additional cost;
- reimbursement of the ticket price and, where relevant, a return service free of charge to the first point of departure, as set out in the transport contract, at the earliest opportunity.

2. Where a passenger service is cancelled or delayed in departure from a port for more than 90 minutes, passengers shall have the right to such re-routing or reimbursement of the ticket price from the carrier.

The payment of the reimbursement provided for in paragraphs 1(b) and 2 shall be made within 7 days, of the full cost of the ticket at the price at which it was purchased, for the part or parts of the journey not made, and for the part or parts already made where the journey no longer serves any purpose in relation to the passenger’s original travel plan.

Finally, according to Article 19 on the compensation of the ticket price in the event of delay in arrival:

Without losing the right to transport, passengers may request compensation from the carrier if they are facing a delay in arrival at the final destination as set out in the transport contract. The minimum level of compensation shall be 25% of the ticket price for a delay of at least:

- 1 hour in the case of a scheduled journey of up to 4 hours;
- 2 hours in the case of a scheduled journey of more than 4 hours, but not exceeding 8 hours;
- 3 hours in the case of a scheduled journey of more than 8 hours, but not exceeding 24 hours; or
- 6 hours in the case of a scheduled journey of more than 24 hours.

If the delay exceeds double the time set out in the previous points, the compensation shall be 50% of the ticket price.
ANNEX 2: Outline and example output from EUROCONTROL WX Risk Assessment Project & Tool

Figures are copies from the presentation by Christian Faber (EUROCONTROL) held on 9.9.2014

The Network WX Resilience Roadmap
### Capacity Reduction: Generic Airport

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Each cell contains performance reduction estimates (0 – 100%) provided by EUROCONTROL experts.

![Network Weather Resilience, Inc.](image-url)