Collaborative project co-funded by the European Commission

Seventh Framework Programme

Aeronautics and Air Transport

FP7-(AAT)-2012-RTD-1

Theme [AAT.2012.7-26]

[Efficient Airports for Europe]

Project MetaCDM

D2.2– WP2 report:

Contributions of Information Sharing, Collaborative Decision Making and Multimodality in improving passenger experience during disruptive events

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Submission date: 28/2/2014

Dissemination level: PU

Change Log

Release	Date	Details of changes
0.1	15/01/2014	First version of the report
0.8	26/02/2014	Final Draft
1.0	28/02/2014	Final Version

Table of contents

EXECUTIVE SUMMARY

The MetaCDM (Multimodal, Efficient Transportation in Airports – Collaborative Decision Making) project aims to define the future of Collaborative Decision Making (CDM) at Airport – a future where CDM techniques can be used to address major disruptive events, and where the needs of the passenger are the centre of attention.

The project has three main stages: a literature review of current CDM efforts, including the Airport CDM (A-CDM) concept as implemented at most of the major European airports, disruption handling and passenger-centric metrics (work package 100); a series of interviews at airlines, airports and other major stakeholders on CDM and disruption handling (work package 200), and a concept development phase based on the outcome of the first two work packages (work package 300). This report is the final output of work package 200. It focuses on information gathering from airports and other stakeholders in relation to CDM practice during disruptive events, and how the passenger experience can best be optimized under these conditions. It draws conclusions on the current areas of strength and weakness in CDM and disruption handling, and provides further input information, alongside the work package 100 results, for the identification and development of a possible new concept of operations in work package 300.

Eight airports of various types and sizes in Europe were interviewed for this report, together with landside stakeholders that are currently not addressed by A-CDM (such as Border Control). Views drawn from partner discussions with some non-European airports have been added to provide a global perspective where possible. The first section of this report records the airports chosen, the rationale for these choices and their key characteristics from the airport and passenger perspectives. The second section of the report describes the nature of the interview and survey process, its structure and scope. Findings from the investigation process are described in the third section of the report, linked to three main categories: CDM, multi-modal connectivity and the passenger airport/access experience.

The outcomes of the interview process show that there has been significant learning and improvement in CDM and crisis handling in recent years with the application of significant dedicated resources to address on-airport problems. However, landside and multi-modal connectivity, and the passenger experience associated with them, are still beset with various problems. Sometimes this is the result of disruption on a larger or wider scale than the airport and/or airlines have resources to handle; at other times, it is a result of suboptimal information sharing, conflicting priorities between stakeholders

or shortcomings in existing crisis plans. Communication deficiencies remain a key topic to address amongst stakeholders and with passengers. Lack of mutual understanding of perspectives and priorities between stakeholders causes problems and there are concerns about emerging threats and system resilience as a result. Crisis prevention handling and mitigation is expensive and this colours views on the way that stakeholders engage; each stakeholder needs to make a practical decision on what level of crisis response is cost-effective under the constraints they are working under. This also applies to measures which improve the smooth running of airports under non-crisis conditions. For example, smaller airports remain to be drawn in to CDM on account of its perceived cost and complexity, but there is an appetite to do so on the right terms. In terms of future developments, the use of smartphones to provide improved information to (and potentially gain improved information from) passengers was of interest. Similarly, greater engagement with ground transportation modes for passenger transportation in crisis situations is considered desirable but there are significant problems with data compatibility, spare capacity, liability and response time and which may prevent highly integrative solutions being an option in the short term. However, many of the airports interviewed were using or pursuing smaller-scale solutions.

This report ends by summarising the main findings and messages from the interview process which will have a direct bearing upon MetaCDM's concept development phase in work package 300.

Abbreviations

Abbreviation	Description
ACC	Airport Control Centre
A-CDM	Airport Collaborative Decision Making
ACI	Airports Council International
ADP	Aéroports de Paris
AMAN	Arrival Management
ANSP	Air Navigation Service Provider
ANZ	Airways New Zealand
AO	Airport Operator
AODB	Airport Operational Database
API	Application Programming Interface
BAT	Basic Assistance Team
CAA	Civil Aviation Authority
CDM	Collaborative Decision Making
CDG	Paris Charles de Gaulle Airport
CFM	Collaborative Flow Manager
CFMU	Central Flow Management Unit
CTA	Controlled Times of Arrival
DGAC	Direction Generale de l'Aviation Civile
DMAN	Departure Management
DSNA	Direction des Services de la Navigation Aérienne
EOBT	Estimated Off-Block Time
EFTMS	Enhanced Tactical Flow Management System
EPGT	Estimated Pax at Gate Time
FIDS	Flight Information Display System
FUM	Flight Update Message
KPI	Key Performance Indicator
L-CDM	Landside CDM
MetaCDM	Multimodal, Efficient Transportation in Airports and Collaborative Decision Making
MVT	IATA Movement Messages
PIT	Passenger Irregularity Team
SNA	Aerial Navigation Services
SWIM	System-Wide Information Management
TAM	Total Airport Management
TAMS	Total Airport Management Suite

TMAN	Turnaround Manager
TOBT	Target Off-Block Time
TSAT	Target Start-up Approval Time

1 Introduction

The literature review stage in MetaCDM highlighted the current state of CDM, including the A-CDM concept and its implementation status, and crisis response in Europe, concentrating on how past disruptive events have been handled. The interview phase of the project (Work Package 200) complemented this by adding a picture of the realities of CDM as experienced by a range of airside and landside stakeholders, under both normal and crisis situations. On-site interviews have been conducted with various organisations at a range of major hub and smaller airports, concentrating particularly on those that have experienced significant disruptive events. The aim has been to:

- Obtain information about CDM functionality from a wide range of stakeholders;
- Identify the practical consequences and bottlenecks resulting from highly disruptive events, especially as these affect passengers;
- Allow operation experts and stakeholders to express their views on CDM related aspects of airport operations and performance (in normal and disruptive conditions), in structured and unstructured interviews.

The objective of the interviews is to draw out practical experience that adds to the information drawn from the Work Package 100 examination of literature. This will then help to inform the development of ideas for a new concept of more resilient and passenger-friendly operations in Work Package 300.

The interview phase of MetaCDM involved three major tasks. Initially (Task 200.1) a set of airports were identified and selected for on-site interviews. This is described in Section 2. These airports were chosen to cover experience of a wide range of past disruptive situations. Additional criteria for selection were the airports' importance in the European air transport system; their experience of particularly representative disruptive events; and existing links with project participants and/or advisory board members that were able to facilitate the data-gathering process. This task also included priming work in which the questions to be asked during the interview and survey processes were developed, drawing upon the literature analysis from Task 100 (see e.g. Annex 3).

The second and third tasks (200.2) were to carry out the on-site interviews with major aviation stakeholders at the airports identified in Task 200.1, and similarly with ground transportation providers. These tasks are described in Section 3. The list of aviation stakeholders included strategists, planners, service operators and managers from airports, airlines and air traffic service providers. These interviews focused on characterizing operational practice and the features critical to CDM under normal

operations and in crisis management situations identifying chains of command, system interdependencies and bottlenecks; and assessing existing crisis management arrangements. Ground transportation providers were included due to the scope for MetaCDM concept to include providers of ground transportation in the CDM process, for example to facilitate modal shift in response to disruptive events or to enhance the travel experience to and from the airport. Interviewees were selected as appropriate to the airports chosen (e.g. bus, taxi, or train operators and bodies responsible for local road infrastructure). These interviews focused on the practicality of delivering a coherent and connected service, co-ordination of information between modes and what information could enhance passenger satisfaction.

A list of the interviews carried out is given in Annex 2[1]. The on-site data-gathering process was also complemented with survey work and by a discussion workshop at Frankfurt Airport in November 2013[1].

[1] Note that passengers were not directly surveyed as part of MetaCDM; it was felt that this was outside the project remit as many passenger surveys already exist, as well as potentially adding a prohibitive time and cost burden to interview sufficient numbers of passengers.

2 Identification of a set of airports for on-site interviews

The initial MetaCDM literature study (WP100) identified a number of airports which were interesting because they had particular experience of dealing with severe disruption and/or because they had established A-CDM procedures. Disruption is invariably experienced most severely at international gateway airports as they are more prone to system knock-on effects and thus are prime candidates for examination in greater detail.

London Heathrow, Paris Charles de Gaulle and Frankfurt airports are currently the busiest airports by passengers handled in Europe; in 2013 they were ranked third, eighth and tenth in the world by passenger numbers [2]. The MetaCDM partner organizations have established contacts with the main hubs in their respective countries so these three airports were highly relevant and practical targets for the conduct of interviews. A range of personnel, both immediately connected with the airports as well as organisations that have a significant stakeholder connection, were targeted. As identified in WP100, the key relevant attributes of these airports are:

- London Heathrow: snow, aircraft incidents, volcanic ash etc.; strong capacity constraints; multiple-airport system; A-CDM in use.
- Paris Charles de Gaulle: snow, volcanic ash, strikes etc.; A-CDM in use.
- Frankfurt: snow, volcanic ash, strikes; capacity constraints; A-CDM in use.

In terms of the resilience of the European airport system, these are front-line airports that are both susceptible to crisis events and have a disproportionate effect in spreading any disruption throughout their networks. As such, these airports are the backbone of the project interview work.

Furthermore, it is considered to be important both to look at airports that link to the key European hubs and those smaller point-to-point airports supporting low cost and charter markets rather than full service carriers. Considering the connections of project partners, the following airports were additionally selected for the conduct of interviews:

- Brussels Zaventem
- Toulouse Blagnac
- London Luton
- Vienna
- Dusseldorf

Apart from Toulouse, which was highlighted as a non A-CDM airport, these European airports were not specifically identified in WP100. However, they had many similar characteristics to those that had emerged from literature review, and allowed a significant range of airport sizes and target markets to be studied.

Two regions were inspected for the selection of non-European reference airports: North America and New Zealand. While the first region is (next to Europe) the busiest area for Air Traffic Management, the second region was selected because of its approach to handling demand-capacity balancing.

3 Information gathering and interview process

Following the selection of airports, the process for interviewing involved three main steps:

- identifying and securing the participation of as many experts as possible at the selected airports so as to cover the broad range of interests;
- following a broadly structured set of interview questions (albeit that it was necessary to adapt and expand the questioning according to the particular role and circumstances of the interviewees);
- following up with dynamic and unstructured questioning where appropriate to pursue interesting points arising in discussion.

Prior to the main interview process, a pilot tester survey was conducted with attendees at the first MetaCDM workshop, which took place at London Heathrow in January 2013. This survey covered a diverse set of questions of interest to the project rather than the more structured and focused approach of the main interviews. Following the outcomes of this survey and of WP100, structured questioning with the chosen interviewees took place from Summer 2013 onwards. As noted previously, the MetaCDM project did not survey passengers directly. As a result, the passenger points noted all come from stakeholders with different perspectives on the needs and experience of the passenger.

3.1 Initial survey at META-CDM Workshop 1

The first and preparatory phase of the information gathering from stakeholders took place at the first MetaCDM workshop in January 2013. Questionnaires covering a number of topics relevant to the project were provided to attendees. The outcome was summarised in the first workshop report[3], an extract from which is at Annex 1 to this report. Although the spread of respondent interests was wide, the sample size was small with only 13 responses. However, the views expressed may be generally regarded as indicators of interest and concern amongst professionals engaged in A-CDM and wider delivery of the airport service to travellers. A brief summary of the view expressed is set out below:

- Concerning the **most important sources of disruption at airports**, weather effects were regarded as most important present-day disruptive events. Accidents, incidents and strikes were also discussed. Looking forward the main trends expected to 2050 were changes in the type and severity of weather effects and the impact of increasing numbers of airports operating close to capacity;

- On **obstacles to optimal crisis management**, there were two key stands: from the passenger viewpoint, staffing levels at immigration and security and flight information were thought to be deficient. More broadly, problems over information sharing amongst stakeholders, institutional barriers and sub-optimal infrastructure use in crisis situations were thought to be impediments;

- A clear consensus view was that **a greater integration of ground transport providers into A-CDM** is worthwhile. Challenges were foreseen concerning passenger acceptance, differing needs of stakeholders and how to share information across operator boundaries. Crisis planning amongst stakeholders and reconciling competitive and commercial positions were also seen as challenges.

- When asked about existing **ideas, CDM concepts and CDM enabling technologies** to be investigated for development, respondents mentioned management tools for departures, arrivals and turnaround. Information sharing technologies, integrated airside and landside CDM (supporting crisis situations) were also noted. Looking towards new ideas, concepts such as Total Airport Management (TAM) should be investigated along with greater exploitation of smart phone technology to assist the passenger;

- The main view about **deficiencies in current systems/ processes** was that information sharing was inadequate. The lack of passenger data collection and weak collaboration between modes was also cited;

- Asked about **missing performance KPIs for passenger benefit**, the gaps identified included door-to-door travel time and efficiency, passenger delays and arrival times/punctuality. Passenger costs in terms of value of time and overall satisfaction on meeting expectations were other areas where metrics and KPIs were missing.

The views received in these questionnaire responses helped to inform the development of more tailored questioning in interviews.

3.2 Scope of interviewing and question setting

3.2.1 Organisations and stakeholders interviewed

As noted in 2.1 and 2.2 above, interviews were conducted with a number of airports of differing sizes and market orientation. It was important to gather views from experts in a range of organisations linked to these airports. At larger airports it was possible to

interview experts in different roles within the airport as well as people in government, authorities, service companies, etc., that have a stake in the smooth operation of the airport. At smaller airports where budgets, resources and crisis effects were all smaller, discussion with the responsible manager was as far as it was practical and necessary to go in order to build up a picture of the CDM application and passenger experience. Indeed, personnel at these smaller airports tended to have multiple roles linked to aspects of CDM and resilience and connection with ground transport operators was more simple and periodic.

Experts interviewed included the following:

- Airlines: legacy, low cost and freight
- Handling agents
- Air Navigation Service Providers (ANSPs)
- 'Blue light' services and border agencies
- Ground transport providers
- Government departments
- Local authorities

A list of those interviewed is given in Annex 2.

3.2.2 Questionnaire format

Following the literature review and pilot survey at the first MetaCDM workshop, a brainstorming process was used to identify question ideas for the main project questionnaire. In the initial process, 55 questions/issues were identified as relevant to the project. This number of questions was clearly far too much to use in a standard set of questions that could be applied to a broad range of stakeholders and used to enable some comparison of response and elicit themes and patterns more easily. Accordingly, it was decided to distil these into a relatively short questionnaire that could be used consistently. Fourteen question areas were chosen, covering the main topic areas given below with regard to A-CDM and disruption response:

- Planning
- A-CDM engagement
- Alert process
- Communication downstream
- Training
- Tools
- New technologies
- Performance

- Effectiveness
- Scope to improve
- Cost
- Regulation
- Contingency
- Complaints

A copy of the questionnaire template is given in Annex 3. For the purposes of the airport interviewees, this includes a number of factual questions about the airport to provide context and understanding relative to the answers to the substantive questions.

As may be expected, given the diversity of interviewees and organisations, the standard script often acted as a launch pad for supplementary questions. Indeed some questions were not relevant for a few stakeholders. This means that the dialogue followed the broad structure of the questionnaire but often tended to broaden out and encompass issues that were not on the core list. Questions that were initially identified in the original brainstorming list of 55 questions were also used and the result was a hybrid selection of questions and impromptu discussion suited to the individual interview.

3.3 Interview results and findings

The interview process resulted in insights in a number of key areas relative to the MetaCDM project. For the purposes of this report, these have been grouped into the following broad categories:

- Resilience of airports
- Information sharing and decision-making between stakeholders
- Multi-modal transport connectivity, and
- Passenger access/airport experience.

In this section, the results are discussed for each of these categories in turn. A number of views that were expressed are anonymised as the interviewees had noted either commercial, competitive or confidentiality concerns.

3.3.1 Resilience of airports

The first MetaCDM interviews were carried out at Paris Charles de Gaulle (CDG) airport. CDG is an A-CDM airport and is a major European hub with experience of multiple types and levels of disruption. The interviews focused on the operation of A-CDM at the airport and on experiences of major disruptive events, particularly the major snow event in December 2010 which had widespread impacts across many Western European airports. At CDG the main expected benefit of A-CDM processes is the increased

situational awareness and communication between actors in case of severely degraded conditions. When there is an abnormal situation, the stakeholders, including ADP (Aeroport de Paris), AOs (Airport Operators), ground handlers and the Air Navigation Service Provider (ANSP), move to what is known as 'Plateau CDM'[2]. Then the operational managers of the airlines, ADP and Direction des Services de la Navigation Aérienne (DSNA) are included. If the crisis is such that the planned schedule for a day has to be cut down, the decision moves to the Direction Generale de l'Aviation Civile (DGAC). The CDM@CDG website proves very useful in these cases, with up to 200 operators logged in, even stakeholders across the world.

Service recovery covers severe weather disruptions (snow, volcanic ash ...). There is a pre-established plan regarding flights and routes, where the potential impact is evaluated, based on statistics and load ratio. Its impact is re-evaluated upon the organization of the contingency plan. After the crisis, feedback is collected. The freight operator at CDG deals with day-to-day analysis while its headquarters in another city deals with the tactical and strategic debriefing. If necessary, most of the operations can be 'delocalized' in Cologne (packages and options, whether the whole or part of operations). When flights have to be cancelled, trucks (i.e. road mode switch) can help to cope with the situation and transport some of the goods across Europe.

One of the airlines interviewed has the following importance scheme: Safety first, then on-time performance, then customer satisfaction. They have tools to evaluate the knock-on effects of disruption displayed on their screen. Each contingency plan relies on all stakeholders coming together (flight operations, ground operations, press service ...) and emails sent to passengers (there is also a smartphone application available). The CDG team of this airline at CDG only has access to information at CDG, but its headquarters can get wider information from their other locations. Another airline has a crisis cell with representatives of human resources, law experts, communication service, etc. at their Operation Control Center, as well as an integrated plan to handle passengers stranded at CDG.

In parallel a crisis cell is also organized at the airport in connection with the airline crisis cell. The crisis cell is isolated on the airport so as to not disturb operations services, and in close cooperation with ADP. If necessary, the airline has foldable beds and designated areas to organize overnight stays. It also has contracts with bus companies in case there are so many stranded passengers that some of them may have to be sent to various

[2] At hub airports, such as Paris CDG, a room, called Plateau CDM, may be dedicated to gathering all the decision makers and stakeholders in one place to ensure common situational awareness and improved decision processes.

hotels in the Paris and suburbs area. On the interviewed ground handler's side, in case of bad weather conditions, the alert is given by ADP. Such information transfer takes in general around 15 minutes. An alert can also be derived from the CDM tool when observing a lot of delayed flights with the regulation code corresponding to bad weather conditions. If the problem comes from another airport than CDG, the ground handler is directly informed by people in place at this airport. More generally, additional information is collected from direct phone calls to the different stakeholders. During the crisis situation generated by the Islandic volcano eruption in 2010, a map on the cloud evolution across European airspace was provided by their office in England.

Interviews were also carried out at Frankfurt/Main Airport, another major European hub airport with extensive experience of disruption. The two main stakeholders at the Airport, Fraport (the Airport Operator) and Lufthansa (the Hub Airline), would the extension of A-CDM philosophy into landside aspects (common strategic planning) in principle see as a success factor (given all the attending challenges). Process & Irregularity Management is commonly addressed by these stakeholders, e.g. in Winter School (the major motivation for this being the disruption experienced in Winter 2010). They make an important distinction between predictable and unpredictable irregularities, with the current focus being on dealing with predictable irregularities.

Innovative solutions are used to improve passenger queue management already at Frankfurt under normal conditions. This includes the management of queues in the terminal and the usage of queue number automats (so that there does not need to be a physical queue at the counter). A colour-coded terminal concept is used during predicted irregularities to support passenger orientation; this is discussed further in the next section. However, it requires preparation on the previous day. Additional terminal services are offered in case of disruptive events, such as:

- Provision of food and drinks,
- Camp beds,
- Passenger queue management and
- Entertainment.

Additional administrative airline employees (Passenger Irregularity Team, PIT) and airport employees (Basic Assistance Team, BAT) support passenger service in case of disruptive events (on a voluntary basis). The key success factors in this case are

- To have a flexible number of service staff equipped with iPads with either general or (for IRREG situations) customized Lufthansa/Fraport apps to provide waiting passengers with the required information and

- To speak directly to passengers in queues to provide any required information on time (as waiting for access to the counter may waste important time, e.g. to catch alternative flights).

Concerning R&D, the development of strategies that reduce terminal congestion at hub airports in case of disruptive events, e.g. through flight cancellations, and that allow early communication with passengers, was of interest. One particular area of focus was on weather prediction. Here, the key questions to be addressed in R&D are

- What weather data is important to support decision making process at airports?
- How can this information be presented in the most effective way to support decision making (e.g. indication of probability of relevant weather events)?

Further required prediction functionalities in case of disruptive events are:

- Calculation of terminal occupancy, distinguished by destination regions
  - This supports the decision making process on which passengers must be booked to (alternative) flights in order to effectively reduce terminal congestion.
- Calculate hotel occupancy
  - This supports the decision making process on whether camp beds are needed.

A particular challenge to be addressed was the demographic transition and the need to consider the requirements of greater numbers of older people using the airport in future.

The third set of interviews at a major hub airport were carried out at London Heathrow. Here, as with many large international hubs, there are dedicated crisis cells that can be activated in the event that crisis trigger points are reached. In light of the Begg report, reacting to the major snow induced disruption in winter 2010[6], the airport adopted a three tier 'Bronze, Silver, Gold' command and control framework as used by emergency services. These levels represent operational control, tactical command and strategic command respectively and will be activated sequentially according to the severity of any incident.

Alert processes and information routes used to maximize advance notice of potential incidents differ considerably. These draw upon ANSP and airline intelligence, government, security and 'blue light' services, meteorological agencies and local authorities. Additionally, web and media scanning serves to provide advance notice of national or international actions that may have some ramifications for the operation of

the airport, even down to operational practicalities such as a teachers' strike affecting staff childcare requirements which might have an impact on the staff availability at the airport. Threat identification is also becoming an increasingly important issue alongside disruption management. Although terrorist alerting is firmly embedded within the security services and government, there is increasing concern amongst airlines and airports about the risks associated with cyber attacks. A separate but tangible threat is from space weather induced disruption, e.g. solar flares. Increasingly stakeholders are paying attention to these issues and reflecting them in their resilience planning.

At the highest levels, governments will have oversight of airports that are categorized as 'national assets' with monitoring meetings between government, airports, civil aviation authorities and other agencies such as ANSPs to review plans, threats and resilience. In the case that a disruptive event is significant, such committees may convene to initiate special actions and manage expectations and fall-out. Evaluation post-hoc is also an important function. Governments have been keen to promote more predictive modeling and scenario work to assist with resilience planning and aid recovery when crises occur. Lesson learning is generally believed to be improving but there is scope for improved co-ordination and information sharing to improve system robustness.

Supporting the airport's operational personnel in crisis situations are the 'blue light' services and these have their own form of intelligence gathering that link as much to government and the security agencies as to the airport. For these organizations, and especially the police, close co-operation is especially important and interface with the airport duty managers is a daily occurrence. Contingency planning and risk management are continuous activities with contacts in various organizations aimed at forestalling problems and mitigating at the earliest opportunity. Contact tends to be verbal rather than automated but key personnel are embedded in the airport crisis planning arrangements. At larger airports, the number of agencies involved in responding to severe disruption events can be considerable and this can cause problems with exercising responsibility as the lines of command are not always clear.

Duty managers have a pivotal role and, in the event of an incident or forewarning thereof, the relevant category in the crisis command will be activated with representation drawn from key internal units and some external organisations. The airport has close connection with London and nearby local authority resilience fora that can mobilise agencies and resources in the event of need.

Crisis handling is subject to quarterly review and importantly all staff are trained as reservists to be activated in the event of severe disruption through desktop training

modules and lunchtime sessions. Training is an ongoing requirement, quite apart from the mandatory 2-yearly exercises required by regulation. The net effect is a management hierarchy and workforce that is primed to react as needed and able to focus dedicated resources upon crises. The need for a honed strategy and tightly defined procedures is emphasised by the very limited operational flexibility that exists at Heathrow on account of the airport continuously running very close to its operational capacity. An example of the ability to prepare for a major event that had the potential to cause equally major disruption was the 2012 Olympics for which Heathrow Airport mounted a huge number of training exercises – this reinforces the general dictum that 'advance notice is all' and that with time and planning, the majority of situations can be managed. Of course, in the case of the Icelandic Volcano eruption, the effect was such as to defeat the best laid planning at the airport level as 'shut down' approached but the lessons in that case were largely of a different nature related to understanding the scientific/technical impact of volcanic ash upon aircraft engines.

A range of smaller airports were also interviewed by the MetaCDM team. At Dusseldorf Airport, major disruptive events are managed by a crisis team which is supported by monitoring function implemented in the Airport Control Center (ACC). The ACC is equipped with a Decision Support Tool (Performance Manager), which indicates demand, capacity, delays, etc., including prediction and what-if scenario functionality. The integration of landside performance monitoring/management into the ACC is foreseen, but the coordination of landside and airside processes is currently handled by manual procedures (e.g. via telephone) and performance monitoring is based on the current situation (such as queue length at Security Check). The availability of staff is usually the bottleneck for dynamic allocation of resources (allocated strategically).

At Vienna Airport, winter operation is seen as a particular challenge which is managed by dedicated and trained winter operations teams. Significant enhancements are currently underway. For example, Movement Control will be integrated with the Terminal Operations Center to enable direct communication and coordination. The landing time predictions are currently based on IATA Movement Messages (MVT), but will (as part of the A-CDM project) be improved by using Flight Update Messages (FUM) provided by the Enhanced Tactical Flow Management System (ETFMS). Monitoring and management of passenger queues in terminal is done by cameras in the Terminal Operations Center. A particular challenge of handling passenger queues in the terminal is that the queues may require stopping escalators if queuing areas are limited in order to avoid accidents. A potential improvement foreseen for terminal operations is better data provision, e.g. providing the number of handicapped persons in wheelchairs, buggies for children etc. which would enable more efficient gate allocation. [24]

Many smaller airports will not have the resources to dedicate and resilience planning may be just one of several responsibilities for a particular manager. They also have a far harder task to justify the investment in tools and systems needed to interface with the hub airports and, even if they could, there remain data and system commonality problems. Similarly, constraints at smaller airports apply to training which may be confined to a formal annual exercise together with some desktop training. Perhaps understandably, airports wish to maintain their competitive edge so 'best practice' guidance in relation to CDM functionality and experience and training is not usually shared or made available.

Performance requirements are tight on account of external imposed CAA service quality requirements and internal company requirements at airports such as Heathrow that operate on a 'knife edge' will be increasingly rigorous and comprehensive. In the last 3 years significant investment has taken place in relation to resilience planning, procedure development, training and equipment purchase, e.g. in relation to snow clearance.

At smaller airports there is often a reluctance to embrace A-CDM on account of the cost and the reality that the benefits are less as greater flexibility invariably exists to enable reaction to severe disruption events. That said, a smaller airport can often not have a 'resident' airline, meaning that invoking passenger transfer arrangements in the event of disruption can rely upon handling agents for whom this is a far greater logistical problem than for airlines. A number of airports have indicated that they would be interested in a 'CDM Lite' approach that allows for a number of the benefits without requiring the same level of investment. Mid-size airports will be sensitive to reputational issues and those with above five million passengers per annum will invariably have established robust crisis management plans not least, in the case of the UK, on account of CAA emergency planning requirements. The slowness of some potential A-CDM airports to adopt the full A-CDM is often down to inability to unify or connect systems. Another issue for smaller airports is establishing KPIs for crisis situations as these tend to be relatively rare though, for example, ramp up time for crisis teams is an important criterion. In the normal course of events, attention will be on the passenger with 'baggage to belt' time being a critical KPI.

Whilst A-CDM stakeholders recognize the benefits of a regulated air transport system, there is a sense of nervousness about the extension of regulations in the crisis/disruption area, not least as the experience of 'denied boarding' regulations suggests that significant cost penalties can arise. Moreover, there can be inconsistencies in regulatory oversight that cause problems. e.g. in relation to how Regulations EU261 and 966 conflict with UK national legislation through the Civil Contingencies Act 2004.

3.3.2 Information sharing and decision-making between stakeholders

Information sharing is at the heart of the A-CDM concept, which aims to make communication between stakeholders easier by using adapted procedures and tools. The greatest benefits obtained by A-CDM are a common situational awareness between the stakeholders and an increase in operational predictability. Better estimates on arrivals are available through Flight Update Messages (FUM) from the Network Manager (former Central Flow Management Unit, CFMU) while the implementation of A-CDM processes results in better Target Off-Block Times (TOBT) from airlines. The passenger may profit from both if this information is forwarded beyond the stakeholders who currently have access to it.

At the moment, landside performance monitoring focuses on the current situation. According to the MetaCDM interviews various technologies to measure landside performance exist, including passenger detection using Bluetooth, automatic detection via video cameras and light barriers. But few decision support tools are used that provide recommendations for landside processes. The general challenge is to convince users about the benefit of using a certain solution. Successful solutions are quickly communicated within the worldwide airport community and may be widely spread. However, the indication of queuing times of landside processes to passengers may not always be desired by stakeholders and this is a problem in gaining acceptance. The provision of indoor navigation support (via smartphones) is seen as a future market and may support the management of situations during disruptive events.

In nominal conditions of operations, the interviewed stakeholders generally agree on the ability of A-CDM to provide a common situational awareness between stakeholders as well as an increase in operational predictability. However, in case of disruptive events, A-CDM procedures do not yet cover all expectations. Airport stakeholders, both on A-CDM platforms and non A-CDM platforms, complain about the difficulty to get and share information at two levels:

- At the network level,
- At the airport level.

At the network level, stakeholders complain about the lack of information coming from other platforms facing disruptive events. The impacts of the snowball effect in the propagation of the disturbances between airports can be all the more disastrous if stakeholders cannot anticipate them.

An illustration of this is the snowball effect between London Heathrow, Paris CDG and Toulouse Blagnac airports during the heavy snowfall that occurred in December 2010 in

Europe. While Paris CDG airport was functioning close to its maximum capacity due to heavy snowfalls in the region, London Heathrow airport (which was also heavily affected by snow) had to close its operations. However, Paris CDG airport was not aware of this closure until shortly beforehand and had to accommodate long-haul flights that were expected to land at London Heathrow on short notice. Knowing in advance that London Heathrow airport could potentially close its operations and that some flights could be eventually rerouted to Paris CDG airport would have helped stakeholders in anticipating these new constraints and better organizing themselves.

Subsequently, Paris CDG airport also had to close its operations because of missing deicing fluids. This closure had a significant impact on Toulouse Blagnac airport which had to accommodate, on very short notice, long-haul flights supposed to land at CDG. In particular, as Toulouse airport is one of the scarce regional airports having a runway adapted to the A380's requirements, numerous A380 flights were rerouted to this airport, leading to difficulties in aircraft parking as well as large numbers of additional passengers stuck at the airport. Knowing earlier that some long-haul flights could potentially be rerouted to Toulouse Blagnac would not have prevented this critical situation at the airport but such information would have allowed the airport to be better prepared to welcome the unexpected traffic on the platform.

Due to the lack of official information coming from the other platforms, some stakeholders try to get information by whatever means possible. In these circumstances, there is inadequate and sometimes inconsistent data, making transfer of collected information between stakeholders inefficient and potentially conflicting. An example of difficulties in relation to inconsistent data problems exists in the sourcing of meteorological data from two different companies by organisations with a major engagement in the same airport: one was advised that it was reasonable and safe to continue operations whilst information received by the other suggested the contrary. This resulted in significant operational disruption, passenger difficulties and cost to both organisations. These problems become exaggerated if data exchange is not systematic, structured and generally only made by oral exchange between people.

An additional lack in information sharing was also stressed by a cargo company operating at Paris CDG airport. This company explained that, from their point of view, there should be a distinction between closing passenger operations and cargo operations. During the December 2010 heavy snowfall period, the cargo company attributed the CDG closure to the lack of deicing fluid left at CDG. However, they have, for cargo, their own deicing bases and still had enough deicing fluid to keep most of their operations running. At the time, they were not consulted about the issue. This highlights

the fact that, when multimodal hubs close for crowd management reasons, cargo operations might still be able to continue part of their operations. During the volcano eruption in 2010, an example of collaboration between stakeholders was observed: Fedex helped companies transport via the road network passenger luggage stuck in CDG airport when the passengers were stuck in other hubs, thanks to their multimodal capability.

At the airport level, during disruptive events, the A-CDM system is generally in fail soft mode. Communications are only based on a "human system" and generally lead to delays in the receipt of information. Hence, if all airports have a crisis room in which stakeholders can meet regularly, the non-automatic transfer of information leads to a lengthy information sharing process. As a consequence, there is little or no information to communicate to passengers who are stuck at the airport. It was, for instance, the case in Toulouse airport, during the December 2010 crisis, that airline representatives were unable to provide information regarding the location of their planes and had no information to communicate to the other stakeholders or to passengers.

Some airports, however, have started putting in place procedures to provide passengers with as much information as possible and also to provide them with solutions regarding their onward journey in case of disruption. A good illustration of this is the "Terminal Colour Concept" developed jointly by Fraport and Lufthansa at Frankfurt Main airport. In crisis situations, a dedicated team combining the Fraport Basic Assistance Team (BAT) and the Lufthansa Passenger Irregularities Team (PIT) deploys in the terminals. Each area of the terminals is associated with a specific colour and numerous signs referring to these colours aim to optimize the orientation of and information distribution to passengers. One of the first tasks of the Fraport/Luftansa team is to provide to passengers information on the colour of the area to which they have to go. Then, in each area, the staff use tablet computers to access the Lufthansa system in which real time information is available for each Lufthansa passenger. The tablet computer application provides the different solutions that the staff is able to provide to each passenger (rebooking on another flight, rebooking on a train for domestic passengers, hotel booking, etc…). This "Terminal Colour Concept" has been used 5 or 6 times already and received good feedback from the passengers. Fraport and Lufthansa consider this concept as successful mainly because:

- communication channels are well defined,
- the concept is easy to understand for passengers and staff,
- the concept helps reduce waiting time and provides constant assistance to passengers by trained staff.

This concept seems to be a good practice to improve the communication process between the airline/airport and the passengers during crisis events. However, the system is not directly linked to the CDM crisis suite and does not accelerate the human system communication between airside stakeholders during disruptive events.

In case of degradation, at most A-CDM airports, there are predefined crisis plans and associated cells at most airports of sufficient size in Europe. At hub airports, such as Paris CDG, a room, called Plateau CDM, may be dedicated to gathering all the decision makers and stakeholders in one place to ensure common situational awareness and improved decision processes. Several types of events, such as snow falls, icing prediction, social strikes announcements or bomb warnings, trigger alerts that lead to predefined responses.

For instance, at Brussels airport, adverse conditions, attributed mostly to bad weather here, remain to be addressed in the A-CDM implementation. This would entail, for example, sharing data and milestones from Eurocontrol on the start and end of deicing. Better capacity management in adverse conditions and common decisions on reducing the capacity at the airport are needed. In the past, a few severe weather episodes led to serious sequencing problems and it has been identified as an area of improvement. The issue of contingency planning in case of computer system deficiency is also often not addressed at present. If there was a system failure in Brussels, each stakeholder has their own contingency plan, but none exists at the CDM level. As previously noted, accurate and regularly updated tailored weather forecasts are also a key factor to reduce uncertainty in airport operations. For spoke airports of significant size, off-the-shelf solutions may be too expensive and not suited to their needs.

As noted above, one of the obstacles to effective CDM within the core community (let alone the wider community of potentially interested stakeholders) has been the reliance upon human-centric contact in the event of major disruption. Whilst this works increasingly well for large airports for the key actors, the limited application of automation hinders the spread of information to second- and third-tier stakeholders who could directly benefit from early advance warning of problems. This was seen by a number of interviewees as a constraint upon rolling out A-CDM to the wider community. Tools do exist but these are often tailored to suit individual airport circumstances and could not necessarily be translated to other airport situations. The case for a common platform is believed to be strong by a number of stakeholders.

Key lessons here can be learned from some of the non-European airports covered in the interview process. In New Zealand, Airways New Zealand (ANZ) uses the Collaborative

Flow Manager (CFM) to support collaborative decision making between stakeholders, who may display the runway sequence with help of a standard internet browser. The system calculates controlled times of arrival (CTA) for flights into the flow-controlled airports Christchurch, Aukland and Wellington, resulting in Calculated Take-Off Times at regional airports. It is integrated with the Arrival Management System (AMAN) to increase predictability and flight efficiency. Smaller airports can use an appropriate Flight Information Display System (FIDS) for display of departure times to a flow controlled airport. According to ANZ after the first few years of operation, "This visibility, and the accompanying ability for Airlines to move or exchange CTAs of their own flights, enables Airlines to optimise their operations in times when runway capacity is below demand, and to reduce aircraft delays after boarding or when airborne." With this system, ANZ supports airlines in adverse conditions to adjust their operations according to their preferences, e.g. to maintain critical flight connections and increase passenger satisfaction.

Various technologies are currently available to support information sharing. Data link can improve data sharing, several systems can now link the ground and the air, and System-Wide Information Management (SWIM) can benefit from the new generation of Airport Operational (AODB) or flight plan databases.

One particular issue raised with regard to information exchange is getting the Target Start-up Approval Time (TSAT) in the cockpit for A-CDM airports. In Brussels, docking guidance systems displays are installed, but a lot of airports do not have the means to install them.

As well as information sharing within and between airports, information sharing also occurs with other stakeholders. For example, as part of the Heathrow Airports welfare protocol, the triggering of response actions in crisis situations includes providing information on the status of operations to organisations such as Transport for London and the Highways Agency so that third party action can be taken to ameliorate problems. Information exchange with Transport for London and other operators has been enhanced in recent years and now forms part of the planned crisis response package to smooth passenger journeying.

Perhaps understandably, smaller airports feel that they are on the receiving end of problems often not of their making. There is a common view that improved information sharing would be a great help to them and that a network approach is needed to ensure that there is a systemic dissemination of information to those that might become affected by second-hand problems.

The importance of earliest possible advance warning is emphasized by airlines which suffer the compound effect of disruption through crew limitations. In the event of stranding in a destination where back-up crews are not immediately available, airlines can experience serious problems associated with crew going 'out of hours'. The ability to invoke contingency arrangements becomes that much easier if significant warning is available.

Potential A-CDM candidate airports

Through the MetaCDM interview process, we were led to discuss the case of several airports that are considering taking the first steps towards obtaining A-CDM status. The process of gaining A-CDM status is interesting to consider in MetaCDM as it highlights the processes and challenges that are involved in implementing these concepts. Any MetaCDM concept itself would be subject to the same barriers.

For an airport aiming to improve its operations and the coordination between stakeholders, the first step is to gain buy-in from all relevant stakeholders. To ensure that all stakeholders will be willing to participate, the actors need to show the potential benefits that A-CDM could bring to a given platform with its specifics. Organizing workshops to improve or change current processes is the second step, leading to the definition of a calendar and a first basis for the information exchange set-up. The next step is to see whether current tools can be adapted to a more collaborative framework or if new tools need to be developed or bought.

For spoke airports, tailored solutions may be needed, because of the current cost of the A-CDM tools available on the market. The full A-CDM process, as defined by Eurocontrol, takes time to achieve and candidate airports first need to see that the premise of A-CDM, i.e. collaboration, can bring benefits on a particular topic of concern to the stakeholders.

For airports thinking of starting the A-CDM implementation steps, the most appealing aspects are more information sharing between stakeholders as well as better visibility and image. However, they are concerned with the cost and the weight of the full A-CDM procedures. When a spoke airport has a lot of flights to and from A-CDM hub airports, having a system to capitalize on the increased reliability of these airports to improve their own is of significant interest. This would mean providing access to the "CDM network" to non-A-CDM airports to improve performance at the network level.

Setting up a data sharing platform needs to be a tailored process as well. For instance, at Brussels airport, a central database, composed of a system-to-system link, is in place. There is operational follow-up of the data flow. Each stakeholder has a module on which

it can interface its own API (Application Programming Interface) to extract the specific information it needs from the system. The A-CDM milestones have been developed for each stakeholder.

The Brussels A-CDM team also provides communication and training around A-CDM. After an initial major round of training about two years ago, currently no A-CDM information course or refresher is undertaken or requested. Sharing the experience and difficulties met on one's own platform is also part of the spirit of A-CDM, to help other airports improve their operations and bring benefits to the whole network.

3.3.3 Multi-modal transport connectivity

Multimodal transport connectivity is potentially the key to finding a better way to get passengers to their final destinations in the event of major disruption. As discussed in the first MetaCDM report [7], the idea of switching passengers to other modes has been tried before, with mixed levels of success. For major weather events, road and rail networks are often heavily disrupted themselves, and passengers provided with alternative transportation via these modes can find themselves disrupted a second time. Finding short-notice capacity in other modes can be challenging, and the pool of passengers who can use it may be limited (e.g. by visa restrictions). Nevertheless, passengers often choose to switch modes themselves when faced with major disruption, and there are many cases of disruption where mode switching is the only way that passengers have been able to reach their destination.

Making the choice to switch modes easier and the experience more streamlined could be a valuable addition to airline and airport disruption strategies. This could be pursued either via active links with road and rail providers into airport CDM-type processes, or via enhanced information sharing with passengers (enabling them to switch modes themselves). The specifics of this process will likely be highly airport-specific, as they depend on the transport links available at the airport, passenger destinations and national politics. For example, German law has only recently changed to allow long-distance buses to compete with trains and in France intercity bus routes must still be approved by train operators, whereas intercity bus networks are much more developed in Spain. Similarly, Spain has had until recently a policy of separating the air and high-speed rail networks and assuming they will compete, with airports not being linked to the high-speed rail system, whereas Germany has a policy of linking the two networks. In the UK most rail networks are slow and hence roads are a more attractive alternative option, although eventually the HS2 high-speed rail line is planned to link to Heathrow.

The information gained through the MetaCDM interview process suggests that already significant progress has been made in including alternative modes in the disruption planning process. However, problems remain even at the airports with the most advanced plans. These include information exchange, data compatibility and linking systems across organisational boundaries. Rail operators are more included in the disruption planning process than bus, coach or taxi operators and highways authorities but links do exist in the latter cases.

Road and rail networks also carry passengers travelling to airports who may be difficult to contact directly. Disruption management can be improved by preventing passengers arriving at an already-overcrowded airport when their flight has already been cancelled. Therefore, one simple and straightforward link to other modes is to facilitate loudspeaker announcements or other information provision at major rail stations. This was being investigated at one of the airports interviewed. Similarly, information can be provided via dot matrix signs on motorway networks.

This section concentrates on rail and road as alternative modes as these are the most important alternative modes at the airports interviewed. However, in some cases ferry transport may also be an option for part of the journey.

3.3.3.1 General Comments

A number of conclusions arose from the interview process about crisis multimodality which do not depend on the mode specified. This included particularly links to and contingency planning by government agencies and local authorities, where the appropriate alternative mode is determined by the geographic situation of the airport.

Ground transport operators do cover the impact of major airport disruption in their own training exercises, where appropriate. Similarly, government training and exercises covering major disruptive events affecting aviation include the role of highways and/or rail in response. There are also some cross-agency tabletop exercises that have been carried out looking at responses to major airport disruption. In the case of Heathrow, there are regular weekly exercises linked to Heathrow Express access to the airport, although safety is the key driver for these. However, in general interview respondents felt that there was too little inter-agency engagement on full exercises.

Some local authorities can initiate diversion routes and/or city-level control responses in the event of airport access problems. Authorities near Heathrow take active steps to instigate rerouting of traffic accessing the airport during period of disruption and to encourage transfer to public transport means.

However, there was a general theme of data access and systems compatibility problems. In particular, unifying and/or linking systems across organisational boundaries was felt to be a major hurdle, with most systems not designed for interoperability. Therefore, although the data in most cases exists to better enable mode-switching in the case of disruption, interfaces to share that data between operators in different modes and to passengers on those modes are lacking. Where information is shared, it is often static information on e.g. infrastructure, rather than the dynamic information that would be needed for crisis response.

3.3.3.2 Rail and metro

Many airports are linked into the local rail and/or metro systems, and some airports also have high-speed rail links. There are also some notable cases of 'through-ticketing' arrangements in which airline and rail booking systems have been linked up to some extent – for example AIRail linking Lufthansa and Deutsche Bahn at Frankfurt Airport, TGV Air linking high-speed rail with air carriers operating from CDG, and Flyrail in Sweden. The list of airports with current or future planned rail links includes several airports interviewed as part of the MetaCDM process. The MetaCDM interviews suggested that in these cases rail providers are typically involved in at least some parts of the airport contingency planning. However, it was agreed by interviewees that in general ground transport providers lack immediate updates on crisis information. As noted in Section 2.2 above, information sharing during crisis events is typically done via face-to-face meetings in a predefined airport crisis centre rather than automatically; therefore it is potentially a lengthy process and there will be greater delays involved in information sharing than under non-disrupted conditions for everyone.

At one location interviewed as part of MetaCDM (Frankfurt), a protocol had been established to use contingency high-speed rail in crisis situations on domestic routes. This facility is integrated as part of the rebooking process, with passengers given the option of rebooking on high-speed rail or rebooking on an alternative flight for appropriate routes. This facility relies on the integration of the airport into the high-speed rail network and it is therefore a less attractive option for those airports which do not have appropriate rail links. There have also been cases of passengers being redirected to metro systems. In general, however, airlines do not facilitate mode-switching and if passengers switch modes under disrupted conditions, it is usually done under their own initiative. In such cases passenger rights are often ambiguous, as discussed in the first MetaCDM report[7]. In particular, it is unclear who has responsibility to pay for the passengers' travel costs and advice on journey planning

may not be available. For these reasons, many passengers who might otherwise consider switching modes under their own initiative do not do so.

These conclusions were supplemented by discussion at the second MetaCDM workshop on the ability of rail providers to respond at short notice to increased demand from passengers stranded by aviation disruption; as noted there, significant capacity constraints exist throughout rail networks. To run an extra service for stranded air passengers, suitable rolling stock and trained staff are required (not all trains can run on all routes and staff need training for specific routes), as well as an allocated slot for the entire journey. Typically rail networks run close to full capacity already and may also be affected by disruption in the case of weather-related crises. This makes it difficult to put on extra services without at least a day's advance notice. Therefore the possibility of putting extra rail services on for air passengers to reach their destination is limited to those with some advance notice (excluding air accidents and incidents) and which disrupt only aviation (excluding most weather-related sources of major disruption). A suitable rail link must also exist and passengers must have right of access to all countries en route. This limits the routes and situations for which responding by increased train services is plausible. However, there have been specific cases where it has been used successfully – for example, Eurostar's adoption of increased services during the volcanic ash crisis[4].

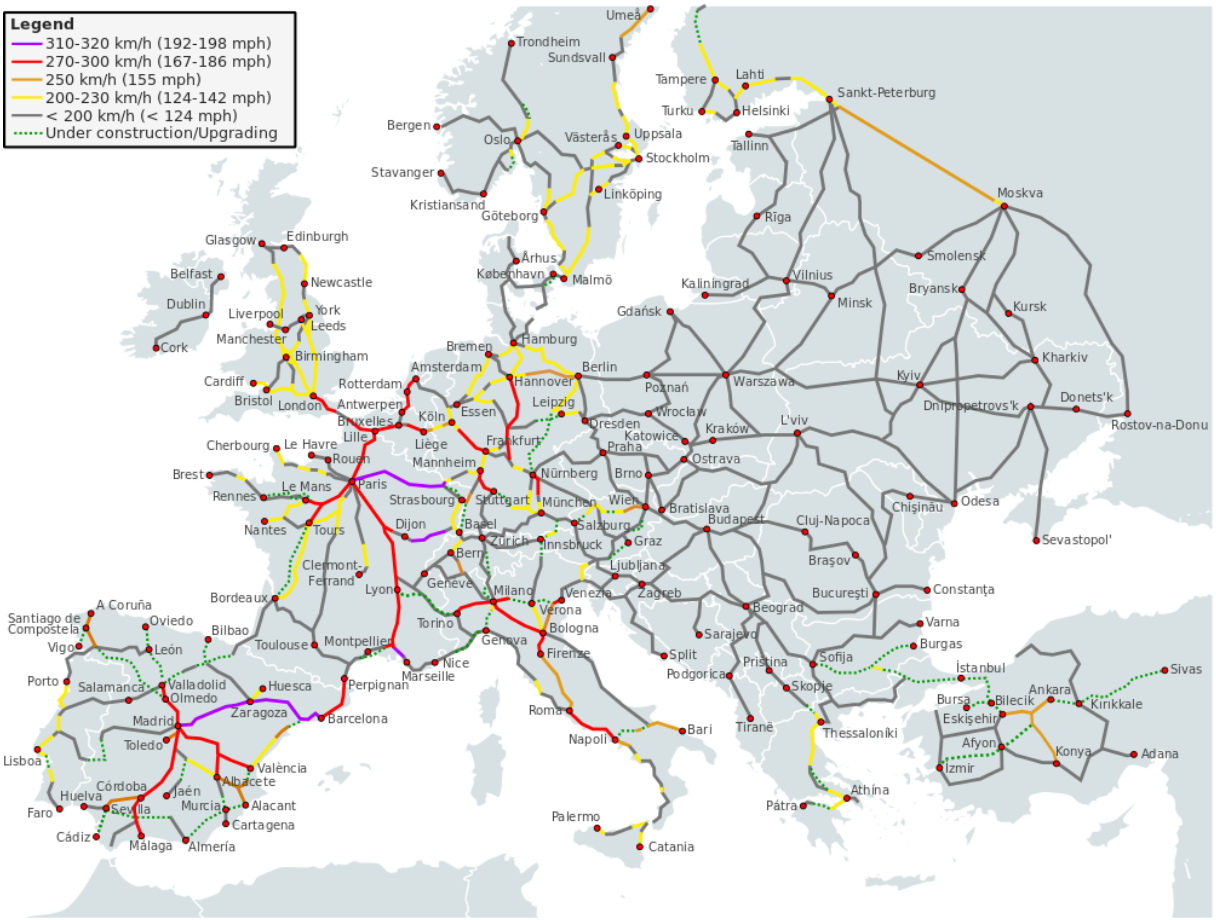

Figure 1. High-speed rail networks in Europe in 2013.

An alternative option in case of a minor disruption is to book passengers onto existing rail services. However, rail companies also have obligations to their existing customers, who may have to stand if trains are overcrowded following the influx of air passengers. There is therefore significant reluctance among rail operators for schemes which may result in complaints from their current customer base. There is also significant concern about who is responsible for costs arising from accommodating air passengers, and who provides these passengers with assistance in negotiating routes they may not be familiar with, given that there are no airline staffs available on the rail network.

Of the top 20 airports in geographical Europe by passengers served in 2012, five already receive high-speed rail service at a train station located at the airport. Another (Madrid Barajas) has a station capable of receiving high-speed trains but does not currently do so, and two more have future planned high-speed rail links at the airport. All but three of the top 20 airports are associated with a city which has high-speed rail service, i.e. passengers could be transferred to a high-speed rail service via a relatively short coach

or metro link. Depending on the nature of their journey, passengers will either want to finish their trip at the destination airport (for example, to catch a connecting flight) or in the destination city centre. In the latter case, the lack of a high-speed connection specifically to the destination airport may not be a barrier. Similarly, if passengers can be contacted before their trip to the airport and rebooked then, they could travel directly to the train station instead and avoid the airport altogether. Current high-speed rail networks in Europe are shown in Figure 1. Although the high-speed network is not continuous in many cases, connectivity in Western Europe is high enough to allow a wide range of potential routes to substitute for delayed and cancelled air services. Whether passengers would reach their destinations sooner via high-speed rail, however, depends on the nature of the aviation system disruption and the nature of the rail connection. In cases such as the volcanic ash crisis, even a multiple-stop rail journey with low-speed segments may be preferable to a delay of several days in travelling. For shorter projected delays only a direct high-speed route may be suitable.

Yet another option is to simply make schedule information available to passengers and let them rebook themselves, providing clear information about the alternative options and about costs which can be reclaimed from the airline. This option can better accommodate passenger individual preferences, but may be overly intimidating for those who are not frequent travellers or are not familiar with the alternative mode.

In general it was felt that any increased engagement with the rail network for airport crisis situations had to be on a win-win basis with advantages for both rail and air operators. Given that there have been examples of disrupted high-speed rail services flying passengers to their final destination [8], it is possible that reciprocal arrangements could be made. Greater integration of rail in automated systems as opposed to inclusion in face-to-face crisis meetings may be difficult due to the different systems architecture involved. Although extensive information is available about rail timetables, routing and delays and about airlines timetables, routing and delays, these databases were not designed to be interoperable. There have been some attempts to link together systems for use in normal operation via “Rail and Fly” schemes with tour operators, including ‘codeshare’ arrangements where rail services are given an airline flight number and can be included in airline schedules. However these have proved difficult to expand due to the different systems involved, the different markets targeted by air and rail providers and different sales strategies. For example, there are a limited number of location codes available for airline schedules, so it is only possible to include a very limited number of stations; baggage cannot be checked though between rail and air services due to security and liability concerns; and there is no framework for liability in the case that a late train causes passengers to miss a flight. Although many of these

concerns are less of a problem in crisis situations, some level of systems interoperability is still needed to streamline the rebooking process.

Dedicated rail services from city centres to airports tend to be well prepared for crisis events on account of their close connection with the airports and their planning processes. In the case of the Heathrow Express service, reservists can be deployed and have well tested procedures for platform management, access control, close and diversion of passengers onto other services such as buses or metro. The ability to deploy coaches is generally more challenging on account of the need for greater advance notice for a bespoke occasional service than for transferring passengers onto existing alternative services where the key obstacle will be capacity.

3.3.3.3 Road

Whilst stranded passengers can and sometimes are provided with hire coach service by airlines to get to their destination, in general airport crisis planning has a poorer connection with highways than with the rail network. Links to passengers arriving by car are minimal, though motorway 'dot matrix' signs have been used to give arriving passengers information about airport disruption. There do exist some schemes under non-disrupted conditions to streamline the road part of a passengers' journey, however (e.g. a current project at Dusseldorf airport is to provide passengers with the possibility to reserve parking lots in advance in order to reduce time at the airport). The MetaCDM interviews confirmed that typically airlines do organise coach service for short-distance journeys. These include diversion response (taking passengers from a diversion airport to their original destination), providing coach service between the airport and the city centre, and transporting passengers between airports and local hotels when the airline has provided overnight accommodation for passengers stranded by flight cancellations.

The advantage of switching to road-based transport is that more airports have road links. Of the top 20 airports in geographical Europe by passenger numbers in 2012, only one was not connected to at least one other airport via the European motorway network (Palma de Mallorca, which is located on an island). Eleven of the airports had long-distance coach services directly to the airport, and all had bus service to local destinations. Some of the same problems which apply to switching passengers to train services also apply in the bus case; for example, the spare capacity on existing long-distance coach services may not be adequate, and providing extra capacity at short notice may be difficult. However, substitute bus and coach service for shorter-distance journeys is used extensively by rail operators. The possibility of implementing substitute coach service was studied in a US context by Zhang and Hansen (2008, [5]). The

relatively slower speed of coach travel means that it may only offer a benefit to passengers in the most disrupted cases.

Greater co-ordination between air and road traffic exists for freight systems. One passenger-relevant example, as discussed in Section 2.1 above, is the role of Fedex in transporting onwards the luggage of passengers stranded by the volcanic ash crisis by truck. One possibility in handling intermodal journeys is to treat baggage as freight which needs to be delivered to the passengers' final destination, separately from the passenger if need be. However, this may clash with the desire of many passengers not to be separated from their luggage, and current delivery times may be too long for this option to work.

Although ferry substitution is less common than road or rail substitution, it had particular relevance in the case of the Icelandic Volcano crisis. Here, through UK and French Foreign Office collaboration, many stranded passengers were able to be repatriated. This serves to illustrate the importance of governmental networks both for alerting airports and airlines of difficulties arising in foreign jurisdictions and also in facilitation contingency means to enable passengers to complete their journeys.

3.3.4 Information sharing with passengers

Passenger expectations have intensively been addressed in previous and parallel projects. They were also been addressed in the literature review of MetaCDM work package 1 ([7], chapter 4). In line with this, it was highlighted during the interviews that the Airports Council International (ACI) supports airports in service quality management [16]. This helps airports to optimize services; however, it does not cover all performance indicators from a passenger perspective. One example is the provision of the predictability of average transfer time between flights at an airport, which is not included in the ACI survey [17]. Passengers normally dislike this lack of notice [18], but stakeholders may withhold this information due to business interests. Another example which is particularly relevant for disruptive events was mentioned: a very important requirement is that groups and especially families should not be separated in disruptive events (see e.g. [15]). Further information on passenger expectations and requirements with particular regard to intermodal journeys is discussed in "Passenger requirements for intermodal transport" [13], presented by J.-F. Perelgritz (MODAIR project) at the second META-CDM workshop in Frankfurt.

In terms of any MetaCDM concept, communicating with passengers in a timely fashion when a disruptive event occurs is likely to be key. Concerning information sharing with passengers some key questions arise:

1. When is the information available?
2. Will the information be shared?
3. How can the passenger be informed in time?
4. Who will pay for the alternative?

The MetaCDM interview process provided some key insights into what the answers to these questions might be. To enable the passenger to find a suitable alternative for his originally chosen flight the information on the disruptive event and its impact has to be communicated as soon as possible. In return, knowledge of the whereabouts of passengers might enable airlines and the affected airport(s) to set in train possible contingency measures and to estimate the necessary scale of these, for example providing a rebooking onto a train connection or sufficient beverages for stranded passengers. An example how the whereabouts of the passenger might be used to enhance the planning of an airline was given by the project TAMS (Total Airport Management Suite). This used the Estimated Pax at Gate Time (EPGT) in the forecast of the TOBT with the day of ops as time horizon, see [14]. The results were visualized with the prototype of an innovative tool called PaxMan, a proactive passenger management tool which coordinated the forecast of the TOBT with the Turnaround Manager (TMAN) from Inform. That information sharing with passengers in disruptive events may benefit from improved indoor navigation support is also suggested by [23].

In the MetaCDM meeting report with Lufthansa [15] it was recommended to use the same degree of information sharing procedures and solutions that are needed when a crisis occurs already under normal conditions to increase user acceptance. A further recommendation was that further research activities should focus particularly on dedicated solutions for older persons.

The answers from Toulouse Blagnac airport [19], on the META-CDM questionnaire show that the first question highlighted above is a critical issue especially for non A-CDM airports. Even though the airport has dedicated crisis rooms where meetings with all stakeholders take place there is not enough information sharing between stakeholders. Brussels Airport Company [21] believes in the possible benefits of some regulation for further harmonisation of local procedures that currently vary from an airport to another. For example, a cockpit crew in Brussels has to follow different procedures than in Munich. In Brussels, the TOBT becomes available 2 hours in advance, whereas at other airports it is 20 minutes in advance. Information becomes available at different milestones in different airports.

Paris CDG [20] answered in the questionnaire that the network aspect needs to be taken into account, either through Eurocontrol or some other way, e.g. Heathrow's AMAN communicating with CDG. A recent example of inadequate information sharing took place in December 2010, where bad weather conditions were affecting France, but also hampering Moscow, Frankfurt and Heathrow. Heathrow was shut down and CDG had to accommodate most of their long-haul flights without much warning. This led to the saturation of the airport, because CDG was already close to parking saturation.

Regarding the second question above, if available information was to be shared, Toulouse Blagnac Airport pointed out that airlines might disagree on the information that should be communicated to passengers. As a result, it is too optimistic to assume that all necessary information will be shared; however, the possibility exists that some information can be provided to the passenger, e.g. a for better handling of a degraded situation through timely information to the passenger not to approach the airport in such a situation. This could lead to greater acceptance that there is benefit in sharing existing information with passengers.

While the question "who will pay" is an important issue for stakeholders, it is out of scope for the META-CDM project, e.g. because information about whether costs can be reimbursed is often unclear, see [22]. Regarding this topic Paris CDG sees no technical limits to what can be achieved, only political and financial ones. Regarding question "How to inform the passenger", possibilities are

- the media (television/radio) in case of a disruptive event,
- the Flight Information Display System (FIDS) within an airport,
- loud speakers and/or news ticker,
- the webpage of an airline and/or airport,
- a call on (mobile) phone,
- an e-mail,
- SMS,
- An app dedicated to retrieve and display flight information and
- Personal information (extra staff for information management).

As the Cambridge synthesis of interviews points out [18], a mixed media engagement is good for information dissemination but is difficult to manage and sometimes might negatively influence planning, e.g. if distributed information is not consistent. One outcome of the survey was that there is the need to exploit social media and active tracking capabilities to a greater degree.

While a disruptive event is normally addressed in the news, the passenger gets no reliable information related to his flight unless the airport itself is shut down. Reliable information concerning flights can be offered by the FIDS of an airport, but it is only available within the airport itself or within its vicinity, e.g. in a nearby train station, and thus is at the moment of limited suitability in many situations for informing the passenger in time. The suitability of FIDS for timely informing the passenger can be extended through closer collaboration with nearby train stations. During the second META-CDM workshop, Frankfurt Airport presented the "Intermodal Hub Frankfurt Airport" [9] where not only the information management but although the check-in at train/bus stations in a larger travel time radius (up to 9h) was examined. The motivation for Fraport (the Airport Operator in Frankfurt) is to:

1. Strengthen FRA's hub function by developing German Rail as a feeder to FRA.

2. Compete with (hub-) airports and airline alliances by enhancing FRA's catchment area.

3. Enlarge slot capacity by shifting feeder flights to train / busses.

4. Develop best practice and reliable services by ensuring accessibility to FRA & by developing intermodal services.

5. Contribute to environmental protection and lowering carbon emissions by shifting traffic to public modes.

Most interesting for META-CDM in particular is the fourth point, i.e. the development of intermodal services. An example for this is the AIRail Service / Code Sharing Lufthansa flight number for "Flight on Level Zero". While a shift of passengers to another airport is under normal circumstances not of interest it might become a necessity in the case of a disruptive event. To have the information distributed at the nearby station before the passenger enters the feeder train/bus offers the possibility to reroute him/her to another airport.

Similar restrictions as for FIDS exist for loud speakers and news tickers. For example, in this domain Toulouse Blagnac is using standard messages that are validated by the top management [19].

Many airports offer some kind of FIDS on their webpage and this way to inform the passenger can be suitable if the information is available early enough or the passenger has mobile access to this webpage. A better means for information sharing is to directly contact the passenger either via a (automated) call to his/her (mobile) phone, an e-mail and/or an SMS. In particular, calls and SMS might be better suited here because they can be received by older mobile phones. Most bigger airlines offer different means to inform passengers, e.g. Lufthansa shares its information via webpage, SMS, e-mail, Facebook or Twitter and Air France shares its information with AF-Connect via call, SMS and/or e-mail.

Another means of information sharing with the passenger is via applications (apps) for smartphones. Along with simply informing the passenger of disruption, an app might offer automatic information on the location of the passenger, subject to their granting the app access to location information. In return the airline or airport would be able to better advice the passenger on alternatives to their originally booked connections, in case that those connections are cancelled or not achievable anymore. This also opens an opportunity for travel agencies to offer additional services to the customer. Testing a random sample of free apps in this domain, such as Flyamo or the FRA Airport Map (for example) shows their potential, but indicates that the information shared via these apps is currently of limited use as the necessary information is simply not available or not shared.

Additionally, personal information management through extra staff can support passenger service in the case of disruptive events. For example, Lufthansa and Fraport appoint additional administrative Airline employees (Passenger Irregularity Team, PIT) and airport employees (Basic Assistance Team, BAT) to support passenger service in case of disruptive events on a voluntary basis. This is discussed already in Section 3.3.1.

Although no direct interviewing of passengers took place in MetaCDM, anecdotal information from stakeholders suggests that, even in crisis situations, passenger experience has improved significantly in recent years. Airports, especially the larger ones, are dedicating more effort and resource to supporting those affected by disruption. As the effect of major disruption has become a greater reputational and logistic challenge, especially at very busy airports, senior management at airports, airlines and

key service providers have injected more investment to improve resilience and this is reflected in the reaction of passengers.

The key expectation that stakeholders report passengers to have is that good information will be provided and that it will be provided promptly. If this information is provided, the generally reported view is that the "airport/airline is doing the best it can".

As practice is sharpened up, the complaints that arise in crisis situations are far less about provision of information than they once were and now tend to be more about practical terminal issues such as lack of seating and speed of response. Several larger airports now deploy terminal 'ambassadors whose job it is to communicate up-to-date information and to provide immediate welfare support. According to passenger support organisations, these steps have had a notable effect upon passenger satisfaction when disruption occurs but there appears to be an ongoing dissatisfaction with queues lengths at bottlenecks such as border/immigration control and security screening. Though airports are getting smarter at flexing staffing according to fluctuations in demand, passengers are reported to be least satisfied with operational delays and also any apparent delay in providing information. The increasing use of smart-phone technology and community websites to alert passengers about expected flight delays (as far as published) is gradually reducing the pool of those who feel 'left in the dark'. Passengers are now generally provided with good airport welfare support and with networks of government and charitable support agencies that provide multiple language capabilities, access to emergency communication calls and immigration and health support. This array of helpers and help seems to have resulted in lower levels of dissatisfaction.

Passengers are also reported to be quite objective about when and how they level criticism. Airlines, airports or ANSPs are all held to account according to understanding of the cause of disruption: blanket blaming of airports seems to be lessening with many passengers using more accurate information to assign responsibility in line with perceived fault.

The area of concern that is still relatively unaddressed appears to be provision of good information before and during the journey from origin to airport check-in. The involvement of multiple stakeholders associated with this part of the journey have hampered effective solutions to date.

4 Interview conclusions

4.1 Crisis management and CDM

The interviews conducted showed that most stakeholders mainly expect A-CDM procedures to significantly improve the fluidity of normal operations. Then, in the case of crisis situations, additional CDM processes and infrastructures (such as the plateau CDM at CDG) help improve the response time, information sharing and recovery process.

One of the key challenges when an airport is functioning close to capacity limits with possible additional constraints (such as weather perturbations for instance) is to be able to detect early enough the upcoming transition to crisis situations. The interviews clearly highlight that it is often the combination of several factors and events, both internal and external to a given airport that creates the crisis. Separately and individually, such situations may have been manageable. An interesting point to emerge is that problems can be exacerbated by conflicts in data, on account of these data being received from different sources or in different formats. If two operationally-linked stakeholders draw upon data from different sources, problems over the type or timing of response and the importance or priority of any response can arise.

The stakeholders interviewed pointed out that a lot of real-time and past data was proprietary and therefore not shared. They suggested that some data could be shared if it was shown in advance how it could positively impact operations and processes for each and every stakeholder. If the stakeholders could agree on just sharing past data, a team debriefing could help highlight the key areas with room for improvement. These points highlighted the need for an understanding of stakeholders' perceptions of crisis events, their concerns about commercial confidentiality and a measure of the potential gains if a more open approach was adopted. A dialogue on these fundamental aspects could open the door to more productive CDM application in crisis situations where the stakes and potential negative impacts to stakeholders are much high than in normal operational conditions.

The expectations of interviewed stakeholders varied significantly depending on the time horizon considered. However, major disruptive events such as the Icelandic Volcano eruption and major snow events have made CDM players more open to a dialogue.

Metrics exist for a number of airports in the A-CDM area, but these tend to be confidential so objective external assessment becomes harder and commonality of approach towards a single A-CDM platform becomes harder. Smaller airports tend to have a few simpler metrics and KPIs that are often more passenger that operationally focused. In-house learning, however, is much stronger as this performance assessment is closely linked to routine training and exercises, especially for the larger airports. Smaller

airports may rely upon desk-top training but even this may not happen at service companies that are part of the overall system.

A general conclusion is that A-CDM stakeholders have invested significantly in recent years to improve their resilience in crisis situations. This covers a number of areas such as systems, crisis cells and monitoring and communication technologies, training and exercises (in terms of comprehensiveness and frequency) and supporting resources (equipment). A key to extending the applicability of the CDM philosophy to landside interests and to smaller airports is that the resulting benefits are shown to equal or outweigh costs. Another conclusion is that, whilst stakeholders generally consider regulation to be operationally benign, there are anxieties about any potential desire to extend regulation in the CDM area, principally for cost reasons. Liabilities arising from the EU 261 requirement to provide compensation and assistance to severely delayed passengers were cited as an example.

4.2 Resilience of airports

Information and intelligence gathering generally works well with many agencies contributing to alerts received by airports. Civil aviation authorities specify certain levels of planning requirements but these regulations tend not to specify the practical working arrangements that help to deliver efficient response. Moreover, the treatment and application of information received is not always consistent or efficient. Lines of command can become confused, especially where a number of stakeholders have potentially conflicting priorities. Systems applied by stakeholders can often be incompatible.

It is apparent that a number of stakeholders are concerned about growing or emerging threats and how these impact upon airport resilience. These topics include escalation of terror threats, cyber-attacks and space 'weather' effects that could disrupt communications.

Crisis response between stakeholders often relies upon human-to-human contact by telephone and email. Whilst this is beneficial for speed of conveying specific and variable information, it can serve to limit the cascade value of crisis information to downstream stakeholders who could both benefit operationally and help to forestall the systemic development of disruption. As a result airside and landside communication can sometimes be less efficient that it might be.

An interesting conclusion from some interview discussions is the need to consider the role of the media in either mitigating or, indeed, fermenting disruption. In relation to

events taking place at larger airports, the media imperative to secure a dramatic story can outweigh the need to communicate useful information to travellers to help them achieve their journey with minimal disruption. At smaller airports, local media tend to be better at fulfilling this latter role.

On training, there is a view from some stakeholders that there are too few inter-agency training activities and exercises. These tend to engage only the core stakeholders, except for major annual or bi-annual exercises, and thus fail to draw in second and third tier stakeholders. There are clear cost implications of significantly extending activity in this area.

With regard to the impact of de-icing (and, respectively, anti-icing), two conclusions can be drawn. First, the effects of de-icing play a significant role for departure management and require a close coordination between all stakeholders at airports. However, the necessary procedures are well covered by the A-CDM concept. Second, and more important for MetaCDM: The non-availability of de-icing fluid was identified as a major reason for disruptions (for example, in December 2010). According to feedback during the interviews, better information sharing and cooperation between stakeholders may at least partially contribute to avoid such situations in the future.

4.3 Stakeholder expectations at a Short/Medium Term time horizon

4.3.1 Expectations on current A-CDM platforms

The interviewed stakeholders on A-CDM platforms stressed the importance of improving the quality and quantity of information sharing. This includes:

- Improved access to A-CDM information/data at any individual airport to enable key players to have real-time knowledge of event progress, including data on hand-held devices;
- Sharing of information between airports to limit systemic effects. A popular idea is for a single website updated with critical information on all key airports as that could be a significant step towards encouraging and facilitating information sharing between airports.
- A move towards standardization of data and system formats is urged as this would assist with encouraging more airports to engage, especially smaller airports. This could facilitate access to key or disaggregated data that could be extracted with ease to serve specific needs;
- The A-CDM system should be improved so as to:
    - Provide information on system bottlenecks in crisis situations,
    - Push notifications from website to smartphone, and
    - Allow a data link with pilots for updated information.

In parallel, they also suggest that A-CDM should evolve so as to optimize the turnaround process by linking arrival and departure management (AMAN, DMAN) systems.

A number of stakeholders would be particularly interested in getting public and transparent A-CDM indicators to identify the system's benefits and bottlenecks and to improve the passenger experience (especially in crisis situations).

4.3.2 Expectations on current non A-CDM platforms

Airport platforms currently without A-CDM systems would be more inclined to implement an A-CDM system if the process become better adapted to their specific needs. At present a number of potentially interested airports do not have the levels of operational planning and resilience resources to support A-CDM as practiced by hub airports. They need to:

- Be able to measure the efficiency gains associated with A-CDM to convince airport stakeholders to collaborate,
- Get the A-CDM label progressively while being free in the order of steps to follow:
    - To avoid "frightening" airport stakeholders with rigid implementation procedures, and
    - To control the implementation cost.

This could lead to the development of a "CDM Lite", for which there is significant support, to enable airports with lesser risk of major crisis impacts and also with lesser resources to adopt A-CDM.

4.4 Stakeholder expectations on a Long Term time horizon

For airports currently considering the possibility of taking the steps to obtain the A-CDM label, one of the main advantages of A-CDM is the positive network effect. This means being able to have more timely automatic and accurate information exchanges with other airports and the common stakeholders at these airports (airlines for instance). Such links would allow for earlier planning and less susceptibility to reactive measures. Moreover, continued collaboration during normal situations brings more trust and openness between stakeholders, both during nominal and degraded conditions.

Most stakeholders pointed out that the passenger aspects were not addressed in detail during crisis situations and that, with the current state-of-the-art technologies, a lot could be done to allow more flexible options for travelers stuck during crisis situations. This links directly to the flexibility and the coordination of air transportation with multimodality.

As with A-CDM, there is a feeling amongst many stakeholders that might engage in Landside CDM (L-CDM) that others do not understand and appreciate their challenges

and issues. This picks up on the need for better communication and for a systematic approach to defining core data needs, interface protocols and forms of communication. In the same way that airside CDM players at a specific airport have an interest in sharing information through a common portal or web-based platform, so landside stakeholders would also value access to such a means of gathering and sharing up-to-date information.

4.5 Multimodality

With regard to multimodality, the conclusions of the interview process are mixed. Ground transportation modes are typically involved to some extent in the crisis planning process, and there was one example of high-speed rail being used to transport passengers to their destination in case of air disruption. However, it was generally felt that issues of data compatibility, the necessities of serving different markets, and lack of spare capacity made options such as providing integrated ticketing or extra rail services to transport stranded passengers to their destination impractical in the shorter term. However, there is typically some spare capacity in existing ground transportation services which some disrupted passengers take advantage of by switching modes under their own initiative. Little to no information about alternative modes is typically provided to passengers experiencing disruption, and it is often unclear whether passengers would be able to claim back the cost of travelling by other modes from the airline. The option of providing this extra information to passengers to allow more of them to switch modes by themselves is therefore still potentially promising.

4.6 Passenger expectations and experience

The MetaCDM project did not encompass direct engagement with passengers so the views expressed here reflect information drawn from stakeholders, including from organisations that represent passenger interests.

A key requirement for future research, as expressed by stakeholders, is to engage the passenger directly. It is apparent that a key source of annoyance and complaint is either lack of or inadequacy of information related to and unfolding crisis and its mitigation. There is a danger that, in the urgency to restore normal operations after an incident of disruption, passenger interests can become a second-order priority.

All the airports interviewed had some level of passenger welfare support in disrupted and crisis situations. This was very comprehensive at larger airports with significant dedicated staff and other resource and good contingency planning. This seems to have

improved in recent years as event impacts have become more severe and lessons have been learned. Emphasis is given to the vulnerable and support includes journey and rights information, eating and comfort supplies and communication support. Support provided by airports and airlines is sometimes supplemented by assistance from local authorities and charitable organisations.

Technology is beginning to be used more effectively by some stakeholders, such as airlines, for communicating with passengers. This tends to be one-way communication related to access and check-in and occasionally to alerts in the event of disruption. Such systems are still fairly basic and do not reflect or apply the immense power of smart-phone technology to improve the efficiency of the system or the passenger experience.

Legal and cost liability of stakeholders has a notable effect upon the experience the passenger receives and perceives. Lack of clarity in some areas can result in mixed messages and delay. Linked to this is the fact that passenger complaint and response information is not always made available so multi-agency group learning can be inhibited.

Passenger experience seems to be improving in crisis situations if stakeholder reporting of views is representative of reality. The dedication of greater resources and awareness of the value of good information provided promptly is helping airports to ease the worst effects of disruption. It is also easing reputational damage. Information is what passengers want and lack of it causes discontent. Experience suggests that lessons have ben learned. The area that appears to need attention is provision of dynamic and hopefully interactive communication before and during the passenger's journey to the airport.

4.7 Pointers for WP300

Work Package 300 of MetaCDM will consider facets of a possible new concept of operations that improves the effectiveness and scope of CDM and with emphasis on benefits for the passenger. Some of the key high level issues arising from the interview stage that could assist this developmental thinking are:

1. the critical importance of advance notice for affected parties, especially where there may be multiple causes or 'snowball' effects, to help ease the intensity of disruption;
2. value of commonality of source data, or least consistency between data sets, that are used by different stakeholders responding to the same incident;
3. the need to improve communications both laterally between stakeholders and downstream into the network of affected organisations and this requires a) a

fresh look at confidentiality and commerciality concerns and to balance these against the disbenefits that arise in crisis situations and b) a dialogue to improve cross-community understanding of the priorities, needs, obstacles and language of each stakeholder;

4. difficulty in sharing data across borders with implicit need to consider complementary tools, systems and procedures that would make that workable;
5. the need to work towards common metrics that jointly assist a number of A-CDM and L-CDM players;
6. risks of confusion over lines of command when dealing with events where multiple agencies are involved;
7. strategic handling of emerging threats such as cyber-attacks and 'space' weather for the benefit of the whole network;
8. uncertainties over working out where the balance should lie between human-to-human and system-to-system communications;
9. extending the scope of and participation in training and exercises to embrace more non-A-CDM players;
10. working out a mutually beneficial arrangement with the media to avoid unnecessary escalation of disruption for passengers whilst preserving the benefits of publicity of crises;
11. improved information exchange and planning over deicing fluid stocks and availability;
12. greater access to 'real-time' data for A-CDM and other stakeholders, including sharing between airports (internationally as well as nationally) and greater use of hand-held devices for immediacy;
13. a stronger dialogue towards 'CDM Lite' for the benefit of smaller airports;
14. increasing the prominence of the position of the passenger in CDM thinking;
15. addressing data incompatibility issues with ground transport providers;
16. helping to stimulate a stronger dialogue on multi-modal ticketing and contingency routing;
17. place quality and speed of information to passengers at the top of the 'non-safety' priority list for CDM in crisis situations.

The majority of these points are fairly predictable and it is necessary to recognize that airports and other stakeholders are considering many of them in varying degrees. However, it is often the lack of inter-organisational dialogue and sector level dialogue that hampers progress. It is therefore appropriate for Work Package 300 of MetaCDM to look at these issues from an international, regional and national perspective as well as the airport/catchment area level.

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Annex 1: Workshop 1 Questionnaires

At the first MetaCDM workshop it was decided to elicit preliminary views from attendees to help guide the later stages of the project and inform the definition of interviews and surveys in WP200. Questionnaires were distributed to attendees to fill in during the course of the workshop, to gather information on topics such as which types and sources of disruption we should be focusing on, which system bottlenecks are most important, and which technologies to overcome these bottlenecks should be investigated by the project. 13 responses were received, with most respondents answering all questions.

A summary of comments by question is given below.

What are the most important sources of disruption at airports?

a) What are they now?

Most answers concentrated on **natural events** as a major source of disruption – particularly weather (11), and especially convective/extreme weather. Examples included snow, fog, thunderstorms and hurricanes, depending on airport location. Other unexpected natural events (e.g. volcanic ash, pandemics) were also noted (4).

Disruption from within the aviation system was also highlighted. Mechanicals, high airport utilisation (90-100% of capacity), runway closure, turnaround, lost passengers, misunderstandings with information, sensitive information, and inefficient management resulting in sub-optimal throughput were noted as potential sources of disrupted operations. Irregular operations themselves, including service delays, diversions, late arrival and congestion were noted by 2 respondents; although these irregular options may stem from the other sources of disruption considered, they can themselves be the cause of further (propagated) disruption.

Accidents and incidents, both at the airport and on route to and from the airport, were also covered. These included crashes, aircraft accidents and incidents on maneuvering areas and aprons (3), as well as service disruption with reduced transport links to the airport. Terrorist attacks and security threats are another source of potentially major disruption. Another weakness highlighted was **IT systems** – either via systems failure or cyber attack (2 responses).

Finally, **strikes/industrial action** were mentioned by 3 respondents.

b) How will that change towards 2050?

Two major strands here were **climate change-induced increases in the frequency and severity of weather events** (3), and increased demand in the aviation system leading to **more airports operating at capacity** (4). In the former case, respondents also noted that weather prediction systems may improve, leading to increased weather predictability, and that airframes will be more resistant to weather perturbation. Mitigation measures to deal with weather impact were also noted as a likely future development. It was also noted from a UK perspective that without runway capacity resilience in the South-East, or legislation to prevent strikes, the only areas realistically controllable into the future are IT and equipment to mitigate poor weather.

In the latter case, reductions in airport capacity/headroom will reduce airport resilience and ability to recover from disruption (no firebreaks) and lead to increased congestion and delay, with more constrained airports.

Future changes may also be expected in **technology and ability to share information**. In particular, policies and regulations regarding confidential information may change. In addition, one respondent considered that most sources of disruption are likely to continue unchanged from the present day.

Obstacles to optimal airport crisis management – what are the major system bottlenecks?

A mix of perspectives was given here: some responses were from the point of view of the passenger, and some from the point of view of the crisis response team, with a number of obstacles relevant to both experiences.

From the passenger's perspective, security (2), immigration/passport control (2), staffing levels, and informing passengers about the status of their flights, and the expected actions resulting (new flight time; transfer to another mode of transport etc.) were highlighted.

From the point of view of crisis response, the major problem highlighted was **lack of or poor information sharing and collaboration**, and lack of communication between stakeholders (7). Similarly, some respondents criticised current crisis response for a lack of preparation and holistic planning involving all stakeholders. The different incentives between stakeholders (e.g. passengers, airlines, ATC, airports) were noted, as well as difficulties arising from the large number of parties involved in crisis response and the need to make early warning available to all stakeholders. One respondent noted that regional crises require regional decision making, which is usually not in place.

Institutional barriers, including a reluctance to use the latest technologies which can help (e.g. GPS, PBN etc.) and safety standards that do not incorporate/reflect the benefits of the latest technologies and practices were also noted, as were pride, power and territorial issues, including greed about high fare passengers. The issue of confidential and/or sensitive information was also brought up by one respondent, who noted that if we could share all information (e.g. SWIM) then management would be better.

Current infrastructure was another obstacle to crisis management highlighted. Two respondents mentioned runway capacity, and how that capacity is used. Access to the airport, and runway/taxiway congestion, were also mentioned.

Greater integration of ground transport providers in airport crisis management:

a) What are the major challenges?

A wide range of challenges were mentioned here. One major concern was **passenger acceptability** (3) and the difficulty of keeping the same level of service for the customer (both passengers and freight) – particularly when passengers are individuals who may have widely differing needs.

Information sharing was also seen as a potential problem with several different dimensions. These include getting information to passengers, sharing information between stakeholders (passenger, road, bus, train, traffic jams etc. through the same system, and knowing what passengers do when they leave the airport on the ground. The importance of mitigating the decision load when providing information on alternative transport options to already-stressed passengers was highlighted by one respondent, who suggested providing (roughly) equivalent mixes of transportation access at all major airports. Another problem for information sharing is the need to have accurate sources of information, including accurate forecasts of disruption.

Similarly, **coordination of ground transport** may cause difficulties. The need for common crisis planning between airlines, airport and the local/extended area public transport system was highlighted by 2 respondents. Problems may arise in efficiently engaging ground transportation, including the issue of providing enough equipment, where the equipment may be expensive and companies do not necessarily have lots of available capacity. The interoperability of air and ground transport systems, and determining relevant events that can inform good decision making using them, were also highlighted, as was the problem of finding a solution algorithm to make airline operations work optimally with the new layer of complexity. The need to provide new

infrastructure or adapt older infrastructure to enhance the connectivity between different modes was noted by 2 respondents

Acceptability to transport providers (both airlines and ground transport) was also highlighted as a problem by several respondents. Competition and commercial sensitivities were seen as a potential barrier, as was maintaining a sustainable cost of air transport in a multimodal transport model.

One respondent noted that the benefits of integrating ground and air transportation were unclear, and that arrivals integration would be easier and clearer to see benefits from (e.g. matching the passenger arrival flow with availability of taxis/trains), as the landside system is more random/unpredictable than the airside.

b) Is it a worthwhile goal to try and achieve greater integration?

11 respondents answered **yes** (with the corollaries that it must be for the passengers' benefit; that the benefits need to be proven; 'I speak as a frequently frustrated air traveller'; this would certainly improve passenger satisfaction). One respondent considered it a **partially** worthwhile goal, more likely achievable at newly constructed airports in their planning phase. The final respondent left this question blank.

Which ideas, CDM concepts and CDM-enabling technologies should be investigated?

a) Existing ideas, concepts and technologies

Various already implemented A-CDM concepts were mentioned by 2 respondents: AMANs, DMANs, integrated AMAN-DMAN, and other managers for surface movements and turnaround. TAMs were mentioned by 2 respondents, with one noting that the project should explore multiple TAM approaches. Other concepts mentioned included information sharing, a synthetic view of information per actor, ground-air CDM integration, providing an interface between all players (ground handling, passport control, transport providers etc.), the provision of information and solutions to the passenger, interoperability between local and network systems, punctuality, economics and operations (capacity), crisis-focused research into team-based collaborative decision making, split approaches (one for everyday disruption, one for crises) and approaches to sharing and managing information when some of it is private or confidential.

One respondent commented that though existing ideas are already good, more focus is needed to drive implementation at airports. Another commented that the MetaCDM

project should collect hub airport-public transport organisation and initiatives; a further suggested project direction was to investigate how to enhance the Information System platform to include the necessary information for enhanced CDM.

b) New ideas, concepts and technologies

TAMs were also mentioned in this section by one respondent (here including the turnaround process). Other technological concepts mentioned included real-time data collection and information distribution, terminal processes managers, integration between terminal and airfield managers, ground transportation managers, service orientation, and the work of the TITAN project. One respondent commented that we should explore different CDMs in general.

Ground transportation technologies suggested for investigation included ITS and individual car transport information possibilities related to congested routes at the arrival airport. One respondent noted that the project should explore multimodal transportation which keeps the level of service to the customer at current levels. Another commented that energy options are likely to rapidly evolve in the near future.

Passenger-related concepts included the use of mobile phones to (voluntarily) track passengers, making more options available to passengers with data, understanding passenger behaviour and including passenger perception/soft factors on top of 'hard' system CDM factors.

More research-based concepts included the idea of multi-modal network modelling and analysis, and investigating what the limits and negative consequences of group-based sense-making and decision-making are.

What are the main current systems/process deficiencies?

The most-mentioned systems deficiencies were to do with **data sharing** (4). Respondents commented that too much data was still not shared, was incomplete or fragmented or was only obtainable from different sources. One data source specifically mentioned as lacking was information on passenger flows (e.g. connecting to other flights). Another respondent noted that a consolidated information overview is needed. Similarly, another respondent suggested that the ability to provide a holistic view of everyone's response plans and share that information in real time is needed. However, one respondent commented that (most of) the information and systems to use it are already available (wifi, bluetooth etc.); the main problem being that we don't know how to use it – i.e. that processing information is the problem, but more information itself is not needed.

A lack of **passenger data collection** was also highlighted by two respondents – specifically 'timestamp' data (knowing where passengers are at any given time). One respondent also noted that passenger needs and satisfaction need to have a higher priority in crisis planning.

Weak collaboration between modes was discussed by two respondents. The problem of a lack of interest in collaboration between modes due to lack of understanding of potential gains (where all collaborators suffer if one does not fully cooperate) was also mentioned. Two respondents highlighted the current lack of connections between different modes as a problem, particularly in regard to connecting public transport to the landside. A lack of protocols to respond to crisis collaboratively for different modes was also noted.

The other responses addressed modelling, prediction and the distinction between different types of response. One respondent noted that systems haven't yet satisfactorily incorporated weather models to look ahead and predict disruptions/preventative measures to take. Another noted that crisis systems are different from disruption systems and require different responses. A third noted that current models are incomplete, and a fourth noted that the project should address real systems and derive process deficiencies from their experiences. Finally, one respondent commented that they needed to know what the system end-state is to answer this question.

Which KPIs are missing to measure the performance seen from the passenger's point of view (customer satisfaction?)

Many respondents highlighted measures relating to a passenger's **door-to-door** journey. These included door-to-door travel time/ door-to-door efficiency (3), passenger delay, arrival times and punctuality as opposed to aircraft delay (2), and the on-time arrival of passengers at their final destination with their luggage (the final destination being e.g. a hotel in a meeting location). **Passenger costs** were also mentioned (2), including a passenger value of time (accounting for buffer time) and a higher value of delayed time (approximately 3 times higher). **Overall satisfaction**, as a measure of to what extent the expectations of the passenger are met, was another suggested KPI, as were repeat business and customer complaints. Another respondent suggested customer satisfaction and KPIs mitigated by cost (e.g. to find the optimum points in a 3-D service delay, customer satisfaction and cost space). The incidence of passenger troubles during the trip (change of terminal, of airport, having to collect and re-register luggage) was also suggested. Two respondents suggested the **weighting of delays by perception**, as not all delays are perceived equally (e.g. waiting on the tarmac

'feels' longer than a longer flight time, queuing at the end of the runway could feel longer than a gate delay; passengers have different perceptions of travel time to the airport and processing time to reach the airplane when travelling from small and large airports, so that 1.5 hours would be acceptable at LHR and very unsatisfactory at BEG). One respondent suggested the project could learn a great deal from recent theories and empirical research on trust, loyalty, and experiential marketing – as modern marketing is hugely customer focused rather than product or supplier focused. Finally, some airport ease-of-use KPIs were suggested: ease of orientation at the airport, ease of vehicle parking at the airport, and Increased use of biometric technologies at immigration and customs.

Annex 2: List of experts interviewed

Organisation	Name
Paris CDG Airport (CDM):	Philippe Deregnaucourt
Thales :	Herve Breton
ADP :	Francois-Xavier Rivoisy
Toulouse Blagnac Airport :	Julien Doron
Fedex:	Sebastien Dorat
EasyJet:	Sven Paesschierssens
Brussels Airport :	Kris De Bolle
Egis Avia :	Jean-Luc Martin
Vienna Airport :	Manuela Knotek, Florian Petzke,
Ximes, Vienna :	Dieter Punzenggruber
Dusseldorf Airport :	Ira Fernandez-Larazo, Linda Gerritsen, Thomas Hansen, Ralf Lassak, Anne Schmitter
Deutsche Lufthansa:	Gregor Weil
Heathrow Airport :	Ray Fitzgerald, Michelle Smith
British Airways :	Mark Pierson
London Luton Airport :	Nick Orwen
Airport Operators Association :	Tom Needham
Heathrow Met Police :	Martin Hendy
UK Department for Transport :	Terry Russell
Heathrow Express :	Peter Philips
Hillingdon Borough Council :	Mike Price
Heathrow Travel Care :	Ben Middleton

Annex 3 : META-CDM Questionnaire

META-CDM project – Airports questionnaire

The META-CDM project (Multimodal Efficient Transportation in Airports and Collaborative Decision Making) is gathering information about the practicalities of CDM use in order to identify potential measures that improve the level of service for passengers, in particular under adverse conditions and in crisis situations.

In order to assist the project in its data-gathering phase, we would be glad to receive your feedback on the questions listed below. Your input will be used to both analyze the status quo at airports and to provide recommendations to maximize the broader potential of CDM for the benefit of the system and its users in times of maximum stress. We may wish to follow up responses and request interviews to explore various aspects of the points raised.

Your responses will be treated anonymously and used to distill key findings and recommendations for the META-CDM reports. For further information about META-CDM, please visit our website http://www.meta-CDM.org or contact Isabelle Laplace (isabelle.laplace@enac.fr)

About you and your airport

Name:	
Company:	
Position:	
Email:	
Office Tel No (optional):	
Mobile Tel No (optional):	
Airport name:	
Airport status – hub or spoke	

Annual flight movements (IFR)	
Annual passengers	
Declared capacity (movements / hour)	
Connecting passengers (%)	
Number of runways:	
Number of stands: - terminal - remote	
Market split (%) - long haul/intercontinental - medium haul/regional - short haul/domestic	
Passenger access mode (%) - trains (incl. metro) - public buses - taxi / hotel busses - private or rental car - others	

PLEASE DESCRIBE YOUR PRACTICE/EXPERIENCE IN THE CATEGORIES BELOW:

Planning	**Planning section, core questions**	**PLANNING** - How are your irregular operations (IROPS) logistics organized - your crisis and contingency plan (form, ownership, team structures,	

		external engagement, degree of automation, etc)	
		CDM ENGAGEMENT - Crisis connections and extent of integration beyond your organizational boundaries (emergency services, ground transport, local authorities, etc) and the effectiveness of this cooperation	
	Optional questions	**ALERT PROCESS** - The scope of 'Horizon scanning' and upstream alert processes (safety, weather, security) and how well these work	
		COMMUNICATION DOWNSTREAM - Communication procedures engaging your network of dependent organisations, how the passenger is involved and what procedural developments you would like to see	
		TRAINING - Simulation and training approach and the process for learning from experience	
Section 2: Tools	**Optional questions**	**TOOLS** - The systems, data, modeling and scenarios you use and how you would like to see these enhanced – how far do these measure/reflect passenger experience	

		NEW TECHNOLOGIES - Which existing ideas, CDM concepts, and CDM-enabling technologies should be investigated? a) <u>existing</u> ideas, concepts & techs b) <u>new</u> ideas, concepts & techs	
Section 3: Performance	**Core questions**	**PERFORMANCE** - Performance measurement, KPIs and improvement processes and scope to improve and which KPIs are missing to measure the performance seen from the passenger's point of view or to allow extension of CDM beyond the airport	
		EFFECTIVENESS - Obstacles to optimum crisis management (bottlenecks, etc), the degree of local autonomy to act and effectiveness of 'chain of command'	
		SCOPE TO IMPROVE - What key actions by a) your organization and b) others would improve overall management of crisis situations and CDM cooperation to wider stakeholders	
	Optional questions	**COST** – how do cost considerations influencing crisis management planning and execution	
		REGULATION - How regulation/legal liability affects the execution of crisis management	

Section 4: Passnegers	**Core questions**	**CONTINGENCY** - Contingency travel arrangements for travellers/passenger and the extent of automation to set that in hand	
		COMPLAINTS - What passengers complain about in a given situation	

What you consider to be airports with model good practice?	
Who else you think we should be talking to (at your airport and/or beyond)?	

Do you have results and data from system surveys and audits that you can share with META-CDM?	