Working towards an AI-based clustering of airports, in the effort of improving humanitarian disaster preparedness

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by

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Preface

This document concludes two years of inspiring lectures and meetings at TU Delft. Even during the harsh covid times we've managed to make it work in the online world. Choosing Complex Systems Engineering and Management as my master's programme was one of the best decisions I have ever made, and while the decision was mine only, I was never alone in this journey.

Being able to write a thesis that is so close to my interests was a great experience, and I would not manage to achieve that without the help of my supervisors and advisors, whom I would like to thank. Dr. Tina Comes, my supervisor, who guided me through the process, got in touch with great experts and provided much needed scrupulous feedback. Dr. Karla Saldaña Ochoa, thank you for believing in the potential of this topic, guiding me through all the technical difficulties, always in a kind and understanding way. You were always there for me, for which I am very grateful! And to my second supervisor and one of the best lecturers I have had classes with, dr. Martijn Warnier - your work has been a great source of inspiration, your remarks always extremely on point.

This work would not be the same without inspiring and insightful interviews that I was lucky to conduct with a number of experts representing OCHA, GARD and ACI - their work for humanitarian disaster preparedness of airports is indispensable.

I would like to thank my parents for their patience and belief in me. No matter how unusual my ideas and decisions sometimes were, both before and during those studies, you have always supported me and for that I am very grateful. I would not be where I am today without you.

To my dear friends - Olga and Janek, who I can always count on, supporting and motivating, up until the last minutes before handing in the thesis, no matter the distance. Same goes to Mateo and Tom - my greatest companions of the CoSEM journey - and new friends for life.

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Maria Browarska
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Executive summary

In the past few years, the frequency of onset natural disaster has been rising, causing significant damage to communities and infrastructure around the world. When it happens, airports in the region affected have to rapidly adjust and evolve from serving regular passengers to becoming a humanitarian hub, that handles a massive surge in both passenger, but especially cargo handling. A number of regions are especially vulnerable and prone to experience such a devastating event, and while there are existing initiatives aiming to raise awareness and improve airports' preparedness, authorities are often isolated in their efforts to become more resilient.

This research is an exploration of how data science and novel machine learning algorithms could help in establishing a base for forming collaborations between airports that might face similar challenges when it comes to disaster preparedness efforts. The goal was to build a comprehensive data set describing airports from the perspective of their disaster preparedness and find similarities between them, based on their intrinsic socio-technical features, so that perhaps an airport in Indonesia could be matched with its 'sibling' airport in the Caribbeans. The research involved a number of programming operations - starting with collecting data, through data processing up till applying the Self Organising Maps (SOM) algorithm and visualising results. The whole process can be analysed through the open repository - all results, access to code that allows for investigating similarities between airports and visualisations of SOM output:

https://gitlab.com/maria.browarska/OSM-SOM

In order to achieve previously mentioned goals, first an understanding of what happens at an airport once a disaster strikes was needed. This was achieved by a thorough analysis of literature, reports on historical events, guidelines and guidebooks, accompanied by interviews with representatives of humanitarian and aviation related organisations, such as OCHA, HADRA, ACI and GARD. The key insight from this part of the research was the importance of communication, coordination and available resources in terms of cargo handling capabilities, available storage space, available operations space for handling incoming aircrafts and the connectivity of the airport with the affected region. Affected airports usually have to handle a threefold increase in passenger operations and cargo operations increased by the factor of ten, often while dealing with damage to the airport itself.

The knowledge gained in the first phase of the research was used to identify the key socio-technical features of airports that have an impact on their disaster handling and preparedness capabilities. The list of relevant factors includes structural features, organisational structures, demographic of the region and available resources, among others. Based on international vulnerability indexes, 971 airports were chosen for analysis.

The core of the research was to build a database that would contain all the relevant information needed for clustering airports based on their key intrinsic features. It was an iterative process in which multiple publicly available sources were used, such as ourairports.com, Open Street Maps, Logistics Capacity Assessment, among others, in order to extract quantifiable measures reflecting specific features and capabilities of each of the 971 airports.

The data mining process was followed by pre-processing, in order to apply the Self Organising Maps algorithm. It was chosen due to its capabilities of clustering multidimensional data structures as well as the ease of visualising analysing results. While the clustering process was not fully successful, it led to identifying the key challenges in applying such an algorithm and proved to be a useful tool. In the future, more sophisticated methods for data pre-processing could be used in order to adjust the performance of the algorithm, leading to more directly applicable results.

The last step of the research involved applying the SOM in order to cluster the airports. Some groups were formed, for example one that consists of airports that have no seaports in their vicinity, have medium traffic, 1-2 terminals and a medium disaster risk. Another group consisted of smaller airports with smaller traffic, more alternative airports around and a higher disaster risk. These identified similarities could become a useful tool for airport authorities to find potential partners, who might be facing similar disaster preparedness challenges, due to their similar intrinsic features.

This research offers a valuable framework for analysing and assessing capabilities of airports from a global perspective, paving the way for future research in this domain. It also proves the usefulness of AI-based algorithms and data science in finding similarities between airports worldwide, which can in turn encourage cooperation between those that might face similar challenges. Additionally, the newly built database is a comprehensive set of information about almost a thousand airports worldwide, that could be used both by professionals and scientists.

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1 Introduction

When a natural disaster strikes, the nearest airport becomes the key link for delivering and organising relief aid, while trying to stay efficient in evacuating citizens, and receiving emergency personnel (Deutsche Post DHL Group, 2019). However, the existing infrastructure often cannot handle the sudden spike in volume of incoming goods (Deutsche Post DHL Group, 2021). Reasons for that are either poorly prepared procedures and organisational problems or structural features of a given airport or, in some cases, both. When airports become nonoperational, the only way to receive valuable aid is via road, rail and water, which is often much less efficient and time consuming (Polater, 2020).

Even though disasters and organising humanitarian aid is not the newest of challenges, there is still a lot of room for improvement. Set in an environment of technical and operational challenges, laws and regulations, international and regional co-operations of stakeholders from various fields - improving humanitarian logistics at airports poses a complex socio-technical challenge. However, open access databases such as Open Street Maps (OSM)(OpenStreetMap contributors, 2017) can offer large amounts of geo-spacial and airport specific data such as: the area surrounding, reachability, number of runways, taxiways, and many more. These datasets, with help of experts, can be turned into valuable insights.

This document presents a research that used an unsupervised machine learning algorithm to cluster airports around the world, based on features that influence their performance as a potential humanitarian hub in case of a disaster. The goal of this clustering was to produce group-specific policy advice, form a base for cooperation between similar airports and discover those that are especially vulnerable in case of a disaster. While not all research goals were met at this point, the outputs of sub-steps of the research, such as the database of airports and their features relevant for becoming a humanitarian hubs, are a relevant for both the society and the scientific world, as described in section 1.4.

Chapter 2 presents the current state of the research in the area of managing airports in disasters, as well as the use of ML algorithms for clustering large, multidimensional datasets. The literature review led to defining key concepts (2.1.3) relevant for the study and establishing the knowledge gap (1.1). Chapter 3.2 presents the research approach, followed by defining research sub questions. A detailed description of methods and a research flow diagram can be found in chapter 3.3.

The main body of the research starts with chapter 4, which describes airports' functions, both before and after a disaster strikes. In chapter 5 the process of building the database is described - from translating socio-technical features into numerical values, through data mining, till data pre-processing, for the purpose of applying unsupervised machine learning algorithms. The steps of applying SOM and results are presented in chapter 6, followed by a discussion on limitations, conclusion and societal relevance in chapter 7.

1.1. Knowledge Gap

Currently, there are no global studies dedicated to describing the structural features of both airports and their surroundings that influence disaster response planning. Most of the research focuses on individual cases and assessing historical events. With access to large amounts of geo-spacial data through Open Street Maps (OpenStreetMap contributors, 2017) and easily applicable novel big data analysis tools, such as SOMs, airports from all around the world can be compared to each other and clustered into groups based on their similarities. That knowledge could lead to a better design of airport response plans, identifying those that are especially vulnerable and forming possible fruitful cooperations between airports' authorities.

The specific methods applied in this research were used in the field of humanitarian aid-related research before, but on a local or national scale (Chen et al., 2019). The global approach is a challenge, due to limited availability of trustworthy data, but if successful, it paves the way for more detailed research on a global scale. This approach could especially benefit the less developed countries, which often do not have resources for local advanced research and preparedness strategies.

Up till now, the practitioners in the field, such as GARD, have used very simple methods for assessing the vulnerability of airports and had to prepare separate strategies for each client. GARD's capacity is very limited and this research could lead to finding new ways for authorities to prepare, thanks to establishing collaborations directly with other airports facing similar challenges.

1.2. Problem statement

Airports worldwide are isolated in their efforts to prepare to become a well operating humanitarian hub, when needed. Presently, operational procedures in case of a disaster are often not designed well enough to tackle the sudden influx of goods and evacuations and do not precisely reflect the capabilities and limitations of airports and their surroundings. Airport authorities and humanitarian operations decision makers need to better understand the key features that influence the ability to become a well operating humanitarian hub in order to foster cooperation between airports that struggle with similar challenges and in turn lead to improving their preparedness for a natural disaster.

1.3. Research objective

The goal of this research is to (1) better understand the challenges that airports face when a natural disaster strikes as well as in their preparedness activities. This understanding shall be then (2) translated into a list of socio-technical features influencing the level of preparedness and airport capabilities in facing a disaster. The finding of key features is relevant for (3) building a database that contains valuable humanitarian aid related information about a large number of airports worldwide, composed solely from publicly available sources. The focus on publicly available data is conditioned by a large number of airports being analysed, which makes it impossible to conduct surveys and obtain information directly within the resources and time-frame of this research. The last goal is to (4) group airports based on the identified relevant features, in order to encourage cooperation between airports that are similar to each other, which may result in having similar disaster preparedness challenges.

1.4. Scientific and societal relevance

This research is a result of a multidisciplinary approach at a worldwide challenge of preparing airports for disasters, therefore it is relevant for the practitioners, researchers, everyone in between and the society in general - after all, the main receiver of humanitarian aid when needed, regardless of profession.

From the scientific perspective, this research shows a new way of using clustering as a relevant tool in disasters preparedness. Not only clustering in itself, but with the use of a rather novel method in the field - an unsupervised machine learning algorithm. Before, similar methods were mainly applied on commissioned, comprehensive data sets, prepared by experts and relevant organisations, which meant

that applying an unsupervised ML algorithm was more straightforward. In those previous works, the researcher could focus on the algorithm application and analysing results. Building an own database, counting specific, relevant data from various sources and pre-processing it, as was done in this work, is a relevant contribution in itself, and forms a useful input for future research - the database can be further used as a source of information about 971 airports worldwide, ready for other types of analysis. Moreover, this innovative combination of building a new, comprehensive database and applying SOM reveals new challenges and paves the way for future research.

In the earlier stages of the research, the key scientific input is the way in which preparedness and post-disaster challenges and operations are translated into quantifiable features that reflect and describe airport's capacity to become a humanitarian hub. The research also explores the availability and broad usage scenarios for publicly available data, that, if proven to be not trustworthy enough, can be changed to official data sources, once international cooperation is encouraged by the research.

For society - especially airport preparedness practitioners, international organisations such as GARD, LCA, ACI, WFP, and many others, the database can become a useful and practical tool for assessing airports that are especially vulnerable and form strategies applicable for multiple locations, based on their similarities. Airports could also start cooperations on their own, and form working groups to better prepare for disasters together.

Even if the research does not lead to the perfect answer for each research question, it proposes a useful framework for mass analysis of large numbers of airports, or any other logistical facilities, such as seaports. From understanding key challenges, through translating them into quantifiable features, up till clustering and finding common ground for establishing cooperation.

2

Establishing the knowledge gap

2.1. Literature review

In order to define key concepts, narrow down the scope of the research and precisely define the knowledge gap, a literature review was conducted.

2.1.1. Methodology

Given the interdisciplinary nature of the problem, finding relevant literature in a structured way was a challenging process. The starting point of the research was the Scopus database - two searches were conducted, using keywords *airport, disaster AND / OR humanitarian, classification AND / OR clustering* - resulting in no relevant literature. Having established that similar research has not yet been done, the literature search was then divided into sub-topics - airport management for disaster response, humanitarian logistics and application of AI-based cluster analysis. The exact search strings can be found in Table 1 in the appendix. Initial selection was done solely based on titles, later narrowed down through reading abstracts.

In addition to the core literature review, a thorough search for available data sets was performed, as described in detail in chapter 5.

Even with the strong intentions for a highly structured review, snowballing emerged as the most successful method. In the end, 15 papers were chosen as most relevant for establishing current state of knowledge in the area and establishing the gap. The following chapter presents the most important findings for the knowledge gap and related key concepts defined in literature.

2.1.2. Results

The Table 2.1 below presents main takeaways from the performed research. Columns *research interest* and *research method* are objective descriptions based on the content of each paper, whereas the last column - *key findings for the knowledge gap* is more subjective. It already incorporates a level of interpretation by the author of this research proposal, geared specifically towards establishing the knowledge gap in the topic of airports and disaster management.

Table 2.1: Literature review overview table

Author	Title	Research interest	Research method	Key findings for the knowledge gap
Abdussamet Polater Polater, 2018	Managing airports in non-aviation related disasters: A systematic literature review	To present current state of knowledge in airport disaster management and identify gaps.	Literature review	Most current work focuses on stakeholder collaboration, scheduling problems, medical preparedness, corporate social responsibility.
Sunkyung Choi, Shinya Hanaoka Choi and Hanaoka, 2017	Diagramming development for a base camp and staging area in a humanitarian logistics base airport	To develop a method for diagramming a space for emergency workers and humanitarian logistical operations at an airport.	Synthesis of current literature case study	Highlighting the importance of flexible use of space to improve humanitarian logistics. The method allows for estimating the area needed for operations and visualizes the layout of a humanitarian base. Relevant structural features of an airport were enlisted.
Martijn Warnier, Vincent Alkema, Tina Comes, Bartel Van de Walle Warnier et al., 2020	Humanitarian access, interrupted: dynamic near real-time network analytics and mapping for reaching communities in disaster-affected countries	Near real time model for logistics planning in determining road access from an airport to affected communities.	Case study, network analysis	Reachability is an important factor when assessing airports' qualities as a humanitarian hub. It can change dynamically as a result of a disaster or ongoing humanitarian operations (congestion).
Walter J. Gutjahr, Nilay Noyan, Nico Vandaele & Luk N. Van Wassenhove Gutjahr et al., 2020	Innovative approaches in humanitarian operations	Overview of novel approaches in the area of disaster management and humanitarian operations.	Literature review (brief)	Useful overview of various methods used in the field, valuable as an inspiration for choosing research methods.
Bartel Van de Walle, Maria Freese, Kenny Meesters Van de Walle et al., 2018	Airport Efficiency in Humanitarian Disaster Response	Investigate relations between the humanitarian and aviation sector - a holistic approach to airport humanitarian logistics.	Workshops, interviews, discussions	Proper organisation of an airport humanitarian hub is a complex, multidisciplinary challenge that involves suppliers, logistical infrastructure, government agencies, private funders. New technical solutions are needed - ones that are designed with a holistic approach.

Bartel Van de Walle, Julie Dugdale Walle and Dugdale, 2012	Information management and humanitarian relief coordination: findings from the Haiti earthquake response	Investigating the role and use of information management in coordination efforts.	Interviews, case study	Information management is important and beneficial, but informational overload, reliability and accountability are a concern. The paper also describes standard coordination mechanisms implemented by United Nations, as well as related challenges.
Abdussamet Polater Polater, 2020	Airports' role as logistics centers in humanitarian supply chains: A surge capacity management perspective	To investigate key factors of airport logistics surge capacity.	Case study, interviews	Categorization of factors and sub-factors that influence capacity of an airport humanitarian hub. Strong focus on stakeholdersâ□□ collaboration.
Ahmad A. Abdullah Abdullah, 2018	Conceptual model for airports emergency plans (AEP)	Designing a new approach for preparing airport emergency plans.	Case study	Description of currently existing emergency plans - their challenges and flaws. Conceptual new way of preparing AEPs.
Pandey, B.H. and Ventura, Carlos and RioFrio, P. and Pummell, J. and Dowling, S. Pandey et al., 2014	Development of response plan of airport for mega earthquakes in Nepal	Developing a comprehensive response plan for a specific country - with regards to its geography, demography, institutional arrangements, resources.	Case study	Description of factors that influence humanitarian logistics set in a specific region. There is a strong need for well prepared location specific response plans.
Martina Savin Baucic, Damir Medak Baucic and Medak, 2015	Webgis for emergency at airports	Developing a Web GIS application that supports Airport Emergency Management and is in line with ICAO standards.	Case study, design approach	The research has proven that a model that utilizes geo-spacial data is beneficial for airport humanitarian response planning. There is interest from airport authorities and disaster management stakeholders for similar tools.
Jakub Kraus, Vladimir Plos, Peter Vittek Kraus et al., 2014	The new Approach to Airport Emergency Plans (AEP)	Evaluation of currently existing Airport Emergency Plans and creating a new approach for designing them.	Desk study, multiple case studies	There is a need for developing AEPs that perform better. A lot can be improved by studying historical events. Cooperation of various airports could help in the process.

Michael Veatch, Jarrod Goentzel Veatch and Goentzel, 2018	Feeding the bottleneck: airport congestion during relief operations	To gain a better understanding of airport operations during a crisis and develop a model that helps decision makers choose the right scheduling strategies.	Desk research, case study, literature review, queuing model	Unloading capacity is the key bottleneck for airports - more aircraft parking space is needed. Prioritization strategies should be further explored in order to receive the most valuable humanitarian cargo.
Bernd Hellingrath, Teo A. Babun, James F. Smith, Daniel Link Hellingrath et al., 2015	Disaster Management Capacity Building at Airports and Seaports	Examine the state of the art of port and airport preparedness in research and practice.	Desk study, comparative study of ports and airports, detailed analysis of institutions and initiatives involved	Establishing the notion of international standards for airports and ports disaster preparedness. A global approach - not a single even case study.
Jonas Brock, Martin Lange, Jamie A. Tratalos, Simon J. More, David A. Graham, Maria Guelbenzu-Gonzalo, Hans-Hermann Thulke Brock et al., 2021	Combining expert knowledge and machine-learning to classify herd types in livestock systems	Classifying herd types based on a set of features, such as birth place, movements, disposal.	Applying the Self Organising Maps (SOM) algorithm that is adjusted with expert knowledge	SOM is suitable for classifying herd types and can be applied to other disciplines. The algorithm proved to to be easy to interpret and discuss with stakeholders who are not familiar with AI tools.
Ian T. Jolliffe, Jorge Cadima Jolliffe and Cadima, 2016	Principal component analysis: a review and recent developments	Presenting a coherent overview of the method, what it can and cannot do with applications examples.	Descriptive study of a method based on literature	The method performs best with binary and discrete data. It is more challenging to apply than SOM.

2.1.3. Key concepts

Humanitarian logistics

When a disaster strikes, provision of shelter, water, food, sanitation and healthcare becomes the objective of humanitarian logistics (Warnier et al., 2020). It requires mobilisation of international organisations, local and national government, different suppliers, donors, logistical operators and many others (Van de Walle et al., 2018), which forms a complex system of various information sources, technical and institutional constraints, and pressure. Within this system, airports are a key element to form a humanitarian supply chain. They are not only logistical and humanitarian hubs, they often become coordination centers for all actions in the region, while trying to deal with regular, or even enhanced operations of evacuating passengers (Van de Walle et al., 2018).

Airport

From a passenger's perspective, airport is a complex of buildings, usually far from the city centre, that serves as a starting, transfer or ending point for either a business trip or a holiday adventure. From a more technical point of view, airports offer services such as runway, apron, storage, ground handling for both cargo and passenger airlines for their regular operations (Polater, 2020). But when a

disaster strikes, airports play a key role in the humanitarian supply chain, due to their intrinsic characteristics. Large buildings and space surrounding the airport, intermodal access, well established handling systems allow for airports to become logistical centers, medical centers, sheltering areas and main distribution centers for humanitarian aid (Polater, 2020). The efficiency of operations under such circumstances differs between airports, due to various levels of preparedness, coordination capacity, structural features and the level of damage induced by a disaster (Polater, 2018).

Airport Emergency Plan
Abdullah (Abdullah, 2018) and Kraus et al. (Kraus et al., 2014) focused their work on evaluating airport emergency plans (AEP) that are currently in use. These documents are set of steps or procedures that are to be incorporated in case of events such as hijacks or bomb threats (Abdullah, 2018). There are also some that address natural disasters, however not for every airport (Kraus et al., 2014). According to authors, there is a lot of room for improvement in the field of designing AEP, as many of the currently existing documents were prepared solely due to necessity of international regulations and not with the purpose of actual applicability in a real life scenario (Kraus et al., 2014).

Classification algorithms
When dealing with large sets of data, classification algorithms allow for detecting clusters and patterns. Self-organising map (SOM) is an unsupervised machine learning (ML) algorithm that projects high-dimensional data into topology-preserving maps (Brock et al., 2021). It can be used as an exploratory and visualisation tool for complex datasets, and present insights difficult to perceive with traditional statistical analysis. Combined with expert knowledge, using this novel technique has proved to be successful in a variety of fields such as medicine, natural science and finance (Brock et al., 2021).

2.1.4. Positioning the research in literature

Most of the papers chose a case study as the research approach. They analysed the behaviour of airports in specific disastrous events, mainly focusing on organisational processes and stakeholders' cooperation (Polater, 2020; Polater, 2018; Walle and Dugdale, 2012). While these features, with no doubts, influence logistical operations, they are also unique for each airport. It is challenging to draw general conclusion that could be applicable to other airports, since their organisational structure may differ, due to international and regional regulations, resources and needs.

Some of the authors pointed out the importance of geographical location of an airport, structural features as well as its reachability (Choi and Hanaoka, 2017; Veatch and Goentzel, 2018; Warnier et al., 2020). Pandey et. al (Pandey et al., 2014) proved that utilising geo-spacial data is beneficial for airport humanitarian response planning and that airport authorities are interested in tools that can help to plan logistical procedures. Choi and Hanaoka (Choi and Hanaoka, 2017) developed a model that visualises a layout of a humanitarian base, based on structural features of an airport and proved its potential applicability with a case study, suggesting that more research is needed to generalise the result of their studies.

While some of the authors suggested that cooperation between airports that struggle with similar challenges would have a positive outcome (Kraus et al., 2014; Polater, 2018), none of them explored the possible backbone of such cooperation. That finding, combined with the idea of structural features of airports having an impact on their humanitarian logistical procedures, led to defining the knowledge gap.

3

Research goal and methods

Having established the knowledge gap based on the literature review, this section focuses on describing the research objectives, scope and methods used.

3.1. Research question

The main research question, derived from the knowledge gap, is formulated as follows:

How to describe airports in a quantifiable manner and cluster them using an AI algorithm, in the effort of improving humanitarian disaster preparedness?

3.2. Research Approach

Using a ML algorithm to cluster airports constitutes a need for a structured approach that will tackle the complex socio-technical design requirements. It is in fact building a tool that would provide decision-makers with new information. In order for this experiment to become a trustworthy source of information, a Design Science Research Methodology (DSRM) (Peffers et al., 2007) is chosen. All of the six steps proposed by Peffers at. al (Peffers et al., 2007) will be applied, accompanied by methodologies taught in the Complex Systems Engineering and Management study program.

In line with the research approach, the four research sub questions are proposed. Tackling them one by one allowed for answering the main research question in a structured way, ensuring applicability of the proposed design in real-life scenarios.

3.2.1. Research sub-questions

SQ1: What are the activities and procedures that take place when an airport becomes a humanitarian hub as a response to a disaster?

SQ2: What are the key intrinsic and structural features of airports and their surroundings that influence humanitarian logistics in a post-disaster scenario?

SQ3: How could the data describing airports be obtained?

SQ4: How can airports be clustered based on their structural, geographical and organisational features?

3.3. Research Methods

Each step of the research requires specific data and a method of analysing it, in order to tackle all sub questions, leading to answering the main research question.

First, a thorough understanding of the design space is needed. Getting to know what constitutes humanitarian logistics - what procedures and activities take place at an airport, what are the challenges, what space they require, how does it differ between airports. All these things operate in an institutional environment, bounded by international and regional rules and regulations, which also need to be established in order for the result of the research to be in line with those regulations and applicable in real life scenarios. To achieve that, a thorough desk study was be performed, accompanied by semi-structured interviews with humanitarian logistics professionals and scientists. The desk study involved: scientific literature, international legal documents specifying humanitarian logistical procedures issued by OCHA ("Humanitarian Programme Cycle", 2021; OCHA, 2020), ICAO (Ndikumana, 2021), grey literature published by companies involved in humanitarian actions around the world (Deutsche Post DHL Group, 2019).

To answer sub question two, the general information gathered in the first step was be translated into specific structural features of airports and their surroundings. This led to forming the input for the ML algorithm, that clustered airports according to their intrinsic features. Establishing a vector of features that influence humanitarian logistics is the key part of this research, as ML algorithms are only as good as the data that feeds them (Dwivedi et al., 2021; Nash, 2018). Some of the features might be straightforward - such as number of runways, taxiways, parking space. The rest was chosen based on the research in the first phase of the project.

Once it was established what should be included in the vector of features, the process of data mining started. This was an iterative process - if some of the required data were be unavailable, it was replaced with other relevant features or a combination of some. The main data source was Open Street Maps, operated by a filtering tool - Overpass Turbo, and supporting APIs. This open source detailed map of the world allows for mining relevant geo-data, with specific characteristics of airports under the tag *aerodrome*. Data obtained from this source, and others, was used to build a data based in order to form input vectors for the ML algorithm.

Figure 3.1 presents the whole research flow, with specified steps of DSRM, elements of the process, methods applied and corresponding research questions.

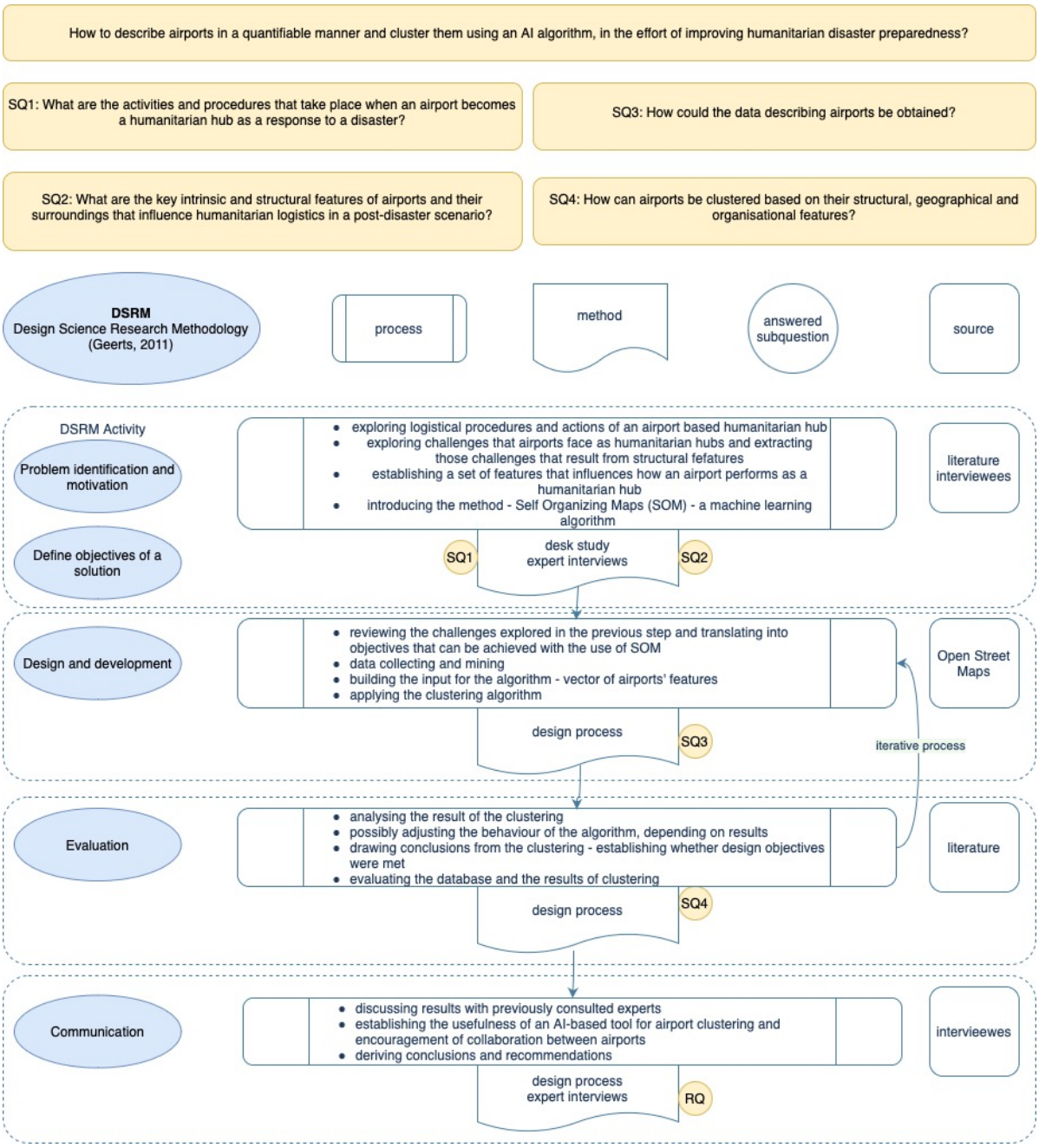
The main threats of this research are the performance of the classification algorithm, based on choosing the feature vectors, and the trustworthiness of the outcome. However, even if the method fails to present valuable output that is applicable in real life scenarios, the research surrounding the implementation of the algorithm - creating a dataset geared specifically for evaluating airports' performance as humanitarian hubs - will become a valuable training set for other potential ML applications and research.

3.3.1. Self Organising Maps

The SOM algorithm is a method for visualising large multi-dimensional data sets, originally introduced by Teuvo Kohonen in the 1980s (Lenard et al., 1999; Ritter and Kohonen, 1989). It is widely used for classification and clustering (Misra et al., 2020) and was also used for that in this case. The algorithm was applied in Python, with the use of specifically designed library - SOMPY (Sevamoo, 2018). It was an iterative process, that required multiple adjustments of the input vectors, in order to achieve proper clustering. One of the challenges here was to asses the truthfulness of the clustering - and that was the goal of the evaluation phase. SOM's results are generally considered as straightforward when it comes to interpretation, due to its visual representation. However, due to ML algorithms nature, the process of clustering is not entirely transparent and has to be treated with caution (Dwivedi et al., 2021). Nevertheless, if performed with enough caution and fed with datasets co-designed by experts, SOMs have proven to perform well and classify data in ways not achievable by classical statistics and classification methods (Veatch and Goentzel, 2018).

In the field of humanitarian aid this algorithm was used as an enhancement for disaster risk assessment in China (Chen et al., 2019). Here, the SOM worked as a visual aid for understanding the underlying factors that influence disaster risk, as well as a clustering tool to find regions that might face similar challenges and risks. In another recent research (Ochoa and Comes, 2021, SOM was used to learn from historical disasters, based on their 19 characteristics, in order to predict the amount of people

Figure 3.1: Research flow diagram

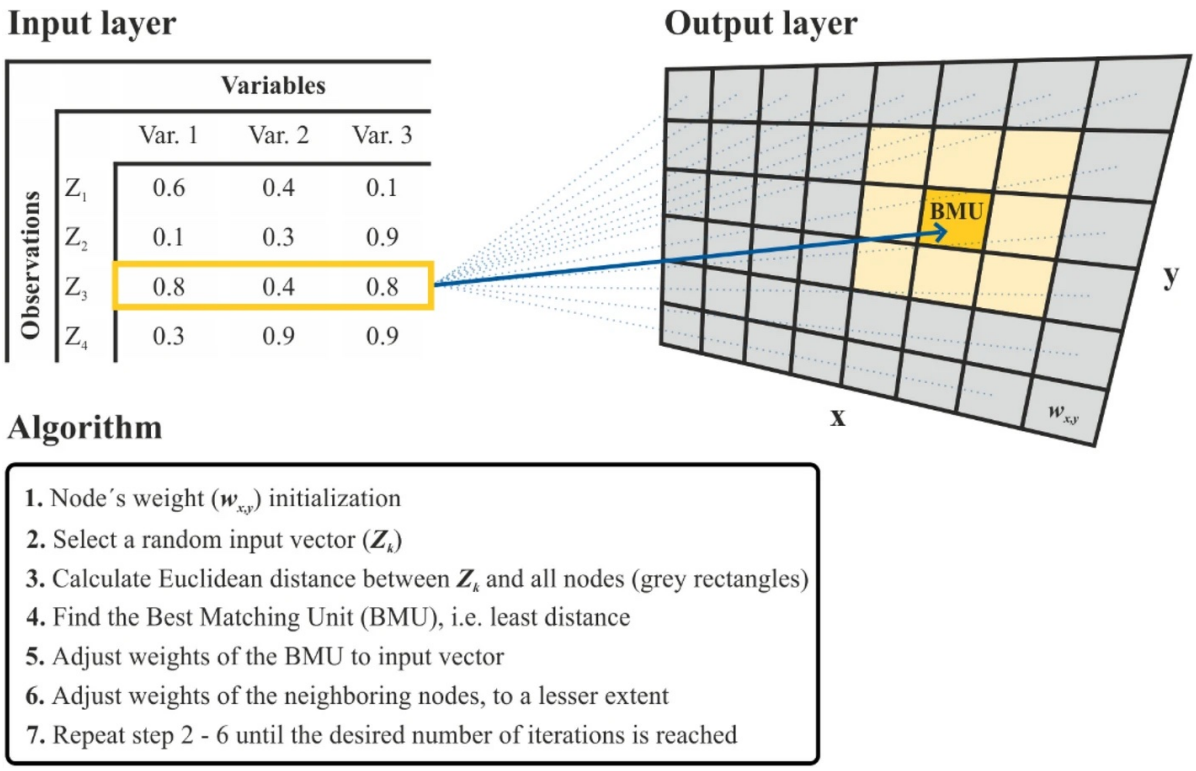


affected, total damage and provide specific recommendation for assessing housing and shelter needs for future disaster cases. The SOM ”learned” how in the past, specific features describing the disaster were related to the effects of the event, therefore the trained SOM can predict effects of a future event, given a set of 19 characteristics.

The goal of using SOM in this research is similar to the one mentioned above - it can provide valuable insight into similarities and differences between airports based on a high number of relevant features. Such comparison of large amounts of data would be very challenging with traditional statistical tools. What is especially important in this case, is that SOM is an unsupervised learning method, which means that unlike supervised ML methods, it can be applied on unlabeled data sets. It can discover patterns and similarities without a human intervention, given that the pre-processing is done correctly. SOM makes it easy to understand which features are the dominating ones in the clustering process, making it easier to adjust the algorithm and input vectors accordingly. The reasonably straightforward implementation with the use of publicly available APIs makes it a useful tool for practitioners and scientists who are less experienced programmers, making it easier to focus on the actual research.
Figure 3.2 aims at visualising how a SOM works. In this research, each observation **Zk** (as named in the figure) is an airport, and the variables rows represent the chosen features of airports. Before running the algorithm, the data that forms the input layer has to be transformed into feature vectors, that can be later compared to each other, in order for the algorithm to place them accordingly in the output layer. It is an iterative process that requires multiple repetitions, before all input vectors are placed in the vicinity of other similar vectors.

The result of a SOM algorithm is a visual representation in form of a map, with all input vectors (in this case, airports and their relevant features) distributed according to their similarities with other input vectors. This means that the result of a SOM can be easily interpreted and visualised - each SOM cell can be investigated, leading to establishing which exact airports were labeled as similar, based on a chosen number of features.

Figure 3.2: Architecture and learning process of self organising maps. Source: Brock et al., 2021



4

Airports in disasters

In order to find specific qualities and features that influence airports' preparedness for a disaster, a thorough understanding of activities and the environment in which they take place is needed. This chapter explains what actions take place at an airport once a disaster strikes, what are the challenges and what can be done to prepare an airport for a disaster.

Information found in this chapter was derived from a desk study accompanied by semi-structured interviews with experts on airports' disaster preparedness and performance.

4.1. Airport's functions

Everyday airports worldwide serve airlines and cargo companies. They also offer services such as ground and cargo handling, aircraft parking, storage, runway, apron, among others (Polater, 2020). When a disaster strikes, airports become especially important, due to their ability to handle large amounts of cargo, intermodal access, storage capacity and available space. Once an airport becomes a humanitarian hub, the list of functions it fulfills grows from the usual cargo and passenger handling.

Emergency airport functions may include (Baucic and Medak, 2015; Hanaoka et al., 2013; Polater, 2020; Polater, 2018):

- establishing temporary medical facilities
- establisihng a storage of humanitarian goods
- organising customs procedures for relief goods
- evacuating people
- handling unusual kinds of aircrafts
- using alternative communication systems
- dispatching staff
- setting up a crisis center
- staging and sheltering areas
- setting up a logistics and dispatch centre for distributing relief goods
- welcoming VIPs
- organising media rooms (providing information to the public)
- accommodating staff

- sorting relief goods
- securing fuel supply
- ensuring availability of aircraft parking
- ensuring availability of parking and handling space for last mile delivery (trucks, cars)
- providing passengers and staff with food and water
- ensuring availability of light and electricity for extended operating hours
- redirecting aircrafts to alternative airports

How well these functions will be fulfilled in a disaster scenario depends on a number of socio-technical factors that together form the level of preparedness of an airport. From coordination challenges, through availability of resources, space and quality of connectivity - all these factors play a role in post-disaster humanitarian logistics.

4.2. Institutional setting and coordination

Airports are not alone in their disaster-related struggles. Starting in the preparedness phase, there are numerous organisations that support and establish standards for airports' emergency planning. All three most important aviation related international organisations - ACI, ICAO and IATA - issue guidelines and handbooks related to preparing for a disaster with operational suggestions. These handbooks however are often very general, and a lot of responsibility stays with the national governments and airports themselves. Moreover, the guidelines are exactly what they are - suggestions and best practices, not strictly enforced rules that would force certain stakeholders to present and practice specific emergency related operations (V. Bohl, 2021).

Another group of organisations involved in disaster preparedness are those that also take part in the active phase, after a disaster strikes - OCHA, UNDP, HADRA, GARD. Get Airports Ready for Disasters is an intuitive run by the Deutsche Post DHL Group and UNDP - with their regular actions aimed at preparing airports, they pave the way to smoother operations, also for themselves, once a disaster strikes. While all actions of these organisations are very helpful, a similar challenge to the previous group persists - they can only educate and present suggestions, which does not guarantee the effectiveness of their actions.

Once a disaster strikes, the main party responsible for coordination is the airport authority and the governmental institutions in which the airport is situated. The incoming professionals and volunteers can only suggest how to organise operations, but the final decision lays with the local official. Of course, official representatives such as UN resident coordinator help substantially, but coordination issues remain a great challenge in humanitarian logistics (Bohl, 2021).

4.3. Categories of challenges and socio-technical features

Apart from coordination issues mentioned in the previous sections, resulting form the division of responsibilities and coordination tools available for stakeholders, there are various logistical challenges that are related to inartistic features of airports and their surroundings.

Deriving from the list of functions presented in section 3.1 challenges and features influencing the performance of an airport in a post-disaster scenario can be categorised, in order to achieve a good starting point for data mining.

Structural and capacity features

In the first group, there are numerous functions dependent on airport's facilities and available space - the facilities include:

- runways and their characteristics

- aircraft parking spots
- apron and its characteristics
- terminals and their characteristics
- storage facilities - both open-air and covered warehouses

Accessibility features
In the second group, related to airports surroundings, the following features can be underlined:

- how well the airport is connected to the population in need (quality of roads, traffic, available vehicles for last-mile delivery)
- geographical surroundings - whether there is space available around the airport, or is it limited by water / mountains / dense population (buildings)
- alternative airports and seaports

Organisational features
On top of the technical features, we can also distinguish social ones, related to airports' organisational structure:

- how much staff is available
- how well the staff is trained
- who owns the airport
- what is the airport's main purpose (civil / military)
- whether the airport was part of any preparedness programmes

Risk related features
In addition to airport specific features, it is also important to look at different levels of risks that each airport faces:

- risk of occurrence of a natural disaster
- regional capacity for handling disasters

These categories form a base for the data mining process that is described in detail in chapter 5.

4.4. Choosing countries

While all airports should be adequately prepared in case a disaster strikes, there are some that are especially vulnerable, due to their location and surroundings. In order to pick the ones that might need special preparedness strategies, the INFORM Risk Index (Inter-Agency Standing Committee and the European Commission, 2020) was used. The final assessment in the RISK Index is based on a number of indicators, not only related to natural disasters but also wars, food security, economic dependency, among others. For the research, two main criteria were chosen: the final RISK class, which takes into account all factors, together with the earthquake hazard, to form a list of countries prone to be facing a natural disaster.

The final list consists of countries that were marked having a *Medium, High, Very High* Risk together with the Hazard Exposure to earthquakes equal and above score 4. This methodology led to choosing 53 vulnerable countries. However, China, Russia and Korea were excluded due to limited access to data regarding those countries, as well as their expressed unwillingness to take part in international disaster preparedness programs (Weeks, 2021).

The goal was to pick the truly vulnerable airports and to have a number of records big enough for the unsupervised machine learning algorithms to perform well. Another important factors was diversity in regions, so that it would be possible to find similarities between airports in various parts of the world.

The final list of 50 countries can be found in 4.1.

Table 4.1: The list of vulnerable countries, which forms a base for choosing airports to be researched.

Country	**ISO - 3**	**Country**	**ISO - 3**
Afghanistan	AFG	Kyrgyzstan	KGZ
Algeria	DZA	Lebanon	LBN
Azerbaijan	AZE	Malawi	MWI
Bangladesh	BGD	Mexico	MEX
Bolivia	BOL	Morocco	MAR
Bosnia and Herzegovina	BIH	Myanmar	MMR
Burundi	BDI	Nepal	NPL
Colombia	COL	Nicaragua	NIC
Congo DR	COD	Pakistan	PAK
Djibouti	DJI	Palestine	PSE
Dominican Republic	DOM	Panama	PAN
Ecuador	ECU	Papua New Guinea	PNG
Egypt	EGY	Peru	PER
El Salvador	SLV	Philippines	PHL
Ethiopia	ETH	Rwanda	RWA
Georgia	GEO	Solomon Islands	SLB
Guatemala	GTM	Syria	SYR
Haiti	HTI	Tajikistan	TJK
Honduras	HND	Tanzania	TZA
India	IND	Timor-Leste	TLS
Indonesia	IDN	Tonga	TON
Iran	IRN	Turkey	TUR
Iraq	IRQ	Vanuatu	VUT
Jordan	JOR	Venezuela	VEN
Korea DPR	PRK	Viet Nam	VNM

5

Building the database

The data mining process performed in this research was a challenging one, composed of two main iterative phases. First, the identified socio-technical features of airports had to be translated into measurable data-points - numerical, categorical or descriptive. The second phase was actually finding the data - since one of the goals was to try and retrieve as much valuable information from publicly available sources as possible. The iterations were the key here - if something could not be found, it had to be replaced with some other measure, or a combination of those existing. In some cases, more databases had to be added and some indicators, such as the airport area had to be calculated using additional geo-data software.

Given the described challenges, it is difficult to assign each measure from the formed database to a specific airport feature, since some of them are meant to account for more than one specific need of an airport during a disaster. When applying this approach of building a data base from publicly available sources it is important to have a strong understanding of what it is that we want to describe, in order to allow for flexibility and easy replacement or adjustment of originally planned measures. In the future, the data mining process could be replaced by conducting detailed surveys with airports - that way it would be possible to obtain the exact measures to account for all planned features, straight from the source, allowing for better accuracy and trustworthiness. Some additional constraints are also described in section 7.4.

This chapter describes in detail the steps that were taken in the process of building the database. Diagram 5.1 shows the process flow, highlighting the order of adding additional databases and how they were combined together.

5.1. Translating socio-technical features into data-points

While all socio-technical features described in section 3.3, relevant to assess airport's disaster preparedness, were to various extents described in scientific literature and professional reports analysed in this research, the challenge here is to translate them into comparable sets of numerical features.

In order to do so, various circumstances need to be taken into account, such as: availability of data, methods of measuring and quantifying specific characteristics, their co relations and level of importance. Section 4.2.2 describes the chosen data representing the key identified characteristics, and while most of them are straightforward - such as the number of alternative airports, to asses the actual possibility for using alternative airports, others are a combination of various characteristics, based on a number of assumptions, due to the availability of data and the limited resources for this research.

As mentioned before, one of the key characteristics of airport surroundings it's the connectivity - in order to properly asses it, various mathematical methods can be applied, such as network analysis. However, due to limited data availability and inconsistent level of detail in OSM data, it was difficult to perform automatised network analysis for a large number of airports. Instead, to get a limited insight

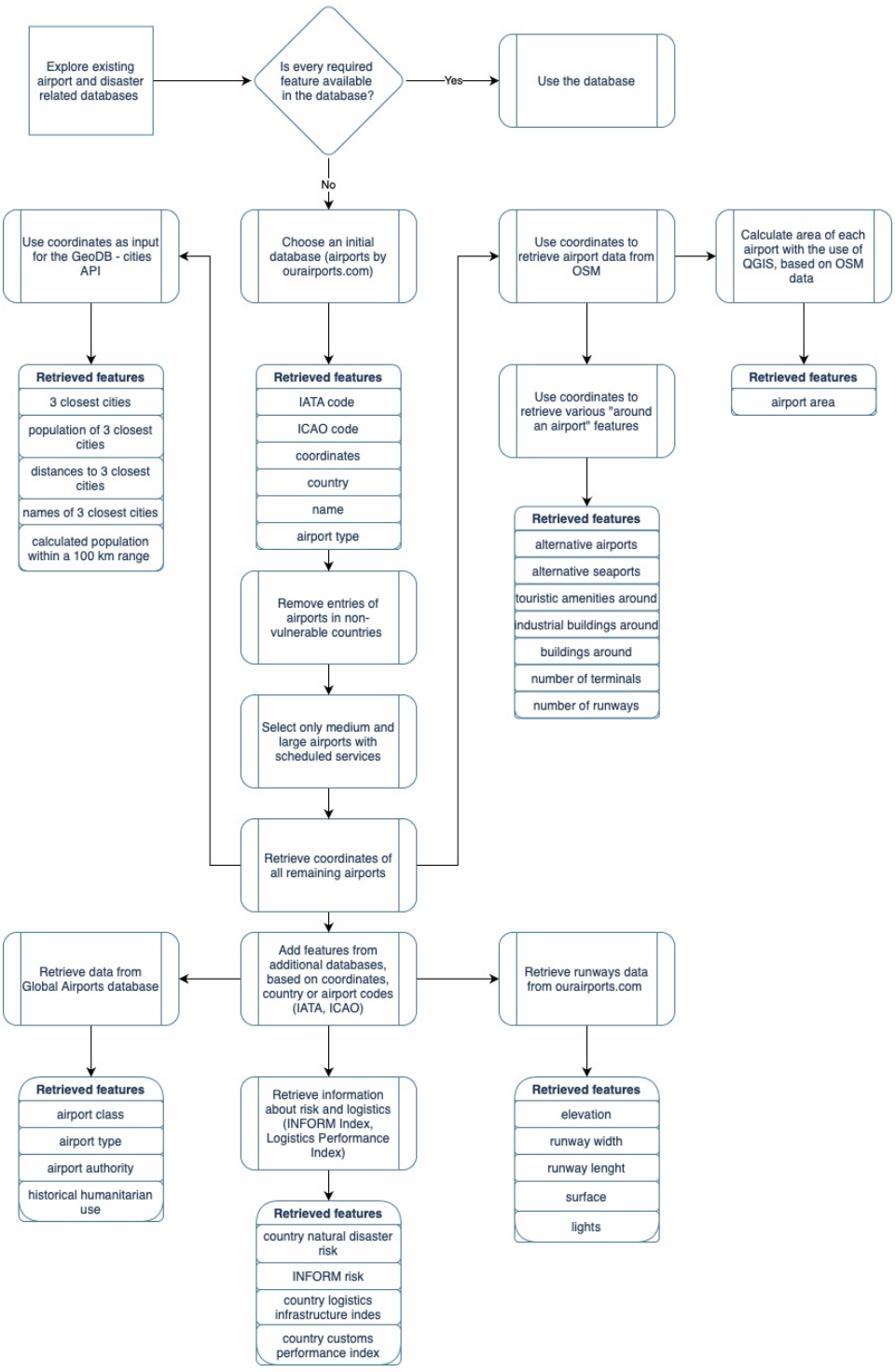


Figure 5.1: Process flow of data mining

into the level of connectivity, the distance to three closest cities is calculated, supported by the Logistics Performance Index for each country, to account for the quality of infrastructure.

Another challenging characteristic is the scale of humanitarian operations needed - this cannot be adequately assessed before a disaster - therefore, to have an idea about the possible scale of operations, the population around each airport is calculated. The main assumption here is that the number of people affected would be proportional the overall population around.

More of the assumptions and steps taken to extract the relevant information representing airports' disaster preparedness can be found in section 5.2.2.

5.2. Finding data

5.2.1. Data sources

OSM

OpenStreetMap is a publicly available, editable map of the world. It is being built mainly by volunteers, resulting in free geographical data, published with an open-source license, unlike the more well known maps providers such as Google or Apple Maps. The way it is developed is both its strongest side and a caveat - all the information comes from a broad community of users, who often provide with detailed information about remote places, that might have been overlooked by commercial map creators (Jokar Arsanjani et al., 2015). On the other hand, the quality of information can be contested - the validation processes are also led by the community of users, which makes it prone to contain false information, much like the well known internet-encyclopedia - Wikipedia. However, over the years OSM has proved to be a valuable source of geodata, often used in scientific research (Jokar Arsanjani et al., 2015; OpenStreetMap, 2021).

In order to extract data from OSM, Overpass turbo was used - a web-based data mining tool, designed to run OSM API queries and present them on a map. Since data needed to be extracted for over 900 airports, multiple scripts were written, with the use of the OverPy API, published under the MIT license (MIT, 2021). A detailed documentation of the scripts and queries can be found in the attached GitLab repository.

OurAirports

OurAirports is a free and public service that maintains data about airports around the world. Similarly to OSM, it is run by volunteers - members create records individually - but at the same time much of the information comes from official governmental institutions such as the U.S. Federal Aviation Administration (OurAirports, 2007). Apart from exploring an online interactive map-based tool, users can also download daily updated files with data records of all airports that are part of the service. For this research, data set of all airports and runways was used.

Logistics Capacity Assessments

Hosted by the WFP, Logistics Capacity Assessments (LCAs) is an online platform containing logistics capacity information of countries, relevant for humanitarian emergency preparedness and response (World Food Programme, 2011). In a given country, assessments are conducted every two years, mainly by WFP logistics staff as well as representatives of other humanitarian organisations and private companies, with the use of standardised questionnaires. As of 2021, information about over 100 countries was gathered, including descriptions of seaports, airports, roads, relevant contacts, customs, relevant administrator framework, among others. However, the level of detail varies between countries, as well as the structure in which the information is presented. There are no means of downloading the information, apart from exporting a PDF or a Word file, in which various relevant values such as warehouse area of an airport or available staff are hidden within a long text, rather then presented explicitly in form of tables or data sets. The staff responsible for maintaining the website was unable to help with the extraction, since the way LCAs are gathered limits the possibility to create a data set that would be easier to analyse en masse. After a few unsuccessful attempts of automated extraction of relevant data from text, it was decided to drop this data source, since it would have only enriched the list of features of only a limited number of airports in the final data set, due to differences in the level of detail available, as mentioned before.

Global airports

So far, the most comprehensive, publicly available, data set aimed at providing information on disaster logistics is called *Global airports* and was published by the Humanitarian Data service (Humanitarian Data Exchange, 2019). Officially coordinated by the World Food Programme, based on openly available data from sources such as OSM and OurAirports, it also contains inputs from partners though the Logistics Cluster and Logistics Capacity Assessments (Humanitarian Data Exchange, 2019). Even though the data set is updated, according to a WFP representative that was contacted, for many places the data has not been checked since the original upload in 2013. Furthermore, the data set contains fairly basic information on airports, as presented in 7.4. Data points presented in the table are not available for every airport in the set.

The Logistics Performance Index

The Logistics Performance Index (LPI) provides information on how easy or difficult it is to transport goods in the analysed countries. The World Bank, together with various logistics-related partner organisations conducts the survey every two years (Arvis et al., 2018). While aimed at assessing the logistical capacity in the context of trade and merchandise, some of the indicators are relevant for humanitarian logistics, such as the ones chosen to be included in this research: the assessment of customs procedures and the assessment of general quality of trade and transport related infrastructure.

The INFORM Risk Index

Led by the European Commission, INFORM is a global, open-sourced risk index for humanitarian disasters and crises, that describes three dimensions: hazard exposure, vulnerability and lack of coping capacities. In addition to being the qualification criteria for the final airport database, parts of the INFORM Risk index were also used to characterize airports.

5.2.2. Extracting data

Airport surroundings

Two strategies in OSM were tested in order to asses the surroundings of each airport. First, the ”landuse” tag was explored - all the nodes containing information on the land use within 5km radius from each airport were extracted. However, this led to inconsistent results - visual validation of multiple query outputs was conducted and it led to a conclusion that buildings-related nodes are highly over represented as compared to fields or other unused spaces. Therefore, for many airports, the result only showed a number of buildings within that radius, and no information describing the empty fields that were the true dominant surrounding.

The second strategy, which led to more representative results, was one based on purely the number of nodes with the tag ”building”. The assumption was that if the buildings are well tagged in OSM, simply the number of those nodes within the radius would describe how densely built the surrounding of the airport are. The lower the number of buildings around - the more useful space for organising humanitarian aid. A visual validation of multiple records was conducted, with a special focus on the outliers - airports with very low or very high number of buildings around. The surroundings of some remote airports was underrepresented, resulting in 0 buildings reported. While it was not true, the number of buildings was very little and the result was still useful.

Alternative airports

With this query, surroundings within a 100km radius were analysed in order to find and alternative airport. Unlike with choosing airports for the main database, with alternative ones there was no exclusion of those that are smaller or do not have an IATA code. The assumption was that any kind of airport within a close vicinity to the main one might work as a supporting space, even if not for landing the same size of airplanes, but perhaps storage and other humanitarian operations. Since airports are well tagged in OSM, the validation of results was positive - there were no overlooked airports found. However, depending on the quality and density of roads, an airport within 100 km radius might in fact be many hours away, which would not be a useful alternative. In future research it is worth considering finding a more accurate qualifying feature than the radius.

Alternative seaports
Similarly to alternative airports, alternative seaports were inspected within a radius of 100km. Vast majority of results showed 0 seaports and that was validated thoroughly and resulted to be true. Validation was also conducted for a high number of seaports counted - for some, the counted results was higher than the actual number of ports, because of multiple tags within the same seaport. It did however indicate the size of the seaport - often the nodes were indicating more seaport terminals or storage facilities. Given the small number of records that indicated seaports at all, all results higher than 0 were validated and manually corrected if needed.

Tourism vs. industry
In order to asses how well an airport is equipped to handle a sudden influx of cargo handling and not only a growth in passenger turnaround, it was decided that it can by assessed by the surrounding of an airport. Based on the insights from the interview with Chris Weeks, it was determined that airports that are situated in mainly touristic destinations are less likely to have a good capacity for handling cargo. Therefore, for each airport the amount of nodes tagged as ”industrial” and ”tourism amenities” was calculated. In order to account for over/under representation of certain regions, a ratio of tourism and industry related facilities is calculated - based on the assumption that if the region is under / over represented in OSM, it will happen for both types of amenities.

Runways
For each airport, the number of runways was calculated by counting the number of nodes/ways/relations with a ”runway” tag. All outliers were manually validated - those that resulted in 0 runways were corrected, since it is impossible for a functioning airport to have runways. The same was done for all record that showed more than 2 runways, since it is not very common for airports to have multiple runways, especially in remote places, which the final database mainly consists of.

Cities and distances
In order to asses how distant an airport is from the population it might be serving when a disaster strikes, three closest cities for each record were found, together with the direct distance (not by road) and population of each city. For this purpose, the GeoDB - cities API was used (Mogley, 2017). Based on the coordinates of each airport the three closest cities within 100km, containing population information were chosen. Validation was performed for a number of randomly chosen records and outliers, and manually corrected if needed. The API works with GeoNames and WikiData, which similarly to OSM are considered trustworthy sources, thanks to the user community input and validation scheme.

Population
Data gathered to describe surrounding cities was used to calculate the general population around each airport - as a summation of population in all three closest cities found by the GeoDB - cities API.

Airport area
In order to assess the storage capacity as well as the area available for setting up a humanitarian hub, the area of each airport was calculated. In OSM, each airport is not only indicated by a single node, but by a relation that indicates its borders. This geodata was exported and analysed with the QGIS software (QGIS Development Team, 2009). Thanks to built in features, the area of each airport was calculated. Validation was conducted on a random sample of results and the method proved to be effective.

5.3. Building the database

Data used in the research came from a multiplicity of sources, in various data-types and formats. In order to keep track of changes in the records and make the database easy to navigate, an SQLite database was built, with the use of DB Browser software. The OSM queries, the GeoDB - cities API and applied unsupervised machine learning algorithms were connected to the database through Python queries, as can be seen in the attached GitLab repository.
In order to add records and features to the database, outputs from various sources were converted in to the .csv format. Results of OSM and API queries were automatically written into the database directly.

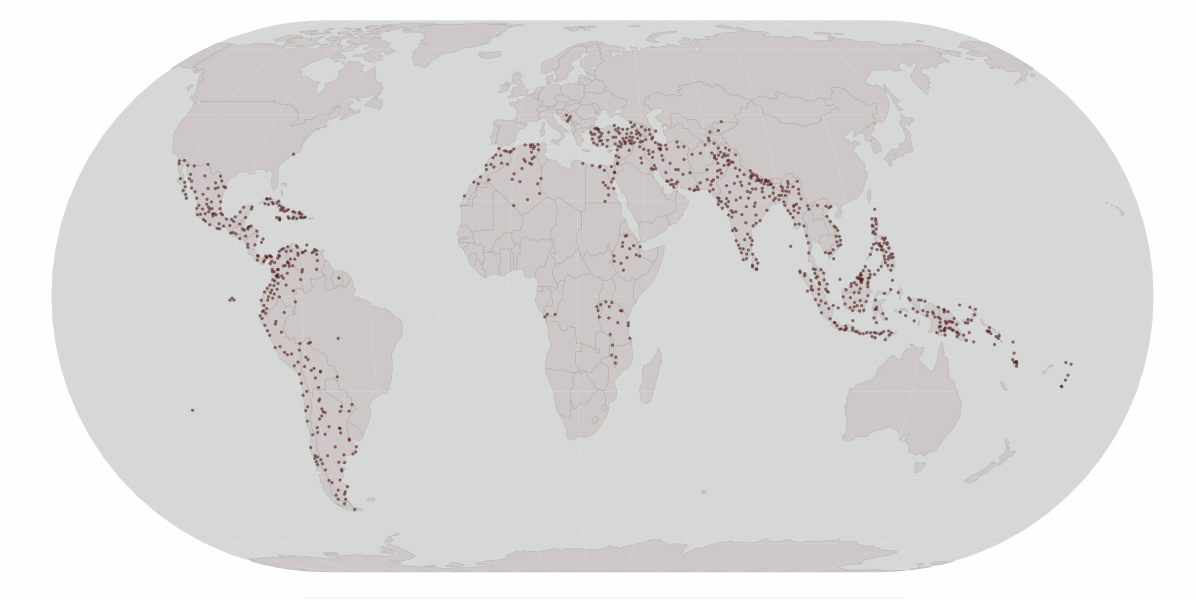


Figure 5.2: Analysed airports placed on a map

5.3.1. Choosing airports

Once the list of vulnerable countries was finalised, a list of airports from these countries had to be built. First, a list of all airports that are located within these countries was exported. For that purpose, OSM queries were used to find all nodes with the ”aeroway = aerodrome” tag, together with the IATA code, coordinates and any additional info attached to a node.

Next, the airports.csv file from OurAirports was used to select only airports that are currently operating, i.e. - have scheduled services. An additional criterion was the airport type - heliports, seaplane bases and closed ones were excluded, while small, medium and large were chosen.

These operations resulted in forming a list of 971 airports, with their names, coordinates, IATA codes and ICAO codes. This list would form the base for all mass queries applied via APIs described in previous sections. Figure 5.2 presents the 971 airports on a World map.

5.3.2. Adding features

The final list of all airports and corresponding features was built in the DB Browser and made available through the GitLab depository, both as a .csv file and a SQLite database. Features selected for each airport, together with the corresponding source, are presented in table 5.1.

Table 5.1: Final list of features and sources

Feature	Source
iata	OurAirports
airport_name	
latitude_deg	
longitude_deg	
country	
iso_country	self
seaport_count	OSM

Table 5.1 continued from previous page

Feature	Source
airport_count	
build_count	
industrial_count	
tourism_count	
terminal_count	
runways_count	
name_city_1	GeoDB - cities API
dist_city_1	
population_city_1	
name_city_2	
dist_city_2	
population_city_2	
name_city_3	
dist_city_3	
population_city_3	
population_around	self
elevation_ft	OurAirports
lighted	
max_length_ft	
width_ft	
aptclass	Global Airports
apttype	
authority	
humuse	
natural_dis_risk	INFORM Index
informrisk	
lpi_customs	Logistics Performance Index
lpi_infrastructure	
gard	GARD
airport_area	OSM & QGIS calulation
airport_type	OurAirports

5.4. Data pre-processing

In order for airports to be comparable for the unsupervised machine learning algorithms, the features that are describing them need to be turned into an *understandable* form for mathematical processing.

In this section, the pre-processing of text, categorical and numerical features is described.

Table 5.2: An example of encoding categorical features

	small_airport	medium_airport	large_airport	airport_type
Airport A	1	0	0	small_airport
Airport B	0	0	1	large_airport
Airport C	1	0	0	small_airport
Airport D	0	1	0	medium_airport

5.4.1. Empty fields

Due to the fact that various data sources were used, there was a number of empty fields for some features. Depending on the feature, these empty fields were filled either with zeroes or the mean value of all existing records. Missing fields in features describing whether the runway is lighted and whether there was a GARD training conducted before, as it was decided that if there is no information available, it is safer to assume the negative outcome. The elevation, length of the runway, width of the runway and missing INFORM and LPI risks were replaced with the mean values.

5.4.2. Categorical data

A number of features in the final data set describes each airport as a member of a certain category. For example, the `airport type` feature categorises airports into `small airport, medium airport, large airport`. While it is a clear and understandable distinction for a human eye, the mathematical algorithms require a numerical expression (Pedregosa et al., 2011). As proposed in the original publication on Self Organising Maps (Ritter and Kohonen, 1989), the categorical feature with three values was transformed into three binary features, with on equal to 1, and all others to 0, for each airport. An example result can be seen in table 5.2. To achieve that for each categorical feature, the LabelBinarizer function from SciKit (Pedregosa et al., 2011) was used.

5.4.3. Numerical data

It is common for many machine learning algorithms to require standardised data inputs, in order to perform well (Pedregosa et al., 2011). This also the case with unsupervised learning algorithm used in this research - the SOM. There are various mathematical transformations that can help to achieve a normally distributed data and it is important to choose one that fits the type of data the best. Again, the SciKit documentation, supported by various scientific sources (Huilgol, 2020; Kikugawa et al., 2019; Qian et al., 2019) and experiments was used to choose the right approach.

The Yeo-Johnson transform (Weisberg, 2001) was used to change the distribution of numerical data, since it was one of a few transformations that can be applied on negative and zero values, which the data set contained. The effect of the transformation can be seen in figures 5.3 and 5.4. While it was not possible to successfully transform all features, especially the ones consisting of 0/1 values, for most features the improvement is visible.

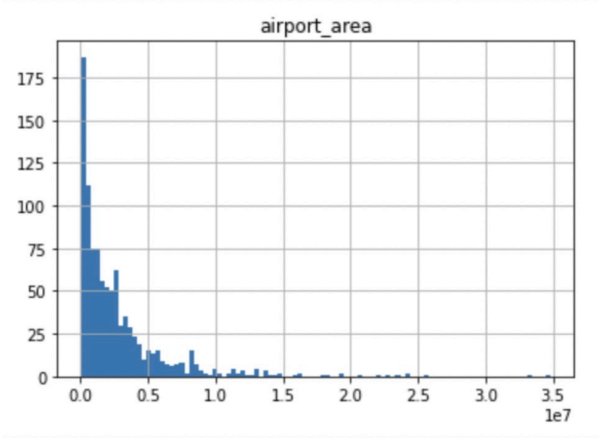


Figure 5.3: An example of data distribution before the Yeo-Johnson transform. Most of the data points are concentrated around the lower values. Applying SOM directly on a non-normally distributed data could lead to specific features being over represented, therefore the transformation is needed.

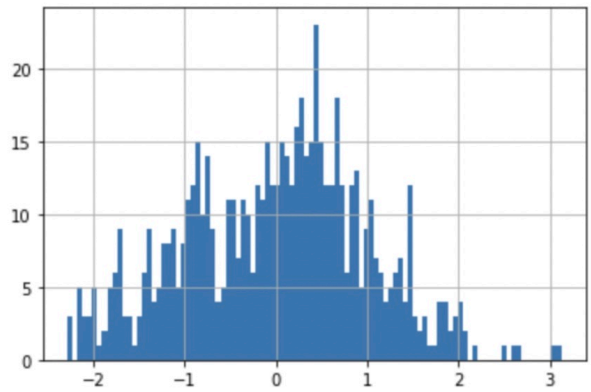


Figure 5.4: Example of data distribution after the Yeo-Johnson transform. The range of values has changed, however the relations between specific values are kept and the distribution is now closer to normal.

6

Unsupervised machine learning

This chapter describes the process of applying two unsupervised machine learning algorithms - Self Organising Maps and K-means Clustering - on the data set built in previous steps.

6.1. Self Organising Maps

In order to cluster airports based on their distinctive features relevant for disaster preparedness, an unsupervised machine learning algorithm was applied with the use of SOMPY Python library (Sevamoo, 2018). The whole process was thoroughly documented in the attached GitLab repository.

6.1.1. Training

The data set consisting of 971 records with airports and their features was split into two smaller sets - the training set with randomly chosen 70% of all records, and the testing set with the remaining 30% - resulting in the training set with 650 rows and the test set with 321 rows.

After the pre-processing was finished, all records from the training set were transformed into input vectors that can be processed by the SOM. For the first attempt each vector was a series of 36 numerical values, describing all the chosen features for each airport. Within the SOMPY API, each vector was normalised before the training of the SOM.

The training phase was repeated 100 times for various, randomly chosen sizes of the final SOM map, in order to find the best performing one, based on the calculated topographic and quantisation error of each training run. The smaller these values, the better the performance of the feature map (Anh Tu, 2020). Once the best performing map was chosen, a visualisation of each feature on a map was performed, as shown in figure 6.1.

6.1.2. Analysing results

The initial result, which is the SOM map shown in figure 6.2, tells us that the clustering was achieved only on a small number of airports. Each cell is labeled with a number of input vectors that were chosen as the closest to the best matching unit. By comparing the final SOM to the individual representation in figure 6.1, we can see that there were multiple dominating features that led the process of clustering. The dominant features were the categorical ones, a problem known as the *the curse of dimensionality* (Trunk, 1979). Simply put, there were too many 0/1 dominating features that influenced the whole clustering process.

6.1.3. Adjusting input vectors

Given the result of the first attempt at applying the SOM algorithm on the whole data set, a number of attempts at adjusting the input vectors were performed.

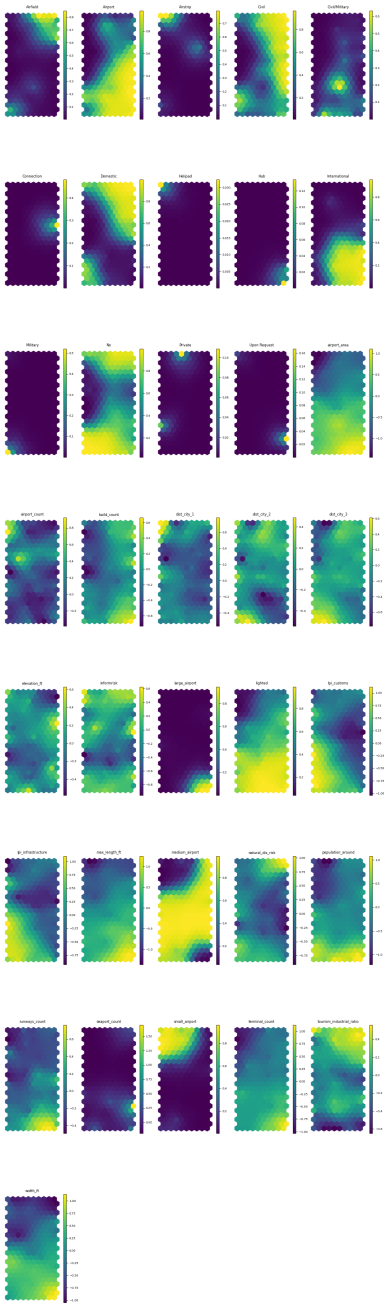


Figure 6.1: Visualisations of each feature in the first attempt at SOM. Each airport is placed in one of the cells on the map - the brighter the cell colour, the higher the value of the feature (eg. more terminals) or the value is equal to 1 for categorical features (eg. lighted airstrip - yes). From this figure, we can derive that there is a number of features that may become dominating, due to their distribution - concentration of the bright cells in a small area. It may lead the clustering algorithm to focus on these strong features, which does not necessarily reflect their importance in real life. We can also observe some correlations - large airports have more terminals and runways, which tend to be longer and wider than at medium and small airports. While it is a very straightforward conclusion, it can serve as a verification tool.

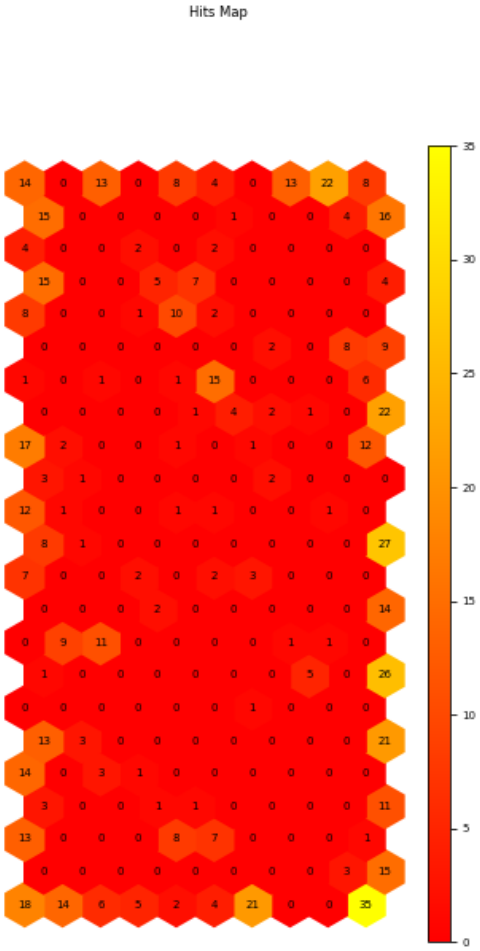


Figure 6.2: Result of the first attempt of the SOM. The brighter the cell, the higher the number of airports within it, meaning - the higher the number of airports that were grouped as similar to each other. By comparing this figure to 6.1, we can see that the biggest cell with 35 airports at the bottom right represents large international airports, with many terminals, lighted long and wide runways, with large area and many buildings around. Because these features are so strong, others are considered less important by the algorithm and can be very different within one cell (eg. both military and civil airports). The next step is to limit the number of repetitive features that describe the same kind of airport, so that others would also be considered.

First, the most dominating features were excluded from the data set, based on the individual representation of each feature in figure 6.1. The categorical feature of airport type was changed from the binary representation to a translation of *small, medium, large* into numerical values: 1, 2, 3. While it should not be performed for features describing non-continuous categories, the airport type does in fact sort the airports from the ones with smallest traffic to the largest, therefore it is acceptable to translate it into continuous values.

6.1.4. Adjusted input vectors - results

Again, the remaining features went through all the steps of pre-processing, transformed into input vectors and normalised. The result of running the SOM algorithm on input vectors reduced to 20 features is represented in figure 6.3.

A small improvement can be observed, with more input vectors clustered into groups of similar records. When analysing the SOM cell by cell, we can observe that cell 228, which consists of 24 records represents airports that have no seaports in their vicinity, have 2-4 alternative airports, have 1-2 terminals, are all of the medium traffic type and have the natural disaster risk between 4.0 and 6.7. For the rest of the features, no dominant value exists, there is a broad representation of each feature.

Another cell - number 0, that consist of 21 records, includes airports with a large number of alternative airports - between 6 and 27, 0-1 terminals, small traffic and higher natural disaster risk then the previous group - between 5.8 and 7.7.

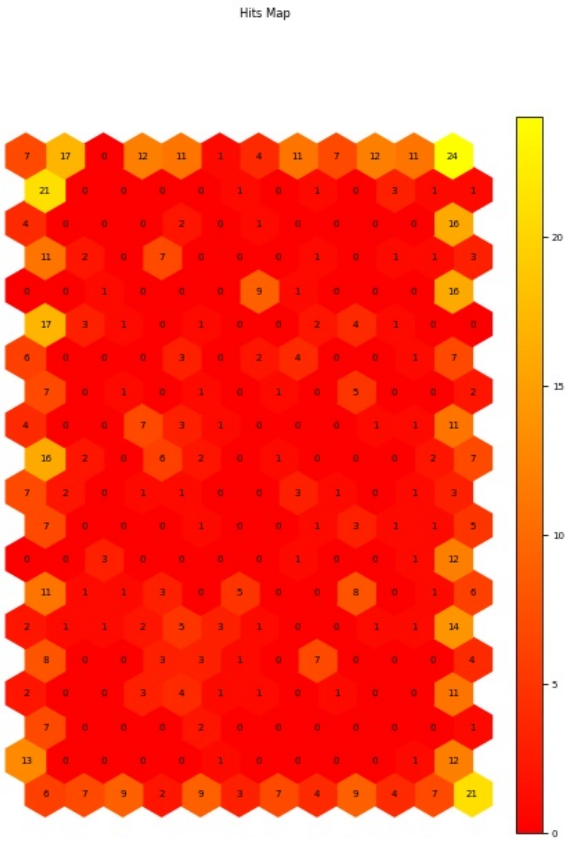


Figure 6.3: Result of the adjusted SOM. Thanks to removing some of the dominating features and adjusting others, we can see that the clustering is no longer focused on large international airports, and other features - not related to size and traffic - became more relevant. There are more cells with similar airports, as described in section 6.1.4. The attached repository (https://gitlab.com/maria.browarska/OSM-SOM) allows for investigating the output map in details - it can be derived which exact airports were put together in a cell, meaning - which ones were chosen as the similar ones.

6.1.5. Adjusted input vectors - clustering

The next step would be to cluster individual cells into groups. An example result is shown in figure 6.4. However, given the current performance of the SOM, the clustering results is forcing records that are not very similar to become part of one group. This leads to forming clusters of heterogeneous airports.

6.1.6. Verification

In order to verify the the way the SOM operates, a mock input vector was built and added to the input data. This mock vector consisted of feature values nearly identical to one of the records in cell 228. The algorithm was run again and the result was positive - the mock vector was added to the cell with other similar ones, proving that the SOM operates correctly.

6.1.7. Using the SOM map in practice

Regardless of the current performance of the clustering algorithm, or rather, the level of preparedness of the input data - since those two are strongly dependent - we can discuss how the proposed approach could be used in practice.

The attached repository allows for investigating the output map in details. With a results like the one shown in figure 6.3, it can be derived which airports were put together in a cell, meaning - which ones were chosen as the similar ones. This is the starting point for determining on what areas these airports could cooperate with one another. Sometimes, the similarity will result from a specific dominating features, with others fairly different, therefore it is important analyse the result before stating which airports are similar, only by looking at their cell membership. On this cell-level analysis we can also find very small groups of 2-3 airports that are grouped together, which could constitute an opportunity for a stronger cooperation. The higher level of similarity can be derived from additional clustering of cells, as presented in figure 6.4. Here bigger groups of airports are formed - while still different from one another, there will be a bigger diversity within members of each group. This can form a base for another type of cooperation, with more members who might not be identical, but still have some strong similarities. Here again it is important to analyse what are the common features that mainly influenced the grouping.

An example described in section 6.1.4, with airports grouped in one cell showing strong similarity in the low number of alternative seaports and airports, and medium traffic type, could be used to form a cooperation focusing on ways of preparing an airport with these specific conditions. Even though the airports themselves can be in distant parts of the world, their preparedness strategies can be similar, given their dominant features. Of course, these are only a couple of areas in which these airports can be seen as similar, and it is important to note the possible organisational and cultural differences. While the *airport authority* feature aims at describing the possible organisational scheme, there still might be more factors at place.

To sum up, the SOM map can be used as a tool to quickly group and find the dominating features of a big group of airports. The better the data describing the grouped institutions, the more accurate the result will be. It is easy to visualise and interpret, and it can be used by humanitarian aid and aviation experts without advanced programming or mathematical skills. A task of grouping such a big number of records while taking into account more than 20 factors would be impossible to perform by hand, therefore it is a great combination of using sophisticated unsupervised machine learning algorithm in an easy to interpret way.

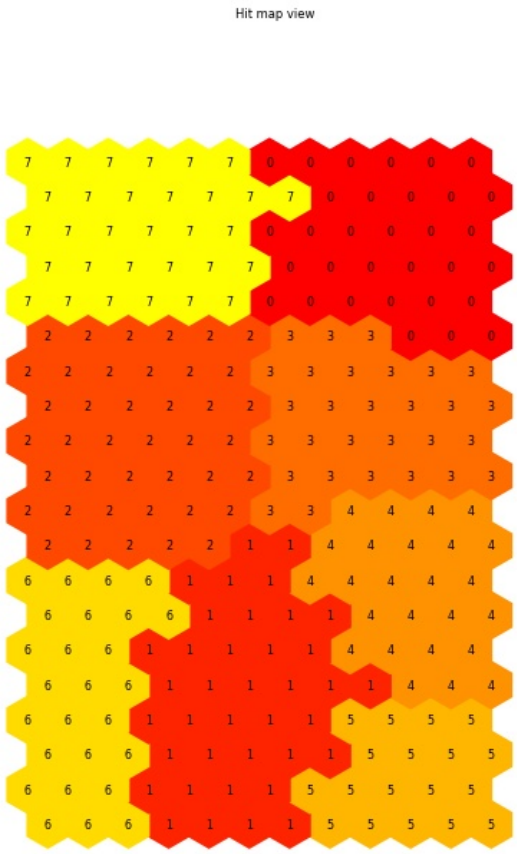


Figure 6.4: Result of clustering a SOM. Here, on top of the original SOM clustering and additional K-means clustering is performed. Cells from 6.1.4 were put into larger groups in order to find main 8 types of airports. However, given how dissimilar members of these clusters are, it was not possible to use this result for deriving binding, real-life applicable conclusions. More iterations of data pre-processing and adjusting feature weights are needed for this algorithm to perform better.

7

Limitations, discussion and conclusion

7.1. Limitations and discussion

This research offers an innovative approach on quantifying and clustering airports, with a special focus on their humanitarian disaster preparedness. While it was proven that there is a potential for building comprehensive data sets in order to assess airports' disaster preparedness and find similarities between them, the result of AI based clustering proved to be not good enough to find definite groups of airports that could start cooperation based on their similarities right away. There is a number of reasons that led to this outcome.

First, in order to produce relevant results with the ML clustering algorithms based on a self-built database, more iterations of pre-processing and input vectors adjustments are needed. Each small change influences the final output in a substantial way and a more detailed analysis of the influence of these changes is needed. With more experiments, a better performing clustering algorithm can be found, leading to actually grouping airports based on relevant features. The pre-processing techniques such as implementing ranges of instead of continuous values, as it was currently implemented for the airport area, should be explored. More over, various weights can be given to more or less important features. These actions proved to be more challenging than expected, due to the programming complexity of applied algorithms. However, there is a number of straightforward experiments that can still be implemented, together with more comprehensive validation procedures.

Secondly, as mentioned in chapter 5, the quality data sources used in the research can sometimes be contested, as the level of detail available for various airports and their surroundings was not always equal, which may lead to inaccurate results. This is also a problem with official sources, widely used by the humanitarian community, such as the Logistics Capacity Assessment. Interviewees mentioned the importance of access to dynamic data that describes the state of each airport and its surroundings at a precise moment in time, after a disaster strikes, because the static information gathered in assessments earlier can be inaccurate the moment a disaster strikes. However, interviewees involved in preparedness programmes rather than immediate response operations, underlined the importance of building comprehensive data sets with static information, in order to better assess what can be done ahead of a tragic event.

Another challenging factor is the accuracy of assumptions made - especially for assessing airport's connectivity. As proved by historical disasters, inability to distribute humanitarian relief from the airport to the population in need, can undermine all the operations and preparedness of the airport itself. A more sophisticated and accurate way of quantifying the level of connectivity could be used in future research.

7.2. Answering research questions

While answers to each research sub-question can be found in the body of this document, it might be useful to sum up the main findings that led to answering the leading research question - *How can AI-based clustering of airports help find a base for cooperation in the effort of humanitarian disaster preparedness?*. This section will sum up the results described more in detail in previous sections.

SQ1: What are the activities and procedures that take place when an airport becomes a humanitarian hub as a response to a disaster?

No matter the level of preparedness of any airport, when a disaster strikes, authorities can be sure of a surge in both passenger and cargo traffic - the first one related to possible evacuation of people, but also incoming humanitarian personnel and rescue teams. Those people coming in to help will be accompanied by large amounts of humanitarian goods, to provide food and shelter, there can also be plenty of rescue dogs - all these incoming people and things pose a challenge for customs procedures and storage facilities. According to GARD's estimates, the surge in passenger traffic reaches three times the usual, whereas the cargo operations are increased by the factor of 10. On top of that, the airport has to welcome media teams and VIP guests, ensuring all security measures. Once the airport operations are handled, there is also a need for logistical handling of all the people and goods that should be distributed outside of the airport - to the region struck by the disaster.

SQ2: What are the key intrinsic and structural features of airports and their surroundings that influence humanitarian logistics in a post-disaster scenario?

What happens at an airport once a disaster strikes is a complex mixture of structural capabilities, organisational preparedness, cultural habits, legal environment and many others. The activities described above require a great level of coordination that can be difficult to obtain without proper training and preparedness strategies. Operations in a post disaster scenario require vast amounts of space - both outdoor, for loading and unloading planes, parking, and landing as well as inside, for storing large amounts of goods and accommodating people. To that account, the area of the airport, the land available around, the number of runways, terminals and storage facilities become key features. When it comes to distributing goods outside of the airport, it is important to asses the connectivity and quality of infrastructure. Given the possibility of damage to the airport, resulting from the disaster that took place, it is also worth investigating alternative airports and seaports in the area, that can support the operations and offer additional capabilities. Coming back to the coordination challenge - while it is difficult to numerically assess the level of organisation, features such as private or public ownership, civil vs. military authority as well as history of preparedness trainings can provide some insight into the matter. Last but not least, it is also helpful to understand the risks which the airport is potentially facing - both in terms of vulnerability and general assessment of region's capabilities to face a disaster.

SQ3: How could the data describing airports be obtained?

While there are some existing databases collecting some of the above mentioned relevant features, not one that would take into account all relevant factors was found. The one closest would be the LCA, prepared by the Logistics Cluster, which contained detailed information about various vulnerable airports, obtained with detailed surveys and experts' teams. This information however was not suitable for mass algorithmic analysis, due to the lack of structure and non standardised, mainly text-files entries.

Therefore, the iterative process of data mining was needed for this research. Once gaining a thorough understanding of what capabilities should be described by numerical, categorical or descriptive database entries, various publicly available data sources were explored. Starting with internationally known airport databases such as ourairports.com, followed by user-based geo-data in Open Street Maps and various additional humanitarian and aviation related sources were analysed. Some of the features, for which no straightforward measurement could be found, were translated into various modifications of available data, such as calculating the area of an airport, based on its geo-data, in order to asses storage and aircraft handling capabilities.

SQ4: How can airports be clustered based on their structural and geographical features?

Once the database is build, it requires a thorough pre-processing, in order to be fed to a clustering algorithm. The SOM - unsupervised machine learning algorithm proved to be a useful tool, that allows for clustering airports based on a number of selected features. Even though the final result of clustering is not entirely applicable right away - there is still room for improvement of the data pre-processing, hopefully leading to better results - the applied method offers promising results, once refined. The SOM allowed for an easy interpretation and visualisation of the clustering result, making it a useful tool scientists and professionals not acquainted with advanced programming and mathematical operations.

Answering the main research question - the AI-based clustering can help in finding the base for establishing cooperation between airports that may face similar challenges in the process of preparing for a disaster and facing it. While it could not be fully proved with this research, the subsequent steps taken provide a valuable framework that guides through what should be done to successfully conduct a SOM clustering, based on a self-made database. This approach can be adjusted, both on the level of forming the database or in the direct application of the algorithm to the newly formed database, which is further discussed in section 7.4.

7.3. Scientific and societal contribution

Regardless of the limitations discussed in section 7.1, the database built during the research is a relevant and valuable output. It can be further analysed in a more detailed research, updated accordingly and used as a way of assessing airports' venerability and preparedness. Consultations with a founding member of GARD led to a conclusion that such a database would be a valuable asset for any organisation that specialises in preparing airports for disasters. Furthermore, the Vice President of ACI Safety and Operations expressed a need for a similar database with a stronger focus on airports' capabilities, that could be used by operators regionally, in order to better know their closest alternative airports.

From the scientific perspective, this research proves that there are now ways of analysing detailed, specific challenges with a global overview, based on numerous publicly available data sets. It also shows that scientists need to be very careful when using not precisely scientific sources, and that building a specific, tailored database is a lengthy, challenging process. Nevertheless, it can be achieved not only by IT professionals, but also multidisciplinary researchers.

The subsequent steps taken in this research provide a valuable framework for approaching similar challenges - from understanding a complex socio-technical environments of airports and their disaster preparedness, through building a database with relevant features, based on interviews and literature, using only publicly available data, followed by a thorough data pre-processing, and finally applying the SOM algorithm to finds similarities between database entries. The challenges and problems encountered along the way, both solved and unsolved can form a useful tool for other professionals and scientists willing to conduct a similar research, not only related to the domain of aviation and disaster preparedness.

An additional finding, not directly related to the outcome of the research, is identifying the need for a common, reliable database with all relevant information about airports in vulnerable locations. The one designed during this research could form a base for a one built with official data sources, that are otherwise unavailable to the public. With that however comes the challenge of security, since detailed information about airports can be viewed as sensitive data, therefore access to such a database should be regulated.

7.4. Future research

The ideas for future research can be divided into three sections - (1) related to the data mining and the process of building the database, (2) data pre-processing and applying the SOM algorithm, and (3) using the results in various ways in order to improve airports' disaster preparedness.

Building a database solely from publicly available sources has some drawbacks, as discussed in section 7.1, such as limited trustworthiness and inability to retrieve the exact types of information that are needed in order to describe specific features. In the future, it is worth considering building a similar database with direct involvement of the airports that are being described - with the use of surveys and possible involvement of international humanitarian and aviation related organisations such as ACI or OCHA. This would allow for retrieving more specific data, up to date information. Moreover, if regularly updated and maintained, it could become a useful resource for airports that themselves would like to know more about capabilities of alternative ports in the region - not only for research purposes, but for operations once a disaster strikes and help from neighbouring ports is needed. Other scientists could also use such a database for various additional analyses, saving time for gathering the data and focusing on what can be derived from it.

However, the database that was built in this research is itself a valuable resource for improving the clustering analysis or performing other research related to airports' preparedness for humanitarian disasters. With additional iterations of the data pre-processing, there is room for gathering more insightful knowledge on similarities between airports, that would form a solid base for establishing cooperations. In order to achieve that, future research should focus on identifying the dominating features and adjusting the algorithm accordingly. This could require more sophisticated methods of data pre-processing and automating the process of analysing results, in order to quickly pick up combinations of features that cannot offer trustworthy results.

Once the algorithm and data pre-processing is adjusted correctly, there is room for deriving additional conclusions from the results. It could be used to identify the airports that are especially vulnerable, due to their inartistic features and capabilities, which could form a base for building policy advice. This process would have to be accompanied by a thorough analysis of historical events that took place at similar airports, and the lessons learned could be used for improving preparedness of those that might face similar challenges in the future.

Regardless of the area chosen for future research, it is worth involving organisations that specialise in raising awareness and preparing airports for disasters, such as ACI, GARD, HADRA, among others. Representatives of all above mentioned groups expressed the need for a better data gathering and sharing between airports and were interested to get involved in similar projects in the future.

Appendix

Table 1: Scopus search strings

Number	Search String
1	TITLE-ABS-KEY (airport AND humanitarian)
2	TITLE-ABS-KEY (airport AND emergency AND plan) AND (LIMIT-TO (EXACTKEYWORD , ”Airports”) OR LIMIT-TO (EXACTKEYWORD , ”Airport”) OR LIMIT-TO (EXACTKEYWORD , ”Disaster Planning”) OR LIMIT-TO (EXACTKEYWORD , ”Disaster”) OR LIMIT-TO (EXACTKEYWORD , ”Emergency Plans”) OR LIMIT-TO (EXACTKEYWORD , ”Emergency”) OR LIMIT-TO (EXACTKEYWORD , ”Mass Disaster”) OR LIMIT-TO (EXACTKEYWORD , ”Tsunami”) OR LIMIT-TO (EXACTKEYWORD , ”Tsunamis”) OR LIMIT-TO (EXACTKEYWORD , ”Emergencies”) OR LIMIT-TO (EXACTKEYWORD , ”Emergency Planning”) OR LIMIT-TO (EXACTKEYWORD , ”Rescue Work”) OR LIMIT-TO (EXACTKEYWORD , ”Architectural Design”))
3	TTITLE-ABS-KEY (self AND organising AND maps)

Interview with Virginie Bohl, 2.06.2021

Maria Browarska: What are the main challenges in the first 48 hours after a disaster strikes?

Virginie Bohl: When the airport is damaged, there is a need for assessment and the key decision to make is, when do we reopen, what ways can we use, considering that, from time to time, there are some works being done on the runways. I remember one example where all the information that we had received was to that the length of the runway was X, I don’t remember exactly. And I had received a contradictory information that said, no, no, no, it’s not. And in fact, the runway was under under repair when the, when the emergency stroke. It becomes an issue, and we need to find the information very quickly because the sizes of airplanes differ. So, then you cannot come with a big airplane if the runway is shorter than usual. So again, the first challenge is the power operational, do we have the light to receive planes during the night? Or can we reopen it only during a daylight? So, this is the very first question. Then for us, as you might know, the challenge we are having is the number of incoming flights after an emergency. What are the priorities? Which planes to accept first? So, most of the time the military planes are treated first, because of their strong capacity. They are quick to offload and load, et cetera, and it’s mainly the cargo. And then you have all these commercial flights, that are coming with search and rescue teams that with, with emergency relief terms, with emergency medical teams, with dogs et cetera to respond to the disaster. Another challenge is the staff itself. Where is the staff, is the staff at the airport? Are there any injuries, but also, the staff that should, go back home and those that are coming to the airport for work, what is their situation? So, in terms of staff, it’s also important to know that another challenge are the passengers, you have regular passengers at the airport, what do you do with them? How do you provide them with water? For example, if they have to stay here for, for 24 hours or 48 hours, whatever time you need to look after them. So, it’s very important. And another point are VIPs. You always have a minister; you always have the emergency relief coordinator of OCHA, and all these are high level people that want to come. And when they come, it means that more security is needed. And it means that, there’s less room for workers and for people that need to work and to arrive. So, you need to book the VIP room, for example, at the airport, which could be used for the media, for example. Then you can say, okay, this room would be familiar It’s a bit isolated from the rest. We all know that these rooms are a bit away from this, but then if a VIP comes, we need to find a place for them as well. And then you prevent you from having a room for the media that are a bit isolated and do not disturb the operations. So, these are the several challenges that I see at the beginning of the interview, more might come in my head, but these are the first one that I can think of.

Maria Browarska: The challenge of welcoming VIPs is something new for me, I have not though about it before. But it does make sense, they do require security and are important for the public image.

Virginie Bohl: If you have Macron or I don’t know who are coming on sites because they want to help, et cetera. There is a lot of security measures that are taken and an additional burden for the

Table 2: Global Airports Contents

Attribute name	Description
rwlengthm	Runway length (meters)
city	Nearest city served by the airport
icao	ICAO code
iata	IATA code
aptclass	International, Domestic
status	Open, Closed, Restricted
dmg	Existing damage (Yes, No, Unknown)
rwlengthf	Runway length (feet)
elevm	Elevation (meters)
elevf	Elevation (feet)
humoperatedby	Humanitarian organization operating through this airport
locprecision	Precision of the location
longitude	Longitude of the point in Decimal Degrees (WGS 1984, Calculated automatically from the geometry)
iso3_op	List of ISO3 code (separated with a character '-' or ','). Use to quickly filter the data for the features of interest for 1 operation
lastcheckdate	Date of the last check of all (or a part) of the attributes. The date has to be specified manually during the edits
remarks	Notes/Description/Remarks
nameshort	Name short
namelong	Name long
namealt	Alternate name
gdb_geomattr_data	
shape	Geometry
url_lca	Reference to the LCA page of the feature
geonameid	geonameid of the closest village/town from the geonames database
rwwidthm	
latitude	Latitude of the point in Decimal Degrees (WGS 1984, Calculated automatically from the geometry)
iso3	ISO3 code of the country where the feature is located. This field is calculated automatically at the database level
country	Name of the country where the feature is located. This field is calculated automatically at the database level
rwpaved	Runway paved: Yes, No
createdate	Date when the feature has been created. Calculated automatically at the database level while saving (commit) the edits.
source	Source of the information. It could be the source of the geometry or the source of the main attributes. Several sources can be accepted for the same feature(list of names)
authority	Authority managing the airport: Civil, Military, Civil/Military, Private
humuse	Used by WFP for humaniatarian assistance: Unknown, Yes, No
updatedate	Date of the last update. Calculated automatically at the database level while saving (commit) the edits.
apttype	Type of Airport: Airport, Airfield, Airstrip, Helipad

airport in particular in the first days. The scale of emergency is important to consider, whether there has been a heavy damage or not. That changes a lot.

Maria Browarska: I wanted to ask you a question about the coordination of all the things that you just mentioned - who takes charge of the situation and how does this legally. Because you said that this one situation received information that wasn't really true about the runway length and how does it work? Because I know that airports have to have their emergency plans and they have some staff that has some roles, but I can imagine in many airports, they're not actually prepared to the scale of the disaster. And emergency plans are often only for a fire of an airplane, but not for an earthquake and everything damaged. So, I wonder how it is with taking over responsibilities and who gets to decide on what is happening, where. Is it the international organization that did just get there and take over things? Or the airport itself and its authorities?

Virginie Bohl: The responsibility always remains on the affected country. It's always that the very first responders are the government agencies. So, the responsibility remains to the national authorities. There is no way we can, well, except in Haiti, but it is a different situation I, during which, the Americans cover the airport and as organize everything from that, otherwise, as UN or any intergovernmental organization come to compliment the efforts of the national authorities. So whatever capacities, they have a weak government or a strong government in any case they have capacities and then we come, we come and compliment what they are doing. So, the overall coordination is done officially by the national authority, but the UN has several mechanisms, that come and can assist the government in strengthening these response capacities and coordination capacities. You have the UN resident coordinator. That is the first contact we see with the higher authority of the countries that the president or the prime minister or the national disaster management agency that coordinates the work. At the airport, the civil aviation and the director of the airport is, most of the time, calling for a meeting, to make all the decisions and the HADRA working group that I was co-chairing until the end of December, was immediately in contact with these people to let them know what's going to come, such as, as I said, search and rescue teams, dogs and emergency medical teams, et cetera, so that they know exactly what is coming to assist them in their efforts. We do work a lot with DHL as well. They have a program that you have probably heard of, which is called GARD, Get Airports Ready for Disaster, which is a preparedness measure and provide a support to governmental agencies. But you also have a disaster response team DRT that are made of volunteers of DHL and that are deployed to assist the airport. We used the management of the airport and the planes that are coming to the affected country.

Maria Browarska: Thank you for clearing this out. You have been involved with various organizations. Are there some kinds of conflicts of interest of those organizations? The main goal is to always help in humanitarian aid, but it's a lot of organizations together. And there's plenty on different manuals and rules and guidelines on how to do this. And does it change from region to region?

Virginie Bohl: Well, first of all, I have always been with OCHA for 20 years and I left in December 2020. And during the work with OCHA, I was the chair co-chair or HADRA and I was a co-chair with ICAO. I have created these group myself, during the networks and partnership week, and then I've asked ICAO to join, which is the obvious partner with OCHA. The biggest problem is coordination. The word coordination is key because, they all want to see things coordinated, but they don't want to be coordinated. So, of course there are conflicts. OCHA has the role to coordinate, this is why OCHA signs different MOUs with different organizations, with DHL. The collaboration is very strong with IATA and ACI as well. Depending on the willingness of all the partners of the group and the members of the group, then the coordination is very efficient because all these partners understand their role. This is a win-win situation in a way, because you benefit from the expertise of OCHA, you benefit from the expertise of DHL or from the expertise of ICAO. And then the coordination works well, but you will always have some organization that try to reinvent the wheel that want to jump in without knowing the international mechanism, that are in place So indeed, it is a challenge, but, when you are in the UN then your connection with the government is easier, let's say, and then you have the chance to have other words to say during this coordination and this moment where, this is a nightmare and a major, major crisis, and you can make sure it can be coordinated. And the governments, more often ask OCHA to coordinate that if people contact them directly, they say, please talk to OSHA. So then more and more the government, and the sense, the importance of this coordination role and understand that working hand in hand and not separated brings a major benefit to the response. So, it's a challenge, but more and more mechanisms are in place to make sure this coordination is efficient and effective in the field and at the airport. The highest UN representative in the country, called the resident coordinator and

he's the key person that has a direct contact with the president or minister of all the countries. And of course, this is OCHA's first focal point when there is an emergency. He helps coordinating the process of issuing or accepting the assistance that is offered, which is two different things on the legal point of view that I can explain if you need. And then the mechanisms are activated and deployed to the field.

Maria Browarska: I asked this question about different groups and coordination, because I also found the Sphere Standards handbook. But it seems like a completely different approach and way of working. And is this used everywhere or is it just, like you said another approach in different groups?

Virginie Bohl: is used everywhere. It depends on what you're talking about. Me, I'm talking about the immediate response to an emergency. So, I'm talking about, let's say the 48 hours or the first days in the emergency, and then you have specific mechanisms. Sphere is to standardize. For example, they have this idea that a family tent for four persons should be that size. And if you want a kitchen sets, then it should be composed or this and that. To make sure that if you import tents for example, the tents will be a useful for six months and not import tents that are used for a weekend after a week as they are destroyed, because it's too windy or whatever. So, so this is the kind of things that are used in the provide phase of an emergency to make sure that what is used is standardized and people should respect these standards. So, it's very useful and very why we used by the humanitarian community.

Maria Browarska: Is setting up tents already in the first 48 hours?

Virginie Bohl: Well, it is, it is as well, but if if your question is about the airport, then the quality of the goods that come at the airport are not the responsibility of the airport.

Maria Browarska: I wanted to ask about one of the links that you shared was from the logistics cluster. The logistics capacity assessment website, we have information in various countries. And from what I understood, it's assessed by some local groups that are allowed to do this. I saw the guidelines of how to take that information. Is it something that is actively used when a disaster strike?

Virginie Bohl: It's not updated. So, this is why we created the HADRA group. This is useful information, but it is static information. If we take the example of the runway, I was mentioning earlier. In LCA you have the length of the runway in normal time. It does not include the information if there are some repairs, if the runway is closed and in times of emergency, we need to have live information. This is why the HADRA group was created. And we have a WhatsApp group that I have created that I had created two get immediately from ICAO the information about the capacity of the airport now. After the emergency, I don't mind what it was one hour ago. I don't want to know what it is now, so that OCHA and the decision makers can make the best decision and an informed decision to deploy staff or not to deploy stuff. And I cannot wait for the information. I need information. Now, this is why we were working on an automated system to transfer the information from the app or to an automated system to OCHA. So, then they immediately known, and of course share the information about the situation. Now, now, now it's, now I need that. I don't need it one hour ago. I don't mind because there was no earthquake, but now there is one and all the situation has changed. So, what do we do now? And it's very urgent because people are dying. So, so we need information now. So, the LCA is very useful. It's a very important information that we base our work on but it's not enough in times of emergency.

Maria Browarska: You mentioned that you are working on automating this, is it already happening or you're trying to set up some system that could help?

Virginie Bohl: Not yet. If you look at the website, of the humanitarian networks and partnership week. I had the two meetings on the third week of that event. And the second meeting was about this tools that the HADRA expert group is developing. So, the idea that we had set up when I was a chair is - we had created an airport situation form with standard fields. And it includes information about the position of the airport, the name of the airport, and some static information that you have also in LCA. But you also have fields indeed the runway you have fields about the possibility to have fuel at the airport. You have enough fuel at the airport for planes? Are we talking for fuel for the lorries that will take the goods from the airport to the affected area? What about the electricity? Is it working, is it enough? Yeah, so you have some information that are changing all the time after an emergency and can change every two hours or whatever, every half an hour. And then we have created a template that they have automated thanks to blockchain mechanism. So, a presentation was made but I don't think it is finalized. Unfortunately, I could not attend this meeting and I'm not chairing these rooms anymore. So I have some other work to do on a customs and imports, which is my key activities now. If you have anything that you can share about this, that that would be great. First of all, I will send you the template of the reports and different situation reports that we have issued during previous emergencies, so that you can see from situation report number one, two, three. Often, we share the information. It is most

of the time daily, sometimes it is even twice a day because the situation changed so quickly, and you might have actors needing information. So even if you only have two updated information, we publish it because it is useful for decision makers to have this information.

Maria Browarska: Do you happen to know more about designing a humanitarian hub? What goes where, what is it decided on?

Virginie Bohl: The work is made by the coordination team. You have a mechanism that is called reception and a departure center. If you look at the website, you have this and when the search and rescue teams and OCHA they do work with the government to set up the hub. It's for the coordination team that works with the government to tell us where tents can be established, if there is a hub to stock items when they arrive before they are cleared by the customs, a lot of information is, is needed and it is the teams that most of the time organize these we with the reception and departure center. And you can find a lot of information and guides on the internet and on the website of OCHA.

Maria Browarska: I wanted to ask about more the practical side of your work that you used to have, if there's a disaster and then the humanitarian teams come and is every event like this assessed afterwards? On which things went wrong and which things went well and in order to learn for the future.

Virginie Bohl: Yes, of course. I can share with you the assessment; I think for after Mozambique. And then after I left and where there was no major emergency, but of course there are and available and shared with always the government and recommendations to make sure that next time it's better and better prepared. Then the problem is that major emergencies do not happen all the time. Even if you have if you have an emergency in a Mozambique, as we had, for example where the country was not prevailed at all, even if you make a recommendation, now the next emergency may happen in 20 years. So, how do you make sure that the government implements the recommended measures in Katmandu? For example, the previous emergency was at the beginning of the previous century, so a hundred years before. So, you have no power, and you cannot ask the government to implement these recommendations. And in these poor countries they have a lot of other priorities that incrementing measures, for an emergency that might never happen while they are having their role in the government. Recommendations are made, then there is no one single entity that can impose and they're the government to do it. For example, unfortunately they have not realized that they are not ready because they have not implemented the measures, we have asked them to implement, or we are recommended to implement our they're trying to make efforts.

Maria Browarska: Do you see a potential in grouping similar airports and encouraging them to cooperate, and perhaps offer similar recommendations? You mentioned it's mainly about the coordination, but is it also about the technical features of an airport?

Virginie Bohl: For me it's both. You may remember the attack in Brussels. It's not a natural disaster but a major event and how well they were prepared to these types of events. So, I'm not sure it is a question of having a nice airport and a big airport. It's about the willingness and awareness to organize. If you look at the other trainings that are done by DHL and and others during the GARD training, you may have got trainings in very nice apples, and then you'll realize that they are not ready at all. They do exercise for airplane crush. They do have firefighters and they have exercises, et cetera, et cetera, for a natural disaster they just don't do all these exercises. So, wherever you are, if you don't do simulation exercise, if you don't understand what the humanitarian community will come with what type of equipment they will bring, what they do, you can bring et cetera. Then you can have a nice airport. If you're not prepared, you are not prepared, and you won't be able to cope with that.

Maria Browarska: Do you think it is something that should be better regulated legally?

Virginie Bohl: One of ICAO's annexes talks about it, but it's mainly for airplane crash and not natural disasters. HADRA was created because we have realized, and ICAO has confirmed that they do not take into account these types of events. So, they are ready, but not for the cycle of event, which brings different challenges and bottlenecks and difficulties if they don't think of it before. They just cannot cope with that. And this is the objective of HADRA. And this is the work that we have been doing with ICAO for two years is to raise awareness, to try to draw lessons from, and to have best practices from different airports to issue a guidance. To inform the civil aviation and members of ICAO and take into account the risks that come with climate change – there will be many more emergencies. Capacity building is very important.

Maria Browarska: I can imagine it might take some time with big international organizations.

Virginie Bohl: Members are slow that it's very difficult. They are different. And the problem there is that when you have a group of experts that work with emergencies, whenever something happens, they

have to pause all the long-term work in order to help with the current emergency. We were working last year and had a plan to finalize these guidelines I think February this year, COVID-19 and then there was Lebanon. And then we have to stop everything because our priority is to save lives during this emergency. So, we are unable to write and to continue our regular meetings to do this work. So when there is no emergency you have to cope with the work that you have not done, and then try to resume these activities and boom another emergency. And then you have to stop again, because otherwise we have to contribute to these guidelines because we are the experts. And these experts are not available when there is an emergency. And unfortunately, it happens more and more. So, it takes time. In addition to the challenges with government, then it's not that easy even with a strong, willingness to back things up, but I'm happy that HADRA is working and making progress. I'm happy that I have created this group, it does make a difference. We try to find gaps and not reinvent the wheel. So, we need to have everyone on board, all the experts that have the expertise on board takes time, but I never give up. So, then I could influence.

Maria Browarska: HADRA is an organization formed with experts from other organizations, are they getting involved in their free time?

Virginie Bohl: Usually yes, but step-by-step, they do include this work in their work plan. It becomes something that is their regular activity. Step-by-step you build on that and if there is a win-win situation, then people contribute and then include the work into the daily activity. So, yeah. But initially it's a bit difficult because they cannot necessarily understand what the issues are and why they are part of this group. But then they realized that there is a lot of things to do. Same thing with customs administration. I work a lot on the importation and customs challenges, and they realize it's a lot of things to be done.

Maria Browarska: I was going to ask you that because you've now moved into this topic. And is it because you felt like this is now the most pressing topic?

Virginie Bohl: So, I worked on this topic on importation and customs for 14 years. And then I was involved in the GARD workshops several times. And I could not understand. DHL and UNDP and OCHA, they were doing a lot of work on provideness and this activity to prepare airports with these experts from DHL was key. Unfortunately, there was no connection between the providers and the response. I said, then you are doing a lot of work at the airport to train people, but when there is an emergency, how do we use the work you did? So, I said, we need to work together. We need to get the information we know is good to make an assessment of the airport. It's good to train people, but what is the trigger to activate this mechanism in case of emergency. It does not serve any purpose. If you don't get in touch with these people, if you don't know what the challenges are, the airports are to give me information out. So, this is how it started. I'm not going to reinvent the wheel. I'm just going to try to connect the dots. And this is my main strength in my work is that I don't do the job. I just ask people to do the job because they are the expert. So, I just make sure that they are online and they are with us and contribute. And again, a win-win situation and airports, they have realized that by connecting with the humanitarian community, they better understand who we are, and we better understand who they are. And then how can we work together? Which was not the case. All these things were completely separated. And same thing with customs. I had a meeting, we sat with the customs administration, and they said, we, everything is in place. We know how to deal with this influx of goods and, and diplomatically I said, no, you don't, you don't use it. You have your rules, but your rules are not adjusted to the needs of the humanitarian community, which is a different world from yours. You have rules and regulations. You have customs code at the airport. You have simulation exercise for planes. It's the truck. It's not the same at all. You have one plane that is burning. When there is an emergency, you might have a hundred of planes that are waiting in the air to land. How do you do that? How do you inform them in advance that they cannot come because you don't have the capacity? How do you inform them there that you need fuel? And you don't need any new cargo books for kids, but you need fuel, and you need you need the tents for people and all these types of things. You don't need that. How do you communicate all this information? How do I know that my plane cannot land during the lights because your electricity is down or this type of information, they just don't realize how big a humanitarian response is when there is a major disaster, and this is why these groups needs to be created. And analysis as you are doing, needs to be done so that they better understand their role and how important they are. These are the two main customs administration, and an airport are the two first entities that we meet when we arrive in a country. They the first one, if we just talk to the managerial level, this is not an operational thing. They are just deciding how to implement these things, how to be effective and efficient. You need to know the actors; you need to know who they are. You need to

know what they want to go, where they want to go to, to bring you to your country. And you need to control, you have to protect your borders as well. So how would you do that if you don't work together in advance?

Maria Browarska: That's great work that you are doing.

Virginie Bohl: We make a difference. So, so that's good. And I really appreciate students when they are studying and making analysis of all these, because it's me also sources of information and additional arguments to the government. So that's why academic it's academic is very important. Such as a private sector or whatever we need, we need all the brains to convince governments that there is a need something to do to protect the population. This is what we are doing. We are saving lives in the end. So, the work you are doing is to save lives.

Interview with Thomas Romig, 15.07.2021

Maria Browarska: I'm very happy to be able to talk to you about the things that you were doing at the Airport Council International. So you've already seen a bit about my research. I'm investigating how well airports are prepared for a sudden onset disasters. I'm doing in a way in which I want to find some similarities between airports around the world and the way they're built and their capacities and various things related to how they operate in order to find airports that are similar to perhaps start some kind of cooperation. I build this huge database, getting data from various websites like ourairports.com, and a lot of things from open street maps, global airports and other data sources I could find. And for each airport, I have 18 features that describe them. So how big are its operations? What's the area? How well it's connected to to the cities nearby, how big the runway is and various things to account for how it would perhaps behave in case of a disaster. So whether there will be enough place to to set up tents, to set up medical centres, whether they would be able to to handle cargo and other things like this. What I would like to know from your site is how ACI is looking into such things. And you said you've all been working on resilience and looking into the future of airport preparedness. I'm looking into a very specific kind of resilience to a complete disaster. So either an earthquake or a typhoon or something like this, I know you can also look at resilience in a more general way. Not necessarily an earthquake right away, but just more rain or perhaps even the financial resilience in terms of sustainability, because aircrafts have to change and be more sustainable, have different fuel, etc. I would like to to know what ACI is generally doing in terms of this resilience. And I've read the report that you sent me about the survey and we can talk about it in a moment. For starters, the general agenda of ACI onresilience would be great.

Thomas Romig: Sounds good. Just maybe to qualify before I give you an answer because there is about a hundred different areas that we could talk about. Yeah, but just to clarify, in terms of your research, are you looking at resilience in terms of responding to significant weather, let's say natural disaster type events? Yes. So it's not it's not resilience in terms of management of climate future evolution of climate change. It's not resilience in terms. Well, I mean, obviously, major weather events are generated to the extent by climate change, but it's not adapting airport infrastructure or making airports more resilient to economic situations that we've been experiencing over the past 18 months with covid and so on. It's you're looking more at the major catastrophic type events.

Maria Browarska: Yeah, I narrowed down to those extreme events. It only happens to some of the airports, but it does happen and repeats.

Thomas Romig: Yeah. There's a lot of different things we can talk about in that particular space actually ACI has initiatives in terms of on the highest level, has initiatives in terms of airport system resilience in in making sure that we have a longer term sustainable aviation system. So that's one of the highest level approaches that we're taking. If we then break that down into different areas, we have, you know, looking at resilience of airports and airports being a lifeline to communities that are affected by major events. We have initiatives underway and we're working actually with with a number of different organisations on this particular topic in an area which we call more humanitarian assistance and disaster recovery. HADRA, as we call it, um, where basically well, actually, most recently we've been working with ICAO. The International Civil Aviation Organisation, I'm sure you know them, and a number of different aviation stakeholders to develop some guidance material for states and then operators underneath in terms of how to respond to or how to prepare for the response to these types of events. We've been also working with DHL and the GARD programme, which you may have read about - getting airports ready for disaster. And so what we have been looking at and working with

them on is actually that's the last element. It's the training portion, if you like, where basically we're providing with GARD training to two states here. It's more operational level type of training and as well as the the airport operators and different stakeholders at the airports. And then in between those two levels, we've also been working on developing specific guidance material, which we will be working on this because we're still finalising an agreement with the World Food Programme to develop guidance material for airport operators, to allow them to understand the impact of the initial response and sustains a response which takes place by the different recovery agencies, all of the UN agencies which come in - the Red Cross and so on, which come in to support communities once there's been a major event somewhere. And so we're working, you know, bringing expertise from an airport and bringing expertise from the city's response agencies, UN agencies, to to build guidance material for airport operations, which will allow them to be able to have a much clearer view in terms of how they need to prepare and and what they need to be looking at in terms of ensuring that the operation will be as safe and efficient as possible. One of the big challenges that a lot of airports who are affected by these types of events have is for one, they have to have the right resources, human resources available still to be able to manage the operation. Often they are recovering themselves from, you know, infrastructure damages and others. So they're rebuilding or clearing debris and so on when at the same time there's suddenly an influx of huge or and bigger aircraft than they often have within their operating conditions, which they then have to find space for parking. They have to find fuel supplies, they have to find handling supplies and so on and so on. And so this can often be a big challenge for the airport operators that don't traditionally have very sophisticated plans to be able to manage these types of events. Unfortunately, one of the problems that we've identified, too, is that the a lot of airports who are affected by these types of events are unfortunately in regions of the world that aren't necessarily the most developed. I mean, there are some obviously, you know, if you look at what's going on across Germany right now with huge amounts of floods and stuff there, I don't know if there's any airports that are flooded. But there's you know, those would have the right response mechanisms. But then, you know, we've been working very specifically with the Caribbean airports. We don't necessarily have, you know, huge amounts of funds for developing systems, tools, methodologies, having the right human expertise in terms of, you know, bringing in the right resources to be able to develop their plans. And so this has been one of the challenges we've been faced with, too. So those are some of the areas that we're currently working on. And there's another project which I'm involved in. But this is just very recently, which is a project with this CDRI. I don't know if you've heard of them.

Thomas Romig: They are the Coalition for Disaster Resilient Infrastructure. It's a UN unissued type of organisation there. They have some ties to the UN. And what they're actually doing is it is a fairly extensive study which is going to be touching on one hundred and fifty different airports. So they're interviewing one hundred and fifty different airports to identify what has been done and what areas. Well, what are key elements necessary to manage the disaster recovery? Basically, the project is focussing on infrastructure, resilience, and in particular for airports as a lifeline during recovery of operations following major events. So it seems to be very similar to what it is you're looking at, except they're obviously doing this on a very broad scale and they've actually hired in a consulting company to do the interviews and so on. But there may be some once this has been released, there may be some similarities or at least some elements that you could pick up from in your in terms of your research they're working with NACO. NACO is based in The Hague, just around the corner from you.

Maria Browarska: Yes, pretty close by. And do you also cooperate with CDRI like an outside consultant?

Thomas Romig: I'm just I'm part of the steering group. They need the airport input.

Maria Browarska: Thank you for the comprehensive response. I also talked to Chris weeks from guard before, so I got to know a bit more about how they're working. Regarding the CDRI study - they will be getting into all these airports one way or another probably and getting to know everything about it. And what I am trying to do is kind of gather insights from the information that is already out there. So, since I could not find any comprehensive data set, there are some that were done in the last years, like the logistics capacity assessment, for example, from the logistics cluster. And this is also done by people just being at the airport and actually listing all the things that they see, the runways, how it works, the important context. But then it is stored just as this PDF or word document with the desription of an airport. And then also World Food Programme at some point had a database of airports and the things that are relevant in case of a disaster and it was called global airports. But they kind of dropped it at some point. So they're not updating it anymore. And then I also talk to Virginia Bowl. She said,

she mentioned that there is this new group or new database being built. And I'm not sure if you know about it, but the general need for a database that kind of gets information about all the airports around. So this is what I'm doing on my own. But of course, it's not going to be perfect because I'm basically using freely available data and because I can not to talk to nine hundred seventy airports, because that's how many I have now from.

Thomas Romig: Well we have one thousand nine hundred and thirty three members.

Maria Browarska: So yeah, I'm probably looking into some that they're not members of the ACI because I use the various risk assessments to find airports in vulnerable areas. So it's Asia and South America. I'm wondering how useful that is, because I also saw in the in the survey that you sent that there was mentioning of databases and airports saying they would like to have access to databases. And I wonder what they mean exactly by that. And what kind of data do airports want to have or they want to collect or what could help them in such situations?

Thomas Romig: Well, I think there's different different answers to that. One of the things that we've heard a lot from airports is the need to be able to have or is the cross collaboration between airports that are affected either in, you know, jointly in a single region or otherwise, one airport which is close to another, where here there's the major event and this one is 100 or 200 kilometres away and becomes the base of operations and people are trucked in and out and so on and so on. And so there's there's been a I'd say, one aspect of the communication or coordination which is necessary amongst airports in certain regions, which has been brought up in a number of discussions. Another one is to understand the capabilities on a regional basis between different airports that can support each other. And we've had a number of discussions over time between airports who basically have offered help to one area which is struck by disaster or an airport struck by disaster, is requesting for help. But they don't know the capabilities of the other airports around them. So there's having a comprehensive view or at least having more of a an easier understanding for the exchange of these types of information would be useful to the database, which were the tool which has been developed or has been developed by by the HADRA group, which probably told you about is a tool which in my understanding is more used for communication and coordination once an event has occurred than an actual database of consolidated information. Today, a lot of the communication coordination is done with smartphones. And sort of a coordinated WhatsApp group which works itself. But it's not the most effective way of doing things, especially since you have to rely on the, you know, a few people who have access to that WhatsApp group, at least to initiate the process. Yeah, this this new tool which has been developed as has gone one step further. And it's really sort of institutionalising and structuring the communication coordination process between the different response agencies and the aviation sector. If I mean, if you're interested, you could probably have a meeting with the people, who are managing this tool.

Maria Browarska: Yeah, that would be nice, thank you. I liked the things that you said before, this is not something that I thought initially about because I was looking into it like a very wide perspective with airports around the world and finding other similarities between them to kind of start cooperation between airports that might face similar challenges, even though they're in completely different sides of the world. If one already had a guard training, for example, and it's very similar to the other one, maybe they wouldn't have to be in training at the other end, that they could just cooperate the airports themselves and find some similar ways of dealing with their problems. But what I'm thinking is that the information gathering is also could be useful for establishing this this capability in a smaller region. And I wanted to ask you, do you think it's actually possible to for airports from very different sides of the world to cooperate, once it's established that they're on some level similar to each other? And by that I mean, for example, it's an airport on an island with no alternative airports around and just two roads getting to it, with low cargo capabilities, for example. And do you feel this is something that would be possible to arrange once those similarities are fully established and they're believable and you can see that there would be room for them to talk about the same kind of problems.

Thomas Romig: I mean, there's different mechanisms which are already in place to do that. And I mean, that's one of the purposes of our organisation, is to connect airports amongst each other. We have technical committees and operational committees which bring together the operators of different airports, either on a regional basis or on a global basis, to discuss exactly these points through through various other programmes. We also have what we call the Apex in Safety programme, which is a peer review programme where an airport requests a peer review and a number of people from other airports, you know, similar size, similar complexity, similar type of environments and we put together a team and we send them off to that airport for them to do a review to have an exchange with the airport operation.

So so I'd say those mechanisms are already very much in place and work. Well, I like the idea of finding similarities between airports. The challenge I think around that is there may be infrastructure similarities, but then there's two sides to how an airport works. There's the infrastructure and there's the operation and there's people behind the operation. And then you have if you build in to the people or to the operation, the people, you have a culture. And the way of operating in one airports, even if it's a very similar infrastructure to another one, is going to be quite different because of the operating model and because of the the cultural aspects, as well as the the traffic types that you have within the airports or within that that airspace, the country and the demand in terms of passengers. This is across the thousand, almost two thousand airports we have, we always tend to see one airport as one airport. You very, very rarely have very specific similarities. And so it may be that, yes, from an infrastructure perspective, you've got a runway with a parallel taxiway in a building here and this and that. But if you think about it from then the you know, you take the two halves of what I was just saying, the operations and the where the operations are on this side, the infrastructure and the operations, you end up with some significant differences, even if this portion, the the infrastructure is very similar. So so I think I mean, from a general principle. Yes. What you're getting, you know, where you're going with your thought process is correct. But in the practical terms, I think it may be a little bit challenging. And then you have to also bear in mind there's another big challenge that we have is the is the language barrier. And we find often in particular in smaller airports, English is not a common language. You know, there'll be one or two people who have a decent level of English. Which is the common aviation language, but it's not necessarily going to be the right people for discussing operational recovery or infrastructure resilience. And so then what we find is we spend a lot of time and energy either doing translations or trying to coordinate the language barrier across our different members.

Maria Browarska: Well, the language barrier is not something I thought about, but it's pretty obvious now that I know it. So you're talking about these two sides. And this is something I kind of am taking into account. But of course, let's say, it's a proof of concept - I am trying to find a way to do this, because on this database that I'm building, that I'm applying machine learning algorithms and they're just grouping those airports based on what I feed them. And so I have both the structural things, but also the more organisational ones. So whether the airport is private or is it a military or a mixture of this, how big the traffic is, whether it's more a touristy place or an industrial area to see whether they're going to handling cargo or not, how populated everything around is, how well connected it is, the general, the airport class, whether it was used in humanitarian events before and some other things like this. So I'm kind of trying to to have both of those sides. But of course, there's plenty of other things to try to assess, but I think it could be doable. And I wonder, do you have a way of classifying those things somehow, the organisational ones?

Thomas Romig: I mean, we would love to - that's one of my future projects would be to have a comprehensive database of, the operational capabilities of airports. I think it would be fantastic to have that. But it's a big challenge being able to have that amount of data and that amount of up to date data. I mean, we tried a few years ago to get a capacity study to basically understand the available airport capacity from the terminal process, aircraft parking process and runway capacity tied with the airspace and put together a short questionnaire and more series of questions around that and capture that information and the challenge that we then had or I would with at the time. But when the teams that did that put that together, the getting of the response in common taxonomy across those those different areas from a global perspective was a nightmare. And so having everybody agree on when we say passenger per our capacity is this and it's based on that or runway movements per hour, it's this. It's a very complicated way of being able to work their complexities to the global scale of what we're looking at. I think what you're doing to me makes a lot of sense. But there would maybe be a regional scope that you need to bring into it. I mean, I understand, you know, let's say an island state in the Pacific may have a similar configuration and let's say operating model ish to a similar airport somewhere in Africa. But, you know, coming back to what I was saying in terms of the needs from an airport side, it's to understand across those island states, for example, what the capabilities and what the the options are in in that particular region. Or if you go to Africa, to the Caribbean - what is there that similar between different airports where they can support each other and they can bring in expertise, they can bring in material help if necessary, one when one is affected by a major event. I'd say that's the the fundamental of the a lot of the discussions that we've had with airports in terms of the data that they would like to have available, the information they would like to read. So if you can if you can find a way to solve that problem, I will hire you, no problem.

Maria Browarska: When I'm, finished with this one! This is very interesting - the more regional angle, and it also seems like a more applicable right away, but also using the things that I already did, I think that would be a nice mixture. You usually do a lot of reports and guidelines, and I wonder how is it from the legal perspective andwhat's your view on that? Because, well, there are some things that are legally required from airports like that, for example, the airport emergency plans. But there are mainly for a terrorist attack or a fire in the airport or something, but not necessarily weather related events. So how do you see the difference between the things that are required by law and just the guidelines? And how should it be with resilience adjustments?

Thomas Romig: It is a very good question. In terms of regulation, you have, let's say, several different levels. You have the global regulation, which is established by ICAO, which which is applicable then to the Civil Aviation Authority. So it's the state which receives the obligation from ICAO to implement something. And then the state goes to the operator of the airport and says, please do this. Then each state has their own way of, putting that into application. Some states will do a direct application of ICAO regulation. And so what's written in the ICAO annexes, pens and guidance material is directly applicable to the airports. Some other states, for example, France, would do what's called a declared ministerial, which would basically be a transformation of that international regulatory material into the French law, which allowed it to then be applicable to the airports. That's the case here in Canada, for example. So that's that's the legal mechanism. And what we do as an industry representative body is we work on two different levels. We work on industry guidance material, which is only guidance, and airports decide whether they apply or not. And then we work on the upper level in with ICAO very, very closely. And me and my team spend probably 60 or 70 percent of our time working with ICAO, and that's why we're based here in Montreal to bring the industry level, bring what we've developed from a regular and from a recommendation level into the regulatory framework. And so what often happens is that the the industry knowledge, the industry intelligence, if you like, which we've developed through our guidelines, gets transformed a couple of years later into best practise or recommended practises or standards through the industry, through the sort of regulatory bodies with. There's a very similar mechanism which takes place with the EASA having the European states being regulated by EASA. And we have a European regional office based in Brussels that does exactly the same thing as we do, working very, very closely with EASA in Cologne. So we've got very, very similar model being done there. And then we have regional offices working with the specific case, the civil aviation authorities across the world. You know, a big, strong office here in Washington, for example, working with the FAA, having a huge reach. So from a legal perspective, what ACI develops in terms of guidance material is purely guidance. But we work very closely with the authorities, which actually develop the legal documentation, legal regulations, or to then make sure that the operators views are integrated into that and that we solve challenges with regulation that we are faced from an operator perspective. So if we find that there is a particular area where we have an operational or safety challenge or security challenge or environmental one, let's not get into sustainability environment because we could spend all day talking about that. But but you know, where we find that there's a challenge where we need a new piece or to adapt the regulation will work with to get that, as best as possible formulated so that it's applicable to the states, it takes a long time. You know, going from the initial thoughts to the actual regulation being applicable can take up to four to six years. But that's that's the way it goes.

Maria Browarska: That was going to be my next question, how well this this operation works and how fast can things be done? And I imagine not so fast.

Thomas Romig: I mean, the answer to the first question is important. So the cooperation is excellent. And that's why we were lucky, I'd say, to have built over the past what now has been here in Montreal for 10 years to have built a very, very close relationship with ICAO and to be listened to by the regulators, by the states. If we come and we say there is an issue in this particular area or this regulation which has been proposed is going to have a negative impact in terms of the industry, very often that's very well understood and taken on board by the regulatory bodies. So there's a very, very close mechanism in relationship which is there. We actually sit in all of the different levels of the organisation to make sure that we have checks and balances, so to speak. And so we'll be in the working groups will be in the panels, which are the the formal mechanisms to validate what's been developed by a working group. We also sit on the commissions, which are much higher up, as well as on the council, which is the final decision making body for any regulatory developments. And through that, those different levels, we we keep an eye very closely and build the coalition necessary to steer the regulation in one way or another. And so it works well. And then the timeframes is an interesting question, because now

it takes, let's say, about four years to be able to go from initial question, initial problem to a regulation being implemented. But we do there are some mechanisms which we're working on to do sort of a streamlined approach where if from an industry side there has been industry or even a state regulatory body, there has been sort of tested, proved and guaranteed results out of a regional or local solution, there is now a mechanism which exists to basically do a direct submission. And this becomes pretty much regulation through a streamlined approach. And it doesn't have to go through all this organic development from a working group to a panel and so on and so on. So that's a good, good solution. But we diverge a little bit. Sorry.

Maria Browarska: No, that's great to hear. That's actually kind of surprising because you tend to imagine big organisations not working very fast, especially if they don't share all interests.

Thomas Romig: Think of the challenge that we have in a very different domain - urban air mobility and drones, you know, the speed of development from industry is huge. And we're sitting here in airports saying, well, you know, we're going to have various types of unmanned traffic flying in and out of airports. And there is already now and there will be more in the next five years. And in ten years there's a good chance they'll be people sitting in there and they'll be coming in directly to the terminal building to go into their aircraft. And how do we, you know, from a regulatory side that the mechanisms are so slow that there is no accompanying regulation. And that's why now there's been this accelerated type of process which has been brought in to allow for much more streamlined and reactive, agile process, if you like. You know, everybody's talking about agility nowadays, but it is really that's an agile process, iterative, agile type of process, which allows for a much faster regulatory development. There's still, you know, those people hanging onto the edge of their desk say, no, no, no, no, let's not do this.

Maria Browarska: Also the way of forming the law so that it's adaptable and doesn't have to be changed soon because the technical things will change.

Thomas Romig: So that's also important. And when we work to formulate regulation always before we look to be performance based. So we're not saying how you do something. You're saying what it is you should be doing. What's the objective? And then how to do it is up to somebody who's going to decide how that's implemented specifically and us, the airports, we can then, you know, it says this is what we should be doing, how we achieve that, what is going to be up to us to decide with our local states?

Maria Browarska: Thank you. My next question, also related to this sort of guidelines versus rules. What I heard from people in humanitarian organisations you have the vulnerable airports, but it's not like all of them are very keen or just you know, they don't realise the things that can happen to them. And they're not the first one to start working on their capabilities, on their preparedness. I was thinking from their perspective, is it something that you feel like you should be keeping an eye on and kind of forcing or at least maybe not focussing, but suggesting somewhere that they have to do certain things in order to still stay part of their organisation? Or should it be more the airport sides? And then you're going to be there to help if they if they ask for it or. How how would that work?

Thomas Romig: So we don't have any programmes which are mandatory to be part of it. If an airport would like to sign up and be part of our organisation, that's fine. There's no new requirements which are set on airports. Just to be clear on that, what we do though is build awareness campaigns when there's particular challenges which have been identified for the moment. Unfortunately, I'd say this has not been something which has been particularly high on the agenda of the organisation since I've been here. I only joined the organisation in November last year. I used to be based in Geneva, Switzerland, running the operations at the airports in Geneva and having a fair component of humanitarian response. And with the international organisations which are based in Geneva, we've got a lot of contacts and a lot of people within that space, too. So it's been something which since I've joined the organisation here, I've raised the awareness a little bit more around it. We've had also a lot of discussions with our office in Latin America who are very concerned about the increase in the number of major weather events in that region. And I mean, we saw last year more hurricanes than there has been in the past. And this year is expected to be, again, more so it's starting to become more and more of an issue. And that's why I mean, there's you know, this awareness is is now very timely. But that's more or less where it ends for us. We don't go in and say, you have to do this, you have to do that. Now, if we do identify that there's a particular requirement to have a business continuity plan or a or an infrastructure resilience or operational resilience plan for disaster recovery, then there would be mechanisms which could be involved through the regulatory processes to be able to mandate that. But it's not something

which is globally applicable. So then I come back to where you started with the and we never finished that discussion on the airport emergency plans. Yeah, there is there is an obligation to have an airport emergency plans that's inscribed in the annex 14 to the ICAO convention, which is one of the regulatory documents. And there's a lot of guidance material which goes with that. And it's part of an airport emergency plan, a well developed one. The airport should look at the risks around it to what to what extent is my airport prone and subjected to major weather events? You know, I developed fifteen years ago the airport emergency plan for Geneva Airport. And one of the first elements we did was to do a risk assessment was to base ourselves on the the National Risk Assessment, which had been done by the states as well as various risk assessments we did ourselves and look at historical events to say these are the types of events we need to cater for in our emergency response plan. And snow operations became a core element of the emergency response plan is in Geneva. There's not as much as here in Canada, I now realise, but there is still still a fair amount of snow. And so, you know, typically that something. I went and did a peer review of the airport in Togo a couple of years ago, and they had in their emergency response plan, snow. And I said, how often does it snow here? And they said, oh, no, that was the French consultants that said we needed to have snow in our emergency response plan. I said, yes, OK, well, you can cross that part out because it hasn't snowed here and it won't. It's 30 degrees all the time. But, you know, these are typically the types of things which that's a bit of a joke. I mean, it was real, but, an emergency response plan should cater to the risks that the airport is affected by. So it's not just a terrorist attack or an aeroplane accident or a fire in the terminal. And as part of the guidance material, which we provide to airports and the courses that we provide in terms of training material, that's inscribed in there is the notion of risk assessment to develop here.

Maria Browarska: What I meant with my examples is that often it is just more or less copy paste of the airport emergency plan, and not a very thoughtful process, like in your snow example.

Thomas Romig: That's another big challenge. I mean, if you want to look at the problems and we could you know, we need another couple of hours to talk about it, but if you want to look at what you're trying to do is is find ways the airports can be more resilient, right? Yeah, but the problem that we have today, you know, another regulatory requirement is to be certified and aerodrome has to be is a certified organisation and to be certified. It's the state who has to come and audit that. In some regions of the world, we've got up to 50 percent of the airports that are not certified. And even in some regions, it's up to 75 percent of the airports, if I'm not mistaken, who have not undergone an official certification process. And the reason why they haven't done that is because of exactly what I was saying, that they don't have either the airport or the state don't have the right understanding, the right competence to be able to actually develop the procedures and maintain the infrastructure in in such a way that it can be certified. And the translation of the regulatory material into the actual operation on the field is today lacking in, unfortunately, many, many states. And so that's really one of the big challenges that we have, is is making sure that both from a state level but from an airport level to the operator has the right understanding of the regulation, has the right understanding of the of the requirements to be able to implement them properly. So if you back up a little bit and you bring this to the resilience issue, and when you can't, you really you know, states or airport operators have challenges doing so-called simple things like developing standards, airport emergency plan. If you want them to think even further down the road and say, OK, well, how would you respond to, you know, a major climate event and influx of operations and going on this sort of you know, they get completely lost. And that's today one of the big, big, big challenges which we're faced with, which is why we've been trying to do these various guidance materials and training.

Maria Browarska: But it's a big challenge. You mentioned that every year there are so many areas that are uncertified but are still operating airports with numbers like that. Well, that's also surprising. I mean, it's such a highly regulated industry in which you would never think that that things can happen.

Thomas Romig: I mean, then, you know, you come back to commercial and passenger demand. If you have an airline, it's there's a few airlines that say, no, we're not going to fly to an airport because it isn't certified. What the airline will then do is put in place a number of mitigation measures or risk management measures to manage the risk of that non certified airport where the pavement may not be in the best condition o you have you know, you have challenges with the lighting systems, which sometimes will go out. So you're flying in at night and. Suddenly, there's no lights on the airport or you've got wildlife issues and the airlines are conscious of this and with your aircraft operators are conscious of this and will put in place mitigation measures. This was a few years ago, but a good friend of mine who was a pilot for a major airline used to fly into an airport in Africa where they had it in their

standard operating procedure to do a low pass over the runway. They would do the loop and come back and land and the load pass over the runway was to scare away the animals. Because nobody else is doing it. And they didn't want to have a big animal on the runway.

Thomas Romig: I mean that's one of the problems that one of the multiple problems that we're faced with these types of situations is, you know, coming back to what I was saying earlier. Unfortunately, often these major events happen in countries that don't have that level of competence or the level of financing which is available in European countries or let's say others.

Maria Browarska: Thank you! I think I have most of the questions answered and I can get back to finiding similarities between airports.

Thomas Romig: I think the thing to bear in mind from my perspective is really the the difference between what you can perceive in terms of infrastructure and type of operation and then the operation itself and having knowledge of the operation itself, unfortunately, unless you have direct access or contact to the airport, is going to be challenging. And having been to a lot of airports around the world, it's really that those two sides of the the system which steer how effective the response is going to be.

Maria Browarska: You mentioned that you tried this global capacity assessment of airports. Are there other things that you would be looking into? Apart from just a capacity to have the general understanding of what those airports are?

Thomas Romig: Well, no, for the moment, I mean, like I said, I would like to, but we don't. I mean, we have an extensive economics and airport, and passenger and movement data. We've got huge amounts of that because we've got a whole team that provides forecasting. But that's probably less relevant to what it is that you're doing. We have airport safety data, which is the incidents and accidents, but again, is less relevant to what you're doing from a, you know, capacity and infrastructure and operational perspective. Unfortunately, we don't have any really global benchmarking type of approach in the future. I'd like to be able to have that.

Maria Browarska: The safety data collection programme. Right. This is more about incidents at the airports themselves, right?

Thomas Romig: Yeah, exactly.

Maria Browarska: OK, but it means that there are things that are being quantified and assessed and then grouped together in some databases. So there's hopefully also a possibility to do this right for emergencies.

Thomas Romig: To go one step further with your project, the best thing to do would actually be to create an interface for airports and this is something we could look at as a project where this is to create the interface, where airports actually put data in and make it available to the community on the other side. That would be one opportunity to be able to look at to take it a little bit further in the future.

Maria Browarska: This is one of the things that this kind of part of the conclusion and discussion that this could be useful if the data there was 100 percent real coming from the airports and not just from publicly available sources. OK, I'm not going to keep you any longer. Thank you so much. This is really, really helpful.

Interview with Chris Weeks, 10.06.2021

Maria Browarska: Since you've already sent me those Excel sheets about picking airports for the programme. I wanted to ask a bit more about this because in some videos and reports about GARD, what I saw was that it's airports that come over to you and ask for your help, I think, and they can do that. But I assume that you're not going to go to absolutely every airport that asks for it. So now I see that you have procedures for picking those.

Chris Weeks: We use the priority list that I sent you as a kind of a check, really. The way it really starts is we look at airports in a particular region and we like actually it works very well taking airports that have been already affected by a disaster. And then we tend to take airports nearby that are likely to be affected, but we use that. The priority list is just to check that they are in the red zone, they're there, they really are affected. Sometimes it's the reason we've done this is that sometimes airports want to have it done, but they're not actually high risk, so. That might sound a bit odd, but part of the trouble we have with all this is that we're not aircraft operator, rather than airport organisation, as you can imagine, and we're not naturally connected to, you know, the people that run the airports, but that they're highly relevant, obviously, when things go wrong or disasters or whatever, but to make an approach to an airport, to say, you know, we'd like to do a disaster response preparation project, the

GARD workshop. Sometimes we get through to the wrong people, sometimes they get the wrong end of the stick, sometimes they think it's for an airport emergency rather than for after a natural disaster and we've had instances where airports want to have the GARF programme, but actually they're not particularly at risk. And others we've had where the airport we think is at risk, but they won't agree to have it done. So, you know, we tend to work with airports that are in a disaster zone and are willing to listen and understand what it is we do and what that commitment is. Because the programme is designed more of an education programme than a consultancy programme, and it's not that we teach them. We show them what problems they might have if a disaster hits the country that their airports located in or the region, and it's up to them to do the work once we've done that, the teaching part of it, it's not us doing the work. So they have to put between 20 and 30 people available for the programme for a week, just about, and then they have to commit to some follow up. So there is quite a lot of effort needed on their part, although financially it is minimal. We don't charge anything for running the programme. We cover our own costs and we expect them to find a meeting room or and provide transport. And some places we even provide meals for for the delegates, that sort of thing. So we're probably spending twenty to twenty five thousand euros each time on various things, whether it's meals or I suppose on direct costs are our hotels and flights and all that kind of thing, but then they have to, you know, get their people there and make them available and stuff. So that's what the stuff on that side as well. So somewhere between the two, we get them to commit to taking part, finding a date, finding the right people to do that, to do the workshop. We try and involve the disaster management agency of the country, we try to get the government involved as well and the NGO sector and the airlines and other stakeholders to to make it kind of a all round preparation work, so rather than just having airport people.

Maria Browarska: From what I understand, the whole programme is financed by German government and that goes through the United Nations.

Chris Weeks: I'm not quite sure what the status of that is at the moment. The German government helped finance some of the preparation work for five years, but they had to stop. The money was not allowed to be continued. It was sort of a start up loan or start up grant. But I think that's finished now.

Maria Browarska: You said you're not an airport manager, more the airline operator, but I assume that the original idea was that you're going to fly to those places anyway when something happens. So you're just trying to make them prepared for when you are coming.

Chris Weeks: Yeah, exactly. Exactly. Long term is going to save some money and resources.

Maria Browarska: Yeah. Nice. OK, so now once you're already there and you're doing the assessment of the airport, first you have the basic one to check whether they're at risk at all or not. And then once you do perform assessments of the airports what could be their main bottlenecks or what would be the worst thing that could happen - are those based on where their location?

Chris Weeks: Yeah, I think probably the best thing now is if I share my screen and I'll show you the programme. OK. Right. So this is how we run it, we start out with an opening ceremony and a theory session. We do an opening ceremony because we want to kind of raise the profile of it to make the participants realise that they're part of something important. So we do a press conference type launch at the beginning with especially if the government is involved will try and get some of the press along to listen to a few speeches about why we're doing it, what it's about and how it's going to help that country. So start out with an opening ceremony and then theory is a best part of a day of presentations and interactive work now, and it's usually done by four of us. This guy sitting down there is my partner in crime is Kim Melville, him and I tend to run it with two others who and we take turns to do the the presentations we try to kind of impart a sense to them that if they haven't been on the front line in terms of being a disaster airport, they could be one day. And we will tell them what has happened at previous airports, why airports are so important to the response effort, they could be important to the recovery effort as well. We then what we do is we tend to get into the different areas of the airport that will come under pressure if disaster happens and we use previous examples in other countries to tell them what happened in terms of passenger numbers, in terms of cargo numbers. We tell them that passenger numbers usually go up. By around 3 times. Back to a story, that's what we use aircraft numbers could go up by. Well, passenger aircraft numbers will go up accordingly. The cargo volumes could be up by a factor of 10, depending on the location. You know what they used to somewhere like Saint Martin that we looked at with your previous colleagues are very much tourist destinations and they hardly get any air cargo at all. So when a disaster happens and they get cargo aircraft coming in, it can present real problems because they haven't got the equipment to offload them as they're not used to having

them. So a lot of cargo at a tourist destinations, a lot of cargo goes in the belly of a passenger aircraft. It doesn't go in dedicated cargo flights. This is why when you go on holiday now, you have to pay like a premium to put an extra bag on your flight. And the reason is that the airlines are selling the cargo space or the belly space that that used to take passenger bags. They're selling that to the cargo. This is why during the pandemic now a lot of passenger flights have been cancelled and but it's affected cargo transfer to a lot of countries. And, you know, people think, oh, it won't affect them if they cancel the passenger flights. I guess you're in the Netherlands, aren't you? Yeah. So you get a lot of flowers in from from Kenya.

Maria Browarska: Yes, exactly.

Chris Weeks: And a lot of the flowers used to come on passenger flights.

Maria Browarska: Because they are time sensitive.

Chris Weeks: Yeah, they would create a section in the plane from Nairobi. I remember coming on a KLM flight from Nairobi and about one third of the passenger section was actually converted to take flowers. But if you haven't got the passengers, you can't afford to ship the flowers as well. So it disrupts. But what happened in St. Maarten is that for the response for the hurricane, they got a lot of military and cargo charters, but they didn't have the equipment to offload them because they're not normally doing that. And that being an island, it's very difficult to bring in equipment all of a sudden unless you're a big island, you've got several airports. How are you going to bring in this equipment in a hurry? And that's the kind of thing we talk to these airports about, is how they're going to respond and effectively be able to handle what's being sent if they haven't got the right equipment.

Maria Browarska: You said Saint-Martin was a good example of this, but I imagine there are more places like that. Have you seen it more often in other places and was it only the case with tourist islands? And then the airport is just used to receiving people and their luggage instead of cargo?

Chris Weeks: No, it's not limited to island tourist destinations and islands, although they are quite a big category, as a lot of them tend to be in these disaster zones like, you know, Indonesia, Bali, for instance. It's all earthquake zone down through the Caribbean, all the Caribbean. There's certain geographical sections of the Caribbean is a hurricane zone. But if you take the Andes and the and the earthquake zone down through there, somewhere like in Chile, Concepcion and Santiago - the country was affected, but the airports were also themselves affected. So it's not limited to to tourists. It's just the the problems are different.

Maria Browarska: OK, yeah. I'm thinking know in my study, the thing that I'm trying to generalise a lot of things. And of course, there's a lot of assumptions to this. But since I'm trying to build this bigger database, like the kind of you have for assessing the airports, so you're looking at risk and I'm trying to put there more features of an airport that makes it kind of special, but at the same time, maybe very similar. Like you said, maybe the airport in the Andes have the same problem because, for example, they usually have tourists coming. So whenever I hear something that was significant for an airport, I'm trying to think of, oh, maybe if I add a feature of this area being a tourist destinations, there is a big chance it's going to mean it's mainly for tourists usually and not for cargo. So there might be a similar problem in the future. And it's not that I'm ignoring the complexity, but I'm trying to have a broader perspective on that.

Chris Weeks: One feature that, you know, from a geographic point of view, on islands, you find that short of space and certainly some of the ones we've been to and I'm thinking like the Maldives, you know, they have to kind of reclaim any land they want for something like an airport. They have to reclaim it, which is very expensive and time consuming. In the past, they built the airports next to the sea. And with sea level rising, they are becoming more vulnerable, this is what we found in San Juan, in Puerto Rico. Some of the modern, more modern airports like we did in Montego Bay are built a little bit higher and a little bit more thought going into the current climate situation. But, you know, on the other hand, you take somewhere like Santiago, they've got masses of space, I mean miles and miles of space, and it's flat, relatively flat. And, you know, they can put enough runways down there. Doesn't really seem to matter. And they have. But they have less problems because it's more organisational problems rather than space or equipment. Yeah.

Maria Browarska: I will try to generalise it somehow and put it in. I am looking at airport size and the land use around the airport, whether it's densely populated with buildings or maybe just fields or mountains. So that should cover some of those things. And once you are at the airport, do you also assess the its connectivity to outside, let's say? I mean, the cargo comes into the airport but then it has to be distributed around the island or the region.

Chris Weeks: We look at access to the airport by trucks and traffic. Somewhere in Asia where they built the airports like 30 years ago, and now the city has come out to the airport and surrounded it, and you can have a lot of traffic problems for not just for getting cargo out, but for passengers getting in and out. And incidentally, we found out that they tend to have a cultural thing - for every passenger there are about three people going to see them off.

Maria Browarska:Wow, that's even more traffic.

Chris Weeks: Yeah, exactly. One of the one of the solutions was to put out radio advisories asking people not to go to the airport with the passengers or, you know, only letting passengers into the airport road or something, rather, to try and stop congestion by people who weren't actually flying.

Maria Browarska: Maybe COVID has helped with this, because there was no way of doing it anymore.

Chris Weeks: I think it probably has a little bit. Exactly, yeah.

Maria Browarska: Do you have any specific ways in which you're assessing this accessibility or is it you just go there and you talk to the people how it is?

Chris Weeks: Well, as I said earlier, we have an education role. And we're telling them what can be the issues. Telling them, giving them a good understanding of why a surge in aircraft, people, passengers, aid cargo can happen after a disaster. So this is about telling the airport staff about the humanitarian response system. A lot of people don't know how response works on a global scale and they don't realise what what the setup is. I suppose so. If you lived in a major earthquake prone zone, say, Indonesia, and something happens, the response there would be from the country itself, so you'd have your Red Cross equivalent, you'd have civil defence. And you'd have government intervention and staff, and then you'd have regional staff as well, where someone like an organisation like ASEAN would send in people to help or send in cargo or send in rescue teams. Other countries in the region would have rescue teams they would send in. So something happened in Indonesia - Japan could send easily send a 50 strong medical emergency team to go and help. And that team would arrive within a day or two and expect to be received. They might have doctors with, they might have drugs, they might have search and rescue, people might have dogs, how are you going to let the search and rescue people from a foreign country arrive with dogs in your country when you might have some two week quarantine for dogs, right? So it's that kind of thing that we tell them in this section that, you know, there's a big machine out there that's ready to roll into your country if something happens and you're at the airport, need to understand how to receive this with the machine or the parts of the machine. I mean, how are you going to respond to military, foreign military coming in? I mean, usually as long as they're not armed, they're usually OK. But who's to say they're not armed? So all the politicians get involved or the defence attaché to get involved to make sure the protocols are observed so you get more VIPs turning up at the airport. And VIP is a very resource heavy in terms of they need to be looked after, they need their own areas, and that can take away people from running the ordinary day to day stuff at the airport. I show a slide, a picture I took in in Haiti. I can't find it. I'll have to show you some other time, but basically it's a picture of Bill Clinton arriving in Haiti and, you know, 30 vehicles turning up to him in a huge line and basically closing the airport down for half a day while he comes in. So, yeah, that's sort of the pressures on the airport for when VIPs turn up. So this is the understanding why a surge can happen. And then secondly, recognising the challenges that the surge will create. So it's all very, well, just sitting there and going, oh, you're going to have lots of VIPs. But what does that mean for you? It means staff know it's tied up. It means having to divert aircraft, maybe because of security, it may be stopping other operations while the VIP goes through and then getting a plan together to address the challenges. Yeah, using what resources? You've got VIPs. You've got to look at what you've got there in terms of space, primarily, saying go where if you needed an overflow area for your cargo. Where would you put it so it doesn't interfere with other operations, you know, or if you need a bigger VIP section. What are you going to use to do that? And how are you going to do it? Have you got the permissions? And can you quickly bring that building into play? We did one in Bangladesh, in Dakar, in Bangladesh, and we discovered a whole new terminal that they had about a mile away from from the airport, which they used when they all go to Mecca. They have this surge in passenger traffic and they have a whole new terminal that's just been built for Mecca, so it sits there for 11 months of the year not being used. But you know what we said to them as well, if you have a surge outside that Mecca month, then you could bring that one into play. And it's things like that, it is using existing resources that are there by looking for them to solve a potential problem. OK, so the second the second session here is the airport assessment, right where we send them out in four

groups to go and look at particular parts of the airport to do a deep dive into whether particular areas are likely to be a problem. So in this instance, they've gone to the fuel farm to check what the capacity is of the fuel farm, how they get fuel delivered. And is that likely to be a problem, right? Yeah, that's just one part of it. The four groups you've got one group that goes and looks at all the facilities, which is this group. You have another group looking at all at the cargo section, another one looking at the passenger section and the one looking at the airport operations, the aircraft landing, the ramp space, air traffic control, that sort of thing. So they'll go out and and the the four groups look at the four areas. They have a template with them that they asked to fill in. And this is the beginning of the process of looking to see where the vulnerabilities are before writing an action plan and seeing how to mitigate in case something happens on particular parts of the airport so they'll complete the report using the information that they've collected. And then the session three is writing an action plan. And then finally they present back to each other, each group will present what the findings are. So. I'm just trying to think, one of the recent ones we did, they found that the road between the cargo section and the airport was too narrow. And one of the action items was to widen it so that you could get to a traffic through this section, for instance, to a low cost solution that might take three, four months. But, you know, it's not going to break the bank. It's not big budget stuff, but it'll just make them a little bit more resilient. You've got a structured report, you've got an action plan and you've got trained staff who understand it. And it's not an audit. We're not looking at it. It's kind of which as I said, it's an education process. So getting them to own the whole thing afterwards. Yeah.

Maria Browarska: I really like this notion of giving the responsibility to them and the ownership or whatever they do.

Chris Weeks: Yeah. And you have to make it pretty clear that that's what it is at the very beginning. Sometimes you realise why these countries, a lot of them are underdeveloped because they kind of often they expect you to be coming in to do it all for them. And we haven't got the resources to do that. And those days are over. You know, it's up to them to do it themselves. And this is what we try to show them. But there's only a limited amount we can do, you know, we're not a government agency, we don't have any authority as such. That's up to them to give us the space to tell them what it is and for them to be receptive enough to put it into place. You have to take your Western hat off sometimes and and look at it from their point of view. At this stage often talk about the in Jakarta or in Indonesia. We've come across what I call the inshala mentality where even at airport management level, you can have this inshala mentality where if it happens, it's God's will. You've got to sort of trying to get through that and say, well, maybe, but there are things you can do as well right now. It helps to take your Western hat off and think of it in terms of the people who are running these places. Privately run airports tend to run a little bit more receptive than government run facilities, but I mean, that's probably for another day. But we can we can carry on with it. I know we haven't got very far in your list of questions, but I think the best thing you can do is have a look at what I've sent you there and reflect on what I've said in this brief call and then set up another call. And I we'll go through the next bit. I've got time at the moment, so it's OK.

Maria Browarska: I'm happy and there is nothing happening right now. I will go through the things that you send me.

Chris Weeks: You'll probably have more questions from it, but, But that's fine. You know, it's, it's something, it's an area I can really help you with. And as long as you know, you have to keep yourself on track. You know, make sure you're clear in your head what your aim is and don't let me take you off because, you know. Just keep it keep it to what you want. All right.

Maria Browarska: OK, perfect. So if I have extra questions, just I'm going to email you and see if some are you there. Thank you so much.

Chris Weeks: Thank you. Thanks. Bye.

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