CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF TRANSPORTATION SCIENCES

Department of Air Transport

Assessment of hazards during and after the low operation regime at the airports

Bachelor thesis

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Název tématu (anglicky): Assessment of Hazards during and after the Low Operation Regime at the Airports

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Při zpracování bakalářské práce se řiďte následujícími pokyny:

- Cíl práce: Identifikace a hodnocení nebezpečí během a po režimu sníženého provozu na letištích.
- Analyzujte provozní změny v oblasti letištního provozu během pandemické situace.
- Identifikujte nebezpečí a rizika během a po pandemické situaci v kontextu letištních procesů.
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BACHELOR'S THESIS ASSIGNMENT

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- Thesis goal: Identification and assessment of the safety hazards during and after the regime of the low operations at the airports.
- Perform the analysis of the operational changes in airport operations during the pandemic situation.
- Identify the safety hazards and related risks during and after the pandemic situation in context of airport processes.
- Evaluate the identified risks.
- Propose the corrective measures.
- Discuss the results and define the conclusions.

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Graphical work range: according to the instructions of thesis supervisor

Accompanying report length: minimum of 35 text pages (including figures, graphs and sheets which are part of the main text)

Bibliography: ICAO Doc 9859, Safety Management Manual

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b) in case of postponing the submission of the thesis, next submission date results from the recommended time schedule

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I confirm assumption of bachelor's thesis assignment.

Xinpei Rao
Student's name and signature

Prague .... January 23, 2023

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Declaration

I declare that I prepared the bachelor's thesis entitled Assessment of hazards during and after the low operation regime at the airports independently and for this I used the complete list of citations of the sources used, which I present in the list attached to the bachelor's thesis.

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Název bakalářské práce

Hodnocení nebezpečí během a po ukončení nízkého provozního režimu na letištích

Abstrakt

Výskyt kovidu-19 v roce 2020 vážně ovlivnil rozvoj leteckého průmyslu, což vedlo k období nízkého provozního režimu letiště. Od roku 2020 všechna letiště přijala řadu nových opatření pro rozvoj a zavedení nového provozu na letištích. Díky novým způsobům, metodám a nápadům, jak se přizpůsobit nízkému provoznímu režimu letiště, který přinesla pandemie, lze účinněji kontrolovat nebezpečí způsobená nízkým provozním režimem letiště.

Díky tomu, že je Covid-19 pod kontrolou, se provozní stav letiště postupně stabilizoval a vedení letiště si uvědomili a odhalili nebezpečí, která přináší nízký provozní režim letiště. Tato nebezpečí nejen snižují efektivitu provozu letiště, ale také přímo ovlivňují systém řízení bezpečnosti letiště.

Proto je hlavním cílem této práce identifikovat nebezpečí v nízkém provozním režimu letiště, vyhodnotit tato nebezpečí.

Klíčová slova: Bezpečnostní rizika, rizika, provoz letiště, letecká doprava, pandemie (COVID-19)

Bachelor Thesis Title

Assessment of hazards during and after the low operation regime at the airports

Abstract

The covid-19 outbreak in 2020 has severely affected the development of the aviation industry, resulting in a period of low operational regime of the airport. Since 2020, all airports have adopted a series of new policies to develop and implement new airport operations. With new ways, methods and ideas to adapt to the low airport operation mode brought about by the pandemic, the hazards caused by the low airport operation regime can be controlled more effectively.

With covid-19 under control, the airport's operating status has gradually stabilized, and airport managers have realized and discovered the hazards brought about by the airport's low operating regime. These hazards not only reduce the efficiency of airport operations, but also directly affect the airport's safety management system.

Therefore, the main research purpose of this thesis is to identify these hazards in the low operating regime of the airport and evaluate the hazards.

Keywords: Safety hazard, Risk, Airport operation,Air transport, Pandemic (COVID-19)

Contents

List of Abbreviation

A/C	Aircraft
A/P	Airport
ATS	Air Traffic Service
ATC	Air Traffic Control
CA	Control Actions
CAA	Civil Aviation Authority
FOD	Foreign Object Debris
GSE	Ground Service Equipment
GHD	Ground Handling
GPU	Ground Power Unit
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
SC	Safety Constraints
STPA	System-Theoretic Process Analysis
STAMP	System-Theoretic Accident Model and Processes
SMS	Safety Management System
SOPs	Standard Operating Procedure
UCA	Unsafe Control Actions

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Introduction

Airports are vital to the economic development of cities, regions and countries. They contribute directly to the economy by providing services to airlines, transporting passengers and moving goods. The movement of goods and people also benefits governments, consumers and industry. However, the COVID-19 outbreak has hit airports hard, which could hamper the development of the civil aviation market. In the context of COVID-19, how will it affect human lifestyles and airport operations? Obviously, COVID-19 has changed the way we travel, for international travelers, variable and broad border measures,and they need to consider not only the risk of disease spread, but also need to take into account the need for quarantine at their destination, on their return, or both. Travel restrictions and quarantine are often the first response against emerging infectious disease threats.[1] Epidemiological experts in different countries will gradually formulate travel bans according to their own national conditions, which makes it difficult for the number of international travelers to rise up in a short time. Domestic travel has been overall less restricted.

The outbreak of COVID-19 brought to the period of low operation of the world airports. According to past experiences, like long-term closure or limited operations, the airports may face various challenges during periods of low operations. Therefore, in order to adapt to this period more quickly, the airports have to reform the traditional operation mode, to innovate and introduce more efficient management practices, while considering the development after the low operation period. The process and extent of reform depends on the airport. In general, there are hazardous problems in every airport, such as the significant reduction of airport personnel, the reduction of personnel training cycle, the simplification of operating procedures and so on. These problems may be hazards and if not solved in time, it is likely to cause accidents. In order to bring the detailed view on the possible hazards caused by low regime operations, this thesis will focus on the identification of the potential weak spots and critical processes and piece of airport infrastructure.

The structure of this thesis indicates that the main purpose is to identify and assess the hazards of airports in the event of a pandemics. Firstly, the situation during pandemics at the airport will be analyzed and described. This include the description of the traffic volumes falls and overall operation regime and implemented measures. The next step is potential hazard identification and assessment of associated risks. Airport system covers wide area of the processes, entities and infrastructure, therefore this thesis is limited to the operations where several entities are involved, like aircraft taxiing and ground handling. Performed method of the hazard identification and following risk assessment is applicable to any process at the airport. In this approach the STPA hazard analysis method was applied. STPA (System-Theoretic Process Analysis) is a relatively new hazard analysis technique based on an extended model of accident causation. STAMP (System-Theoretic Accident Model and Processes) is the name of the accident causality model based on systems theory, which provides the theoretical foundation for STPA.[16] STAMP enables easy description of the system's control structure and supports the idea of the establishment of the functioning control mechanism.

In the next step, the risk assessment is used to assess various hazards consequences, which can further judge the risk degree of identified causal factors. Finally, the corresponding strategies are given according to outcomes.

1. Analysis of the Impact of COVID-19 Pandemic on the Air Transport

Since the outbreak of the pandemic in 2020, the aviation industry, as a pillar industry in the world, has also been greatly negatively affected. The airports the transportation hubs in the aviation industry. It not only brings great inconvenience to passengers, but also affects aircraft operation within the airport area in normally. During pandemic period, words such as airport closures, travel restrictions, and high-priced flight tickets have appeared frequently, and people have begun to attach great importance to their own means of transportation, especially the choice of planes. [2] However, the emergence of the pandemic has made every country to pay attention to the restrictions on travel. This restrictions have also implicated the normal operation of the airports. Some airports have been hit hard by the pandemic and are facing closures, while others are struggling. Relevant governments have also issued regulations to ease the operating pressure on airports. Overall, the impact of the pandemic on air transport is mainly reflected in passenger traffic volumes, passenger security procedure and airport stuff.

1.1 Impact of Pandemic on Traffic Volumes

The COVID-19 pandemic has had a huge impact on airports around the world, leading to massive restrictions on air travel and even 'lockdown' periods that prevented millions of traveler from travelling at all. According to report by Airports Council International (ACI), from 2019 to 2020, the period most affected by the pandemic, traffic volumes dropped by 61%. As shown in the figure 1, after 2021, the traffic volumes show a significant upward trend, which indicates that after the ease of restrictions, passenger demand is in a backlog, which is likely to recover in a short time. For the full-year 2022, global passenger traffic is expected to be 6.6 billion, which is 71.7% of 2019 levels, improved from the last year’s traffic of

4.6 billion or 50.5% of 2019 levels. Global passenger traffic is forecast to reach 92% of 2019 levels in 2023.[3] According to the current situation, this expectation is in line with the actual situation.However, there is still a limited rebound situation, which is related to the regional war,riot and the complex international situation, causing a lot of anxiety for international traveler.

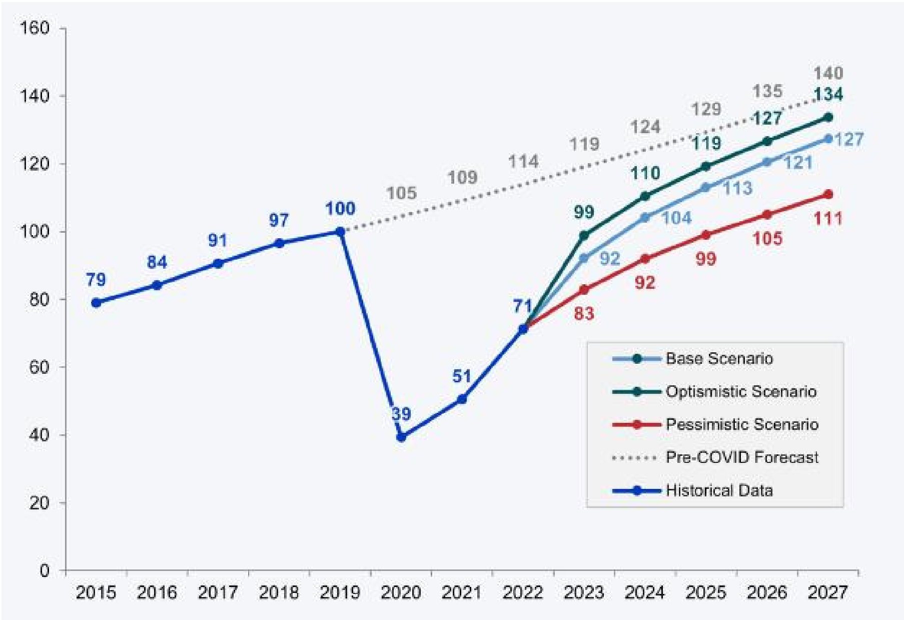

Figure 1 - Global passenger traffic projection (indexed, 2019 = 100) [3]

Due to travel restrictions, each country has stricter regulations on foreigners, which makes international tourism hard to believe during the pandemic, so each country does not expect international tourism to generate revenue for tourism. They are focusing on domestic travel and stimulating domestic tourism through new management models, as shown in the figure 2, domestic passenger traffic accounted for more than 70% after the COVID-19 outbreak, and it is also increasing year by year.

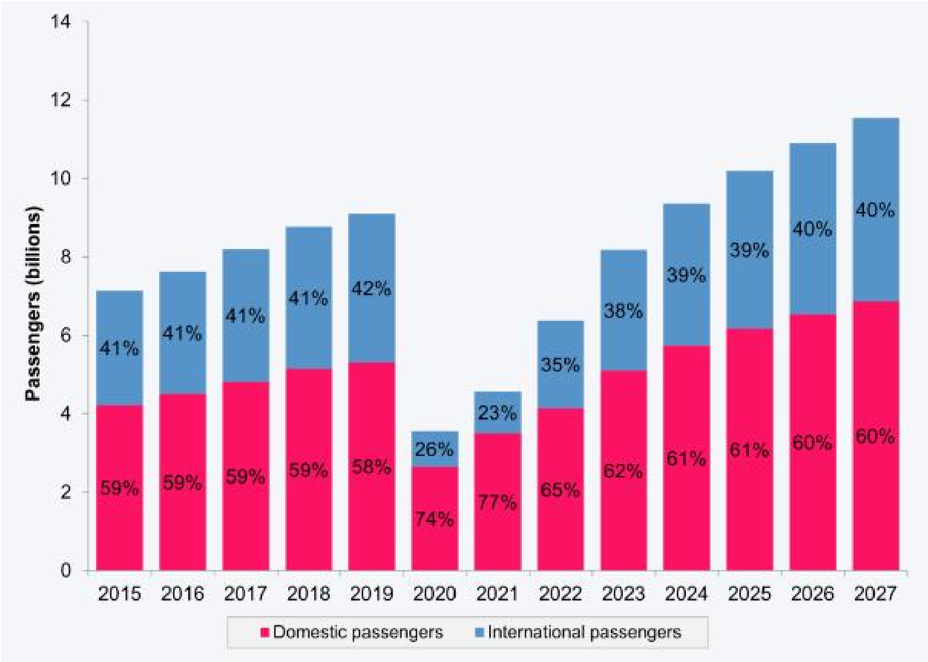

Figure 2 - Global passenger traffic by type (in billion passengers) [3]

The decline in traffic volume has led to a sharp decline in aviation revenue, which is directly related to traffic volume and includes levies from aircraft operators, related fees from passengers and related fees from aircraft. As traffic has declined, so has revenue. Non-aeronautical revenues, which include such streams as rental from stores, duty free, car parking, and food and beverage, are also very much linked to passenger traffic and throughput. As airports have little flexibility in operating expenditures but also have capital costs that are largely fixed, the crisis has represented an unprecedented challenge for the airport industry's financial viability [4].

1.2 Impact of Pandemic on Passenger ground handling

Due to the high infectivity of the virus, combined with the high traffic density, airports are undoubtedly the convenient place for the virus to spread. Once an infected passenger appears this can lead to repeated local outbreaks, and some passengers can be difficult to identify when they have no symptoms. That adds to uncertainty about travel restrictions or quarantines taken by local governments. The figure 3 illustrates the change in airport departure procedures during Covid-19. If symptomatic passengers are identified, the quarantine staff will trigger the quarantine procedure and try to isolate these passengers.

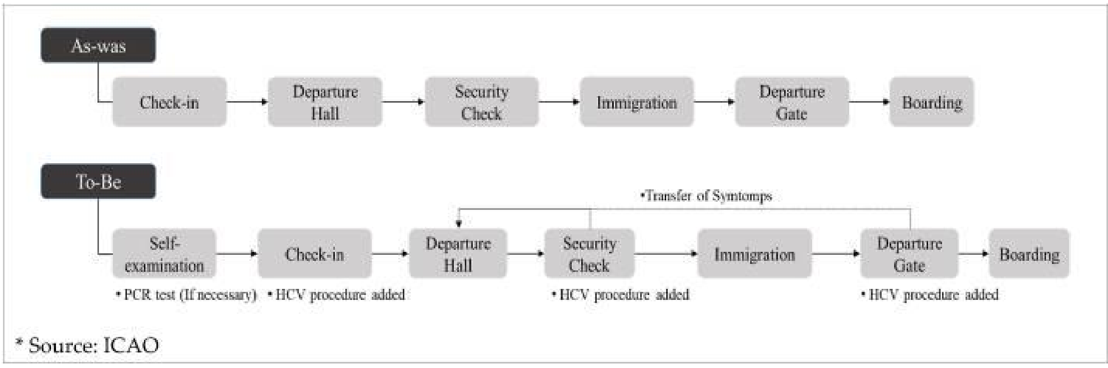

Figure 3 - Change in airport departure procedures post-Covid-19 [5]

Therefore, the focus is on implementing risk-based measures, which may include health screening of arriving and/or departing passengers, in addition to maintaining physical distancing and enhancing sanitation. During pandemic, certain additional procedures were implemented :[6]

Thermal temperature screening – it was implemented at several airports in the initial phase of the pandemic, but has been identified by EASA as a high-cos,t but low efficiency measure, because passengers without symptoms (up to 75%) were not easily detected.

PCR testing before departure – it could be done off-airport, before travelling or at the airport with results provided 2 to 3h after the test. Some countries have implemented requirements for recent negative PCR test (e.g. 48-72 hours before departure).

PCR testing on arrival – it was implemented, in particular for defined “risk areas”. National authorities put rules into place but currently have difficulties with local testing capacities to ensure timely results.

Health self-declaration – is was requested by some governments as further measure. Airlines had to ask health questions related to COVID. That was initially performed during check-in by agents, but most airlines have now integrated this to the online check-in. Some governments request this information online before travel.

Passenger locator cards / online health forms - it was established by some national authorities (e.g. Spain or Greece) in order to ask self-declaration health questions and to enable contact tracing in a more efficient way (requesting passengers to fill in online forms). With an online system, passengers had a generated QR code used during the check-in and eventually on arrival as a proof of registration.

1.3 Impact of Pandemic on Airport Staff

Referring to IATA data, 25 million jobs are created by air transport globally.[7] The pandemic deeply impact on the aviation industry by forcing airports efficiency layoffs. Suddenly, staff in different sections of the airport had to work longer hours and take on more responsibilities to cover for their laid-off colleagues. For example, airport security personnel are now required to cover a larger area with fewer resources, making it more difficult to identify and respond to potential security threats. This job requires a high alert mode, rapid response, a combination of different scenarios in an emergency, and many other responsibilities. This does not concern only security staff, almost all positions within the airport, air traffic control or airline are in the similar situation. Although this policy is reasonable and reduces costs for airports, it also brings some potential issues. High-intensity work patterns, for example, can make employees increasingly stressed because they now have more responsibilities, more areas to cover and sometimes longer shifts, leading to burnout, decreased satisfaction and, in some cases, a higher risk of absenteeism. On the other hand, after the lifting of restrictions and the increase in demand for air travel, the airport is faced with a shortage of staff, in order to fill the number of positions at the airport, it has to recruit new staff, including inexperienced staff, who also need to go through professional training. In a short period of time, it is difficult for new employees to effectively perform their duties.

1.4 Current Situation

Airports still face many challenges in the aftermath of the pandemic and are desperate to return to their pre-pandemic operations, especially the airlines. At present, the aviation industry is in a recovery phase, and airports are also facing new problems post COVID-19.

In the first half of 2023, the World Health Organization declared COVID-19 to be considered a common disease. This means that industries that were previously affected by COVID-19 will slowly start to recover. However, for the airports many experts predict non-optimistic initial recovery scenario. In fact, since the summer of 2022, there has been chaos at many airports. For example, most of flights are delayed or cancelled, passengers have problems with their luggage and employees are on strike and so on. Such problems occur frequently at European airports. Similarly, long queues at immigration checkpoints in London, Amsterdam and elsewhere. And once they get through, there’s no guarantee their bags will be waiting for them. Baggage handlers are also in short supply, meaning days-long delays in getting luggage to customers in some cases.[8]

In response to flight delays and cancellations, the problem is attributed to a shortage of airport personnel. As the figure 4 shows, this is the rate of flight delays and cancellations after the COVID-19 pandemic, flight delays at some airports are unexpectedly high

BY ORIGIN AIRPORT				
Cancelled		Delayed		AIRPORT
#	%	#	%	
67	9%	330	47%	Guangzhou Baiyun Int'l (CAN)
46	8%	139	25%	Jakarta-Soekarno-Hatta Int'l (CGK)
33	16%	51	25%	Naha (OKA)
31	3%	180	18%	Denver Intl (DEN)
27	4%	262	45%	Beijing Capital Int'l (PEK)
26	5%	306	66%	Beijing Daxing International Airport (PKX)
23	6%	147	39%	Shanghai Hongqiao Int'l (SHA)
20	3%	322	56%	Shenzhen Bao'an Int'l (SZX)
17	2%	216	30%	Tokyo Int'l (Haneda) (HND)
17	4%	190	45%	Hangzhou Xiaoshan Int'l (HGH)
17	10%	49	29%	Sultan Hasanuddin Int'l (UPG)

Figure 4 - Flight delay and cancellation[9]

The high frequency of flight delays, which is a bad experience for passengers, and the potential for other flights to be delayed again for overall airport operations, can lead to potentially unsafe actions. Problems with sudden traffic growth have been a real challenge for airports, especially for ground handlers. Ground handling services providers have been unable to scale up staff recruitment to cope up with increased passenger traffic.[10] As an example, the CEO of London Heathrow, John Holland-Kaye, says he warned ground handling services providers that they needed to recruit and train more staff. He said: “Airline ground handling shortage is now the constraint on Heathrow’s capacity. The number of people employed in ground handling fell sharply over the last two years, as airlines cut costs during the pandemic.” Heathrow estimates that airline ground handlers have had no more than 70% of pre-pandemic resources, and there has been no increase in numbers.[11] Although the pandemic has now been declared over and air traffic returned , the hazards left over from the pandemic period must be analysed, assessed and tracked in order to prevent potential deterioration of the operations.

2.Current approach to COVID-19 related safety hazard and risk identification

Safety Management System (SMS) is an important safety management approach introduced in the early 2000s with a view to improving safety in activities related to air transportation and to maintain such activities at acceptable risk levels.[11] The SMS manual sets out the recommended minimum standard that shall be applied throughout companies functioning in the aviation industry.[12] SMS is currently a safety tool used by the airport operators, implemented to ensure safety in the defined fields.

SMS includes four key elements:

- Safety policy
- Safety risk management
- Safety Assurance
- Safety promotion

Airports have some limitations and passivity in using SMS approach to identify safety hazards and risks in the context of COVID-19. An aerodrome SMS can only provide a means of controlling those hazards which originate within the aerodrome system, or in which some element of the aerodrome system could be a contributory factor.[12] For example, the aerodrome safety system cannot directly address the cause of the emergency landing caused by the failure of the aircraft system, it can only address the consequences of the emergency landing at aerodrome. The SMS approach is therefore limited in its ability to identify hazards for dynamic changes in pandemic events.

According to the sources of airport safety hazards[13], they are mainly reflected in the dangerous state of things, human's unsafe behavior and management deficiencies. The identification of airport safety hazards can be analyzed from three perspectives (Table 1):

Management system---This refers mainly to the basic aspects of the airport organization, management , processes and procedures.

Human performance and environment---This refers mainly to human factors, personal training systems, and environmental impacts on airport operations.

Technology---This refers mainly to the air navigation facilities within the airport, operation, maintenance etc.

Table 1- The sources of airport safety hazards

No.		Hazard scope	Type of unit or system
1.	Airport	Management Systems	Regulatory Oversight
2.			Customer Management
3.			Safety Management System
4.			Emergency System
5.			Operations Planning and Scheduling
6.			Documentation
7.			Finance Management
8.		Human performance and environment	Human factor
9.			Training system
10.			Environment
11.		Technology	Ground Handling
12.			Airport Facilities
13.			Wildlife protection
18.			Air Traffic Service (ATS)
19.			Aircraft loading
20.			Flight Operations (within airport airspace)
21.			Maintenance

3.Safety Analysis Approaches

By discussing the preliminary problems of the accident and the scenarios caused by various hazard sources, all possible hazard sources can be analyzed to reduce the threat of danger in time. In the context of the pandemic situation and its influence on the airport operations, safety is one of the central topics for national and international aviation bodies.The International Civil Aviation Organization defines safety as the "state in which the risk of injury to persons or damage to property is reduced or maintained at an acceptable level, or below it, by means of a continuous process of hazard identification and risk management".[14]

There are many different methods developed for safety analysis, such as Fault Tree Analysis (FTA), HAZOP, Failure mode and effect analysis (FMEA) and so on: These traditional methods are still applied in aviation industry. While aviation is further developing, and becomes more and more complex socio-technical system, safety analysis become more challenging to perform. These mentioned approaches are not always efficient in cases of the complex and integrated systems today, because the estimates they produce do not necessarily represent the actual safety issues that should be addressed.

As discussed by Vrijling, van Hengel and Houben (1998) and Braithwaite, Caves and Faulkner (1998), in order to guarantee adequate safety levels, system development and decisions should be based on acceptable risk assurance, that is, the product of probability and severity of an undesirable event to take place should be sufficiently low. Thus, to achieve safety levels and reduce occurrence rates, the risk must be quantified and balanced with appropriate mitigation measures.[15] Modern approaches in safety engineering, especially those focusing on the system-level approach supports the idea, that safety could be defined as the control issue. As an effective tool in this approach the model STAMP[16] emerges as an interesting solution.

Leveson (2004) proposed STAMP model (System Theoretic Accident Model and Process), Which describes the control structure of the system and supports the idea of establishing functional control mechanisms. This approach has been applied to different industries and by many entities. While airport with all defined process and entities represents the example of a complex socio-technical system, STPA method will be applied in this thesis to identified the hazards in the airport environment during the low regime operations during pandemic situation.

3.1 STPA Method Overview

STPA or System Theoretic Process Analysis is based on the safety model STAMP and it is commonly used within the hazard analysis process during all phases of system/product life cycle. In order to better understand the practical application of this method, firstly the STAMP model will be briefly described.

3.1.1 STAMP

STAMP is an accident causality model, based on system theory. It was originally developed by Prof. Dr. Nancy Leveson at MIT [17].The main goal of STAMP is to find out why accidents occur and how to use that understanding to create new and better ways to prevent accidents from happening. It is based on three main concepts: [18]

1. Safety Control Structure - a hierarchical representation of the system under analysis on which upper-level components impose constraints on lower-level components.
2. Process Model - a model of the process that is being controlled.
3. Safety Constraints – requirements for the system components that must be fulfilled to assure safety.

It is based on systems theory and control theory, which considers the safety of the system as the emergent nature of the problem, and the constraint of the interaction between the system components is a control method for this emergent nature, i.e. the behavior of each component of the system and the interaction of the components are constrained to achieve and maintain or enhance the purpose of the safety state of the system. In figure 5, a Hierarchical Functional Control Structure (HFCS) represents system components and interactions. Components (white boxes) interact through control actions (black arrow downwards) and feedbacks (orange arrows upwards). In an inadequate enforcement of safety constraints on controlled processes behaviors, inadequate control actions are provided to controlled processes, leading to a hazardous system state where accidents or undesirable losses inevitably take place.[19]

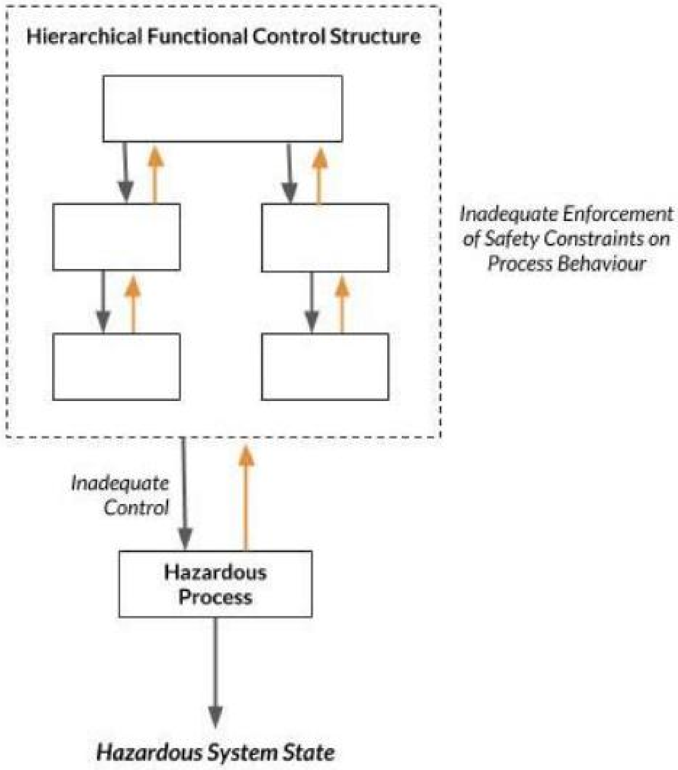

Figure 5 - Hierarchical Functional Control Structure (HFCS) [19]

3.1.2 STPA

The method STPA is divided into four steps. Step 1 defines the purpose of the analysis. Step 2 model the control structure. Step 3 identify Unsafe Control Actions (UCA). Lastly step 4 identify loss scenarios.The steps in basic STPA are shown in figure 6 along with a graphical representation of these steps.

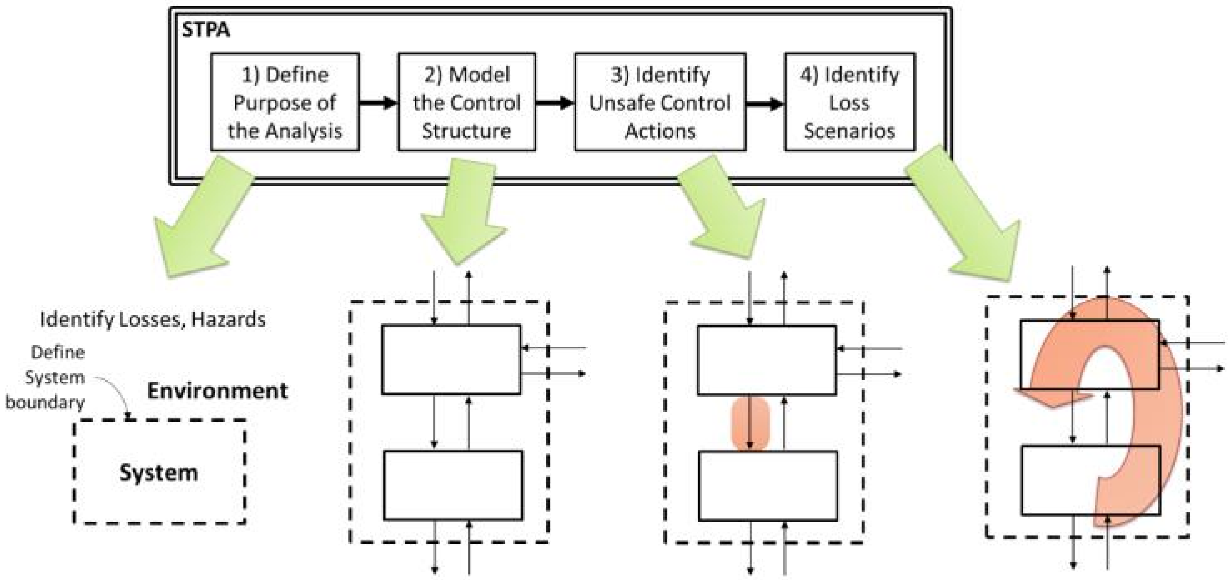

Figure 6 - Overview of the basic STPA Method [16]

A hierarchical control structure is a system model that is composed of feedback control loops. An effective control structure will enforce constraints on the behavior of the overall system,as figure 7. In general, a hierarchical control structure contains at least five types of elements: [16]

Controllers

Control Actions

Feedback

Other inputs to and outputs from components (neither control nor feedback)

Controlled processes

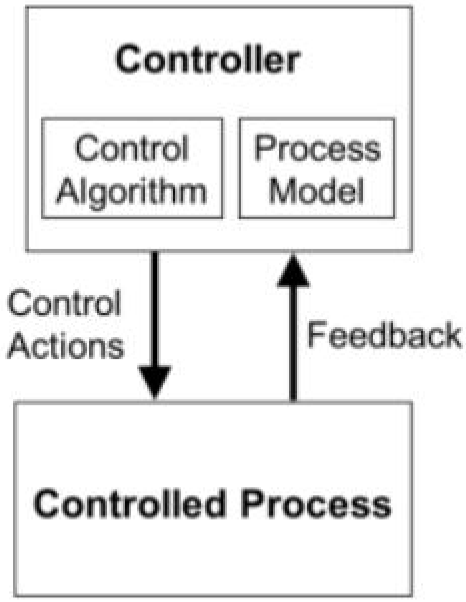

Figure 7- Generic control loop

The vertical axis in a hierarchical control structure is meaningful: it indicates control and authority within the system. The vertical placement represents the hierarchy of control from high-level controllers at the top to the lowest-level entities at the bottom. Each entity has control and authority over the entities immediately below it, and each entity is likewise subject to control and authority from the entities immediately above.[16]

Through identification of the unsafe control action (UCA) it is possible to create possible loss scenarios. CA (control action) is a command sent to a low-level component or controller. The analyst must identify provided control actions, and the environment in which the CA can be hazardous. There are generally four cases when CA can become unsafe:

- Providing CA causes hazard ;
- Not providing CA causes hazard;
- Providing CA too early, too late, or in wrong order causes hazard;
- Stopping CA too soon or applying CA too long causes hazards.

In order to clearly define the unsafe control action, the context must be well described. Contexts could represent the specific states or configuration of the analysed system/process.

3.1.3 Terminology and Characteristics

Terminology that appears in STAMP and STPA methods:

Accident -An unplanned and undesired event that results in a loss. Accidents can be caused by unsafe interactions among system components, that have not failed, and also satisfy all requirements[17].

Loss -A loss involves something of value to stakeholders. Losses may include a loss of human life or human injury, property damage, environmental pollution, loss of mission, loss of reputation, loss or leak of sensitive information, or any other loss that is unacceptable to the stakeholders.[16]

Hazard - A hazard is a system state or set of conditions that, together with a particular set of worst-case environmental conditions, will lead to a loss[20].

System-level constraints - A system-level constraint(safety constraints) specifies system conditions or behaviors that need to be satisfied to prevent hazards (and ultimately prevent losses) [17].

Unsafe Control Actions - Unsafe Control actions are used to create functional requirements and constraints for the system. [17].

As defined above, hazards can directly lead to accidents if prevention is not applied or prevention failed. This will further lead to corresponding losses. The following are examples of accidents and hazards(Table 2):

Table 2 - Distinction of hazard and accident

Accident	Hazard
The aircraft collided with ground vehicle	Communication issues with ATC during taxiing
The aircraft moves on its own on the stand and collides with airport infrastructure	The chokes are not properly places during ground handling.
Aircraft engine parts damaged due to inhalation of foreign objects	The foreign objects on the ground was not cleaned up in time

The aircraft excursion from taxiway	The visibility extremely low on the ground

Hazards manifest themselves in uncertain forms at the airports, depending on their characteristics. The main characteristics of the hazard:[21]

- Complex Diversity

The complexity of the airport system determines the existence of safety hazards, which are complex and uncertain. Safety hazards can be manifested in the process of controlling passengers in the terminal, and can also be manifested in various forms such as the operation process of air traffic controllers and maintenance personnel, or defects in management systems and support facilities.

- Latent

Safety hazards are potential conditions and therefore have the characteristic of being hidden and not easily detected. In a given situation or environment, safety hazards are in a stable state until they encounter an excitation state that leads to a manifest failure and then to the development of an accident. Some safety hazards can only be detected and solved by investing certain technical and financial resources, and this becomes part of the consequences of the safety hazard.

- Serendipity

There is also uncertainty in the existence of safety hazards, in the occurrence and development of hazards, in the kind of accidents that lead to them, and in the fact that the same hazard can lead to multiple accident consequences, but there is uncertainty about where, when and how they occur.

- Controllability

Accidents can be prevented by identifying hazards and taking action to keep them within acceptable limits.However, safety hazards are constantly regenerating and new hazards can be created in the process of managing them.

3.1.4 Risk Assessment

The risk matrix is a generic risk evaluation method and due to its simplicity it is recommended by ICAO to be used by airports within their safety management system. [22] In this method, risk is evaluated qualitatively by rating the probability and severity of the possible worst case scenario. The resulting risk index represents the combination of these two values, indicating the different levels of risk. Both values, severity and probability are represented through 5 values scales (Table 3 and Table 4). In the ICAO Safety Management Manual, the likelihood of risk and the severity of risk are combined in a typical risk matrix.

Table 3 - Meaning risk probability [23]

Likelihood	Meaning	Value
Frequent	Likely to occur many times (has occurred frequently)	5
Occasional	Likely to occur sometimes (has occurred infrequently)	4
Remote	Unlikely to occur, but possible (has occurred rarely)	3
Improbable	Very unlikely to occur (not known to have occurred)	2
Extremely improbable	Almost inconceivable that the event will occur	1

Table 4 - Meaning of risk severity [23]

Severity	Meaning	Value
Catastrophic	• Aircraft / equipment destroyed • Multiple deaths	A
Hazardous	• A large reduction in safety margins, physical distress or a workload such that operational personnel cannot be relied upon to perform their tasks accurately or completely • Serious injury • Major equipment damage	B

Major	• A significant reduction in safety margins, a reduction in the ability of operational personnel to cope with adverse operating conditions as a result of an increase in workload or as a result of conditions impairing their efficiency • Serious incident • Injury to persons	C
Minor	• Nuisance • Operating limitations •Use of emergency procedures • Minor incident	D
Negligible	• Few consequences	E

Safety Risk		*Severity*				
Probability		*Catastrophic A*	*Hazardous B*	*Major C*	*Minor D*	*Negligible E*
Frequent	5	5A	5B	5C	5D	5E
Occasional	4	4A	4B	4C	4D	4E
Remote	3	3A	3B	3C	3D	3E
Improbable	2	2A	2B	2C	2D	2E
Extremely improbable	1	1A	1B	1C	1D	1E

Figure 8 - Risk Matrix [23]

According to the ICAO definition of the risk matrix, risk levels are divided into three main ranges, with different colour to indicate the level of risk.(Figure 8) Red indicates that the risk of the event is unacceptable and immediate action should be taken to stop the event, otherwise it could easily lead to a catastrophic event. Yellow indicates that the event can be tolerated under the safety risk mitigation, which also require appropriate decisions to reduce the risk. Green indicates that the event is acceptable and does not require risk mitigation.

4. Safety analysis of the chosen processes at the airport during low regime operations

This thesis will focus on the process of aircraft activity on the ground, analyzing ground handling and aircraft movement. Airport ground handling is an important part of the industry, and the aviation industry relies heavily on people who service aircraft on the ground, as their work directly impacts flight safety in airline and airport operations. The International Air Transport Association (IATA) definition is used: ‘Ground Handling covers the complex series of processes required to separate an aircraft from its load (passengers, baggage, cargo and mail) on arrival and combine it with its load prior to departure’.

1) Taxiway
2) Aircraft stand
3) Aircraft stand marking
4) Aircraft stand clearance line
5) Aircraft clearance line
6) Movement area Jetway
7) Fuel hydrant pit
8) Parking space ground handling equipment with height restriction
9) Parking space ground handling equipment
10) Access/exit
11) Jetway

However, in contrast to our long-held perception of the aviation industry as being highly safe, for those working in ground handling, the profession is known to be exceptionally hazardous. A 2017 study conducted in the United States revealed that the frequency of non-fatal accidents in the ground handling sector was four times higher than the accident frequency of the industry as a whole. [24]

Therefore,aircraft ground handling is also related to the aircraft taxiing, which involves from pushing back to before takeoff or arriving at the apron.

4.1 Defining the Purpose of the Analysis

At the beginning of the use of STPA, it is first necessary to determine the general system-level hazards in the relevant processes defined by the scope of the analysis. In order to do this, the possible loss events should be determined. As defined above, this includes loss of life or injury, damage to property, environmental pollution, mission loss, economic loss, etc. In this context the following losses were defined within the performed analysis(Table 5):

Table 5 - Identified Losses related to the airport operations – defined scope

Level	Loss
L1	Loss of life or injury to people
L2	Loss of or damage to aircraft
L3	Loss of or damage to ground infrastructure
L4	Delay or loss of flight slot

The next step is to define the system-level hazards by identifying system states or conditions that will lead to a loss in worst-case environmental conditions. The following list provides identified system-level hazards within the scope of the performed analysis:

H-1 Distance between aircraft and other object on the ground decreasing more then allowed. {L1,L2,L3}

H-2 Procedures (GHD) applied for different aircraft type {L4}

H-3 Airport or GHD personnel missing training or knowledge {L1}

H-4 Handling capacity exceeded {L2,L3,L4}

H-4.1 Personnel number during GHD/operations less than required during the process

H-4.2 Applied GSE less than required or inadequate during the process

H-5 Airport surface used for taxiing inadequate or with degraded state {L4}

H-6 Foreign object around aircraft during taxiing and ground handling. {L2}

In general, a hazard may result in one or more losses, each of which should be traced back to the resulting loss. This traceability is usually recorded in parentheses after the hazard description. At the same time Hazards (H-n) and Safety Constraints (SC-n) derived from these losses are enumerated:

H-1 Distance between aircraft and other object on the ground decreasing more then allowed. {L1,L2,L3}

SC-1 Aircraft must satisfy standard separation from other aircraft or objects during operations on the ground

SC-2 If aircraft violates standard separation from other aircraft or objects, then the violation must be detected and measures taken to prevent collision

H-2 Procedures (GHD) applied for different aircraft type {L4}

SC-3 Aircraft type should be verified and GHD process prepared according to the actual traffic situation.

SC-4 If change of the aircraft type is not detected before start of the processes, immediate change of procedure after detection should be triggered.

H-3 Airport or GHD personnel missing training or knowledge {L1}

SC-5 Personnel training and knowledge shall be carried out according to the set requirements.

SC-6 If any personnel missing training or knowledge, this fact should be detected and acted immediately

H-4 Handling capacity exceeded {L2,L3,L4}

H-4.1 Personnel number during GHD/operations less than required during the process

SC-7 The minimum number of personnel should meet the requirements

SC-8 If personnel missing or changing, process performance standard should not be deteriorated.

H-4.2 Applied GSE less than required or inadequate during the process

SC-9 The minimum number of GSE should meet the requirements

SC-10 If GSE less than requirement, process performance standard should not be deteriorated..

H-5 Airport surface used for taxiing inadequate or with degraded state {L4}

SC-11 Airport operator should continuously provide adequate surface for taxiing, GHD and other operations.

SC-12 If pavement surface less than requirement, detection must be ensured before operation on this infrastructure.

H-6 Foreign object around aircraft during taxiing and ground handling. {L2}

SC-13 Keep ground clean when the aircraft is operating on the ground or according to the set plan(No foreign objects).

SC-14 If foreign objects is occur on the ground, detection must be ensured before operation on this infrastructure.

4.2 Modeling the Control Structure

The scope of the analysis includes the processes where identified entities are the following:

- Civil aviation authority(CAA)
- Air Traffic Control (ATC)
- GHD Company
- Airline
- Airport Operator

Defined control structure is defined in the following graph (Figure 9)

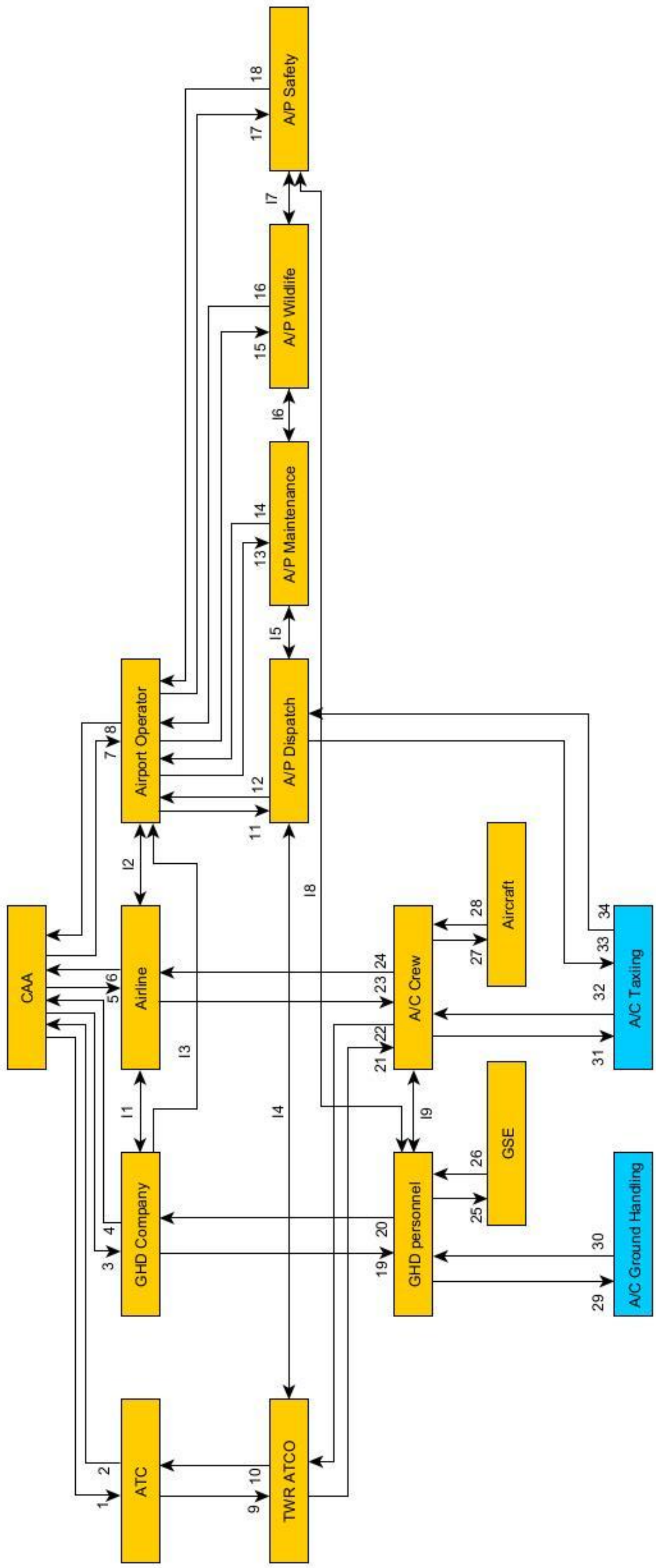

Figure 9 - Airport control structure

While control structure represents the relevant control loops and controllers, the problems in form of UCA can occur at any point within the defined structure. For example, a process model that is inconsistent with the real situation,which can lead to control actions that are unsafe. The structural design may lack necessary feedback, or it may provide delayed feedback, resulting in incomplete process models and unsafe behavior. However, STPA provides a way to systematically identify these and other scenarios that could lead to loss or disaster. The following table 6 is a list of responsibilities, control actions and feedback in the processes that are the subject of this analysis.

Table 6 - List of Control Actions (white background) and Feedbacks (gray background)

CA/Fee-dback (n.)	CA/Feedback
1	Perform audit/inspection of the relevant processes Requires implementation of the set regulations
2	Audit/Inspection response and reports Process/regulation implementation
3	Audit/inspection of the relevant processes Issuing request for implementation of the set regulations Verifies the requirements for licensing Assigning licenses to the corresponding subject
4	Audit/Inspection response and reports Process/regulation implementation
5	Audit/inspection of the relevant processes Issuing request for implementation of the set regulations Verifies the requirements for licesing Assigning licenses to the corresponding subject
6	Audit/Inspection response and reports Process/regulation implementation
7	Audit/inspection of the relevant processes Issuing request for implementation of regulations Verifies the requirements for licesing

	Assigning licenses to the corresponding subject
8	Audit/Inspection response and reports Process/regulation implementation
9	Train and exam personnel Assigns the personnel to the task within shift Sets the procedure and verifies its integrity Prescribes daily working plan Opens or interrupts the work shift for the given positions according to the given limits
10	Training completion and exam fulfillment Confirms the post engagements according to the shift settings Applies the procedure at the given position Start or stop working at the designated position according to the work limits Confirms the coordination with other ATC units
11	Sets aircraft dispatch procedure Engage required personnel to the working posts Train and exam personnel Monitors and verifies dispatch systems provision Delegates the funds for the initiatives and processes
12	Aircraft dispatch procedure implementation Training completion and exam fulfillment Confirms the post engagement according to the shift settings Applies the procedures at the given position Indicates the dispatch systems functionality and provision Confirms the coordination with other airport units
13	Sets the implementation of airport infrastructure maintenance procedure Assigns the airport infrastructure maintenance equipment Assigns personnel for the maintenance positions Trains and exams personnel Delegates the funds for the initiatives and processes
14	Performs the infrastructure maintenance and changes Training completion and exam fulfillment Performs FOD check and elimination Performs inspection of the infrastructure changes

	Infrastructure maintenance procedure implementation Confirms the post engagement according to the shift setting Indicates the maintenance system functionality and provision Reports the Airport infrastructure state Confirms the coordination with other airport units
15	Sets the implementation of airport Wildlife control procedures Assigns airport Wildlife control equipment Assigns personnel for the Wildlife control posts Trains and exams personnel Delegates the funds for the initiatives and processes
16	Performs the wildlife control Training completion and exam fulfillment Implements preventive wildlife control procedures Wildlife control equipment implementation Confirms the post engagement according to the shift setting Indicates the wildlife control system functionality and provision Reports the Wildlife control state Confirms the coordination with other airport units
17	Sets the implementation of airport safety procedures Assigns airport safety equipment Assigns personnel for the safety management Assigns the Safety Manager Sets the safety priorities and processes through safety groups Priorities the safety mitigation measures and initiatives Trains and exams personnel for the safety management posts Delegates the funds for the initiatives and processes
18	Performs safety management procedures Training completion and exam fulfillment Identifies hazards and assess the risks Confirms or prohibits the procedures which do not fulfil safety standards Reports safety events and statistics Starts and leads safety mitigation measures Performs safety audits and inspections Confirms the post engagement Indicates the safety management system functionality and provision

	Leads the safety initiatives and programs Confirms the coordination with other airport units Reports to the state of safety management systems of the third parties
19	Sets the implementation of GHD procedures Assigns the GHD personnel Assigns the functional GHD equipment Trains and exams personnel Sets the daily shift and engagement plans Corrects and manages GHD performance Performs the on-site inspections and audits Delegates the funds for the initiatives and processes
20	Implements the GHD procedures Performance of the GHD services Training completion and exam fulfillment Reports safety events or irregularities Confirms the post engagement Indicates the GHD system functionality and provision Confirms the coordination with other GHD units
21	Issues clearance for taxiing from parking position Issues clearance for aircraft taxiing to or from the stand Issues corrects during movement Issues clearance for aircraft pushback
22	Confirms clearances and readback Requesting clearances and instructions Reporting states Reporting safety or other relevant events
23	Sets the implementation of crew procedures Assigns the crew Assigns the aircraft and other relevant equipment Trains and exams personnel Sets the daily shift and engagement plans Monitors and assess crew performance Performs the on-site inspections and audits Delegates the funds
24	Implements the crew procedures Performs flights

	Training completion and exam fulfillment Reports safety events or irregularities Confirms the post engagement Indicates the airline system functionality and provision Confirms the coordination with other airline units
25	Manipulates the GSE before, during and after ground handling Sets the GSE into or out of service
26	Equipment reported in or out of service
27	Flying and maneuvering of the aircraft
28	Aircraft movement Status indication
29	Aircraft ground handling: Aircraft refueling (grounding, fuel amount setting, hose connection/disconnection, dead-man switch setting, fueling trigger turning on/off) Aircraft catering (catering truck connecting, galley trolley insertion, equipment temperature regulation) Passenger services (passengers stairs/bridge connection/disconnection. Passenger disembarkation/embarkation directing) Aircraft water services and cleaning (Truck connection/disconnection, Refilling initiation) GPU services (connects/disconnects the electricity cable)
30	Fueling indication Catering completion report Passenger stairs/bridge positioning indication Passenger boarding/deboarding completion report Liquid filling indication GPU connection/disconnection indication
31	Maneuvering of the aircraft
32	Status indication
33	Parking stand allocation Parking stand closure and opening
34	Stand allocation confirmation Stand closure/opening confirmation

4.3 Identifying Unsafe Control Actions (UCA)

Once the control structure has been modeled and Cas defines, the next step is to identify Unsafe Control Actions(UCA). UCA is a control action, which will lead to a hazard in a particular context and worst environment. According to the control actions analyzed above, the corresponding UCA can be defined – presented in the following table (Table 7). Unsafe control actions are defined for the relevant processes defined within the controllers process model. These are commonly stated in the UCAs as “process”. (full list of defined UCA is presented in the Annex 1)

Table 7 - List of Unsafe control actions

n.	Not providing causes hazards	Providing causes hazards	Provided too early, too late	Stopped too soon, applied too long
1	Audit/inspection not performed	Regulation implementation brings the degradation of the process performance	Audit/Inspection performed before process change/modification implemented	
3	Personnel licensing not performed before process initiation	Personnel licence issued for inadequate personnel position	Personnel licence issued before confirmation of the requirements	
5	New regulation implementation not required before process initiation	Regulation implementation brings the degradation of the process performance	Audit/Inspection performed before process change/modification implemented	
7	Audit/inspection not performed before long-term work	Regulation implementation brings the degradation of the	Audit/Inspection performed before process change/modificatio	

	interruptions	process performance	n implemented	
9	Training and examination not performed before engagement to the given position	Assigned personnel less then set limit during intensive workload	Training and examination finished too early before process initiation	Training and examination not finished before process initiation
11	Personnel not engaged and assigned for the dispatch post	Assigned personnel trained for inadequate procedure	Engage required personnel to the working post too early,too late	Assignment and engagement f the personnel not finished before process initiation
13	Funding not secured before processes initiation	Funds is insufficient when processes initiation	Funding not secured after processes initiation	
15	Wildlife control procedure not set before traffic initiation	Wildlife control procedure not in line with the infrastructure, existing processes and traffic	Reports the wildlife control state before setting	
17	Safety management procedure not set before traffic initiation	Safety management procedure not in line with the infrastructure, existing processes and traffic	New safety management procedures sets after traffic initiation	
19	Ground handling procedure not set before traffic initiation	Ground handling procedure not in line with the infrastructure, existing processes	Ground handling procedure set after traffic initiation	

		and traffic		
21		Clearance for taxiing/pushback/ to parking position issued for inadequate parking position		Clearance for taxiing/pushback/ to parking position issued with the long delay
23	Crew procedure for the given airport not set before traffic initiation	Crew procedure not in line with the infrastructure, existing processes and traffic		
25	GSE not used	GSE manipulated differently then stated by producer during the ground handling		
27		Aircraft maneuver crosses aircraft or infrastructure limits		
29	Particular ground handling procedures not performed during traffic	Particular ground handling procedures performed during traffic with aircraft, equipment and personnel limits crossing		
31		Aircraft maneuver crosses aircraft or infrastructure limits		
33	Allocated stand before official activation of the	Allocated stand inadequate for		

	stand	expected aircraft type		

4.4 Identifying loss scenarios

Once unsafe control actions have been identified, the next step is to identify loss scenarios. As definition of STPA, a loss scenario describes the causal factors that can lead to the unsafe control actions and to hazards.[16]

The scenarios for the analyzed processed and identified UCAs were defined in a context of the low-regime operation at the airport. This practically means that all scenarios takes into consideration the existence of the potential influence of the traffic changes all other effect that such change brings. Low-regime operations factor is explained in the context of the particular scenarios and could be described with the following states:

- Process routine
- Process experience and knowledge
- Lack of capacity (number of required personnel for the given task)
- Inadequate planning (GHD capacities, parking stand capacity, stand allocation priorities, GSE allocation, Passenger bus/airbridge operator planning, etc.)
- Unexpected procedural changes (changes of the standardized or previous procedures)
- Unexpected traffic changes (delays, aircraft type changes, flight times changes, etc.)
- Increased time limits for the operations

In this context the following scenarios were defined (examples – full list of defined scenarios is presented in the Annex 2)

n.	Scenario	Recommended mitigation
S-1	Aircraft damaged during the GHD procedure (relevant procedures	Recurrent check of skills and knowledge after defined time period

	defined in CA) as GHD personnel crossed the manipulation abilities of the GSE due to lack of knowledge or experience	service interruption.
S-2	Aircraft damaged during the GHD procedure (relevant procedures defined in CA) before GHD personnel disrespect aircraft safety zone by GSE due to lack of knowledge or experience	Improved safety campaign in the basic safety training, and issuing of safety brief increasing awareness of the aircraft safety zones, for the new employees and within the existing safety initiatives.
S-3	Aircraft damaged during GHD procedure (relevant procedures defined in CA) with the GSE, due to contact with the vehicle/equipment caused by insufficient visual contact or sign list missing	Interruption of the vehicle operation if the sign list not present, controlled during the first 3 months after traffic recovery. Installation of the distance sensors and cameras.
S-4	Aircraft damaged during the GHD procedure (relevant procedures defined in CA) due to unexpected movement of the aircraft caused by insufficient chock positioning performed by misinformed personnel	Chock placement standardization for all customers at the given airport. Pre-GHD briefing initiation for the inexperienced personnel targeting variable requirements processes - coning, chokes, etc.
S-5	Aircraft damaged with the stairs/airbridge due to provision of the services to the inadequate aircraft type, whose change was not reported	Confirmation of the aircraft type in the link between airline-atc-airport dispatch-GHD. Implementation of the sensors within VDGS detecting irregularities in reported aircraft type. Interruption of the GHD operations before adequate GHD equipment Insurance
S-6	Aircraft damaged with the unsecured FOD or movable object unsecured during the adverse weather conditions, due to lack of procedure for the responsible personnel	Adverse weather condition prediction involved in intensive infrastructure check plan. Insurance of the addition monitoring shift in case of storm prediction at least 30 minutes before it. Safety campaign targeting GHD

		personnel processes before adverse weather conditions.
S-7	Personnel member injured during the handling procedure due to decreased distance between running engine and before anti-collision lights off. Personnel misinformed or lacking basic safety knowledge.	On-stand marking for anti-collision lights on zone. Intensive monitoring of the compliance after the traffic recovery for three months.
S-8	Personnel member injured during GSE manipulation due to not respecting vehicle/equipment operational limits and lacking skill/experience at the given position	Several steps training process and validation of the knowledge and skills for the all operating aircraft types at the given airport.
S-9	Personnel member injured due to collision with the FOD or moveable object not secured or eliminated by infrastructure maintenance unit (snow, ice, loose objects or pavements)	Daily surface check during the days of decreased temperature.
S-10	Personnel member injured due to entering jet engine protective zone behind the engine during engine start, during the procedure performed with the personnel number less then required	Improved safety campaign in the basic safety training, and issuing of safety brief increasing awareness of the aircraft safety zones, for the new employees and within the existing safety initiatives.

5. Risk assessment based on loss scenario

As stated in the methodology, risk assessment is performed using the standard ICAO risk matrix. The assessment process starts with the definition of the subject of the assessment, in case of this matrix, a worst-case scenario.

This scenario represents the safety accident/incident, which is assessed on probability/frequency of the occurrences, and severity.

This assessment is focused on the main defined scenarios within the STPA analysis. There are approaches for risk assessment recommended by STAMP authors, however, scope of this thesis is limited to the basic estimation of the risk indexes, not strictly focusing on the potential effectiveness of the mitigation measures.

As defined in the previous chapter, according to the STPA analysis outcomes, low-regime operation is defined through several states. These states are used to properly define potential loss scenarios, and while many scenarios are common in its sense among all identified controllers, the selection of the loss scenarios, representing the subject of the risk assessment is the following:

S-1: Aircraft damaged during the GHD procedure (relevant procedures defined in CA) as GHD personnel crossed the manipulation abilities of the GSE due to lack of knowledge or experience

The probability of the risk is evaluated with the value 2 while GDH company involves the standard training with the GSE equipment. Number of the occurrences related to the issue are evaluated as low or moderate. Severity is assessed with index C.

S-5: Aircraft damaged with the stairs/airbridge due to provision of the services to the inadequate aircraft type, whose change was not reported

Change of the aircraft type is common situation. In the period of traffic recovery it happens more often, bringing a need for improvement of communication and reporting. Probability is evaluated with 2 and severity with index D

S-9: Personnel member injured due to collision with the FOD or moveable object not secured or eliminated by infrastructure maintenance unit (snow, ice, loose objects or pavements)

Having in mind the size of maintained surface by the delegated airport unit, occurrences of the FOD originating from the airport infrastructure is expected to be frequent. In winter conditions, surface contamination is quite common particularly in the zones with the presence of the equipment or devices producing condensation. Probability in this case is evaluated with the index 3 and severity with the index D.

S-13: Passenger injured due to entrance to the aircraft protective zone during the GHD operations. Corridor not monitored due to absence of the personnel or lack of experience.

With the trend of high employee fluctuation in the sector of aircraft ground handling, training becomes more challenging process. Insufficient awareness of the personnel in the high-risk areas like engine protection zone could be considered as common. Probability is evaluated with the index 3 and severity with the index C.

S-31: Aircraft damaged due to contact with the damaged pavement on the taxiway during taxiing. Pavement check and control performed before infrastructure damage occurred or not detected

Commonly as in the case of S-9, ensuring FOD-free zone on the airport surface is time-consuming and challenging task. Presence and following suction of the FOD into the engine for instance is considered to be probable case, therefore index 3, while severity with index B.

S-40: GHD personnel injury during the GHD process due to not obeying on-stand traffic rules, due to negative attitude to job position. Lack of experience in aviation sector and unknown working environment.

Incorporating human factor into safety analysis is in the socio-technical systems a common thing. Reluctance or demotivation caused by many internal or external factors could lead to serious process violation. Having in mind that lack of personnel in the current years becomes more and more serious issue, probability is evaluated as high 4, and severity as minor, D.

S-44: GSE equipment damaged due to existing previous technical difficulties while exploited in high traffic volume. Maintenance check not performed due to inadequately set procedures

State of GSE equipment is a well known problem, which became bigger with the low-operation regime during last years and decreased investments in such kind of equipment. Increased number of the technically inadequate GSE raise the attention and therefore a probability of the issue to a level marked with the index 3, however severity remains at the level of C, bearing in mind that such kind of equipment operates at lower speed and extensive damages are not expected.

Assessment of the risk could be performed for all defined hazard consequences. It is important to be noted that, classic risk assessment is common in aviation industry, mainly to the recommendations and request placed on entities in this industry to implement Safety Management System. It still remains a question, mainly in academic circles, whether such kind of evaluation bring a useful information, that can serve for active management, or it is valuable only for statistic evaluation and comparison.

6.Discussion

Low-regime periods of operations, brought a new view on the aviation industry and become a challenging state of the global aviation system. The focus of the performed analysis is on the processes that are taking place at the airport. While performed hazard analysis takes into consideration certain set of airport operation processes, results will be discussed within this scope.

Analysis was performed for the processes mutually interconnecting several entities. These processes are aircraft taxiing process, and ground handling process. According to such scope limitation, firstly the losses were defined. Losses in the case of this analysis do not differ from the standard losses that could be find within the analyses in the aviation domain. Define loss represent the consequence, worst case scenario event, caused by identified factors within the context of the low-regime operations. It cannot be concluded that airport operation within low-regime state creates specific loss events, not common in other system settings or states. Such conclusion confirms the appropriateness of the applied methodology.

Set of the identified controllers, relevant for the scope of the analysis covers the fundamental activities, necessary for process to be performed. While analysis is focused on the airport operations, it is important to distinguish the responsibilities and competencies. Proposed control structure defines the strictly airport-related controllers, hierarchically presented below airport operator. It can be concluded that analyzed processes could be assessed on the systemic level only if all relevant entities are defined in the control structure, due to wide interconnection and cooperation between them. Defined system level hazards were defined and then defined at the conclusion of the analysis.

Defined control actions were derived from the responsibility, accountability and authority of the defined controllers. All CA are the actions derived from the standardized setting of the particular work positions. This means that all relevant activities, set to change the current state of the process/system were considered.

Based on the defined control actions, the third step of the analysis brings the set of the defined Unsafe Control Actions. Definition of the UCAs was done in accordance to the proposed methodology. UCAs serve as the core of the loss event creation. Results show that many of the defined UCAs highlight the common issues that are related to the low-regime operations. These aspects were stated in order to practically define such kind of operational regime. All of the aspects were successfully used for the loss scenarios definition. This implies that low-regime operation state is represented in the loss scenarios through a defined context that respects these aspects.

Loss scenarios showed the quite easily detectable relation between common hazards related to the defined processes and new factors represented as the aspects of the low-regime operations. This relation confirms that such factors in a certain case could boost the UCAs and practically speed up the occurrence of the unwanted scenarios.

While applied method takes into consideration the interactions between several

UCAs it is quite practical for setting of the corrective measures. In this context, Corrective measure is understood as the measure created to ensure the required safety constraints. All mitigation measures were defined in the sense of the practically applicable solutions that leads to a better ensuring of the required safety constraints or eliminating the potential for UCAs creation.

Risk assessment was performed for the certain set of the identified hazard consequences, that includes defined low-regime operation factors. Risk assessment as such bring the general view on the risk in form of the probability and severity. Practical application of such conclusion depends on the needs of their user and further analytical intentions.

7. Conclusion

Airport safety is currently a major concern and the urgent resolution of safety hazards is the vision of all airports. This thesis describes the impact on airports during the pandemic. For example, traffic trends at airports, changes in passenger boarding procedures, airports facing labor shortages and currently airports facing post-pandemic impacts. In briefly, the airport is under a low operating regime and there are many safety hazards. If the relevant personnel at the airport do not identify and solve these hazards in advance, it may increase the rate of accident. Therefore, this paper adopts STPA method to identify airport hazards,which is mainly divided into four steps: 1) Define the purpose of analysis; 2) Establish the model of airport control structure; 3) Identify unsafe control actions through the control loops; 4) Identify how the hazard is formed in combination with the scenarios. Each hazard does not exit alone, when multiple hazards exist and interact with each other, there is the potential to reduce safety margins and lead to unimaginable consequences. Therefore, the hazards in the scenario are assessed with the ICAO risk assessment tool, which quickly retrieves the level of risk and understands the threat that each hazard poses to the safe operation of the airport.

By analyzing unsafe actions and major scenarios at airports, it is concluded that airport hazards mainly exist in the management system, GHD personnel's control of GSE and the functionality of airport equipment. The management system is mainly manifested in the training and examination of personnel, the issuance of licenses, shift system, personnel allocation and related supervision units; The operational changes of GHD personnel are mainly manifested in knowledge and experience, GHD procedure operation and the usage of GSE; The infrastructure of the airport is mainly manifested in the maintenance of equipment, the functions of equipment and the number of equipment.

Airport safety hazards are widely distributed and each individual affects the other. Other parts of the airport can be further analyzed, such as the influence of airlines on airport procedures and so on. The current global situation is tense and the low operational status of airports could fall into another negative state at any time. In order to ensure safe airport operations, airport operations need to consider airport safety in the planning and construction of airports in the post-pandemic era, and to reduce or eliminate safety hazards wherever possible. Adjustments should be made according to the actual situation and strategies need to be continuously improved to ensure the safety quality of the airport and to achieve sustainable development.

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Annex 1- List of UCA

n.	Not providing causes hazards	Providing causes hazards	Provided too early, too late	Stopped to soon, applied to long
1	UCA 1 - Audit/inspection not performed before long-term work interruptions UCA 2 - Audit/inspection not performed after irregularity/safety event occurrence UCA 3 - Regulations implementation not verified before process initiation UCA 4 - New regulation implementation not required before process initiation	UCA 5 - Regulation implementation brings the degradation of the process performance	UCA 6 - Audit/Inspection performed before process change/modification implemented	
3	UCA 1 - Audit/inspection not performed before long-term work interruptions UCA 2 - Audit/inspection not performed after irregularity/safety event occurrence UCA 3 - Regulations implementation not	UCA 5 - Regulation implementation brings the degradation of the process performance UCA 8 - Personnel licence issued for inadequate personnel position	UCA 6 - Audit/Inspection performed before process change/modification implemented UCA 9 - Personnel licence issued before confirmation of the requirements	

	verified before process initiation UCA 4 - New regulation implementation not required before process initiation UCA 7 - Personnel licensing not performed before process initiation			
5	UCA 1 - Audit/inspection not performed before long-term work interruptions UCA 2 - Audit/inspection not performed after irregularity/safety event occurrence UCA 3 - Regulations implementation not verified before process initiation UCA 4 - New regulation implementation not required before process initiation UCA 7 - Personnel licensing not performed before process initiation	UCA 5 - Regulation implementation brings the degradation of the process performance UCA 8 - Personnel licence issued for inadequate personnel position	UCA 6 - Audit/Inspection performed before process change/modification implemented UCA 9 - Personnel licence issued before confirmation of the requirements	

7	UCA 1 - Audit/inspection not performed before long-term work interruptions UCA 2 - Audit/inspection not performed after irregularity/safety event occurrence UCA 3 - Regulations implementation not verified before process initiation UCA 4 - New regulation implementation not required before process initiation UCA 7 - Personnel licensing not performed before process initiation	UCA 5 - Regulation implementation brings the degradation of the process performance UCA 8 - Personnel licence issued for inadequate personnel position	UCA 6 - Audit/Inspection performed before process change/modification implemented UCA 9 - Personnel licence issued before confirmation of the requirements	
9	UCA 10 - Training and examination not performed before engagement to the given position UCA 11 - Required personnel not assigned to the respective post UCA 12 - Integrity of the process not	UCA 16 - Assigned personnel less then set limit during intensive workload UCA 17 - Integrity verified only for certain processes even though all of them initiated		UCA 19 - Shift closed before another opened during high intensity traffic

	verified before initiation UCA 13 - Daily work plan not provided before process initiation UCA 14 - Work shift for the given position not opened in case of overload UCA 15 - Work shift for the given position not closed in case of time limit crossed and fatigue of the personnel	UCA 18 - Shift closed before another opened during high intensity traffic		
11	UCA 20 - Aircraft dispatch procedure not set before traffic initiation UCA 21 - Personnel not engaged and assigned for the dispatch post UCA 22 - Training and examination not performed before engagement to the given position UCA 23 - Dispatch system not provided before	UCA 25 - Aircraft dispatch procedure not in line with the infrastructure, existing processes and traffic UCA 26 - Assigned personnel trained for inadequate procedure UCA 27 - Dispatch system provided not in line with the	UCA 28 - Funding not secured after processes initiation	UCA 29 - Assignment and engagement f the personnel not finished before process initiation UCA 30 - Training and examination not finished before process initiation

	and during the traffic operations UCA 24 - Funding not secured before processes initiation	infrastructure, existing processes and traffic		
13	UCA 31 - Airport infrastructure procedure not set before traffic initiation UCA 32 - Personnel not engaged and assigned for the infrastructure maintenance post UCA 33 - Training and examination not performed before engagement to the given position UCA 34 - Airport infrastructure equipment not provided before and during the traffic operations UCA 35 - Funding not secured before processes initiation	UCA 36 - Airport maintenance procedure not in line with the infrastructure, existing processes and traffic UCA 37 - Assigned personnel trained for inadequate procedure UCA 38 - Airport infrastructure maintenance equipment provided not in line with the infrastructure, existing processes and traffic	UCA 39 - Funding not secured after processes initiation	UCA 40 - Assignment and engagement of the personnel not finished before process initiation UCA 41 - Training and examination not finished before process initiation

15	UCA 42 - Wildlife control procedure not set before traffic initiation UCA 43 - Personnel not engaged and assigned for the wildlife control post UCA 44 - Training and examination not performed before engagement to the given position UCA 45 - Wildlife control equipment not provided before and during the traffic operations UCA 46 - Funding not secured before processes initiation	UCA 47 - Wildlife control procedure not in line with the infrastructure, existing processes and traffic UCA 48 - Assigned personnel trained for inadequate procedure UCA 49 - Wildlife control equipment provided not in line with the infrastructure, existing processes and traffic	UCA 50 - Funding not secured after processes initiation	UCA 51 - Assignment and engagement of the personnel not finished before process initiation UCA 52 - Training and examination not finished before process initiation

17	UCA 53 - Safety management procedure not set before traffic initiation UCA 54 - Personnel not engaged and assigned for the safety management posts UCA 55 - Training and examination not performed before engagement to the given position UCA 56 - Safety management equipment not provided before and during the traffic operations UCA 57 - Funding not secured before processes initiation UCA 58 - High risk safety issues not mitigated or prioritized UCA 59 - Safety training not performed for the airport posts before airport operations	UCA 60 - Safety management procedure not in line with the infrastructure, existing processes and traffic UCA 61 - Assigned personnel trained for inadequate procedure UCA 62 - Safety management equipment provided not in line with the infrastructure, existing processes and traffic	UCA 63 - Funding not secured after processes initiation	UCA 64 - Assignment and engagement of the personnel not finished before process initiation UCA 65 - Training and examination not finished before process initiation

19	UCA 66 - Ground handling procedure not set before traffic initiation UCA 67 - Personnel not engaged and assigned for the ground handling posts UCA 68 - Training and examination not performed before engagement to the given position UCA 69 - GSE not provided before and during the traffic operations UCA 70 - Funding not secured before processes initiation UCA 71 - High risk safety issues not mitigated or prioritized before operations UCA 72 - Safety training not performed for the ground handling posts before initiation of the processes UCA 73 -	UCA 74 - Ground handling procedure not in line with the infrastructure, existing processes and traffic UCA 75 - Assigned personnel trained for inadequate procedure UCA 76 - GSE provided not in line with the infrastructure, existing processes and traffic	UCA 77 - Funding not secured after processes initiation	UCA 78 - Assignment and engagement of the personnel not finished before process initiation UCA 79 - Training and examination not finished before process initiation

	Audits/inspections not performed after irregularity/safety event occur			
21		UCA 80 - Clearance for taxiing/pushback /to parking position issued for inadequate parking position UCA 81 - Clearance for taxiing/pushback /to parking position issued for inadequate aircraft type		UCA 80 - Clearance for taxiing/pushback/to parking position issued with the long delay

23	UCA 81 - Crew procedure for the given airport not set before traffic initiation UCA 82 - Personnel not engaged and assigned for the crew posts UCA 83 - Training and examination not performed before engagement to the given position UCA 84 - Funding not secured before processes initiation UCA 85 - High risk safety issues not mitigated or prioritized before operations UCA 86 - Safety training not performed for the crew posts before initiation of the processes UCA 87 - Audits/inspections not performed after irregularity/safety event occur	UCA 88 - Crew procedure not in line with the infrastructure, existing processes and traffic UCA 89 - Assigned personnel trained for inadequate procedure	UCA 91 - Funding not secured after processes initiation	UCA 92 - Assignment and engagement of the personnel not finished before process initiation UCA 92 - Training and examination not finished before process initiation

25	UCA 93 - GSE not used	UCA 94 - GSE manipulated against set traffic rules UCA 95 - GSE manipulated differently then stated by producer during the ground handling		
27		UCA 96 - Aircraft manipulated against traffic rules UCA 97 - Aircraft maneuver crosses aircraft or infrastructure limits		
29	UCA 98 - Particular ground handling procedures not performed during traffic UCA 99 - High risk safety issues not mitigated or prioritized before operations	UCA 100 - Particular ground handling procedures performed during traffic with aircraft, equipment and personnel limits crossing		
31		UCA 96 - Aircraft manipulated		

		against traffic rules UCA 97 - Aircraft maneuver crosses aircraft or infrastructure limits		
33	UCA 101 - Allocated stand before official activation of the stand UCA 102 - Parking closure information sharing not performed	UCA 103 - Allocated stand inadequate for expected aircraft type		

Annex 2- List of Scenarios

n.	Scenario	Recommended mitigation
S-1	Aircraft damaged during the GHD procedure (relevant procedures defined in CA) as GHD personnel crossed the manipulation abilities of the GSE due to lack of knowledge or experience	Recurrent check of skills and knowledge after 1 month service interruption.
S-2	Aircraft damaged during the GHD procedure (relevant procedures defined in CA) before GHD personnel disrespect aircraft safety zone by GSE due to lack of knowledge or experience	Improved safety campaign in the basic safety training, and issuing of safety brief increasing awareness of the aircraft safety zones, for the new employees and within the existing safety initiatives.
S-3	Aircraft damaged during GHD procedure (relevant procedures defined in CA) with the GSE, due to contact with the vehicle/equipment caused by insufficient visual contact or sign list missing	Interruption of the vehicle operation if the sign list not present, controlled during the first 3 months after traffic recovery. Installation of the distance sensors and cameras.
S-4	Aircraft damaged during the GHD procedure (relevant procedures defined in CA) due to unexpected movement of the aircraft caused by insufficient chock positioning performed by misinformed personnel	Chock placement standardization for all customers at the given airport. Pre-GHD briefing initiation for the inexperienced personnel targeting variable requirements processes - coning, chokes, etc.
S-5	Aircraft damaged with the stairs/airbridge due to provision of the services to the inadequate aircraft type, whose change was not reported	Confirmation of the aircraft type in the link between airline-atc-airport dispatch-GHD. Implementation of the sensors within VDGS detecting irregularities in reported aircraft type.

		Interruption of the GHD operations before adequate GHD equipment insurance
S-6	Aircraft damaged with the unsecured FOD or movable object unsecured during the adverse weather conditions, due to lack of procedure for the responsible personnel	Adverse weather condition prediction involved in intensive infrastructure check plan. Insurance of the addition monitoring shift in case of storm prediction at least 30 minutes before it. Safety campaign targeting GHD personnel processes before adverse weather conditions.
S-7	Personnel member injured during the handling procedure due to decreased distance between running engine and before anti-collision lights off. Personnel misinformed or lacking basic safety knowledge.	On-stand marking for anti-collision lights on zone. Intensive monitoring of the campaign after the traffic recovery for three months.
S-8	Personnel member injured during GSE manipulation due to not respecting vehicle/equipment operational limits and lacking skill/experience at the given position	Several steps training process and validation of the knowledge and skills for the all operating aircraft types at the given airport.
S-9	Personnel member injured due to collision with the FOD or moveable object not secured or eliminated by infrastructure maintenance unit (snow, ice, loose objects or pavements)	Daily surface check during the days of decreased temperature.
S-10	Personnel member injured due to entering jet engine protective zone behind the engine during engine start, during the procedure performed with the personnel number less then required	Improved safety complain in the basic safety training, and issuing of safety brief increasing awareness of the aircraft safety zones, for the new employees and within the existing safety initiatives.

S-11	Personnel member injured during the manipulation with the GSE due to lack of protective equipment during high intensity operations	Safety campaign with training process, escalating the issue with the visual connect describing consequences of not wearing protective equipment
S-12	Passenger injured during embarkation/disembarkation due to presence of the ice/show, or other slippery contaminant on the passengers corridor. Corridor not monitored due to absence of the personnel or lack of experience.	Daily surface check during the days of decreased temperature.
S-13	Passenger injured due to entrance to the aircraft protective zone during the GHD operations. Corridor not monitored due to absence of the personnel or lack of experience.	Procedure set to open/close passenger corridor only by the monitoring personnel member
S-14	Passenger injured while passing on stairs, not stabilized adequately due lack of experienced personnel during high-intensity traffic	Obligatory re-check of the stairs stability by ramp agent after walk-around procedure for set time frame
S-15	Passenger injured while stepping on the loose pavement or unstable surface on the passengers corridor, due to inadequate maintenance provided within given time frame	Two-step surface check performed with two teams after long/short-terms operations interruptions and after adverse weather conditions.
S-16	Aircraft safety zone corrupted by GSE equipment before or during the GHD procedure due to GHD personnel lack.	Improved safety complain in the basic safety training, and issuing of safety brief increasing awareness of the aircraft safety zones, for the new employees and within the existing safety initiatives.

S-17	Aircraft safety zone corrupted by GSE equipment before or during the GHD procedure due to GHD personnel procedure violation	Improved safety complain in the basic safety training, and issuing of safety brief increasing awareness of the aircraft safety zones, for the new employees and within the existing safety initiatives.
S-18	Aircraft safety zone corrupted by GSE equipment before or during the GHD procedure due to GHD personnel omission or loss of situational awareness. Issue not assessed on risk.	Improved safety campaign in the basic safety training, and issuing of safety brief increasing awareness of the aircraft safety zones, for the new employees and within the existing safety initiatives.Extensive safety study on the situation awareness of the new employees with the aircraft ground handling environment.
S-19	Aircraft parking stand contains FOD due to lack of stand check before GHD procedure and aircraft get in collision with the FOD. FOD check not performed due to lack of personnel and earlier arrival of the aircraft.	Implementation of the stand CCTV FOD sensors and monitors.
S-20	Aircraft parking stand contains FOD due to lack of stand check before GHD procedure and aircraft get in collision with the FOD. FOD check not performed due to lack functionality of the scanning systems	Confirmation for the FOD check within the VDGS, and interruption of the parking procedure if FOD check not detected.
S-21	Loose FOD collides with the GSE during adverse weather, causing damaged to the GSE, which need to be eliminated from the operations	Adverse weather condition prediction involved in intensive infrastructure check plan. Insurance of the addition monitoring shift in case of storm prediction at least 30 minutes before it. Safety

		campaign targeting GHD personnel processes before adverse weather conditions.
S-22	Aircraft parking stand contains FOD or other obstacles during the aircraft parking procedure, causing collision. Aircraft stand allocated was not opened and information was misinterrupted by airport dispatch	Double stand availability check and confirmation between dispatch and maintenance unit.
S-23	Aircraft in collision with the object or building at the aircraft stand during parking procedure due to inadequacy of the stand with the aircraft type. Dispatch stand allocation not taking into consideration aircraft type change	Confirmation of the aircraft type in the link between airline-atc-airport dispatch-GHD. Implementation of the sensors within VDGS detecting irregularities in reported aircraft type. Interruption of the GHD operations before adequate GHD equipment Insurance
S-24	Aircraft in collision with the object or building at the aircraft stand during parking procedure due to inadequacy of the knowledge and experience. Flight crews did not takes into consideration changes of airport procedure change	Double stand availability check and confirmation between dispatch and maintenance unit.Addition notice to the crew entering reopened stand after long and wide changes
S-25	Aircraft in collision with the object or building at the aircraft stand during parking procedure due to inadequacy of the marking or sign.	Perform wide-range marking adequacy check after the long/short-term operations interruptions.
S-26	Aircraft in collision with the object during taxiing procedure due to inadequacy of the lighting. Maintenance crew not check the availability of lighting system.	Perform wide-range lighting adequacy check after the long/short-term operations interruptions.

S-27	Aircraft in collision with the object or building at the aircraft stand during parking procedure due to use of incorrect of communication. Incorrect communication used due to lack of knowledge	In order to improve the effectiveness of communication, standard aviation terminology must be used between communicators.
S-28	Aircraft in collision with the object or building at the aircraft stand during parking due to misinformation provided to the crew regarding the infrastructural changes	Double stand availability check and confirmation between dispatch and maintenance unit. Addition notice to the crew entering reopened stand after long and wide changes
S-29	Aircraft in collision with the object or building at the airport stand during parking due to low experience of the engaged crew with the given airport	Hot-spot or infrastructure changes bulletins distribution and dialog.
S-30	Aircraft in collision with the object during taxiing procedure due to violation of the aircraft SOPs . Flight crew did not finished SOPs before taxiing	Before taxiing, the flight crew shall check and complete in accordance with SOPs.
S-31	Aircraft damaged due to contact with the damaged pavement on the taxiway during taxiing. Pavement check and control performed before infrastructure damage occurred or not detected	Two-step surface check performed with two teams after long/short-terms operations interruptions and after adverse weather conditions.
S-32	Aircraft in collision with the birds during taxiing procedure due to the non-functional of bird repeller. Maintenance crews did not taking into consideration the available of bird repeller	Wildlife control performs double check of the functionality of the bird repeller in the months of the increased flock appearance
S-33	Collision of the aircraft with the wildlife on the taxiway surface due to facing system corruption. Fencing control not performed due to lack of procedure, experience or	Wildlife control performs double check of the functionality of the fencing in the months of the increased

	funding.	animal activity
S-34	Aircraft damaged during GHD procedure(relevant procedures defined in CA)before the GHD personnel not comply with unexpected procedure changes due to limit of information	Unexpected changes to procedures should be updated and notified to GHD personnel to comply with the new procedures.
S-35	Aircraft damaged during GHD procedure(relevant procedures defined in CA),ground personnel operate procedure in urgently due to increase time limits for operations	Standard personnel number monitoring for the given time frame after long/short term operation interruption
S-36	Aircraft damaged due to inadequate GSE/equipment usage for the given aircraft type. Change of the type not reported through required channels. Low experience of the personnel in aviation environment.	Confirmation of the aircraft type in the link between airline-atc-airport dispatch-GHD. Implementation of the sensors within VDGS detecting irregularities in reported aircraft type. Interruption of the GHD operations before adequate GHD equipment Insurance. Safety complain on increasing aviation knowledge.
S-37	GHD personnel injured during the GHD process due to misinformation of the given signal. Lack of procedure interpretation and safety assessment	Improved safety complain in the basic safety training, and issuing of safety brief increasing awareness of the aircraft safety zones, for the new employees and within the existing safety initiatives.Extensive safety study on the new employees awareness in the GHD environment.

S-38	GHD personnel injured during the GHD process due to missing information on procedural change.	Improved safety complain in the basic safety training, and issuing of safety brief increasing awareness of the aircraft safety zones, for the new employees and within the existing safety initiatives.
S-39	GHD personnel injured during the GHD process while not respecting traffic rules during high intensity operations. Lack of situational awareness due to lack of experience. Safety assessment not performed for the new, inexperienced personnel members	Extensive safety study on the new employees awareness in the GHD environment. Improved safety complain in the basic safety training, and issuing of safety brief increasing awareness of the aircraft safety zones, for the new employees and within the existing safety initiatives.
S-40	GHD personnel injury during the GHD process due to not obeying on-stand traffic rules, due to negative attitude to job position. Lack of experience in aviation sector and unknown working environment	Personnel attitude survey focused on the task routine potential and satisfaction with the working environment.
S-41	GHD personnel injury during GHD process caused by low attention during high-risk operation. Dwell-time chat with the personnel decreasing attention to the given task	Personnel attitude survey focused on the task routine potential and satisfaction with the working environment.
S-42	GHD personnel injury during GHD process due to applied routine actions, not appropriate for the process after the system/process changes. Risk assessment on new working environment or condition not performed	Extensive safety study on working environment changes in GHD at the given airport. Personnel attitude survey focused on the task routine potential and satisfaction with the working environment.
S-43	GSE equipment damaged due to existing previous technical difficulties while exploited in high traffic volume. Maintenance check not	GSE extensive monitoring and tracking. Implementation of the GSE database,

	performed in the given time frame	validated on daily basis. Information available for all interested entities.
S-44	GSE equipment damaged due to existing previous technical difficulties while exploited in high traffic volume. Maintenance check not performed due to inadequately set procedures	GSE extensive monitoring and tracking. Implementation of the GSE database, validated on daily basis. Information available for all interested entities.
S-45	GSE equipment damaged due to existing previous technical difficulties while exploited in high traffic volume. Maintenance check not performed due to inadequate knowledge of responsible personnel	GSE extensive monitoring and tracking. Implementation of the GSE database, validated on daily basis. Information available for all interested entities.
S-46	GSE equipment damaged due to existing previous technical difficulties while exploited in high traffic volume. Maintenance check not performed due to lack of funding	GSE extensive monitoring and tracking. Implementation of the GSE database, validated on daily basis. Information available for all interested entities.
S-47	GSE in collision damaged aircraft due to structural defects. GSE not removed from operation after detection of technical insufficience. GSE technical control not set.	GSE extensive monitoring and tracking. Implementation of the GSE database, validated on daily basis. Information available for all interested entities.
S-48	GSE in collision damaged aircraft due to structural defects. GSE not removed from operation after detection of technical insufficience. GSE technical control not performed through regular safety inspection.	GSE extensive monitoring and tracking. Implementation of the GSE database, validated on daily basis. Information available for all interested entities.
S-49	GSE in collision damaged aircraft due to structural defects. GSE exploited by operator due to insufficient number of available GSE.	GSE extensive monitoring and tracking. Implementation of the GSE database,

		validated on daily basis. Information available for all interested entities.
S-50	GSE in collision damaged aircraft due to structural defects. GSE left unbraked on the surfaced, causing the self and uncontrolled movement. Lack of technical experience of the engaged personnel	Certification of the GSE maintenance unit, responsible for GSE state monitoring and GSE database update
S-51	Collision of the GSE with the aircraft or other object caused by improper manipulation with the equipment due to absence of the procedure or guidance. GHD operator not providing procedure description or training to the respective personnel	Regular ad-hose GSE manipulation skill within the given time frame after the the long/short term operation interruptions
S-52	Damage of the aircraft during the push-back procedure due to crossing the maneuvering limits of the used equipment. Training not performed or lacking experience for the particular aircraft type.	Regular ad-hose GSE manipulation skill within the given time frame after the the long/short term operation interruptions
S-53	Damage to the aircraft or airport infrastructure by GSE manipulated by inexperienced personnel member, due to insufficience in the procedure description. Authority body not confirming inexperienced personnel member hazards during oversight activities	Wide-scope authority audit of the main functional aspect of the airport after long/short term operation interruptions
S-54	Damage to the aircraft or airport infrastructure by GSE manipulated by inexperienced personnel member, due to insufficience in the procedure description. Responsible safety manager not confirming inexperienced personnel member hazards during oversight activities	Wide-scope authority audit of the main functional aspect of the airport after long/short term operation interruptions. Integrated activities with the responsible safety management.
S-55	Misinterpretation of the airport operations changes due to lacking information distribution channels. Leading to the damage	Refreshing the communication platforms with the response confirmation

	or injuries caused by unawareness of the existing risks.	functionality. Frequent update and operability check implementation.