D3.1 – Cultural Risk Assessment Methodology Report
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Impact of Cultural aspects in the management of emergencies in public Transport – IMPACT
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<td>ATM</td>
<td>Automated Teller Machine</td>
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<tr>
<td>COTS</td>
<td>Components Off The Shelf</td>
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<tr>
<td>EICCS</td>
<td>Environment, Information, Crowd, other Crowd members and Staff</td>
</tr>
<tr>
<td>ESG</td>
<td>Expert Steering Group</td>
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<td>FMEA</td>
<td>Failure Mode and Effect Analysis</td>
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<td>HAZMAT</td>
<td>Hazardous materials</td>
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<tr>
<td>HAZOP</td>
<td>Hazard and Operability Study</td>
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<td>HVAC</td>
<td>Heating, ventilation, and air conditioning</td>
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<td>ID</td>
<td>Identifier</td>
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<td>IROPS</td>
<td>Irregular operations</td>
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<td>LEP</td>
<td>Low English Proficiency</td>
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<td>MAS</td>
<td>Multi-Agent Systems</td>
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<td>SMS</td>
<td>Short Message Service</td>
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<td>VIP</td>
<td>Very Important Person</td>
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EXECUTIVE SUMMARY

The document reports the work done in WP3 of IMPACT and, specifically, the activities carried out in Tasks 3.2 Design of the Cultural Risk Assessment Methodology.

This report proposes the approach for risk assessment/management of cultural risk assessment in transport hubs, starting from applicable standards and then dealing with general risk assessment methodology, followed by a proposal to include cultural behaviour specific risk assessment.

The document builds on the ISO 31000/31010 standards and identifies the parts of the proposed approach in which cultural characteristics and behaviours can play a role.

Then, a high-level hazards and threats analysis is reported, highlighting two macro categories:

- Generic hazards and threats whose consequences could be amplified by cultural characteristics and/or behaviours of involved crowds.
- Culture-induced hazards, i.e. hazards directly generated by cultural hazardous behaviours.

Starting from these two categories, it has been possible to propose changes to the standard risk assessment focusing on the culture-related aspects. Due to the difficulties to correlate psycho-social characteristics to hazardous cultural behaviours and therefore to quantify likelihoods and consequences, the work has mainly concentrated on the identification of culture-specific control actions able to mitigate identified hazards and threats.

The work has led to the following conclusions:

- The proposed cultural behaviour risk assessment methodology can be applied to transport hubs where:
  1) The overall general risk plus cultural behaviour is applied from first principle.
  2) The cultural behaviour risk assessment is an add on to an existing overall risk assessment.
  3) Only cultural behaviour risk assessment is performed to examine its contribution to the overall transport hub risk.
- It has been proven that is very difficult to assess consequences and likelihoods of events leading to escalation due to specific cultural behaviours based on the findings of WP1. Therefore, the emphasis on the report has been on expert elicitation of likelihood and consequences of these hazards leading to risks and mitigation measures that are more consolidated.
- Various mitigation action to be applied to specific cultural clusters/ethical minorities have been reported in the areas of first-aid and long-term health cares, communication, training and awareness and signs. However, most of them relates to US specificities while EU is apparently not yet aligned in providing guidelines in case of cultural diversities.
- Whenever evacuation of crowds is involved, computer models could help to quantify consequences. The survey of the both literature and market has highlighted that
  - Only few models allow to model cultural differences inside the crowd and most of these models are only at the research level.
  - The selected cultural parameters in the proposed approaches are very different and often not comparable. Moreover, the number of parameters to be tuned is quite high in each model and sources on which tuning can rely are very limited.
  - Proposed models have been validated only with very limited data sets, thus making adoption into a risk assessment process very difficult if not impossible.

All the above reinforces the need of further research in the area of cultural agent based modelling as is currently proposed in WP2.

- The proposed approach needs to be tuned to a specific transport hub under assessment to consider the hub design, staff training level, number of people in the hub, transport modes, as well as the expected cultural mix of passengers and visitors. The assessment should include the feasible scenarios with their relevant internal and external hazards and threats, etc.
1 Scope and introduction of the document

1.1 Scope
As described in Annex 1 of the IMPACT H2020 Grant Agreement no. 653383, the scope of this document is to produce a cultural risk assessment methodology and the associated mitigation actions for the emergency preparedness and management for the public transport sector based on the findings of the psycho-social and cross-cultural behavioural theories.

The document reports the work done in WP3 of IMPACT and, specifically, the activities carried out in Tasks 3.1 Synthesis of Psycho-Social and Cross-Cultural Parameters for Cultural Risk Assessment and Task 3.2 Design of the Cultural Risk Assessment Methodology.

1.2 Introduction
The chosen approach starts from existing standards for generic risk assessment and discusses the changes to be introduced when cultural factors are considered.

The document is therefore structured as follows:

- Section 2 proposes a methodology of risk assessment for the IMPACT project, with focus on specific aspect of cultural behaviour.
- In section 3 the relationships between threats, hazards and culture are discussed, highlighting the cases in which culture can either hamper the consequences of generic threats and/or hazards or be a trigger for new hazards.
- Finally, D3.1 section 4 analyses the changes to the general risk assessment procedure when considering cultural factors and section 5 provides the conclusions drawn.
2 GENERAL RISK ASSESSMENT PROCEDURE

The objective of this report is to propose a methodology of risk assessment for the IMPACT project, with focus on specific aspect of cultural behaviour.

The WP3 goal is to propose how to conduct a risk assessment from the point of view of cultural behaviour (goal of present task) and to enable the design of a risk assessment course including cultural behaviour to help transport hubs to assess their own risks and to train their own risk assessors.

This report proposes the approach for risk assessment/management starting from applicable standards and then dealing with general risk assessment methodology (section 2), followed by a proposal to include cultural behaviour specific risk assessment (sections 3 and 4).

2.1 Applicable standards

The proposed methodology is based on a standard risk assessment approach compliant with the following standards

- ISO 31000 “Risk management” [1];

It will then focus on the aspects arising from the specificities of cultural behaviours including:

- How to integrate the specific aspect of cultural behaviour into an overall risk assessment methodology.
- The inclusion into the approach of the various intangible aspects of cultural behaviour impacts (e.g. loss of reputation, risk perception, awareness as mitigation, etc.).

![Diagram](image)

*Figure 1 – ISO 31000/31010 approach and the role of culture*

This methodology will be based on work carried out in WP1 where cultural hazardous behaviours have been identified based on collected data.
The risk management process proposed by the ISO 31000/31010 International Standards and the steps in which IMPACT (and culture) augments the standard approaches is indicated in Figure 1 where the steps in orange boxes are those affected by specific cultural aspects.

In the following sections, the IMPACT adaptation to the overall risk management will be identified and discussed.

### 2.2 Assessment approach

When considering the risk assessment approach in the contents of cultural behaviour it is necessary to establish how human behaviour is adding to risk situation or/and modifying any specific hazards. Once assessed, the risk methodology can proceed in a standard way, specific to a given transport hub.

In the context of IMPACT project, it is necessary to define what constitutes Cultural Behaviour. The definition adopted for IMPACT project refers to the classical definition of “culture” reported in Tylor’s essay on Primitive Culture [61]: “Culture, taken in its broad, ethnographic sense, is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society.”

It is possible also to refer, more in general, to the more recent and broader definition by Hofstede [57]: “[Culture] is the collective programming of the mind which distinguishes the members of one group or category of people from another.”.

Main assumptions in the proposed methodology are the following:

- The risk assessment as far as the cultural behaviour is considered, applies to the following transport hubs:
  - air passenger terminal hubs;
  - railway passenger terminals;
  - marine passenger ports.

- The assessment will concentrate on air terminal being more complex and sensitive to hazards, threats and emergencies. But a general approach will be applied to any hub.

- The risk assessment as applied to:
  - health and safety;
  - operational/business,

  will be considered.

### 2.3 General risk assessment procedure

Risk assessment is a process that allows to understand risks, defining acceptable levels of risk, risk criteria and reducing risks by proposing risk mitigation. The assessment will be limited to transport passenger hubs.

A risk is defined as the product of probability of hazard occurrence and the severity of the resulting consequences [1].

Following the ISO 31000/31010 standard, the overall procedure for risk assessment is summarised in the following paragraphs.

The risk assessment can be conducted, using a) qualitative, or b) quantitative risk assessment method.

#### 2.3.1 Qualitative risk assessment

The qualitative risk assessment approach is based on identifying threats/hazards and consequence, and evaluating the estimated risks from the perceived likelihood and consequence of each. For example, scales such as those shown in Table 1 and Table 2 below can be devised to categorise the likelihood and consequence of a given risk event.
The evaluated risk can then be categorised as “low”, “medium” or “high” using the “Boston Square” method [2].

The Boston Square approach has the advantage of relative simplicity but is very subjective and open to bias.

2.3.2 Quantitative risk assessment

Quantitative techniques may be more appropriate in several circumstances, including:

- when there are concerns that significant hazards may be overlooked by qualitative approaches;
- where there may be uncertainties over the likelihood or consequence (or both) of a system going wrong and where quantifying these may reduce uncertainty;
- where qualitative assessments indicate a significant number of risks in a system, hence there is a need to prioritise risk reduction or mitigation work using more robust techniques, especially when significant levels of spending are required.

The quantitative risk analysis techniques available are generally those that have been used in health and safety risk assessment for some time. However, it is important to understand some of the limitations of these techniques when applied to cultural behaviour risk assessment. These are discussed in some detail in the following section.

The more detailed risk assessments may be based upon a scenario approach or be based upon Monte Carlo simulation (probabilistic systems assessment (PSA) approach) taking advantage of qualitative data and quantitative inputs and assessments.

2.4 System definition

It is essential to define precisely the physical and operational boundaries under the assessment of the cultural behaviours and will involve the normal operation of the system and their processes.

2.5 Risk criteria

The risk criteria will need to be defined to be sure what criteria can be applied to judge the tolerability of the predicted risks (system and components). There are several options that must be considered, mainly, general principle of risk control, the risk envelope, average or peak risk, measure of risk, and values of risk limits.

Risk criteria defines the frame of reference used to evaluate the significance or importance of an organization’s risks. The risk criteria help to determine whether an evaluated level of risk is acceptable or tolerable.

Risk criteria should reflect industry, organization’s values, policies, and objectives, should consider the views of all the stakeholders, and should be derived from standards, laws, policies, and other requirements. The criteria will encompass the organisation/industry operation and type of risks. These can be classified [1] as:

- human health and safety where criteria for societal risk are well established;
- operational/business;
- environmental protection;
- legal and regulatory compliance;
- cost;
- project schedule;
- reputation;
- finances.

From these only the first two will be considered since cultural behaviours cannot have significant impact on the remaining risk criteria within the framework of the IMPACT project.
2.6 Threats and Hazards Identification

The next step is aimed at identifying threats/hazards associated with the system under investigation including any existing controls. The success of any Risk Assessment depends on comprehensive identification of these potential hazards/threats.

These threats/hazards can fall into two categories:
1. Internal threats/hazards - Hazards intrinsic to the organization or activity under consideration;
2. External threats/hazards - Hazards imposed by external factors;

![Figure 2 - Interrelation between internal and external hazards](image)

Consider: physical, temporal, operational, ownership, etc.

At its simplest, hazard identification means establishing what could go wrong with the site, transport hub system or procedure being considered. Therefore, there is a need to identify all the ways in which the assets and their protective procedures/systems involved may fail either through malicious activities or through human errors. Unfortunately, it is often easier said than done to ensure that all the hazard/threats have been identified. It is challenging to ensure that all the vulnerabilities have been correctly identified and to prioritize the right ones.

A variety of more or less formalized hazard identification techniques have been developed to ensure that identification is as comprehensive as possible. The simplest example is the use of pre-defined checklists. These are quick and easy to apply, but have the danger of limiting the range of thought - if a hazard is not on the checklist the assessor may not look for it.

More thorough but more time-consuming and costly approaches include structured techniques based on group sessions such as Hazard and Operability Study¹ (HAZOP) or Failure Mode and Effect Analysis² (FMEA).

The advantage of a group session is that the interactions between participants with differing experience and expertise tend to promote broader thinking, and take better account of the interfaces between subsystems and activities. Such sessions can also have more immediate and wider benefits in terms of the overall safety or security culture, by promoting awareness of existing hazards and understanding of differing viewpoints.

To help in identification and assessment of hazards/threats, a technical risk log should be established in the form of a database. This should contain the assets name/number hazards affecting it, owner

¹ See for example IEC 61882:2001 "Hazard and operability studies (HAZOP studies) - Application guide"
² See for example IEC 60812:2006 “Analysis techniques for system reliability - Procedure for failure mode and effects analysis (FMEA)”
of the asset etc. With this log, it easier to manage any changes to such assets and threats as they change over time.

### 2.7 Probability, likelihood and consequences assessment

It is necessary to estimate the risk for each hazard identified, keeping the results for each risk type separately (e.g., financial, health & safety, technical). The scales for likelihood and consequence and hence risk are assigned here for illustration purpose.

#### 2.7.1 Likelihood of a hazard

The likelihood of a hazard identified occurring is a function of probability of the resulting consequences being materialised and the possibility of the subject being exposed at a given location and time.

<table>
<thead>
<tr>
<th>Scale of Likelihood</th>
<th>Likelihood of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly probable/Likely</td>
<td>10 1 per day - Very likely hazard</td>
</tr>
<tr>
<td>Medium/Possible</td>
<td>5 1 per week - Possible hazard</td>
</tr>
<tr>
<td>Low/Remote</td>
<td>2 1 per month - Remote hazard</td>
</tr>
<tr>
<td>Negligible/Unlikely</td>
<td>1 1 per year or less - Unlikely hazard</td>
</tr>
</tbody>
</table>

#### 2.7.2 Consequences of a hazard

The consequences as result of a hazardous event can be different depending on organisation and transport hub activities. The consequences from any threat can be estimated using the scale presented in Table 2.

<table>
<thead>
<tr>
<th>Level</th>
<th>Consequence on assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/Severe</td>
<td>Irreparable harm to the company (1) may result in the highly costly loss of major tangible assets or resources; (2) may significantly violate, harm, or impede an organization's mission, reputation, or interest; or (3) may result in human death or serious injury.</td>
</tr>
<tr>
<td>Medium/Major</td>
<td>Significant harm (1) may result in the costly loss of tangible assets or resources; (2) may violate, harm, or impede an organization's mission, reputation, or interest; or (3) may result in human injury.</td>
</tr>
<tr>
<td>Low/Moderate</td>
<td>Moderate harm (1) may result in the loss of some tangible assets or resources or (2) may noticeably affect an organization's mission, reputation, or interest.</td>
</tr>
<tr>
<td>Minor</td>
<td>Very unlikely to cause any harm to the company or caused injuries</td>
</tr>
</tbody>
</table>

Consequence scale as above can be generated for different types of consequence including business, environment, safety etc.

#### 2.8 Risk Evaluation and Acceptance

After having set the values obtained for likelihood and consequence for a given threat, asset and risk type, a risk level is estimated from a risk matrix see Table 3 (where cells in red correspond to HIGH risk, yellow to MEDIUM risk and GREEN to low risk).
Table 3 - Example of a risk matrix (for each type of risk)

<table>
<thead>
<tr>
<th>Likelihood of threat(s)</th>
<th>Highly probable/Likely</th>
<th>10</th>
<th>20</th>
<th>50</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium/Possible</td>
<td></td>
<td>5</td>
<td>10</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>Low/Remote</td>
<td></td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Negligible/Unlikely</td>
<td></td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>

Consequences (severity) of associated threat(s)

The risk can fall into:
- Low Risk (in Green) – can be considered as acceptable without review,
- Medium Risk (in Yellow) – Acceptable risk level but review is required by management and controls put in place,
- High Risk (in Red) – Risk reduction is required to acceptable level.

When assessing the risk, each aspect of risk e.g. financial risk, health and safety, environmental or reputational are evaluated separately, since each can have different metrics and as such cannot be added directly. For example, Environmental risk can be measured using loss of habitat, Health and Safety using mortality or degree of injuries and Financial risk using monetary value. Therefore, to be able to combine these different types of risk, the risks should be brought to a common metric e.g. monetary. Using simple approach based on Multi Criteria Analysis (MCA) should be sufficient to apply, to combine different types of risk.

Once the risk level is evaluated it will be assessed against defined risk criteria. For events exceeding the risk criteria, measures will be postulated for risk reduction /mitigation. The process to ensure ALARP (As Low As Reasonable Practicable) risks must be carried out during the assessment.

### 2.9 Risk Controls and Mitigation

For each hazard, identify risk control measures that can reduce the risks to acceptable levels.

For risk in excess of risk criteria, measures to meet the risk limit, a mitigation will be proposed and the risk assessed again, to check on the effectiveness of the mitigation suggested. The concept of mitigation is presented in Figure 3.

Risk is the product of likelihood and consequence. Thus, to reduce the risk one can reduce the likelihood of risk (frequency of occurrence) or changing the system design to reduce the impact.

Other methods will involve:
- elimination;
- substitution;
- control;
- improving the ability for recovery from an occurrence;
- transferring the risk to another entity (e.g. an insurance company).

The mitigation proposed should be investigated and record for future reference.

### 2.10 Risk Management

Risk management is a process which must be considered throughout the life of a project, life cycle of system operation. It is required to ensure that the control measures put in place are effective: to this extent the process is required to be supervised and reviewed periodically.

The monitoring of the operation should ensure that controls put in place are effective and used, new equipment or/and processes when introduced, these are recognised and appropriate risk management controls are applied.

Since the risk is function of time, the status of risk must be monitored and if changes occur, evaluated. The overall cycle of risk management must include these time dependent changes and QA.

![Figure 4 - Risk management process](image)

### 2.11 Data requirement

Data collection is needed for the analysis of risk assessment that will be required i.e. system description, operational procedure, likelihood estimation etc. Data collection and analysis is a major task in any assessment and it is particularly important for the successful completion of a Quantified Risk Assessment (QRA).

The data requirements range from specific enterprise operation to simple system process operating diagrams, including historic data required to establish frequencies of failures and accidents. Data may be required on human behaviour and reliability as well as system reliability. Appropriate data should be collected and if hard data is not available then data elicitation should be initiated.

The quality of the risk assessment relies on the quality of the data collected.
3 Threats, Hazards and Culture

3.1 Threats and hazards for crowds in hubs

To analyse the impact of culture in emergency situations in transport hubs it is necessary to identify main categories of threats and hazards generating situations where cultural aspects can play a role. First of all, it is necessary to provide, within the IMPACT context, a definition of hazard and threat, even if having a clear distinction between these two concept is not always easy:

- A (security) threat is defined as anything that can intentionally exploit a vulnerability, and obtain, damage, or destroy asset(s) or a service and/or harm or kill person(s).
- A (safety) hazard is defined as anything that can accidentally exploit a vulnerability, and obtain, damage, or destroy an asset or a service and/or harm or kill person(s).

These can be emanating from:
- internal to the system (hub);
- external to system (hub).

Cultural aspects in risk assessment can be:
- A possible trigger for new hazards e.g. stranded passengers fighting for resources amongst themselves, sport supporters starting violence in a hub, etc.
- A possible amplifying factor for general consequences of a threat/hazard e.g. long clothes of Muslim females may slow down evacuation, Jehovah witness may refusal to receive medical care (e.g. refuse blood transfer) thus worsening their health status, etc.
- A possible diminishing factor for general consequences of a threat/hazard e.g. familiarity with places may improve the wayfinding during an emergency thus reducing the consequences (injuries and fatalities, for example).

Starting from the above assumptions, the cultural risk assessment on transport hubs concentrates:
- On movements and/or behaviours of crowds and the role of culture in either affecting consequences or triggering new potential hazards.
- On minorities’ behaviours impacting majorities’ behaviours but only on those aspects for which culture plays a central role.

The work explicitly excludes:
- Individual behaviours if they do not affect crowds like for example a mentally-instable person attacking a group of tourists in ferry hub is not part of IMPACT, since the behaviours do not depend on culture but only on the person’s health status.
- The behaviour of terrorists, in the sense that IMPACT does not intend to analyse the cultural aspects driving terrorists’ behaviours and acts.
- The pure management of crowds without cultural aspects.

This section of the document concentrates on all the above aspects that may happen in a transport hub and in particular on three main areas of interest:
- Hazards that may generically happen in a transport hub, i.e. all possible aspects related to safety, in which culture may play a role (see section 3.1.1).
- Hazards explicitly triggered by culture (see section 3.1.2).
- Threats that may generically happen in a transport hub, i.e. all possible aspects related to security, in which culture may play a role (see section 3.1.3).

The possible crowds-related situations in which culture can play a role to be considered by transport hub managers, potentially generated by the above hazards and threats, are discussed in more detail in section 3.1.4 while the possible consequences to be considered are reported in section 3.1.5.
3.1.1 Generic safety hazards

The analysis of the generic safety hazards – i.e. those hazards that may generically happen in a transport hub - is summarised in Figure 5.

The identified hazards are subdivided into two main categories:
• Internal Hazards;
• External Hazards.

It is important to note that internal and external hazards can meet in some point for operations. For instance, security issues in terminal may affect flight safety.

3.1.1 Internal Hazards

Internal Hazards are generated inside the system (the hub) and can be either system specific – i.e. generated by failures or inadequacies of the hub – or human induced – i.e. generated by human actions/errors (e.g. a strike that reduces for a period the functionality of the hub, a driver error that hits the platform with a train interrupting the service, a member of the staff that misperceives a hazard thus generating panic, etc.). Examples of these hazards are:

• The fire at the Fiumicino airport in Rome on 7 May 2015 [6], where fire and the consequent smoke started from air conditioning systems. Thousands of passengers were hit by delays and many flights were diverted. Some passengers were treated for smoke inhalation.
• The false alarm at Kennedy Int. Airport in New York on 15 August 2016 [3] where a “report of gunfire at 9:34 p.m. outside the security checkpoint at Terminal 8 led to complete turmoil across one of the nation’s busiest airports. ... In the absence of official information or instructions, unconfirmed reports from social media fuelled the hysteria.”.
• The strike of the employees of Pakistan International Airlines in Lahore (Pakistan) in February 2016 [8] that stranded thousands of passengers at Allama Iqbal International Airport.

3.1.2 External Hazards

External Hazards are generated outside the hub (extreme events happening either in the immediate vicinity of or at thousands of kilometres from the hub) and can be:

• natural events like floods, forest fires, extreme snow falls, volcanic ash in the atmosphere, etc.;
• connection problems with feeding and/or departing transport modes;
• special events (e.g. political meetings, concerts, sport events, etc.) that may concentrate in a place conflicting cultural groups (e.g. supporters of two rival football teams) or protests that may interrupt transport services (e.g. blocking hub’s access roads).

They may have an impact either interrupting the service or damaging the hub infrastructure thus limiting/interrupting the transport services.

Examples of these hazards are:

• The eruption of the Eyjafjallajökull volcano in 2010 [7] that caused impressive effects on air transport: 100,000 flights cancelled in total, peaking at 19,000/day with over 10m people stranded or unable to board flights.
• The Typhoon Usagi in Hong Kong in 2013 [9] that forced thousands of passengers to camp in the airport’s departure halls for days. As reported “For Hong Kong Airlines, the backlog took well over a week to clear. The added strain on frontline staff from furious passengers forced the airline’s president to promise to hire more staff to ease workload.”
• The heavy rains fell in southern China in May 2015, causing crippling delays at Shenzhen Bao’an International Airport [10]. Here the stranded passengers started rioting: “... 20 to 30 men encircled the Southern China Airlines counter and began berating the staff. Airlines distributed take-out boxed meals, bottled water, and instant noodles to the stranded passengers, but by this time it was too late. The customers hurled the food back at the staff. Then it escalated. Equipment was smashed in a fight. Riot police rushed in to form a human barricade between the tired masses and the surrounded airline staff.”
• The protest of nine members of Black Lives Matter UK that got on to the runway and chained themselves together forcing London’s City airport to cancel flights on 6 September 2016.
reported in [66], “there were chaotic scenes at the departure lounge as a large queue of passengers snaked through the adjacent DLR station with some expressing their anger at the protest”.

### 3.1.2 Culture-induced hazards

The cultural-induced hazards are those directly generated by (cross-)cultural behaviours. They can be grouped into four macro categories (summarised in Figure 6):

- **Crowd interactions**
  - Within-crowd interactions, i.e. interactions with others in the crowd
  - Interactions between individuals of different cultural clusters
  - Interactions between different groups of different cultural clusters
  - Interaction individuals and groups

- **Crowd interaction with information equipment**
  - Aural message (Audio alarms; public messages),
  - Digital and physical signage
  - SMS
  - Social-media (Twitter, Facebook, etc.)

- **Crowd interaction with physical environment**

- **Crowd interaction with staff**
  - One-to-one and one-to-many interactions between staff and the public.
  - Stereotyping (Alt: discrimination)
  - Tensions with staff due to staff’s lack of cultural competence (Alt: lack of cultural sensitivity in handling passengers)
  - Tensions between staff and passengers stranded in a close environment
  - Miscommunication
  - Refusing healthcare treatment
  - Intentionally refusing to comply with staff instructions during emergencies

This list will be augmented during expert elicitation for specific hub assessment where also likelihoods, level of consequences and mix of cultures will be determined.

Examples of culture-induced hazards are the following:

- The case of a woman that, while being in the process of being checked at Frankfurt airport on August 2016 [58], bypassed air security check due to a signage misunderstanding. As a result, security called the police, which upon arrival evacuated the terminal as a preventive measure. The incident created delays (100 flights were cancelled due to the evacuation) and stress on passengers that had to leave the terminal and re-do the security check.

- The rioting of Chinese passengers with the police already reported in section 3.1.1 above [10]. A group of Chinese passengers, exacerbated by the delay caused by heavy rain in the area, started rioting with police, thus generating further delays involving all remaining passengers.

- As described in [59], “Beginning in 2002, Airport Staff became aware that some passengers who were carrying alcohol - often visible in the plastic bags from duty-free shops - had been refused taxi service. The drivers, many of whom were Muslims from Somalia, explained that their faith did not permit them to consume or transport alcohol. ... Yet, given the practical concerns that arose curbside, and the number of passenger complaints, refusals had also emerged as a serious customer service issue. Passengers being moved from one taxi to another disrupted the flow of traffic, and posed a safety concern. Those who were refused service were confused and frustrated, and often insulted: on one occasion, a traveller threw a bottle of wine to the pavement in anger.”
A more detailed description of these hazards and the possible approaches to quantify them can be found in section 3.2.

Figure 6 - Tree of the culture-induced hazards
3.1.3 Generic security threats

The analysis of generic threats - i.e. those threats that may generically happen in a transport hub - is summarised in Figure 7.

The analysis has led to identify two main events that could lead to critical situations to be managed where cultural aspects may play a role:

- A **terrorist act** (and it is important to highlight that IMPACT does not deal with the cultural reasons behind terrorism) that could affect the hub (damaging it), the passengers (with injuries...
and fatalities) or both. A clear example is the Brussels Airport bombing of 22 September 2016 [5] that led to fatalities, injured passengers in need of medical care and a completely blocked airport with thousands of stranded passengers to be managed.

- An **act of sabotage** in the hub that leaves passengers stranded for a long time. An example is the alleged act of employee sabotage at a control centre in Chicago (USA) on 27 September 2014 [4]. More than 2000 flights were cancelled at Chicago airports after worker deliberately set fire in the control centre with thousands of passengers stranded at the two Chicago’s airports.

### 3.1.4 Situations to be managed by the hub manager

Daily work of a hub manager is to have a smooth functioning of the hub with passenger transiting without problems. But the hub manager has also to be prepared to handle emergency situations and, for this, safety cases are considering all possible situations that may arise for considered hazards and threats. The situations to be managed by the hub managers during emergencies in which culture can play a role can be summarised as follows:

1. Evacuation of passengers.
2. Stranded passengers that may compete for resources (food, water, space, travel means, etc.), may start discussing for priorities in queues, etc. and cultural habits may lead to critical/unpleasant/unethical situations (for example a cultural group may tend to overwhelm another cultural group).
3. Passengers in need of medical cares.

### 3.1.5 Possible consequences for the passengers

When dealing with the threats and hazards listed in sections 3.1.1, 3.1.2 and 3.1.3, the possible consequences to be considered are (see Figure 8):

- On crowds (passengers).
- On the system (the hub).
- On the service.

![Figure 8 - Possible consequences for the passengers](image-url)
The consequences of threats and/or hazards can be escalated by cultural factors. Some examples are given in the following:

- **Traditional clothing of some cultures** may slow down evacuation and therefore increase the number of injuries and fatalities. This is for example the case of traditional Saudi Arabia traditional clothing that slows down walking speed by approximately 10% when compared with western clothing [37]. Traditional clothing (e.g. religious dresses covering faces and ears) may also not permit clear vision of moving site equipment or dangers, or a falling object, it may also hinder site interactions and relationship.

- **Slow reaction time** may as well increase evacuation time with potentially more injuries and/or fatalities.

- **Misleading or misunderstood (verbal or signage) communications** or staff non-properly trained to manage multi-cultural crowds may also have an impact on evacuation time or, more in general, on the management of emergencies. These aspects are discussed in more detail in the possible control and mitigation actions in section 4.8.1 and 4.8.2 respectively.

- A hub that is not prepared to provide **medical cares to passengers with special needs** can also potentially increase the fatalities in case of certain type of emergencies. Some examples of special needs depending on cultural aspects are described in section 4.8.3.

- Disasters may leave, often underestimated, long-term **adverse psychological consequences** on surviving passengers [48], especially on cultural/ethnical minorities. Some findings are reported in section 4.8.4.

### 3.2 Cultural-dependent hazardous behaviours in transport hubs

#### 3.2.1 Introduction

This section reports the cultural-dependent hazardous behaviours relevant for the IMPACT project. Cultural-dependent hazardous behaviours correspond to any individual or collective behaviour(s) occurring in large transport hub that poses a potential safety hazard to staff and other passengers, and that potentially results in **negative system effects**, during either normal or emergency situations. Negative system effects include interruptions/slowing down of service, injury to other passengers/staff, equipment damage, reputational damage, and potential for legal litigation.

As reported in the previous sections, the focus is both on normal and emergency situations because cultural-dependent hazardous behaviours may trigger an emergency, or may affect the management of an on-going one.

In the former case the cultural-dependent hazardous behaviours is itself the cause of the emergency. This is the situation that may arise, for instance, when angry passengers stuck on a transport terminal, exasperated by a long delay following a service disruption, behave aggressively with staff, or when passengers of two different cultural groups located in the same terminal start to argue with each other. Although not necessarily triggering an immediate health and safety risk, these situations require an adequate intervention of staff to ensure/restore continuity of service (i.e. flow of passengers) and the security of the involved and the other passengers.

In the latter case, cultural-dependent hazardous behaviours may negatively affect the management of an on-going emergency triggered by non-crowd related factors (e.g. fire, flooding of facilities, terrorist attack, accident, etc.). These situations require a timely and effective response by front/end operators, first responders and infrastructure managers. Such response may be negatively affected by the occurrence of cultural-dependent hazardous behaviours; these can in fact create the potential for more serious consequences that would have occurred in their absence of the concerned cultural-dependent hazardous behaviours. For instance, passengers required to stay in a confined environment due to an on emergency (fire, collision between vehicles), may not comply with instructions due to lack of trust in authorities. Eventually passengers may escape the assigned area, thus exposing themselves to health and safety hazards they are unable to mitigate. The full list of the IMPACT cultural-dependent hazardous behaviours is reported in section 3.2.4.
Cultural-dependent hazardous behaviours have a cultural component, i.e. their likelihood of occurrence depends on the belief and customs of the cultural groups that are present in the transport hub. Individual and collective behaviours, beliefs, attitudes and values are strongly affected by culture. This can be defined as “the body of learned beliefs, traditions, principles and guides for behaviour that are commonly shared among members of a particular group. Culture serves as road map for both perceiving and interacting with the world” [11]. On these basis, it is assumed the hazardous behaviour of the public that can be found in transport hubs vary depending on the cultural group involved. Each cultural group exhibits a different combination of dominant cultural determinants of passengers’ behaviour. In IMPACT, such determinants are named as *psycho-social cultural* parameters, or simply *parameters*, and they have been investigated in WP1 by a passenger survey.

### 3.2.2 Method for identifying the cultural-dependent hazardous behaviours

The IMPACT cultural-dependent hazardous behaviours were identified based following a rigorous three-phase approach, which is described next:

1. **Identification.** The cultural-dependent hazardous behaviours were identified by means of the following data collection and literature review activities:
   a. Internal group session (Sofia meeting, Sept 2015)). The hazard activity identification was initiated in Sofia in September 2015, during the first IMPACT progress meeting. Here, a preliminary list of cultural hazardous behaviours was identified during a structured group session with project partners. The session aimed at identifying relevant emergency situations in transport hubs, current operator response, current hazards and threats, and possible mitigation actions;
   b. Group session with experts (1st ESG meeting - Nov 2015). The event in question here was the 1rst ESG meeting, which was attended by relevant senior industry and government security and safety experts from the airport, railways, and maritime domains. The day was organised around a set of four group exercises, in which feedback was collected by the experts by means of questionnaire and group discussions. The exercise allowed to collect further insights into the challenges and cultural hazards that can be found in the airport, railways and maritime domains;
   c. Interviews at operational facilities. Individual and group interviews were conducted during site visits organised between the periods July 2015–May 2016. Interviews were collected with front end operators and their supervisors at the premises of Italian, Bulgarian, Polish and Turkish end-user organisations. More details on the interviews collected and the facilities visited are reported in D1.2 [56].
   d. Literature reviews. In parallel to the above data gathering activities, data was also collected from the literature. The focus has been on security incidents that happened in transport hubs as reported from the media and from relevant academic publications.

2. **Aggregation.** This phase consisted of integrating and consolidating the cultural-dependent hazardous behaviours identified in the previous phase. More specifically, the behaviours identified were compared and clustered to obtain a generalizable classification scheme applicable across the airport, railways, and maritime domains. This work involved a systematic comparison with safety models available in the literature to define an overarching organising framework that could help to express the hazard in a taxonomical form. Eventually, one ad-hoc model (EICCS) was created in the context for the project.

3. **Verification.** The resulting cultural-dependent hazardous behaviours taxonomy scheme was checked for its internal consistency, to avoid duplication of hazard categories. The classification scheme was also qualitatively validated with relevant experts during the 2nd ESG.

In this context, an emergency generated by hazardous cultural behaviours can arise where/when:

- There is competition for resources, i.e. loss of free availability of something people needs: space, (for moving, or standing), food, beverage, rescue or medical care, etc.
o It may happen mainly between passengers.

- There is dependency of people upon others to get a task finished, i.e. loss of full autonomy in performing tasks or goals where cooperation or good harmony is necessary.
  o It may happen between passengers, between passengers and staff/organization.
- There is a misunderstanding or ambiguity about something, about the events that arise, producing different reaction time, different perceptions of events, messages, orders, etc.
  o It may happen to a single passenger, or to groups of homogeneous people.
- There are communication barriers that prevent full communication, i.e. different languages in exchanging messages
  o It may happen between passengers, between passengers and staff/organization.
- Personalities, behaviours or habits clash.
  o It may happen between passengers, between passengers and staff/organization.

3.2.3 The crowd behaviour model

The IMPACT cultural-dependent hazardous behaviours are presented in the context of the Environment, Information, Crowd, other Crowd members and Staff (EICCS) model. The model assumes that to understand the behavioural hazards that can arise from a multicultural crowd it is necessary to consider the surrounding context in which the crowd is located. Cultural-dependent hazardous behaviours in transport hubs can be found, in fact, lying at the interaction between the crowd (C) and the components of surrounding context. Such components discussed below:

- **Staff** (S), i.e. the operators that can be found at the front end of large transport hubs. These include roles involved in normal day-to-day operations (e.g. screeners, hostess, information desk assistants, police officers) and first responders (medical, fire-fighters, etc.);

- **Other crowd members** (C), these are the other crowd members that a person or a cultural group can interact with in a transport hub. Also, interaction with other crowd members may trigger some types of cultural-dependent hazardous behaviours. And this explains why the C component appears twice in the model;

- **Information** (I). The public’s experience of transport hub includes the gathering of information from various sources, such as aural messages (audio alarms; public messages); digital and physical signage; SMS; social-media (Facebook, etc.). These sources fall in the information component of the model;

- **The physical environment** (E). This component includes the physical layout of the transport hub, the physical equipment, and the movement of other crowd members in the transport hub.

It is in the interactions between the pivotal components of the model, i.e., the crowd, and the surrounding contextual components that one should look at to see the occurrence of cultural-dependent hazardous behaviours. Cultural-dependent hazardous behaviours can be found in the staff-crowd interaction; crowd-crowd interaction (also called within crowd interaction); crowd-information interaction; and crowd-physical environment interaction. Thus, the EICCS model identifies the interactions between the crowd and the different contextual components that may lead to incidents, service interruptions in a transport hub. The model and its components are shown in Figure 9. The pivotal element of the model is the crowd, around which are found the other contextual elements.
3.2.4 Table of cultural-dependent hazardous behaviours

The list of the cultural-dependent hazardous behaviours is presented in Table 4. The table is organised as such:

- Column 1 corresponds to the four main interactions of the EICCS model:
  - Crowd-staff interactions;
  - Crowd-crowd interactions;
  - Crowd information/equipment interaction;
  - Crowd-physical environment interactions.
- Column 2 reports the hazard ID;
- Column 3 reports the categories of hazardous cultural behaviour identified;
- Column 4 explains the hazardous category, and report sub-categories whenever applicable. Some categories of behaviour are self-explaining, therefore do not need an explanation; others do not have sub-categories. Example of specific incidents, when available, are reported in brackets.
- Column 5 reports the origin of the cultural-dependent hazardous behaviours, i.e. literature or data collection.

The list of cultural behaviour presented in Table 4 can be used as a hazard guide to assess whether these can add to any new consequences or lead to modification of any old already identified consequences.
### Table 4 - Complete list of cultural-dependent hazardous behaviours

<table>
<thead>
<tr>
<th>High-level category</th>
<th>ID</th>
<th>Categories of hazardous behaviour</th>
<th>Explanation and/or subcategories if applicable</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crowd-staff interaction</td>
<td>101</td>
<td>Stereotyping/Discrimination</td>
<td>• Staff failing to provide equal (health care/emergency) assistance/treatment to passengers of different cultures (especially ethnical or racial minorities) because of stereotypes and prejudice. As noted in Jones [12] “situations characterized by time pressure, resource constraints, and high cognitive demand promote stereotyping due to the need for cognitive “shortcuts” and lack of complete information. Stereotyping can be defined as “the process by which people use social categories (e.g. race, sex) in acquiring, processing, and recalling information about others” [13]. In general, individuals are frequently not aware of the activation or the impact of stereotyping on their perceptions, emotions and behaviour. Stereotype-linked bias is an automatic and unconscious process, and can occur even among persons who are not outwardly prejudiced ([14], [15]).&lt;br&gt;• Staff neglecting an issue reported by a passenger due to stereotypes;&lt;br&gt;• Staff discriminating some cultural groups when providing assistance (for instance because of religious differences).</td>
<td>[12], [13], [14], [15]</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>Tensions with staff due to staff’s lack of cultural competence</td>
<td>This category involves tensions arising due to staff members behaving in a way considered unacceptable/offensive from the perspective of a passenger of another culture. Such tension may arise due to:&lt;br&gt;• Staff improperly handling sacred/personal items at security checks.&lt;br&gt;• Staff using inadequate body language (e.g. male security officer talking directly to Muslim wife while ignoring the husband).&lt;br&gt;• Staff making requests considered unacceptable by other cultures (e.g. asking a Sikh to remove his hat in public; asking a Muslim woman to remove her head scarf in public; male security officer looking a Muslim woman; a male staff conducting a body search on a Muslim female with the veil).</td>
<td>[16][17]</td>
</tr>
<tr>
<td></td>
<td>103</td>
<td>Tensions with passengers stranded in a close environment</td>
<td>This behaviour concerns passengers complying/arguing following delays/service disruptions. The classic example includes passengers stranded at airport or railway terminal following a weather or technical failure. Lack of information and environmental factors, e.g. hot temperature, long queue, lack of food, may contribute to this hazard.</td>
<td>Interviews with staff</td>
</tr>
<tr>
<td></td>
<td>104</td>
<td>Ineffective reporting of security threats (relative to emergency prevention)</td>
<td>Cases have occurred in which passengers failed to report effectively a potential security threat to authorities.&lt;br&gt;• Passenger failing to report a security threat (e.g. unattended item);</td>
<td>Interviews with staff</td>
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</table>

- Passenger picking up a potential threat to bring it to the police (instead of just calling the police);
- Passenger over-reporting security threats (e.g. following a major disaster/terroristic attack).

105 Miscommunications between staff and passengers

(Emergency) situations in which staff and passengers are unable to understand each other due to language barriers. (Note that this hazard differs from 104 because here the person's intentions are adequate to the situation, only the person is unable to articulate own thoughts)

- Injured/sick passenger unable to report/communicate own (deteriorating) health conditions because of language.
- Inability of passengers to report a problem to staff (e.g. threat or hazard observed; missing relative, their needs) in an emergency situation because of language.
- Misunderstanding staff instructions during emergencies (e.g., not following the direction assigned by staff).

Sofia meeting

106 Refusing healthcare treatment

Motivated by religious/cultural beliefs, this behaviour includes for instance:

- Jehovah witness refusing medical treatment;
- Fundamentalist Muslim woman refusing treatment from male doctor.

Sofia Meeting

107 Intentionally refusing to comply with staff instructions during emergencies

During on-going emergencies, the public may act based on their own initiatives, without considering the guidance/instruction provided by staff. Unauthorised-self initiative may depend by the increased sense of danger, especially following prolonged permanence on a confined environment. Two subcategories have been identified for this hazard:

- Self-initiated responses [e.g. Norman Atlantic; people abandoned the ship contradicting staff instructions; passenger of a broken down train temporary stuck on a station breaking a window to get off without staff authorisation];
- Crowd refusing to take unfamiliar paths [e.g. in the case of the fire at King’s Cross underground station the majority of the casualties took the familiar route instead of the suggested one—they reverted to known patterns of behaviour or to stay in the allocated area.]

Expert interviews (1st ESG) [26]

108 High-ranking individuals behaving arrogantly

High-ranking individuals include VIP, politicians, etc. They may not necessarily be accustomed to security checks and procedures, and therefore may refuse to comply with staff instructions/requests. The following subcategories were identified:

- High-ranking passengers complaining during security checks;

Interviews with staff
<table>
<thead>
<tr>
<th><strong>Within crowd members’ interactions</strong></th>
<th>201</th>
<th>Cultural conflicts between individuals/groups belonging to different cultural clusters</th>
<th>• High-ranking passengers interfering with the instructions/work of front end practitioners during emergencies.</th>
<th>Sofia Meeting Staff interviews [17]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>202</td>
<td>Fighting/revolting for resources (food, space, emergency exists, etc.)</td>
<td>• Proximity conflicts (e.g. Orthodox religious Jew sitting next to a woman); • Political conflicts (e.g. Russians and Ukrainians; Palestinians and Israeli passengers in the same terminal); • Sport conflicts (e.g. Supporters of different football teams in the same terminal, e.g. train station).</td>
<td>Interviews with staff [18], [19], [20]</td>
</tr>
<tr>
<td><strong>Crowd public information/equipment interaction</strong></td>
<td>301</td>
<td>Ignoring physical and digital information found in the transport hub</td>
<td>• Fighting for safety equipment during emergencies [e.g. men beating women and children to escape first, such as in the Norman Atlantic case]; • Fighting for food [e.g. assault to the galley on a NTV train].</td>
<td>Interviews with staff</td>
</tr>
<tr>
<td></td>
<td>302</td>
<td>Slow response to public warnings and observable dangers</td>
<td>People walking slowly, due for instance to wearing traditional clothes</td>
<td>[26]</td>
</tr>
<tr>
<td></td>
<td>303</td>
<td>Slow crowd mobilization during an emergency</td>
<td>Passengers may react differently to visible dangers (e.g. smoke) and public alarms in transport terminals, depending on their perception of the risk typical of their culture. Thus, while some may react immediately (e.g. an Israeli; Japanese); others may exhibit a slower response (e.g. an Italian). Alcohol consumption may play a role in the reaction to alarms and danger.</td>
<td>[26]</td>
</tr>
<tr>
<td></td>
<td>304</td>
<td>Misuse of social media information during emergencies</td>
<td>Publishing incorrect, partial, incomplete information on social media, thus risking to generate unjustified panic.</td>
<td></td>
</tr>
<tr>
<td><strong>Crowd - physical environment interaction</strong></td>
<td>401</td>
<td>Passengers entering forbidden areas</td>
<td>• Passengers crossing rail tracks (e.g. Commuter in a hurry/Immigrant not perceiving the danger implicit in crossing tracks at railways station); • Passengers refusing to stay in dedicated areas (e.g. youngsters’ example mentioned at Pescara airport terminal).</td>
<td>1st ESG Interviews with staff</td>
</tr>
<tr>
<td></td>
<td>402</td>
<td>Hazardous-crowd behaviour</td>
<td>Collective movements of crowds that may result on anxiety, physical discomfort, minor or major injury, death for the crowd members:</td>
<td>[22], [23]</td>
</tr>
<tr>
<td>403</td>
<td>Misuse of equipment due to ignorance</td>
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<td>This behaviour involves the unauthorised activation of physical equipment. The person who engages in this behaviour does not realise the danger/implication of what they are doing, mostly due to ignorance and poor education. It may occur with first time traveller/flyer. Misuse of physical equipment [e.g. high speed train passengers from a Southern Italian region were reported to have pulled the hand brake on a high-speed train just to get off the train; Chinese first time flyer attempted to open the cabin door on a China Southern Airlines flight because exchanged it for the toilet, and activated inadvertently the slide [6]; Chinese first time traveller opening plane door at take-off [7]; Chinese passenger opening the door and inadvertently activating the slide because eager to get off the plane after landing].</td>
<td>Interviews with staff [24], [25]</td>
<td></td>
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4 CHANGES TO THE GENERAL RISK ASSESSMENT PROCEDURE WHEN CONSIDERING CULTURAL FACTORS

4.1 Assumptions and approach

The following applies to risk assessment for transport hubs when considering cultural factors. In general, risk assessment does not concentrate on human cultural behaviour as contribution to the overall risk.

The methodology applies to three different situations:

1. When a completely new case is initiated, then the overall risk can be assessed considering also cultural aspects and behaviours.

2. When a risk assessment for a specific hub has already been analysed, then:
   a. It is necessary to extract from the safety case document or hazard log current hazards/threats-likelihood-consequences-risks.
   b. Then, for each extracted hazard/threat it is necessary to assess whether the hazard/threat is going to be modified by cultural hazard (by using cultural behaviour hazard list and/or elicitation from experts).
   c. If the hazard/threat is perceived to be modified, then the consequence and risk must be re-assessed, otherwise if it may generate new cultural-dependent consequences, then these consequences need to be assessed (by using cultural behaviour hazard list and/or elicitation from experts).

3. When only cultural behaviour is considered to examine its contribution to the overall risk, then likelihoods and consequences need to be re-assessed introducing the cultural aspects (by using cultural behaviour hazard list and/or elicitation from experts).

The methodology

- Defines the system (the hub) and highlighting the characteristics of each specific transport mode, identifying the expected crowd types and providing some suggestions on how to characterise the expected cultural mix of the crowd in each transport mode (section 4.2).
- Briefly describes two aspects that are culture-independent: the risk criteria (section 4.3) and the risk evaluation and acceptance (section 4.7).
- Analyses few examples of existing safety cases of an airport hub and from the railway showing the hazards that could be affected by cultural characteristics and behaviours (section 4.4).
- Proposes the most appropriate approaches to estimate frequencies and likelihoods (section 4.5).
- Opens a window on possible options, mainly related to evacuation, on the assessment of consequences using numerical models and how cultural aspects can be embedded in currently existing models (section 4.6).
- Finally, offers a detailed overview on risk controls and mitigations adapted to cultural groups and minorities ranging from signage to staff training, from communication strategies to health treatments (section 4.8).

4.2 System (hub) definition

The risk assessment objectives are to assess all the risks related to emergencies which can be influenced by cultural factors. The current assessment is associated with transport hubs. These considered here are:

1. Airport terminal hub
2. Railway terminal hub
3. Marine port terminal (passenger)
The emphasis here will be on the hub terminals and the risks emanating from passengers’ cultural behaviours and characteristics (see the hub model in Figure 10).

For all transport modes, the methodology refers only to the land side of the terminal and with the activities of passengers from entry to the terminal to departure from the terminal through the boarding gate/platform. This signifies that all events happening on the vehicle (aircraft, train or ship) are outside the scope of this document, since on-board a vehicle there are significant environmental and legal constraints modifying completely the safety scenarios, thus making the proposed methodology inapplicable.

The hazards associated with the hub and its surrounding environment are reported above in section 3 and can be summarised as follows:

- Entry to/exit from the hub
- Check in
- Luggage handling
- Boarding/disembarking
- Security checks
- Waiting time (shopping, coffee time, ...)
- Transfer to/from departure/arrival gate
- Boarding

In addition, initiation of new consequences caused by internal/external fire, terrorist activities etc. may lead to a requirement that passengers, public and staff be evacuated. The cultural human behaviour in such situations can escalate the consequences further, by slowing down the evacuation, due to reduced speed of moving crowds, difficulties in reading and understanding of signage, or misunderstanding of given directions.

In the following sections, the peculiarities of the hub of the different transport modes are analysed, highlighting the key aspects related to the possible cultural mix of the crowd insisting on the hub and how to estimate them. A full report on the analysis done for terminal characterisation can be found in Appendix 1.

4.2.1 Transport hub: typical structure and areas layout

Independently from the transport mode, in any hub/terminal it is possible to identify three basic sections, based on the kind of people that can be present in any time:

- Technical areas;
- Public areas (uncontrolled);
- Public-restricted areas (controlled).

4.2.1.1 Technical areas

Technical areas are those areas where all the technical devices of the hub are hosted (e.g. apron, traffic control computers and rooms, air conditioning, etc.). In these areas, public access is strictly forbidden and prevented by physical barriers or alerting signs.

4.2.1.2 Public areas (uncontrolled)

In public areas (e.g. the departure hall of an airport, the main hall of a railway station, etc.), any person can enter, move, exit, use any available facilities or service, without obligations or restrictions. People in these areas may be users of the services offered in the hub, accompanying travellers. In the following these people will be named as visitors.

4.2.1.3 Public-restricted areas (controlled)

In public-restricted areas a person shall enter, move, use any available facilities or service inside, only if owner of a valid travel certificate, or permit to travel. In the following these people will be named as passenger.
However, the real physical structures of public transport hubs radically change if we consider airports, railways or maritime terminals layouts; obviously, this is due to the different functional and operational requirements, the volume of transit passengers, the size of terminals and their location in the territory.

Even if the design of terminals must follow specific national and international standards and rules, the structure and the layouts can also reflect specific architectural design, historical reasons or aesthetic choices, as well as the possibility to be expanded and to growth.

In addition, different structural concepts adopted even for terminals for the same transport mode; e.g. airports may have different basic conceptual layout, like: Linear, Pier, Satellite concept, or in some cases, a mix of them. Large railways stations usually follow the “terminus” scheme.

4.2.2 Criteria for identification of potential critical areas

Based on the above functional segmentation of a hub, it is possible to identify “critical areas”. For each functional block, it is possible to identify the potential status or conditions of majority of people gravitating in these areas, in a normal operation of the hubs.

These conditions can be macroscopically identified as:

- People moving from one area to another area in the same directions
- People moving from one area to another area in both directions
- People standing or moving around inside the same area
- People queuing
- People waiting for something or lingering

It is necessary to consider that the design of terminal and hub buildings and staff organization are based on a thorough understanding of all operational, commercial, safety, security, financial, and environmental requirements and constraints of any facilities, to provide the “best possible” level of service, (passenger convenience, accessibility, wayfinding and signage).

The design of facilities considers the space necessary to accommodate waiting passengers and visitors, to facilitate the flow of people and, not only addressing current questions but also providing the necessary flexibility to face emerging trends and issues.
In the context of these work, it is possible to identify as “main critical areas”, the areas of a hub where the consequences of any hazards, emergency, upset events or even unusual conditions, could be potentially amplified by differences in culture of the people, or the cultural behaviour can be a trigger of hazard events.

4.3 Risk criteria

When considering the cultural factors in managing safety- and security-issues related to emergencies in public transport systems, the nature and types of consequences to be included are as follows:

- Safety consequences - these include major injuries and fatalities.
- Operational consequences - these include delays and increase in management effort.
- Commercial consequences - these include loss of reputation.

4.4 Cultural hazards/threats identification from existing assessments

As stated above the proposed cultural behaviour risk assessment methodology can be applied to existing risk assessment in transport terminal.

In the following sections, excerpts of risk assessment from an airport and a railway station are reported: both shows that there are many hazard can lead to the situations highlighted in section 3.1.4 where culture (and therefore cultural behaviours) can play a significant role (in amplifying consequences or triggering new hazards):

1. Evacuation of passengers.
2. Stranded passengers.

4.4.1 Conceptual hazards from safety case of air transport terminal (example)

The list in Table 5 is a set of generic hazards extracted from a real case which can be applied to the set of airport incidents listed in Table 6.

<table>
<thead>
<tr>
<th>Incident not detected/alarm not raised</th>
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<tbody>
<tr>
<td>Passengers do not move from area of own accord</td>
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<tr>
<td>Appropriate incident response plan not put in place</td>
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<tr>
<td>Incident response plan not successfully implemented by staff</td>
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<td>Incident response plan not successfully complied with by passengers</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Structural fire</th>
<th>Chemical agent</th>
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</thead>
<tbody>
<tr>
<td>Active shooter</td>
<td>Civil unrest/riot</td>
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<tr>
<td>Bomb threat</td>
<td>Cyber-attack/disruption</td>
</tr>
<tr>
<td>FAA navigation system failures</td>
<td>Hazardous materials (HAZMAT) spill</td>
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<tr>
<td>Irregular operations (IROPS)</td>
<td>Nonspecific threat of damage to people or terminal</td>
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<tr>
<td>Security breach</td>
<td>Radioactive agent</td>
</tr>
<tr>
<td>Security equipment malfunction</td>
<td>Usurpation/pre-emption of terminal facilities for regional disaster</td>
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<td>---------------------------------------------------------------</td>
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<tr>
<td>Traffic blockage (access roads)</td>
<td>Baggage system failure</td>
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<tr>
<td>Transit system failure (trams, people movers, access and functional needs transport, etc.)</td>
<td>False fire alarm</td>
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<tr>
<td>Electrical outage/power failure</td>
<td>Heating, ventilation, and air conditioning (HVAC) failure</td>
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<tr>
<td>Suspicious package or bag</td>
<td>Picketing/protests/labour actions</td>
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<tr>
<td>Biological agent</td>
<td>Bomb explosion</td>
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<tr>
<td>Hostage/barricade</td>
<td>Aircraft hijacking</td>
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<tr>
<td>Flight cancellations (local or distant)</td>
<td>Aircraft accident/crash</td>
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<tr>
<td>Pandemic/quarantine</td>
<td>Suspicious odour</td>
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<tr>
<td>Structural failure of building</td>
<td>Other criminal act requiring investigation, crime scene protection, and crowd control</td>
</tr>
<tr>
<td>Aircraft diversion (non-signatory carrier)</td>
<td>Passengers’ flow related accidents</td>
</tr>
</tbody>
</table>

4.4.2 Conceptual hazards from safety case of a railway transport terminal (example)
Addressing railway, it is also possible to identify a list of hazards (see Table 7) applicable to railway terminal (not exhausting) that can lead to situations where culture (and therefore cultural behaviours) can play a significant role (in amplifying consequences or triggering new hazards).

<table>
<thead>
<tr>
<th>Table 7 - List of hazards applicable to railway terminals</th>
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<tbody>
<tr>
<td>Passenger fall between stationary train and platform</td>
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<tr>
<td>Passenger fall from platform and struck by train</td>
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<tr>
<td>Passenger struck by / contact with moving train while on platform</td>
</tr>
<tr>
<td>Passenger struck/crushed by train while crossing the track at or near a station on a crossing</td>
</tr>
<tr>
<td>MOP (non-trespasser) struck by / contact with moving train due to being too close to platform edge</td>
</tr>
<tr>
<td>MOP (non-trespasser) fall between stationary train and platform</td>
</tr>
<tr>
<td>Exposure to fire on railway infrastructure at a station</td>
</tr>
<tr>
<td>Exposure to fire in a station not on railway infrastructure</td>
</tr>
<tr>
<td>Exposure to an explosion at a station</td>
</tr>
<tr>
<td>Passenger fall from platform onto track (no electric shock nor struck by train)</td>
</tr>
<tr>
<td>Passenger injury during an evacuation from a station</td>
</tr>
<tr>
<td>MOP (non-trespasser) fall from platform onto track (no electric shock nor struck by train)</td>
</tr>
</tbody>
</table>
4.5 Likelihoods assessment

Several approaches may be adopted to obtain estimates of the frequency of initial threats/hazardous events. The main methods are:

- an analysis of appropriate historical data applicable to the given system and event;
- fault tree analysis (using component and human reliability data), when a combination of failure events is required;
- formalised techniques of eliciting expert judgements can be applied when the historical data is very limited.

4.5.1 Elicitation from experts

The risk methodology outlined in this document relies on risk values elicited from experts (covering expertise on risk assessment, involved transport modes, human factors and behaviours, psycho-social, socio-economic, medical, etc.). It is suggested that this data collection will include:

1. Hazards and threats applicable to cultural behaviour.
2. Likelihood of occurrence (per agreed scale).
3. Consequence magnitude (per agreed scale).

The elicitation can be conducted with individual experts separately or by means of group elicitation. The advantage of a group session is that the interactions between participants with differing experience and expertise tend to promote broader thinking, and take better account of the interfaces between subsystems and activities. Such sessions can also have more immediate and wider benefits in terms of the overall safety culture, by promoting awareness of existing hazards and understanding of differing viewpoints.

In the formal group elicitation, the format of such sessions is usually based on the application of a set of prompts (keywords) to some structured breakdown of the system or process being considered. Thus, for example, keywords such as NOT DONE or MISUNDERSTOOD can be applied to each task in a procedure to prompt participants’ thinking about how it might go wrong. The structured format promotes comprehensive consideration of the problem, whilst the keywords encourage creative thinking.

The elicitation from experts can concentrate on individual value of parameter value or on parameter distribution representing uncertainty.

The hazards collected and elicited together with the likelihood and severity parameters should be stored in hazard log for future review.

4.5.1.1 Approaches to elicitation with uncertainty

Uncertainties will arise throughout a qualitative/quantified risk analysis as a result of sparse data, simplifications and assumptions in the models used, the interpretations and representations of the processes being modelled and in the results generated. In general, the greater the uncertainty, the greater will be the variability in risk estimates for any given situation.

Uncertainty may be regarded as a lack of complete knowledge about the true nature or extent of some effect on the behaviour of a system or process, or in the case of data elicited from experts, from each expert’s view and experience of the process.

The treatment of uncertainty in risk assessment is becoming increasingly commonplace, but generally requires considerable resources to be performed rigorously. Treatments of uncertainty can broadly be separated into two groups:

1. Methods in which risk is derived by summing up the contributions to the total risk from all significant event types. In these methods, the event probabilities and outcomes are derived separately.
2. Methods in which risk is derived directly from a ‘complete’ representation of the system under all possible conditions. In these methods, the probability of any particular event and any associated uncertainty is implicitly accounted for in the distributions of possible values assigned to its inputs.

Examples are:
- Monte Carlo sampling methods;
- Direct integration methods;
- Fuzzy logic

Typically, the proper treatment of uncertainty will involve:
- characterising the full range of system behaviour in a conceptual model, or models, of the system;
- establishing the parameters which influence system behaviour and their ranges of possible values;
- investigating the behaviour of the system over the range of inputs;
- testing the results of the investigation for completeness;
- analysis of the results to establish which parameters contribute most to the variability in system behaviour;
- derivation of the risk under uncertainty.

Using a Monte Carlo approach, this process typically involves the development of a stochastic system representation of all the interacting processes. This model would be run many times, sampling its inputs from specified distributions of parameter value ranges. The results from this stochastic model must then be statistically analysed to ensure the results from the model are converged, to produce the output distribution and risk calculations.

In addition, sensitivity analysis may be performed to identify those input parameters which contributed most to the variability in the output. These so called sensitive parameters may then be analysed in more detail to ensure the results are reasonable, and the model is behaving correctly under extreme conditions.

The uncertainty treatment in the case of a lack of mathematical model is to elicit the risk values by asking the experts to provide the values by means of ‘subjective’ Probability Density Function (PDF) reflecting the expert belief regarding the value range. The experts can also judge the shape of the PDF.

The experts can select the PDF from a range of functions (see Table 8).

In practice Uniform PDF is quite useful, where only minimum and maximum values are available. A Triangular distribution function is also very useful since it can be defined by three parameters: minimum, most likely and maximum values, and has the advantage that it is easy to visualise and understand there mining.

Fuzzy logic models, are built upon fuzzy set theory and fuzzy logic, and they are useful for analysing risks with insufficient knowledge or imprecise data.

<table>
<thead>
<tr>
<th>PDF</th>
<th>Representative values</th>
<th>PDF</th>
<th>Representative values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform</td>
<td>Min, Max</td>
<td>Normal</td>
<td>Mean, Standard Deviation (SD)</td>
</tr>
<tr>
<td>Triangular</td>
<td>Min, Max, Mode</td>
<td>Exponential</td>
<td>Min, Mean</td>
</tr>
<tr>
<td>Beta</td>
<td>Min, Max, Mean, SD</td>
<td>Gamma</td>
<td>Min&gt;0, quantile</td>
</tr>
</tbody>
</table>
Expert elicitation sessions should be prepared and conducted in such a way so as to reduce the bias in subjective judgement and errors in the result outcome. The participants in the elicitation exercise should be provided with a briefing document outlining the elicitation procedure and it should be stressed that consensus is not the main goal of the process. An illustration example of a briefing note and method of recording and analysing such session using Excel application is presented in Appendix 4. The elicitation of risk value should follow the methodology outlined in previous chapter. The risk value from each expert can be a single value or PDF parameters depending on type of risk considered. The elicitation session is normally followed by post-elicitation discussion and feedback analysis of outcome and aggregate of results.

4.6 Consequences assessment

4.6.1 Assessment of consequences using models

To assess consequences of cultural-dependent hazardous behaviours, it is possible to use both off-the-shelf and/or WP2 models to:

- Model the crowd movement with and without cultural behaviour to compute a sensitivity analysis (i.e. the sensitivity to cultural aspects of the consequences of hazardous behaviour).
- Derive simpler models and calibrate them against detailed model (to represent key features of cultural behaviour)

The different factors affecting the consequences of a hazard event that compels evacuation of building spaces, can identified as:

- The building structure and layout (size of the building, number of floor, stairs, number of exits and emergency exits, etc.).
- The type and severity of the hazard event (fire, blast, smoke, flood, crash, structure collapse, etc.), that affects the building or a section of the building.
- The distribution of people inside the building spaces.
- The time to egress from the affected building.

The total egress shall be completed before the conditions in the environment become unsafe for occupants.

Prediction of the movement of occupants during an evacuation and of total egress time is an essential aspect of building safety analysis methods and risk evaluation.

To calculate the egress time from any location within a building, safety engineers are used to perform algebraic calculations following some given equations (e.g. as in the Society of Fire Protection Engineers (SFPE) Handbook of Fire Protection Engineering [36]).

Nowadays, more complex and realistic egress evaluations from buildings are available by computer modelling and more and more are playing a relevant role in safety design of buildings structures, in safety procedure, in risk analyses and risk assessments.

Existing numerical models for assessing the consequences and the role of culture are essentially evacuation models that have been developed since many years for the design of buildings and other public infrastructures (stadiums, airports, shopping malls) by research organisations and engineering companies.

In section 4.6.1.1 the most widely used COTS and research evacuation models are analysed to evaluate how cultural parameters are considered. In sections 4.6.1.2, conclusions are drawn.

4.6.1.1 Existing evacuation models

From a market analysis that does not pretend to be exhaustive but only indicative of the market of egress models, it has been possible to identify some egress models accepting as input parameters some values that may change according to the characteristics of the considered cultural mix of the crowd.
### Table 9 - Existing egress models and input parameters with potential cultural content

<table>
<thead>
<tr>
<th>Model</th>
<th>Input parameters with potential cultural content</th>
</tr>
</thead>
</table>
| PedGo³      | • Vmax: agent speed  
• Patience: The maximum duration, an agent can stand still (e.g. in a congestion) before changing its route and attempting to find an escape route leading in the opposite direction.  
• Reaction: The duration, an agent needs to respond to the evacuation signal, e.g. start moving.  
• Dawdle: The probability, for an agent to reduce its walking speed, e.g. to stand still for the rest of a sub time step.  
• Inertia: The agents try to continue on their walking directions.  
• Clustering: The grade of cohesion in a group (e.g. families, groups) |
| Simulex⁴    | • Body shape and size  
• Walking speed  
• Time to respond to alarm |
| PathFinder⁵ | • Height: the height of the cylinder used for inter-occupant collisions.  
• Acceleration Time: a steering mode parameter that specifies the amount of time it takes for the occupant to reach maximum speed from rest or to reach rest from maximum speed  
• Reduction Factor: a steering mode Parameter that specifies how well an occupant may squeeze past others in tight corridors.  
• Persist Time: the amount of time an occupant will maintain an elevated priority when trying to resolve movement conflicts.  
• Comfort Distance: specifies the desired distance one occupant will try to maintain with others in a queue |
| SIMWALK⁶    | • Walking speed  
• Height  
• Age  
• Breadth  
• Gender  
• Priority  
The parameters are adjusted according to agent’s intention (business, commuting, leisure, etc.) and region (Africa, Australia, Central Europe, etc.) |

All the models considered in Table 9 allow to set-up some input parameters whose value may depend on cultural characteristics of the considered crowd mix. However:

⁴ [https://www.iesve.com](https://www.iesve.com)  
⁶ [http://simwalk.com](http://simwalk.com)
Most parameters are related to basic cultural characteristics like age, height, gender, etc. and, also in the models claiming to culturally characterise the agents, the characterisation is based on very generic look-up tables (i.e. without a proper scientifically sound cultural characterisation).

In the case of those parameters that are referring to cultural behaviours (e.g. comfort distance, patience, etc.), there are no explanation on how to properly quantify those values to evaluate evacuation performances by changing the cultural mix of the crowd.

The models described in literature ([38], [39], [40], [41], [42], [43], [44], [45] and [46]), consider more accurately the characteristics of the environment, the distribution of occupants in the environment, the occupants’ movements. Some of them also try to integrate through specific algorithms, human behaviours and crowd effects, for a more accurate evaluation of differences in the occupant response time to cues, reactions and movements.

However, even within each model category, each model is unique due to the various choices (and limitations too) of modelling methodology used. Moreover, these models despite being much more interesting in terms of the introduction of culture-depended behaviours, have the following drawbacks:

- The number of parameters to be tuned is quite high in each model and sources on which tuning can rely are very limited.
- They have been validated only with very limited data sets, thus making adoption into a risk assessment process very difficult if not impossible.

4.6.1.2 Use of the models in the risk assessment process

The evacuation models application to each hub will be different by the nature of design and usage. The evacuation model should be run firstly without cultural behaviour hazards to ascertain the evacuation time, different level of people in the terminal buildings noticing any pinch points inherent in the design. Secondly the model should be re-run with the same number of people but now with assigned cultural behaviours characteristics, and recording the time to mustering to obtain the effect of cultural behaviour on risks.

4.6.1.3 Conclusions on existing evacuation models

From the analysis done in sections 4.6.1.1 it is possible to draw the following conclusions:

- COTS models have some basic parameters that can be tuned according to cultural characteristics (age, gender, nationality, etc.) but the cultural tuning itself is either not explained or, in one case only, based on very generic look-up tables.
- The models in literature are much more interesting in terms of the introduction of culture-depended behaviours into the models but:
  - The selected parameters are very different in the proposed approaches and often not comparable. Moreover, the number of parameters to be tune is quite high in each model and sources on which tuning can rely are very limited.
  - Proposed models have been validated only with very limited data sets, thus making adoption into a risk assessment process very difficult if not impossible.

Finally, the above analysis reinforces the need of further research in the area of cultural agent based modelling as is currently proposed in WP2.

In the context of transport hubs modelling the consequence from cultural behaviour attributed hazards it is necessary:

1. To postulate how cultural behaviour hazards can be developed to cause an escalation, leading to health and safety or business risks.
2. Such escalation can be modelled using event trees to represent the progress of such escalation and to assign probability at each event. Then using expert elicitation process, evaluate level of consequence and finally the risks.

3. In general, in cases which may lead to evacuation of people from transport terminals, the effect of cultural behaviour hazards on the evacuation process can be assessed using existing evacuation models. This can be achieved by considering how the cultural behaviour hazard can be represented by the model evacuation parameters. Thus, the speed of evacuation can be adjusted to represent the speed of people of different ages and sex, their ethnic origin, intoxication etc. Restriction in evacuation passages can be used to represent those who refuse to evacuate. The modelling agent can simulate people moving in different directions to the mainstream motion, caused by stress, confusion, misunderstanding of the signage or having other communication problems e.g. language.

4. The modelling parameters are then adjusted to represent the cultural behaviour hazards and the model is run:
   a) without cultural behaviour adjusted parameters, and
   b) with cultural behaviour adjusted parameters, to evaluate the impact of cultural behaviour parameters on risk, by considering the effect of these parameters on evacuation time, - health and safety risk or time to restore normal operation of the hub - business risk.

### 4.7 Risk evaluation and acceptance

The output from the elicitation of risk values must be checked for reality and outliers. Reality checks can be agreed in post elicitation session, outliers eliminated during result analysis.

The procedure for risk evaluation presented in section 4.8 based on Boston Square method can be applied to evaluate each risk see Figure 11.

![Figure 11 - Boston square risk matrix](image)

The simplest method of combining the results from individual experts is by giving all the experts equal weight. In the case of single values, these can be aggregated using an arithmetic mean (where N is the number of experts):

$$Risk = \frac{\sum_i Risk_i}{N}$$
Here in the case of multiple experts each providing PDF’s, there is no best method to combine them into a single PDF. Therefore, to explore the uncertainty in output from experts, the individual PDF elicited by experts are combined using a simple stochastic model to produce a single combined probability distribution and hence mean and measure of spread for the risk value. Assessing the risk against risk criteria, any risk above the criteria must be reduced, by decreasing the likelihood or decreasing the consequence. This process of risk reduction is mitigation process.

4.8 Cost-effective Risk Controls and Mitigations

Having completed the previous steps, it is then necessary to determine the risks and assess the acceptability of these risks against criteria and review the option for risk reduction. For each identified hazard – risk combination exceeding the risk criteria level, risk controls must be identified which will reduce the risk to acceptable level.

The control measures to be considered are:

- **Signage.** The risk manager must also review signage position, their clarity and presentation, both for general use and during emergency e.g. evacuation.
- **Mustering points and evacuation routes.** The mustering points and evacuation routes should be identified and assessed for the ease of movements of the passenger, public and staff.
- **Staff training.** The staff must be trained in identifying passengers stress levels, different cultural behaviour and human psychology.
- **Communication strategies.** Communication strategies shall be adapted to the cultural groups that are expected to transit across the considered hub.
- **Health treatments.** In case of emergencies with mass casualties with multi-cultural passengers it is necessary to adopt culture-specific measures. Moreover, in case of disasters with adverse psychological consequences on passengers, it is also necessary to consider specific measures for ethnic minority individuals having difficulties to access mental health cares.

In the following, some of the above control measures are discussed to highlight the possible cultural implications.

4.8.1 Communication in presence of cultural differences

Specific communication strategies have been proposed in literature for several cultural groups. Some important principles are reported in the following:

- The U.S. National Consensus Statement on Emergency Preparedness and Cultural Diversity [27] highlights, amongst others, the following principles:
  - “Design and develop emergency risk communication strategies that utilize trusted sources. Different communities will trust different people, based on direct experience as well as historical, socio-cultural, or legal reasons. Therefore, a wide range of trusted voices and channels, both formal and informal, need to be utilized to ensure messages are received, understood and followed.
  - Assess the cultural and linguistic appropriateness of messages. Once message content is developed, and trusted messengers and modes of communication have been identified, public health agencies and other service providers must ensure messages are audience-appropriate—including being clear, easily understandable, and culturally and linguistically appropriate. Various recommendations, tools and resources exist to assess the cultural/linguistic appropriateness of message content as well as its readability.
  - Collaborate with community representatives to evaluate risk communication strategies.”
Along the same line, communication tips to reach Low English Proficiency (LEP) passengers (in this category fall all passengers speaking less common languages, i.e. those languages beyond the hub’s mother tongue and English and French that are commonly used in hub communications and signage) are provided in [60]:

- Coordinating with non-English media - in TV and radio, as well as through online platforms and social media - to assist with sharing emergency information to LEP.
- Providing a clear message for evacuation pickup points and escape routes.
- Ensuring that emergency call centres have bilingual staff in the highest volume languages and access to telephonic interpretation services and properly training operators on how to handle an LEP caller.

The National Council of La Raza (NCLR) - the largest national Hispanic civil rights and advocacy organization in the United States - has also published guidelines to meet the needs of Latino communities in emergencies. In the following, IMPACT-related aspects are listed:

- “Barriers to full inclusion of Hispanics in emergency planning and response
  - No plan for transmitting critical information and warnings to the Latino community via Spanish-language media and other mechanisms.
  - Few Spanish-language and/or bilingual materials in use for either preparedness or response.
  - Lack of procedures and/or low priority given to recruiting and training Latinos as emergency responders.
  - Inappropriate actions by some responders (elected officials, staff, and volunteers) that create distrust, so Latinos do not come forward and request assistance – even when their lives are at risk.
  - Limited English skills among Latino immigrants, especially recent immigrants
  - Use of Spanish-language rather than mainstream media

Factors affecting communications with Latinos

- Trusted sources: Latinos (like other groups) pay most attention to messages that come from trusted sources. Community leaders, non-profits, faith-based groups, and family members are typically very credible, as are some Hispanic media outlets and personalities.
- Language: Spanish-dominant Latinos may not understand, read, or be aware of English-language warnings or directives. They may get their news from formal and informal Spanish-language sources.
- Access: Latinos may be relatively isolated in where they work and live, and therefore not see or hear most warnings or emergency directives.”

Even though these guidelines are prepared for the Latin community in U.S.A., they are very applicable in Europe and, in particular, in those countries where the Latin community is largely present (e.g. Italy).

In literature, it is also possible to find some hints on how to interact with cultural differences during emergencies. Some interesting tips on eye contact and gestures are provided in [29]:

- Some level of eye contact may be inappropriate in certain cultures (e.g. sustained contact could be perceived as a challenge to authority [30])
- Some gestures may be inappropriate in some cultures or having completely different meaning (e.g. “The thumbs up sign in most American and European cultures meaning things are going according to your plans or something you approve of. However, the going good sign translates into a rude and offensive gesture in Islamic and Asian countries” [31]).
### 4.8.2 Training/awareness to manage cultural differences

One of the key aspects to manage cultural differences is to ensure an adequate level of Cultural Competence\(^7\).

In [27] a set of strategies to for building organisational capacity based on cultural competence is listed:

- “Collaborate with cultural competence experts who can provide training on integrating key principles of cultural competence into emergency planning and response.
- Offer cultural competence education and training to emergency planners and first responders.
- Promote diversity in staffing and leadership.
- Develop a workforce language registry.
- Establish clear procedures for utilizing bilingual personnel and volunteers.
- Develop a repository of translated materials that have been vetted for accuracy and appropriateness.”

These strategies should be adopted by hub managers to increase the capacity of staff to reduce racial/ethnic disparities and improve cultural competences to reduce risks when managing events with cross-cultural crowds.

Similarly, also the U.S. Department of Health and Human Services has developed a checklist [49] for emergency managers whose aspects applicable to transport hubs are summarised in Table 10. As it is possible to see there is a special attention to both cultural/ethnical diversity and disabilities.

### Table 10 - DHHS checklist

<table>
<thead>
<tr>
<th>Action steps</th>
<th>Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you developed your emergency plans in partnership with an array of</td>
<td>Have you trained emergency responders, including shelter staff, on their obligations under civil rights laws and on how to meet the needs of individuals with access and functional needs, including individuals with disabilities?</td>
</tr>
<tr>
<td>diverse community groups, including faith-based organizations and groups</td>
<td></td>
</tr>
<tr>
<td>that serve and advocate for people from different cultures, races and</td>
<td></td>
</tr>
<tr>
<td>ethnicities, limited English proficient individuals, and individuals with</td>
<td></td>
</tr>
<tr>
<td>disabilities?</td>
<td></td>
</tr>
<tr>
<td>Have you engaged in drills and exercises that include people with a range of</td>
<td>Are emergency responders - fire and police, health care providers, and shelter staff - prepared to welcome all who need their care, including lesbian, gay, bisexual and transgender persons, immigrants and migrants, individuals with psychiatric or developmental disabilities or dementia, homeless and institutionalized individuals, and persons of all faiths?</td>
</tr>
<tr>
<td>access and functional needs?</td>
<td></td>
</tr>
</tbody>
</table>

\(^7\) Cultural Competence is defined [27] as “A set of attitudes, skills, behaviours, and policies that enable organizations and staff to work effectively in cross-cultural situations. It reflects the ability to acquire and use knowledge of the health-related beliefs, attitudes, practices, and communication patterns of clients and their families to improve services, strengthen programs, increase community participation, and close the gaps in health status among diverse population groups.”
### Action steps

<table>
<thead>
<tr>
<th>Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you prepared emergency messaging that is short and simple, culturally appropriate, in languages prevalent in your area(^8) and in multiple formats, such as audio, large print, captioning?</td>
</tr>
<tr>
<td>Is your website accessible to people with disabilities? Does it have taglines for people whose primary language is not English, directing them to information in a language they can understand?</td>
</tr>
<tr>
<td>Have you established methods of communication that include addressing the needs for messaging in multiple formats to account for the access and functional needs of individuals with disabilities, with limited English proficiency, from diverse cultural backgrounds, with cognitive limitations, and who do not use traditional media?</td>
</tr>
<tr>
<td>Do emergency responders have ready access to interpreters for persons with limited English proficiency and for persons who are deaf or hard of hearing?</td>
</tr>
</tbody>
</table>

Analogously, training suggestions are given in [60] to manage LEP passengers:

- When testing your communication strategies, practicing how you will translate and distribute translated media alerts, issue multilingual evacuation announcements, work with interpreters, and other critical communications to reach LEP populations.
- Helping prepare responders and volunteers to communicate with LEP disaster victims in emergency exercises at hospitals, mobile health units, shelters, etc.
- Preparing “I Speak” cards and training responders, intake workers, and volunteers on how they can be used to assist to identify languages spoken by disaster survivors.

### 4.8.3 Treatment of patients of different cultures

The management of mass casualties during an emergency poses the first responders in front of the problem of treatment of patients from different cultures that, in some cases, require specific attentions and or behaviours. Not following these prescriptions may either generate conflicts with patients leading to the refusal of care thus worsening the consequences of an emergency.

The following Table 11 provides an example of aspects to be considered when dealing with patients of specific cultural groups.

<table>
<thead>
<tr>
<th>Cultural group</th>
<th>Aspects to be considered</th>
</tr>
</thead>
</table>
| Muslim [32]    | - If possible, healthcare should be given by people of the same sex as the patient. ... In some cases, a close family member of the same sex may assist in the washing of the sick person.  
- Unnecessary touching between non-related people of the opposite sex should be avoided. The left hand is considered unclean, so it is preferred that the right hand be used for feeding or administering medications.  
- A beard is considered a very important religious symbol to the Muslim male patient. Like any other patient, permission must be obtained to shave any part of the beard, which should be done by a man. |

\(^8\) Here “prevalent in your area” should read “prevalent in your passengers or visitors”
### Cultural group | Aspects to be considered
--- | ---
Muslims | - Because death is perceived as predestined by Allah, Muslims disapprove of any medical care that may hasten the death of a patient, even for humane reasons.

**Sikh** [33] | - “Sikhs are required to wear five articles of faith at all times. This applies to both men and women. These articles are known as the Five Kakkars or Five Ks – Kesh (uncut hair), Kangha (wooden comb), Kara (steel bangle), Kirpan (short sword), and Kachera (undergarment). These articles should not be removed from a Sikh patient without permission.
- Hair should not be removed from any part of a Sikh patient’s body without consent from the patient or their substitute decision-maker (this is usually a family member). If a Sikh patient has impaired capacity and their condition is such that their life and health are at risk, and there is no time to obtain consent, medical treatment to avert the threat to life should be carried out without delay. The cutting of any hair should be avoided unless urgent or life-threatening medical treatment cannot be carried out without its removal.
- Some medicines may not be suitable for Sikh patients because they contain alcohol or are of animal origin.
- Sikh patients (both men and women) may prefer to be examined by a health care provider of their own gender.
- Sikh patients may wish to have a family member present during any clinical examination.
- Sikhs are also required to wear a turban at all times. ... If it is necessary to remove the turban during medical treatment, an alternative head covering should be provided.”

**Hindu** [34] | - Modesty is an important consideration for Hindu men and women, and patients may prefer to be examined by a health care provider of their own gender. Hindu patients may also wish to have a family member present during a clinical examination or procedure.
- The need for invasive examinations may need to be carefully explained, particularly if a same-sex clinician cannot be accommodated.

**Jehovah Witnesses** [35] | A specific case is the refusal of Jehovah Witnesses to accept blood products under any circumstances that causes concern to doctors in an emergency. In UK for example, patients have the right to refuse medical treatment for reasons which are rational or irrational or for no reason and therefore Jehovah Witnesses are carrying blood refusal cards. The approach taken by many hospitals in UK is the following [35]: “Physicians should provide the necessary information for an individual to make an informed choice and where this is not possible, physicians should administer blood products in life threatening situations, if any doubt exists about the validity of a blood refusal card.”

### 4.8.4 Mental health care for ethnical minorities
As discussed in [47], US ethnic minorities (African American, Asian Americans, Native Americans, and Latinos) are at elevated risk for adverse psychological consequences after disasters with respect to white Americans.

Generally speaking, the two most likely adverse psychological consequences are:
• Post-Traumatic Stress Disorder (PSTD)⁹;
• Depression¹⁰.

Culture is playing a role in both effects by shaping both experiences and consequences of disaster exposure.

The issues are complex because the effects of ethnicity and culture are pervasive. They may influence the need for help, the availability of help, comfort in seeking help, and the appropriateness of that help.

The recommendations in [47] of more interest for IMPACT are the following:

• **Provide low-cost and easily accessible services.** “Minorities often lack insurance and other means of paying for mental health services. They will be more likely to take advantage of services that are close to home, community-based, and offered in concert with other services and activities.”

• **Work collaboratively and proactively to reduce stigma and mistrust and to engage minorities in care.** “Minority disaster victims, even those who have suffered intensely, will not necessarily seek professional mental health services, as they will tend to rely on families, friends, and other natural sources of help. Viewing this as an asset, rather than as a problem to be overcome, reminds the interventionist to work collaboratively with natural helpers in the community.”

• **Promote community action.** “Novel and innovative strategies should be explored that involve minority communities in their own recovery by working toward specific, achievable goals. Social marketing, advocacy, community organizing, train-the-trainer models, and mentoring programs are but a few examples that can be explored.”

• **Recognize that cultural competence is a process not an end-state.** “Clinicians will only experience despair if they are expected to know everything that would be helpful about every culture.”

As it has been thoroughly discussed in [48], many psycho-socio-cultural parameters are playing a role in poor mental health outcomes after a disaster, including gender, age, prior experience, ethnicity, culture, socio-economic status, etc. All these factors are working together in such a complex way that it is impossible to provide a complete understanding of how all these factors are contributing to increase the risk of post-event poor mental health. Thus, it is necessary to “consider them as additive and propose that individual’s risk will increase along with the number of risk factors present and decrease along with the number of protective factors present”.

The individual-level risk factors for poor mental health outcomes proposed in [48] after having analysed 160 samples composed of over 160000 individuals who experienced 102 different events is summarised in Table 12.

<table>
<thead>
<tr>
<th>Category</th>
<th>Risk factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma and stress</td>
<td>• Severe exposure to the disaster, especially injury, threat to life, and extreme loss.</td>
</tr>
<tr>
<td></td>
<td>• Living in the context of a neighbourhood or community that is highly disrupted or traumatized.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
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<th></th>
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</thead>
<tbody>
<tr>
<td><img src="image" alt="" /></td>
<td></td>
</tr>
<tr>
<td>Survivor</td>
<td>• High secondary stress, regardless of whether it is of an acute or chronic nature.</td>
</tr>
<tr>
<td>characteristics</td>
<td>• Female gender.</td>
</tr>
<tr>
<td></td>
<td>• If an adult survivor, age in the middle years of 40–60.</td>
</tr>
<tr>
<td></td>
<td>• Little previous experience relevant to coping with the disaster.</td>
</tr>
<tr>
<td></td>
<td>• Membership in an ethnic minority group.</td>
</tr>
<tr>
<td></td>
<td>• Poverty or low socioeconomic status.</td>
</tr>
<tr>
<td></td>
<td>• Predisaster psychiatric history.</td>
</tr>
<tr>
<td>Family context</td>
<td>• If an adult survivor, the presence of children in the home and, if female, the</td>
</tr>
<tr>
<td></td>
<td>presence of a spouse.</td>
</tr>
<tr>
<td></td>
<td>• If child survivor, the presence of parental distress.</td>
</tr>
<tr>
<td></td>
<td>• The presence of a family member who is significantly distressed.</td>
</tr>
<tr>
<td></td>
<td>• Interpersonal conflict or lack of supportive atmosphere in the home.</td>
</tr>
<tr>
<td>Resource context</td>
<td>• Lacking or losing beliefs in one’s ability to cope and control outcomes.</td>
</tr>
<tr>
<td></td>
<td>• Possessing few, weak, or deteriorating social resources.</td>
</tr>
</tbody>
</table>

### 4.8.5 Multicultural signs

The safety signs are prescribed by international standards, in particular:

- ISO 7010 [50] prescribes safety signs for the purposes of accident prevention, fire protection, health hazard information and emergency evacuation.

- The shape and colour of each safety sign are according to ISO 3864-1 [51] and the design of the graphical symbols is according to ISO 3864-3 [52].

This should guarantee a common understanding of the safety signs by passengers of different cultures. However, from various studies, it appears that there is an influence of culture on how people wayfind and that cultural minorities may have difficulties in wayfinding in hubs due to the poor signage.

While difficult wayfinding during normal hub operation may simply make the travel experience less pleasant, it can create serious problems during emergencies, in particular during evacuation.

The findings are reported here below:

- In [54], it has been studied how people with diverse cultural backgrounds (Chinese and Americans) may interpret signage layouts differently with respect to symbols and text by presenting them different signs using only English text, only symbols, or a combination of both. They arrived at the following conclusions:
  - There is a statistically significant difference among wayfinding speeds for each of the three sign types for both the American and Chinese groups.
  - The American group navigated significantly faster than the Chinese group, on the aggregate level, for every sign type.
  - There was a clear difference for both groups between what sign type was best for wayfinding and what sign type was preferred by most of the group.

The recommendation is that “airport administrators determine their hierarchy of values for their airports. Ranking values such as wayfinding time, passenger preference, and wayfinding accuracy will help guide an airport administrator as to which sign type will be the best fit for their airport”.

An example in this direction is the Helsinki Vantaa airport [65] that, having experienced between 2014 and 2015 a 50% increase in Chinese travellers, has decided to
- Recruit Mandarin native-speaking guides;
- Introduce two service points dedicated to Chinese visitors;
- Add a customised WiFi portal with instructions that will make it easier to navigate the airport;
- Include Mandarin (but also Korean and Japanese) in signage.

Figure 12 - Mandarin in the Helsinki Vantaa airport signage

- As reported by Reduced Mobility Rights Limited [55], “For many people, deafness is not linked to disability, but rather indicates belonging to a minority language community. Absence of induction loops at key areas like security check points, passport control booths, and check-in counters, poor signage, older information displays, unavailability of text-phones and captioned videos are factors that contribute to unpleasant airport journey”. As stated above, the lack of hubs’ preparedness for disabled people may end up in serious consequences during emergencies. These risks can be mitigated by adopting assistive technologies in hubs. An example of these solution has been introduced by the Edinburgh airport by adopting induction loops in various locations around the departure and arrival terminals.

4.8.6 Language proficiency
Language proficiency of both passengers and staff is a key factor when dealing with emergency in a hub that can:
- Reduce the passengers’ understanding of staff emergency orders and/or the passengers’ wayfinding capacity, thus increasing reaction and evacuation times.
- Increase the stress of passengers with special needs.
On average, only between 40% and 50% of all airport assistance agents have some knowledge of a second language [55] and the level is probably worse in railway and maritime domain. Poor proficiency remains an area of concern across the European Union and shall be improved by training staff to speak fluently a second language.

4.9 Risk Management
The procedure described in Figure 4 is a general risk management procedure for review and supervision of the risks in an organisation as well as in transport hubs. This process should be implemented and be continuous throughout the life cycle of hub operation. Monitoring, revision and feedback must be effective to ensure that the implementation process is working. Any changes in the system or control process must be reassessed and risk re-evaluated.
5 CONCLUSIONS

The following conclusions can be drawn:

- In this report, cultural behaviour risk assessment has been presented based on international standards and modified to take into consideration hazardous cultural behaviours, the escalation of consequences due to specific cultural characteristics and the possible mitigation actions.
- The proposed cultural behaviour risk assessment methodology can be applied to transport hubs where:
  4) The overall general risk plus cultural behaviour is applied from first principle.
  5) The cultural behaviour risk assessment is an add on to an existing overall risk assessment.
  6) Only cultural behaviour risk assessment is performed to examine its contribution to the overall transport hub risk.
- It has been proven that is very difficult to assess consequences and likelihoods of events leading to escalation due to specific cultural behaviours based on the findings of WP1. Therefore, the emphasis on the report has been on expert elicitation of likelihood and consequences of these hazards leading to risks and mitigation measures that are more consolidated.
- Various mitigation action to be applied to specific cultural clusters/ethical minorities have been reported in the areas of first-aid and long-term health cares, communication, training and awareness and signs. However, most of them relates to US specificities while EU is apparently not yet aligned in providing guidelines in case of cultural diversities.
- Whenever evacuation of crowds is involved, computer models could help to quantify consequences. The survey of the both literature and market has highlighted that
  - Only few models allow to model cultural differences inside the crowd and most of these models are only at the research level.
  - The selected cultural parameters in the proposed approaches are very different and often not comparable. Moreover, the number of parameters to be tuned is quite high in each model and sources on which tuning can rely are very limited.
  - Proposed models have been validated only with very limited data sets, thus making adoption into a risk assessment process very difficult if not impossible.
- All the above reinforces the need of further research in the area of cultural agent based modelling as is currently proposed in WP2.
- The proposed approach needs to be tuned to a specific transport hub under assessment to take into account the hub design, staff training level, number of people in the hub, transport modes, as well as the expected cultural mix of passengers and visitors. The assessment should include the feasible scenarios with their relevant internal and external hazards and threats, etc.
APPENDIX 1  TERMINAL/HUB CHARACTERISATION

To analyse the transport hub to be considered for the IMPACT project, it is necessary to start from some assumptions:

- Public transport (or public transportation) is performed by different “vehicles” or transport means (e.g. airplanes, trains, buses, ships), that move large numbers of people at once.
- Public transport usually operates on fixed routes and fixed schedules, and operations is often limited to specific times of the day and/or days of the week.
- Public transport cannot achieve the same degree of freedom of private transport, that allows to start the travel and to stop wherever and whenever a traveller wishes.
- Public transport requires passengers to spend some waiting time for the vehicles arrival, extra time to embark and disembark, to pass the required controls, where necessary (ticket, security, etc.).
- Public transport imposes some social restrictions and specific behaviours on travelling people.
- Public transport produces an unavoidable assembly and mix of people in a common place: there is no possible discrimination or choice for passengers of their travelling companions.
- In any public transport, since passengers do not travel individually, but typically in “batches”, passengers need to be "assembled" in the “vehicles” (trains, airplanes, bus, ships) to follow the selected route and reach their destinations where they are dispersed.

These facts can cause:

- A significant level of heterogeneity of passengers coming from different cultures and having different, sometimes contrasting, motivations for travelling.
- A significant “promiscuity” among passengers forced to stay together in a “vehicle” or in rooms for long periods of time.
- Having a timetable, possible irritations in case of delays and or service disruptions.

The destination of a passenger could be its final destination or an intermediate step where its trips will continue.

The function of “assembly” and “distribution” of passengers traffic flows has to be performed in specific locations or terminals, where:

- Passengers originate their trip and where they have to go first in order to reach their final or intermediate destinations.
- Passengers have to wait the scheduled arrival of vehicles before boarding
- Passengers terminate their trip if they have reached their destination or may continue the travel to another destination.

![Figure 13 – The passengers model in public transport](image)

A terminal can be the location of origin or destinations of a journey or any single leg of a journey. Therefore, it is the facility carrying out the basic functions of any transport system:

- “vehicle” arrivals and departures,
• passengers “assembling” and boarding,
• passengers disembarking and “dispersal”.

Moreover, many other functions are carried out in a terminal:
• Services or operations related to passenger’s travel: ticket sale, check in, ticket control, security check, identity control, etc.,
• Complementary services that are offered to passengers as well as to other people or visitors that can freely access to some terminal areas.

It is also possible to distinguish between different terminals according to the selected main transport mode:
• An airport terminal is a building or a complex of buildings at an airport where passengers and luggage transfer between ground transportation and air transportation and the facilities that allow them to board and disembark from aircraft. Airport terminals are classified as passenger and cargo terminals. If the airport’s cargo volume is not enough to construct a dedicated cargo terminal, then both the passenger and cargo operations are handled in the passenger terminal.
• A railway terminal (or train station, railway station), is a railway facility where trains regularly stop to load or unload passengers. Usually, a rail terminal is a station at the end of a railway line; arriving trains end their journeys and reverse out of the station.
• A maritime terminal is a building or complex of buildings and structures to serve passengers and handle baggage in seaports. Marine terminals and their structures are classified according to basic operations as passenger or passenger-freight terminals, and are related to the types of ships, the water level, the flow of passengers and freight. Many marine terminals serve as transfer points for passengers from ships to land transportation (and vice versa). Particularly, ferries form a part of the public transport systems of many waterside cities and islands. However, ship connections of much larger distances (such in the Mediterranean Sea) may also be called ferry services, especially if they carry vehicles.

Even in the past, but more and more today, with increasing traffics, globalisation and inter-modality, transport terminals are at the centre of critical issues in economic, political, urban, and other geographical fields (e.g. hubs are a preferred target for terroristic attacks, are a point of attraction for illegal immigrants, etc.).

Large transport terminals represent a linchpin of the global economy and one of the most critical part of the transport infrastructure that makes possible the increased volume of passenger (and freight) movements around the world.

Figure 14 – The terminal model
Due to the relevance in term of volumes of passengers and of their geographical location, terminals have become essential links in transportation chains and represent important capital investments. Since much of these infrastructures must be near or in major urban agglomerations, terminals occupy specific strategic locations in a territory and they exert a strong influence over their surroundings, by performing specific economic and social functions and by serving as clusters of specialized activities.

For example, the Seoul-Incheon International, one of the largest and busiest airports in the world (and the “best” since 2005 according the Airport Council International), has a golf course, a spa, private sleeping rooms, ice skating rink, a casino, indoor gardens and a Museum.

Today’s airports are more than just transfer points between air and land transportation and for some metropolitan regions they act as the centre node of integrated business and industrial parks for supporting commerce. This concept is called by Kasarda “airport city” or “aerotropolis” [63].

The use of “Hub concept” for terminals became popular from the “hub-and-spoke model” in air transport under strong drive of airlines companies. Even if the concept is not new, it became the most used paradigm in air transport networks after the U.S. federal government deregulated the airlines in 1978. Hubs existed before deregulation, but the removal of restrictions on market and the policies permitting airline mergers, brought carriers to consolidate hub-and-spoke networks feeding traffic to and from strategically located hubs.

The hub-and-spoke model of scheduling and marketing establishes a number of routes connected to a central hub. Passengers are collected from feeder flights in smaller cities, transferred to other carrier flights in larger cities (the hub), and then transported to their ultimate destination (see Figure 15). The traditional connecting hub entails airlines purposely scheduling resources, aircraft, and ground staff to converge at the hub-site during a short time period.

![Figure 15 – The hub concept](image)

This model allows significant economic advantages (mainly for airlines companies) compared to point to point connections even if this model has been recently abandoned by low-cost airlines. For passengers, the travel time from point to point becomes longer, but the airlines can increase the travel frequency along each route, and make full use of the capacity of each plane, with a possible travel cost reduction. Moreover, centralizing operations at the hub leads to economies of scale.

Because of the centralization of many functions in one location and the resulting high flow of passengers and vehicles, day-to-day operations of hubs shall be carefully synchronized:

---

• Traffic management (of vehicles and passengers) and precise timing are required to keep the hub operating efficiently.

• The hub concept may constitute a bottleneck in the global transport network, in case of failures or mishaps. Delays at the hub (caused, for example, by bad weather conditions) can result in delays throughout the transport national and transnational network.

• Moreover, due to the high flows and density of passengers, the potential consequences of any abnormal event become strongly amplified, mainly if and where the effects of “human factors” and human behaviour are relevant.

• The above effects become particularly critical in specific functional areas of a hub, where both in normal conditions and mainly in upset or emergency conditions there is a significant concurrent presence of people.

• Large hubs are often both national and international.

• In international hubs, the concurrent presence of people and especially passengers of different nationalities (and potentially of different cultures and expected behaviours) may become a further amplifier of “human-related” risk in hazard conditions ([53] and section 3.2).

• Today various large international airports have transformed to global hubs. Airports such as Dubai, London Heathrow, Frankfurt, and Istanbul etc. where intercontinental flights are collected and distributed can handle up to 70 million international traffic yearly. Most different cultures can be seen in these global hubs.

Regarding the last considerations, it is interesting to compare, e.g. for the largest air hubs in the world, the ratio between the figures of total passengers/year and the international passengers/year to discover which are the airports with the highest probability of having multicultural mix of passengers:

• The largest air passenger hub in the world is the Atlanta Airport in USA, but the prevalent passengers are related to domestic US flights.

• However, for instance, for Schiphol Airport, London Heathrow, Paris CDG, the percentages of international passenger reach about 90% or even more thus, in principle, these are hubs where IMPACT project results can have potentially a major impact.

<table>
<thead>
<tr>
<th>Rank for Total pax</th>
<th>HUB</th>
<th>Total pax/y</th>
<th>International pax/y</th>
<th>Rank for International pax</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>London Heathrow Airport LHR/EGLL</td>
<td>74,954,289</td>
<td>68,091,095</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>Paris-Charles de Gaulle Airport CDG/LFPG</td>
<td>65,766,986</td>
<td>58,623,111</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>Frankfurt Airport FRA/EDDF</td>
<td>61,032,022</td>
<td>52,713,013</td>
<td>7</td>
</tr>
<tr>
<td>14</td>
<td>Amsterdam Airport Schiphol AMS/EHAM</td>
<td>58,284,864</td>
<td>54,940,534</td>
<td>5</td>
</tr>
<tr>
<td>&gt;30</td>
<td>Germany Munich Airport MUC/EDDM</td>
<td>39,700,515</td>
<td>30,269,007</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Dubai International Airport DXB/OMDB</td>
<td>78,014,838</td>
<td>69,954,392</td>
<td>1</td>
</tr>
</tbody>
</table>
| 1                 | Hartsfield-Jackson Atlanta International ATL/KATL | 101,491,106 | >30                |}

The hub interesting for IMPACT are those with multi-cultural passengers, e.g. any mix of passengers:

• different nationalities;

• different travel motivations (e.g. business men and tourists);
- different beliefs (e.g. sport teams' supporters, pilgrims, etc.).

It is therefore key for IMPACT to find sources of information to characterise the cultural mix of passengers.

A transport hub can be considered as “multi-modal” terminal with a combination of the following transport modes (see Figure 17):

As public transport:
- Air terminal(s)
- Railways/metro terminal(s)
- Bus terminal(s)
- Maritime terminal(s)

As private transport:
- Car Parking (private and rental cars)
- Taxi stands

![Figure 17 – The hub characterisation in IMPACT](image)

In any case, each terminal is linked to the others via internal connection system of different kind:
- walkway, stairs,
- elevators, travellators,
- shuttle bus or people mover.

A hub is characterized by the main or prevalent transport mode: air, rail, maritime hub. In the following, the different hub types are described in more details.

In particular, each section describes the specific hub in term of:
1. The typical configuration;
2. The typical location and the prevalent use of facilities;
3. The potential mix of cultures of passengers and/or visitors.

The knowledge of the above information is key to estimate the cultural mix of the crowd in the hub and therefore to determine the most likely hazards and threats for which culture may play a role (see section 3).
An air hub is usually a combination of (see Figure 18):

- Many air terminals;
- A railway/metro terminal;
- Bus terminal(s);
- Ferry terminal(s) - not common but there are examples: SkyPier\(^{12}\) at Hong Kong International Airport (HKIA) provides speedy ferry service for transfer passengers;
- Rental car centres & Parking;
- Taxi stands;
- Private Car Parking.

Figure 18 – Typical configuration of an air hub

Large airports follow this scheme of configuration with the highest level of integration.

With quite no exception airport terminals and hubs are located outside the city centre (in Table 13 it is possible to see a list of main airports in Europe and the mean distance from the city centre).

Table 13 - Distance of airport hubs from city centre

<table>
<thead>
<tr>
<th>Country</th>
<th>City</th>
<th>Name</th>
<th>Distance from city centre</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>London</td>
<td>Heathrow</td>
<td>22 km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gatwick</td>
<td>39 km</td>
</tr>
<tr>
<td>FR</td>
<td>Paris</td>
<td>Roissy Charles de Gaulle</td>
<td>23 km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Orly</td>
<td>15 km</td>
</tr>
<tr>
<td>NL</td>
<td>Amsterdam</td>
<td>Schiphol</td>
<td>9.1 km</td>
</tr>
<tr>
<td>IT</td>
<td>Rome</td>
<td>Fiumicino</td>
<td>35 km</td>
</tr>
<tr>
<td></td>
<td>Milan</td>
<td>Malpensa</td>
<td>46 km</td>
</tr>
<tr>
<td>DE</td>
<td>Frankfurt</td>
<td>Rhein-Main</td>
<td>12 km</td>
</tr>
<tr>
<td></td>
<td>Munich</td>
<td>FJ Strauss</td>
<td>29 km</td>
</tr>
<tr>
<td>SP</td>
<td>Madrid</td>
<td>Barajas</td>
<td>9 km</td>
</tr>
<tr>
<td></td>
<td>Barcelona</td>
<td>El Prat</td>
<td>12 km</td>
</tr>
</tbody>
</table>

Due to the relative distance, most of the people gravitating in the air hub are either passengers or accompanying passengers. Therefore, the services offered in public areas, are mostly related to travellers or accompanying passengers with the only exceptions of hotels, congress facilities or meeting rooms rentals that may serve non-travellers.

An example of a layout of an air hub is given in Figure 19.

There are different airport terminal configurations (see Figure 20) such as linear, peer finger, satellite etc. Depending on the configuration, size and operational characteristics, the airport terminal might require different facilities such as rail connection between terminals and/or piers, bus connection or air bridge connection between aircrafts and the terminal.

An international air hub is probably the place where the highest level of mix of culture and nationalities is present.
However, at least for passengers, the security policy adopted in aviation requires an identity check for each delivered ticket and controls at departure gates. Thus, in the airport environment it is possible to identify the actual cultural mix with a reasonably good degree of accuracy.

The potential mix of people nationality and culture (as far as possible to elicit culture from nationality), can be argued from:

- Tickets of passengers on departing and arriving flights.
- Frequent Flyers information.
- List of departure/arrival flights at the different airport terminals.

**Figure 20 - Airport terminal configurations [64]**

In EU, flights are usually classified in three groups, depending on their origin or destination. Schengen, EU Non Schengen and third countries.

**Schengen Associated Countries:**
Flights, from or to countries which signed the Schengen Agreement.

Citizens of these countries may move freely across the interior borders. International Inter-Schengen flights as well as domestic flights are subject to the Schengen Agreement. The Schengen territory is composed by: Germany, Austria, Belgium, Denmark, Spain, Finland, France, Greece, Holland, Italy, Iceland, Luxembourg, Norway, Portugal and Sweden.

For these flights usually no passport is required, but identity check is anyway required at boarding gate.

**Non Schengen EU Countries:**
Flights, from or to countries, belonging to the European Union, which did not sign the Schengen Agreement.

Citizens of the following countries may not move freely across the inter-Schengen borders: Bulgaria, Cyprus, Ireland, United Kingdom and Romania.

**Third Countries:**
Flights, from or to countries, not belonging to the European Union, which did not sign the Schengen Agreement.
A rail hub is usually a combination of (see Figure 21):
- One or more Railways Terminals or Stations
- Metro Stations/Terminus
- Bus terminal(s) or stop
- Rental car centres & Parking
- Taxi stands
- Private Car Parking

Most large railway stations follow this scheme of configuration with different level of integration.

It is possible to characterise a rail hub as follows:
- With almost no exception, railways stations are located inside or very close to the city centre.
- The railways stations and their surroundings are becoming a new central place in the city, even if and where they are located on the edge or even outside the historical urban area.
- The offer of a network of services is not limited to mobility, and can include commercial, housing, education, cultural, tourism facilities.
- The rail stations area is often a “prime” location attracting new developments, business and employment initiatives, and inhabitants, within a sustainable, multi-modal mobility and development logic.
- The extension of the “Station” into the “Hub” concept reaffirms the station, its surroundings and its multi-modal connections as an important civic asset.
- Services offered in public areas are very similar to those of a city mall.
A good example of a railway hub is the Brussel Midi station in Figure 22.
Due to the main national role of railways, the potential mix of passengers/visitors’ culture reflects the prevalent cultural clusters of the country.

From all the assumptions, it is possible to deduct that the people gravitating in a railway hub are largely a mix of passengers (mostly commuters) and inhabitants of the city and of the surroundings. Therefore, the prevalent culture may be related to regional habits and behaviours.

Even if for travellers there is no identity check, a valid ticket is usually required to have access to platforms and trains. Some exception exits for high speed trains (e.g. Madrid Atocha, Eurostar trains in Gare du Nord in Paris or Brussels Midi).

Differently from airports, few means are today available to identify the mix of culture of people in a railways hub with a useful degree of accuracy; these include:

- Destinations of departing or arriving trains (commuters or main lines).
- Tickets purchases (commuters) or multi-modal cards (e.g. Oysters in London).
- Statistics of the local authorities.

A maritime hub (typically a ferry) may usually be a combination of (see Figure 23):

- Water terminal
- Private Car Parking
- Bus terminal(s) or stop
- Railways/Metro Terminals or Stations (often adjacent to Water terminal)
Because of the large number/size and type of maritime hubs, the configurations may change considerably.
The maritime hubs and terminals, mainly for geographical and historical reasons are usually not so far from the waterfront and downtown.
However, differently from railways station, the facilities and services offered in public areas are mainly dedicate to travellers and related operations.
Most part of the people gravitating in the hub are passengers.

Figure 23 - Typical configuration of a maritime hub

Travellers on ferries are usually tourists or commuters. Considering that for national (or Schengen) destination no identity check is required, the potential mix of people nationality/ culture, can be argued mainly from:

Figure 24 - Layout of the Calais port
- Ferry destinations/arrivals.
- Car plates.
- Identity check (for international non Schengen destination/arrivals).

Independently from the transport mode, in any hub/terminal it is possible to identify three basic section, based on the kind of people that can be present in any time:

| Technical areas | Technical areas are those areas where all the technical devices of the hub are hosted (e.g. apron, traffic control computers and rooms, air conditioning, etc.). In these areas, public access is strictly forbidden and prevented by physical barriers or alerting signs. |
| Public areas (uncontrolled) | In public areas (e.g. the departure hall of an airport, the main hall of a railway station, etc.), any person can enter, move, exit, use any available facilities or service, without obligations or restrictions. People in these areas may be users of the services offered in the hub, accompanying travellers. In the following these people will be named as *visitors*. |
| Public-restricted areas (controlled) | In public-restricted areas a person shall enter, move, use any available facilities or service inside, only if owner of a valid travel certificate, or permit to travel. In the following these people will be named as *passenger*. |

However, the real physical structures of public transport hubs radically change if we consider airports, railways or maritime terminals layouts; obviously, this is due to the different functional and operational requirements, the volume of transit passengers, the size of terminals and their location in the territory.

Even if the design of terminals has to follows specific national and international standards and rules, the structure and the layouts can also reflect specific architectural design, historical reasons or aesthetic choices, as well as the possibility to be expanded and to growth.
In addition, different structural concepts adopted even for terminals for the same transport mode; e.g. airports may have different basic conceptual layout, like: Linear, Pier, Satellite concept, or in some cases, a mix of them. Large railways stations usually follow the “terminus” scheme.

Despite the differences in layouts, at microscopic level, in each section it is possible to extract elementary functional modules or functional areas inside a terminal or a hub, or “building block” based mainly on:

- Main basic functions performed
- Functional links and physical connection
- Passengers/visitors flows and hold zones

Most of these functional modules are quite similar for all transport mode.

For airport Hub/Terminal, (which represent the most structured and significant example of hubs) we can identify at least the following blocks:

- **In the public areas:**
  - Access (entrance/exit doors) to terminals from road for arriving, departing passengers and visitors (in some countries a first security check for the passengers and luggage is applied at the entrance of the terminal).
  - Concourses, floors/building connections (walkways, stairs, elevator, travelators)
  - Public Services, usually concessions,
    - Pubs, Bars, Restaurants,
    - Shopping Centres
    - ATM, Currency Exchange
    - Rental Cars desks
  - Rest rooms,
  - Meeting points,
  - Information desk/monitors
  - Departing Passengers dedicated areas:
    - Ticket counters
    - Check in areas (desks or automatic check-in machines)
    - Baggage drop off desks
- **Check Points Barrier for Departing Passengers** to access to restricted areas (or Sterile areas)
  - Ticket Control
  - Security clearance gates
  - Identity check and Passport Control (when required)
- **Departing or Arriving Passengers restricted areas** with:
  - Concourses, floors/building connections (walkways, stairs, elevator, travelators)
  - Travellers services:
    - Pubs, Bars, Restaurants,
    - Shopping Centres/Duty Free
    - ATM, Currency Exchange,
  - Hold rooms for Economy Flights
  - Lounges for Frequent Travellers
- Rest rooms,
- Meeting points,
- Smoking areas
- Information desk/monitors
- Waiting List desks
- Gates for departing flights:
  - Economy Ticket/identity check
  - Frequent Travellers Ticket/identity check
- Jet Bridge or Shuttle bus
- Gates for arriving flights
- Baggage claim lobbies (carousels)
- Lost and founds desks

- **Check Points Barriers for Arriving to final destination Passengers or in-transit passengers**
  - Passport control (when required)

For Railways Hubs/Terminals we can find similar functional blocks. However, railways transport is characterized by the shorter time spent by passengers from entrance to board the train. This is possible because usually no ticket control or identity check is required prior to boarding the train (ticket control is usually made on board).

Platforms are usually shared between alighting and boarding passengers; visitors or accompanying people can access the platform and also the trains.

Today, mainly for security reason, a control of the right to travel is made in the most important stations to enter in the platforms (ticket control but not identity check). Especially for high speed connection, also a screening of passengers and identity check is performed, as in airports.

In railways terminals, the distinction between shared areas and restricted areas was quite “virtual”, but today is becoming a more and more physical (even if restricted to platform and train accesses only), according to the new and more stringent security requirements.

For Railways Hub/Terminal, we can identify at least the following blocks:

- **In the Shared areas:**
  - Access (entrance/exit doors) to terminals from road for arriving, departing passengers and visitors
  - Floors/building connections (walkways, stairs, elevator, travellators)
  - Publics Services, usually concessions,
    - Pubs, Bars, Restaurants,
    - Shopping Centres
    - ATM, Currency Exchange
    - Rental Cars desks
  - Rest rooms,
  - Meeting points,
  - Information desk/monitors
  - Departing Passengers dedicated areas:
    - Ticket counters

- **Check Points Barrier for Departing Passengers to access to platforms (if any)**
  - Ticket Control
  - Security clearance gates
Identity check and Passport Control (when required)

- Departing or Arriving Passengers dedicated areas with:
  - Train Platforms

Also for Ferry Terminals we can find similar functional blocks of an airport or rail station, as well as analogous procedures for boarding and disembarkation, even the facilities are usually less structured and standardized.

The space organization is strongly influenced by the territory, the waterfront and by the kind of service offered. In fact, ferry terminals are quite often characterized by the transport of foot passengers but also by the transport of car passengers with private vehicles (cars, caravans, campervans, motorbikes, trucks).

This fact, implies that passengers have to spend a considerable time between check-in and departures (usually 30 min for passengers and 1h for passengers travelling with vehicles). The queue for boarding vehicle and passengers, after the check-in of vehicles and passengers, is in the apron area (in open air) and is organized in different lanes leading to the ship’s ramp.

Tickets are issued under name, is not transferrable, and is valid for only those crossing specified in the tickets.

For Ferry Hub/Terminal, we can identify at least the following blocks:

- In the Shared areas
  - Access (entrance/exit doors) to terminals for arriving, departing foot passengers and car passenger waiting boarding; visitors are less frequent.
  - Floors/building connections (usually walkways, stairs, elevator)
  - Publics Services, usually concessions,
    - Pubs, Bars, Restaurants,
    - Shopping Centres
    - ATM, Currency Exchange
    - Rental Cars desks
  - Rest rooms,
  - Meeting points,
  - Information desk/monitors
  - Ticket counters
- Check Points Barrier for Departing Foot Passengers to access to the side ramps
  - Ticket Control
  - Security clearance gates
  - Identity check and Passport/Custom Control (when required)
- Check Points Barrier for Departing Foot Passengers to access to the apron
  - Ticket Control
  - Security clearance gates
  - Identity check and Passport/Custom Control (when required)

On the basis of the above functional segmentation of a hub, it seems possible to identify “critical areas”.

For each functional block, it is possible to identify the potential status or conditions of majority of people gravitating in these areas, in a normal operation of the hubs.

These conditions can be macroscopically identified as:
- People moving from one area to another area in the same directions
- People moving from one area to another area in both directions
- People standing or moving around inside the same area
- People queuing
- People waiting for something or lingering

It is necessary to consider that the design of terminal and hub buildings and staff organization are based on a thorough understanding of all operational, commercial, safety, security, financial, and environmental requirements and constraints of any facilities, in order to provide the “best possible” level of service, (passenger convenience, accessibility, wayfinding and signage).

The design of facilities takes into account the space necessary to accommodate waiting passengers and visitors, to facilitate the flow of people and, not only addressing current questions but also providing the necessary flexibility to face emerging trends and issues.

In this context, an emergency generated by hazardous cultural behaviours can arise where/when:

- **There is competition for resources**, i.e. loss of free availability of something people needs: space, (for moving, or standing), food, beverage, rescue or medical care, etc.
  - It may happen mainly between passengers.
- **There is dependency of people upon others** in order to get a task finished, i.e. loss of full autonomy in performing tasks or goals where cooperation or good harmony is necessary.
  - It may happen between passengers, between passengers and staff/organization.
- **There is a misunderstanding or ambiguity** about something, about the events that arise, producing different reaction time, different perceptions of events, messages, orders, etc.
  - It may happen to a single passenger, or to groups of homogeneous people.
- **There are communication barriers** that prevent full communication, i.e. different languages in exchanging messages
  - It may happen between passengers, between passengers and staff/organization.
- **Personalities, behaviours or habits clash.**
  - It may happen between passengers, between passengers and staff/organization.

In the context of these work, it is possible identify as “main critical areas”, the areas of a hub where the consequences of any hazards, emergency, upset events or even unusual conditions, could be potentially amplified by differences in culture of the people, or the cultural behaviour can be a trigger of hazard events.

Following these criteria, it will possible to map a terminal in terms of “potential cultural critical areas” and ranking these areas according to an evaluation of “vulnerability” or “sensitivity” to the different cultural behaviours of involved entity.

Looking at the functional block of a generic terminal, we can select the potentially critical areas where the three main hazardous situations could happen when dealing with hazardous cultural behaviours identified in section 3.1.4:

- evacuation,
- stranded passengers
- and passengers in need of medical cares.

The critical areas are the following:

- For departing passengers:
  - Entry to hub: connections lanes/concourses from a modal terminal to another modal terminal (e.g. rail to air)
  - Meeting Point Areas
  - Check in desk areas
- Luggage handling (baggage drop-off)
- Waiting lounges
- Security check/Passport control
- Transfer Lanes to Departure gate (mainly stairs, travellators, elevators)
- Waiting area at Departure gates
- Waiting list Desk/Area
- Boarding Gates
- Train/metro platform for rail terminals
- Waiting apron for car/passengers for ferry terminals

For arriving passengers:
- Connections lanes/concourses from a terminal to another (e.g. domestic arrival to international departure) for connections flights)
- Train/metro platform for rail terminals
- Passport control/Custom check
- Luggage retrieval
- Meeting Point Area/Picking up passengers
- Rental Car Desks
- Exit from hub: connections lanes/concourses from a modal terminal to another modal terminal (e.g. air to rail); taxi/bus stand queuing lanes

However, an “a priori” level of criticality may change or modified according to
- the considered hazard event or threat
- the mix of culture present inside the terminal at the considered moment

This mapping may address and help to create the scenarios to be selected to evaluate the effect of cultural difference in resulting risk.
APPENDIX 2  EVACUATION MODELS IN LITERATURE

This section reports an analysis of the state-of-the-art of egress models that can be found in literature ([38], [39], [40], [41], [42], [43], [44], [45] and [46]), with the aim of evaluating the possibility of currently existing evacuation models to support the assessment of risks when culture is considered.

The different factors affecting the consequences of a hazard event that compels evacuation of building spaces, can be identified in:

- the building structure and layout (size of the building, number of floor, stairs, number of exits and emergency exits, etc.)
- the type and severity of the hazard event (fire, blast, smoke, flood, crash, structure collapse, etc.), that affects the building or a section of the building,
- the distribution of people inside the building spaces.
- the time to egress from the affected building.

The total egress shall be completed before the conditions in the environment become unsafe for occupants.

Prediction of the movement of occupants during an evacuation and of total egress time is an essential aspect of building safety analysis methods and risk evaluation.

In order to calculate the egress time from any location within a building, safety engineers are used to perform algebraic calculations following some given equations (e.g. as in the Society of Fire Protection Engineers (SFPE) Handbook of Fire Protection Engineering [36]).

The occupants are assumed to be standing at the doorway or at the stair on each floor as soon as the evacuation begins. The calculation focuses mainly on points of constriction throughout the building (usually the doors to the outside) and calculates the egress time for the occupants to flow to the outside.

Nowadays, more complex and realistic egress evaluations from buildings are available by computer modelling and more and more are playing a relevant role in safety design of buildings structures, in safety procedure, in risk analyses and risk assessments.

These models consider more accurately the characteristics of the environment, the distribution of occupants in the environment, the occupants’ movements. Some of them also try to integrate through specific algorithms, human behaviours and crowd effects, for a more accurate evaluation of differences in the occupant response time to cues, reactions and movements.

Human behaviours are complex phenomena; however, some models were developed to capture the main steering parameters, and to translate them into computers as mathematical equations or relationships.

To obtain a good confidence levels in understanding of crowd behaviours would require to tune up models and algorithms with real experiences, exposing real people to the specific environment for obtaining empirical data, which is difficult since such environments are dangerous in nature.

A very useful methodology, that can provide valuable information to evaluate the models performances of computer simulations, is to study crowd behaviour based on observations of historical records and the lessons learned.

The possibility to run the models in several different conditions and with different people behaviours and crowd mix, can really support design, help the planning process for better dealing with emergencies.

Computer simulation of crowd behaviours are becoming useful and powerful tools:

- To simulate phenomena and emergency complex scenarios about which to perform safety evaluation and risk assessment.
- To test design strategies.
- To test scientific theories and hypotheses on human behaviour.
Usually, the existing models are categorized into one of the following macro-groups, according to techniques adopted to model the environment and crowds egress time:

- Flow-based models;
- Cellular automata models;
- Agent-based models.

However, even within each model category, each model is unique due to the various choices (and limitations too) of modelling methodology used.

**Table 14 - Different types of evacuation models**

<table>
<thead>
<tr>
<th>Evacuation model type</th>
<th>Short description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flow-based models</strong></td>
<td>These kind of models are called also macroscopic models. The simulated physical environment is defined as a network of nodes, connected by arcs. Flow-based models use the density of peoples in nodes in continuous flows through arcs. The basic principle is the analogy of occupants with fluid and particle motion. Characteristics of each particle (occupant) are defined in advance; thus all occupants behave in the same way.</td>
</tr>
</tbody>
</table>
| **Cellular automata models** | In this kind of models, the space is discretized, by plotting areas in a two-dimensional matrix. The simulation technique uses a pre-defined time-frame in which the occupants can move from one position (or cell) to another, assuming that it is free or it is not an obstacle. Each element of the matrix can have several values: empty, occupied by a person, occupied by some object, or part of the limits (e.g. walls). The movement occurs at every step of the defined time-frame when occupants can move to one of the adjacent cell. Each person can only move to an empty cell, and directions are limited to the possible nearby cells. Usually the representation and the analysis of movement in the spaces could be implemented as:  
- Microscopic (models divide a floor plan into a fine network of small grid cells that the occupants move to and from)  
- Macroscopic (models divide the floor plan into a coarse network of rooms, corridors, stair sections, etc. and the occupants move from one room to another)  
- Continuous (each occupant has a specific near target point and the escape route is a path of target point)  
This type of models fails in replicate erratic movements of people as in real life, since only limited movement is allowed. Also it is not easy to model different speeds and interaction between people. Nevertheless, this are the most used types for crowd modelling. |
| **Agent-based models** | Multi-Agent Systems (MAS) approach to crowd simulation is probably the most realistic solution since it allows to model each individual person with their own unique characteristics and behaviour, but related with all surrounding persons, thus recreating the real world interactions among human beings. |
Human individuals are modelled as autonomous agents who interact with a virtual environment and other agents according to the individual's characteristics (which may vary from person to person) using global rules derived from the world where the system is created.

In recent years MAS has been used as the preferred method to simulate crowd movement in different scenarios, in spite of the complexity of agent modelling, the need of data and rules to feed the system and the computational time needed. The possibilities offered by MAS are remarkable, as long as social rules and interaction knowledge among people is better known and fed to the model.

Generally speaking, the status of model availability is the following:

- Many models are available to the public freely or on a fee basis. Mainly are movement models, but also few behavioural models are open to public use.
- Other are available on consultancy basis to a client/user. Most of them can make use of CAD drawings, and provide the capability of 2-D or 3-D visualization.
- Other are yet at development stage or academic research or not more supported.
- Some models are also object of verification and validation process.

From a survey of available open literature, it seems possible, among the differences in theoretical approaches and the practical implementations into the various models, to extract some common and basic aspects of interest.

The total egress time is a function, at a very macroscopic level, of a reaction time (pre-movement and escape route selection) and of an action time (the walking time to reach a safe exit).

The reaction time depends from:
- The” intensity” of the cue
- Individual parameters of the occupants, like:
  - Personal perception of hazard
  - Observation of other occupants
  - Communication (verbal and nonverbal) with other occupants
  - Previous experience of similar events
  - Reaction to survival-critical events (fear)
  - Clear understanding of Sign/Sound/Voice indications
  - Attitude to follow the advice of Authorities/Staff
  - Exits location knowledge

The action time/walking time, depends basically from:
- Unimpeded speed of individuals or homogeneous groups of occupants. Groups can be pre-existing cluster of people (like a family, or groups of friends, tourists, school-kids, sport supporters, etc.) or spontaneously formed clusters
  - Individuals speed, basically, depends from:
    - Age, Gender, Body size, Health status/Disabilities,
    - Hand luggage/Bags eventually carried by walking/escaping people
    - Type of Clothing, Shoes, .....
  - Groups speed (assuming a general cooperative behaviour) basically depends from the speed of the slower component of the group.
    - Density of people in flow or queue
The critical density of people in the same area that could reduce drastically the occupant speed (till to cause congestion or blockage), depends mainly from the:

- Personal distance, i.e. the minimal distance between individuals a person normally accepts.
  Proxemics splits and quotes this distance, in four levels: Intimate, Personal, Social, Public. However, in emergency condition, an occupant may adapt the weights of inconvenience, discomfort, frustration to the local circumstances (available space, local geometry, speed of companions and others).
- Different avoidance side for not concurrent lanes of walking/escaping people.
  The instinctive or habitual differences in avoidance side can cause collision between individuals or groups and reduce speed.

Most of these behavioural parameters depend from socio-cultural attributes of each occupant, like:

- Ethnicity-Origin-Nationality: e.g. Afro-American, Basque Spanish, etc.
- Beliefs-Religion -Habits
- Education Level
- Marital – Parental Status
- Group affiliation attitude
- Familiarity with the environment: (e.g. frequent travellers)

By inserting a reasonable set or a combination of these characteristics in the agent definition and interaction rules, in a simulated environment and hazard scenarios, it should be possible from the outcomes of a selected model(s), to observe and to grasp, in the changed dynamics among the individuals or groups, the potential effects of cultural diversity in the total egress time.

The main complexity of the task consists, at the agent parameters definition, in an adequate translation and modulation, matching with the occupants’ culture of some forms of reaction/action or attractions/repulsion generated by the changing environment conditions (e.g. presence of smoke, loss of lightning), by some points of reference in the environment (e.g. exit doors) and by other occupants the near environment.
APPENDIX 3 QUANTIFICATION OF CULTURAL-DEPENDENT HAZARDOUS BEHAVIOURS

Part of cultural-dependent hazardous behaviours quantification means establishing the likelihood of the identified cultural-dependent hazardous behaviours. It was however determined that not all the cultural-dependent hazardous behaviours are eligible for quantification in the context of the project. The following criteria apply to identify quantifiable cultural-dependent hazardous behaviours:

- **Relevance for risk management (WP3).** Although operationally relevant, some cultural-dependent hazardous behaviours are not relevant for the risk estimate done by the typical infrastructure (safety and security) manager of transport hubs, as they do not have a magnifying/reducing effect on the consequences of hub related emergencies. Therefore, these cultural-dependent hazardous behaviours were considered as low priority items for quantification purposes. Note that although not relevant for risk management, such cultural-dependent hazardous behaviours remain relevant for the development of the IMPACT measures developed in the other WPs (namely the multicultural training package (WP5) and the multicultural communication framework (WP4)). This explains why Table 4 reports all the cultural-dependent hazardous behaviours identified.

- **Feasibility, i.e. the feasibility of determining a likelihood score.** In this case it was determined the mean for achieving quantification, namely: (i) survey, (ii) agent-based simulations, (iii) database, or (iv) expert group. These quantification means are described next.

The end of this section, maps the quantifiable cultural-dependent hazardous behaviours to the corresponding quantification method(s).

As mentioned in section 3.2.1, cultural-dependent hazardous behaviours likelihood estimation is based on the identification of the (set of) psycho-social parameters that can trigger any given cultural-dependent hazardous behaviour. Likelihood of cultural-dependent hazardous behaviours can be in fact estimated based in the specific cultural composition of a crowd in a given transport hub. Such composition determines the dominant psycho-social parameters in the cultural clusters involved, and from here it is possible to estimate the most likely and less likely cultural-dependent hazardous behaviours that may occur in the hub considered.

The following sources of statistics for cultural-dependent hazardous behaviours can be used in the context of IMPACT:

1. **Passenger survey.** Data for cultural-dependent hazardous behaviours likelihood determination can be obtained from survey data. In the context of IMPACT, a survey was run by WP1 with the passengers of transport hubs. The survey collected data from a sample of passengers from four different nations: Turkey, Bulgaria, Poland, and the UK.

2. **Agent-based model (ABM) simulations.** Agent-based model simulations can support CHBs quantification. At the time of writing, an ABM is being developed in the context of WP2. It is expected that this ABM will support to the quantification of some of the cultural-dependent hazardous behaviours.

3. **World Value Survey (WVS) database.** Quantification can be achieved by relying on existing data bases. One of such a database is available at: [http://www.worldvaluessurvey.org](http://www.worldvaluessurvey.org). The World Values Survey is a global network of social scientists studying changing values and their impact on social and political life, led by an international team of scholars, with the WVS association and secretariat headquartered in Stockholm, Sweden. The survey, which started in 1981, seeks to use the most rigorous, high-quality research designs in each country. The WVS consists of nationally representative surveys conducted in almost 100 countries which contain almost 90 percent of
the world’s population, using a common questionnaire. The WVS is the largest non-commercial, cross-national, time series investigation of human beliefs and values ever executed, currently including interviews with almost 400,000 respondents. Moreover, the WVS is the only academic study covering the full range of global variations, from very poor to very rich countries, in all of the world’s major cultural zones.

The WVS seeks to help scientists and policy makers understand changes in the beliefs, values and motivations of people throughout the world. Thousands of political scientists, sociologists, social psychologists, anthropologists and economists have used these data to analyse such topics as economic development, democratization, religion, gender equality, social capital, and subjective well-being. These data have also been widely used by government officials, journalists and students, and groups at the World Bank have analysed the linkages between cultural factors and economic development.

The database is therefore highly relevant for the IMPACT project offering also a user-friendly analysis tool that allows the user to select the countries that s/he wants to compare and the variable of interest. This one is chosen from a predefined list including various kind of questions. In turn the tool generates a tabular view of responses based on the user selection. For instance, Figure 26 shows the responses distribution for four countries (Bulgaria, Poland, Turkey, and the UK) relative to the variable “Religion Importance” (which, if crossed by sex, can be used as a proxy for cultural-dependent hazardous behaviour 303, as shown in Table 15.

The following table identifies the cultural-dependent hazardous behaviours eligible for quantification and the associated quantification means.

<table>
<thead>
<tr>
<th>Cultural-Dependent Hazardous Behaviours</th>
<th>TOTAL</th>
<th>Country/Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very important</td>
<td>42.7%</td>
<td>18.4%</td>
</tr>
<tr>
<td>Rather important</td>
<td>25.5%</td>
<td>31.0%</td>
</tr>
<tr>
<td>Not very important</td>
<td>19.3%</td>
<td>31.3%</td>
</tr>
<tr>
<td>Not at all important</td>
<td>11.1%</td>
<td>16.5%</td>
</tr>
<tr>
<td>No answer</td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Don’t know</td>
<td>1.1%</td>
<td></td>
</tr>
<tr>
<td>(N)</td>
<td>(4,388)</td>
<td>(1,001)</td>
</tr>
</tbody>
</table>

*Figure 26. Output from the WVS database: an example relative to “Religion Importance”*

4. The EF English Proficiency Index database. English is widely accepted as the primary international language and is the most widely used language for signage and emergency communications. The EF database is available at [http://www.ef.co.uk/epi](http://www.ef.co.uk/epi) and is providing statistics on the level of English proficiency in all countries in the world. Statistics are also characterised according to age and sex.

5. Expert opinion. Where data is scarce, unavailable or cannot be collected, subject matter expert judgment remain a plausible way to achieve quantification of cultural hazardous behaviours. Structured group sessions remain the most frequently used approach to achieve quantification with subject matter experts. In such sessions, the experts are introduced to the hazards to be quantified and are asked to assign their estimate of probability of cultural hazardous behaviours under the supervision of a facilitator. Also, surveys can be used; they are helpful especially if the
experts cannot participate in the same group session. Finally, other more complex methods exist (e.g. Delphi [62]) that can be used for quantification purposes.

The following table identifies the cultural-dependent hazardous behaviours eligible for quantification and the associated quantification means.

Table 15 - Cultural-dependent hazardous behaviours and their quantification means

<table>
<thead>
<tr>
<th>High-level category</th>
<th>ID</th>
<th>Categories of Hazardous behaviour</th>
<th>Eligible for quantification?</th>
<th>Quantification means/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crowd-staff interaction</td>
<td>101</td>
<td>Stereotyping (Alt: discrimination)</td>
<td>N</td>
<td>Not applicable (N.A.)</td>
</tr>
<tr>
<td></td>
<td>102</td>
<td>Tensions with staff due to staff’s lack of cultural competence (Alt: lack of cultural sensitivity in handling passengers)</td>
<td>N</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>103</td>
<td>Tensions with staff of passengers stranded in a close environment</td>
<td>Y</td>
<td>ABM simulations (WP2)</td>
</tr>
<tr>
<td></td>
<td>104</td>
<td>Ineffective reporting of security threats (relative to emergency prevention)</td>
<td>N</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>105</td>
<td>Miscommunications between staff and passengers</td>
<td>Y</td>
<td>Partially quantifiable</td>
</tr>
<tr>
<td></td>
<td>106</td>
<td>Refusing healthcare treatment</td>
<td>Y</td>
<td>Partially quantifiable</td>
</tr>
<tr>
<td></td>
<td>107</td>
<td>Intentionally refusing to comply with staff instructions during emergencies</td>
<td>Y</td>
<td>• ABM simulation (WP2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Passenger survey (WP1). Relevant parameters: “compliance”; and “evacuation”.</td>
</tr>
<tr>
<td></td>
<td>108</td>
<td>High-ranking individuals behaving arrogantly</td>
<td>Y</td>
<td>Passenger survey (WP1). Relevant parameter: “power distance”.</td>
</tr>
<tr>
<td>Within crowd member's</td>
<td>201</td>
<td>Cultural conflicts between individuals/groups belonging to different cultural clusters</td>
<td>Y</td>
<td>ABM simulations (WP2)</td>
</tr>
<tr>
<td>interactions</td>
<td>202</td>
<td>Fighting/revolting for resources (food, space, emergency exists, etc.)</td>
<td>Y</td>
<td>ABM simulations (WP2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Passenger survey (WP1). Potentially relevant proxy</td>
</tr>
</tbody>
</table>
### High-level category

#### Crowd public information/equipment interaction

<table>
<thead>
<tr>
<th>ID</th>
<th>Categories of Hazardous behaviour</th>
<th>Eligible for quantification?</th>
<th>Quantification means/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>301</td>
<td>Ignoring physical and digital information found in the transport hub</td>
<td>Y</td>
<td>• ABM simulations (WP2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Passenger survey (WP1). Relevant parameter: “Compliance”</td>
</tr>
<tr>
<td>302</td>
<td>Slow response to public warnings and observable dangers</td>
<td>Y</td>
<td>ABM simulations (WP2)</td>
</tr>
<tr>
<td>303</td>
<td>Slow crowd mobilization during an emergency</td>
<td>Y</td>
<td>WVS database. This proxy could arguably be extracted: “percentage of very religious women across Muslim countries”.</td>
</tr>
<tr>
<td>304</td>
<td>Misuse of social media information during emergencies</td>
<td>N</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

#### Crowd - physical environment interaction

<table>
<thead>
<tr>
<th>ID</th>
<th>Categories of Hazardous behaviour</th>
<th>Eligible for quantification?</th>
<th>Quantification means/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>401</td>
<td>Passengers entering forbidden areas</td>
<td>Y</td>
<td>Passenger survey (WP1). Relevant parameter for the sub-CHB “Refusal to stay in dedicated area”: “Compliance”</td>
</tr>
<tr>
<td>402</td>
<td>Hazardous-crowd behaviour</td>
<td></td>
<td>Tendency for crowding might arguable be measured through an individualism-collectivism proxy (as it is well-documented that individualist cultures are less tolerant of crowd density). For instance, Project GLOBE’s collectivism index could be used as it is the most up-to-date.</td>
</tr>
<tr>
<td>403</td>
<td>Misuse of equipment due to ignorance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Starting from the work carried out in WP1 and reported in D1.3 [53], the analysis reported above and the knowledge of the cultural mix of the passengers and visitors insisting on a hub it should be possible to calculate the risk parameters using the process schematised in Figure 27.
The transport operator, without violating privacy, can rely only to few data to characterise the cultural mix of crowd of both visitors and passengers:

- If the ticket is nominal, then it can have access to gender, nationality, sex and (if communicated by the passenger) disabilities of passengers.
- If the passengers are member of a club of travellers, some more info are available (e.g. travel preferences, food constraints, etc.).
- If the national/regional authorities of the place in which the hub is based are particularly active, some studies on the socio-economic composition of the inhabitants of the area can support the identification of travellers’ cultural mix.

Based on the very limited information described above, it has been proven to be extremely difficult to uniquely correlate psycho-social characteristics to cultural-dependent hazardous behaviour and then to the information available.

One of the few exceptions is perhaps the English proficiency that is reported with statistical significance by EF English Proficiency Index (EPI). From the EPI – knowing the nationality of the travellers – it is possible to characterise the English proficiency of the typical clusters of passengers and therefore adapt, for example, communication strategies, training of staff, signs, etc.

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13 [http://www.ef.co.uk/epi/](http://www.ef.co.uk/epi/)
**APPENDIX 4  EXAMPLE OF INFORMATION PACK FOR ELICITATION**

The purpose of the information pack is to support the risk assessment process as described in the Cultural Risk Assessment Methodology Report. This process requires the following information:

- System Description
- Hazard Identification
- Risk assessment

The system under consideration is an airport terminal. This includes a number of interchanges including, bus and train.

This is described in detail in Section 2 of the Cultural Risk Assessment Methodology Report and a summary for the air hub under consideration is given below.

An AIR HUB is usually a combination of:
- Many air terminals
- A railways/metro terminal
- Bus terminal(s)
- Rental car centres & Parking
- Taxi stands
- Private Car Parking

![Typical configuration of an air hub](image)

*Figure 28 – Typical configuration of an air hub*

Large airports follow this scheme of configuration with the highest level of integration.

An air hub is probably the place where is present the highest level of mix of culture and nationalities. However, at least for passengers, the security policy adopted in aviation requires an identity check for each delivered ticket and controls at departure gates.

In an airport it is some possibility to identify the actual mix of culture with a good degree of accuracy. The potential mix of people nationality and culture (as far as possible to elicit culture from nationality), can be argued from:

- Tickets for Departing and Connection Flights
- Frequent Flyers Information
- Images or video snips and information from video surveillance.
• Flights destinations/arrival at the different airport terminals

Independently from the transport mode, in any hub/terminal it is possible to identify three basic section, based on the kind of people that can be present in any time.

• **Technical areas.** In these areas, public access is strictly forbidden and prevented (e.g. apron, tracks, control rooms, etc.) by physical barriers or alerting signs.

• **Public Shared areas** (uncontrolled). In these areas, any person can enter, move, exit, use any available facilities or service, without obligations or restrictions. People in these areas may be users of the services offered in the hub, accompanying travellers. In the following these people will be named as **visitors.**

• **Public Restricted areas** (controlled). In these areas a person shall enter, move, use any available facilities or service inside, only if owner of a valid travel certificate, or permit to travel. In the following these people will be named as **passenger.**

![Figure 29 – The model of the IMPACT hub](image)

However, the real physical structures of public transport hubs radically change if we consider airports, railways or maritime terminals layouts; obviously this is due to the different functional and operational requirements, the volume of transit passengers, the size of terminals and their location in the territory.

Even if the design of terminals has to follows specific national and international standards and rules, the structure and the layouts can also reflect specific architectural design, historical reasons or aesthetic choices, as well as the possibility to be expanded and to growth.

In addition, different structural concepts adopted even for terminals for the same transport mode; e.g. airports may have different basic conceptual layout, like: Linear, Pier, Satellite concept, or in some cases, a mix of them. Large railways stations usually follow the “terminus” scheme.

In spite of the differences in layouts, at microscopic level, in each section it is possible to extract elementary functional modules or functional areas inside a terminal or a hub, or “building block” based mainly on:

• Main basic functions performed
• Functional links and physical connection
• Passengers/visitors flows and hold zones
Most of these functional modules are quite similar for all transport mode.

For airport Hub/Terminal, (which represent the most structured and significant example of hubs) we can identify at least the following blocks:

- **In the Shared areas:**
  - Access (entrance/exit doors) to terminals from road for arriving, departing passengers and visitors
  - Concourses, floors/building connections (walkways, stairs, elevator, travellators)
  - Public Services, usually concessions,
    - Pubs, Bars, Restaurants,
    - Shopping Centres
    - ATM, Currency Exchange
    - Rental Cars desks
  - Rest rooms,
  - Meeting points,
  - Information desk/monitors
  - Departing Passengers dedicated areas:
    - Ticket counters
    - Check in areas (desks or automatic check-in machines)
    - Baggage drop off desks
- **Check Points Barrier for Departing Passengers** to access to restricted areas (or Sterile areas)
  - Ticket Control
  - Security clearance gates
  - Identity check and Passport Control (when required)
- **Departing or Arriving Passengers restricted areas with:**
  - Concourses, floors/building connections (walkways, stairs, elevator, travellators)
  - Travellers services:
    - Pubs, Bars, Restaurants,
    - Shopping Centres/Duty Free
    - ATM, Currency Exchange,
  - Hold rooms for Economy Flights
  - Lounges for Frequent Travellers
  - Rest rooms,
  - Meeting points,
  - Smoking areas
  - Information desk/monitors
  - Waiting List desks
  - Gates for departing flights:
    - Economy Ticket/identity check
    - Frequent Travellers Ticket/identity check
  - Jet Bridge or Shuttle bus
  - Gates for arriving flights
  - Baggage claim lobbies (carousels)
  - Lost and founds desks
- **Check Points Barriers for Arriving to final destination Passengers or in-transit passengers**
  - Passport control (when required)
  - Custom control (when required)

A list of hazardous incidents for airport termini has been derived from work sponsored by the US FAA on Airport Terminal Incident Response Planning (see Table 16)
### Table 16: Airport Terminal Incidents

<table>
<thead>
<tr>
<th>Incident</th>
<th>Probability</th>
<th>Consequences</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural fire</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Active shooter</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Bomb threat</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>FAA navigation system failures</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Irregular operations (IROPS)</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Security breach</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Security equipment malfunction</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Traffic blockage (access roads)</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Transit system failure (trams, people movers, access and functional needs transport, etc.)</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Electrical outage/power failure</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Suspicious package or bag</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Biological agent</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Bomb explosion</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Hostage/barricade</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Pandemic/quarantine</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Structural failure of building</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Aircraft diversion (non-signatory carrier)</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Flight cancellations (local or distant)</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Other criminal act requiring investigation, crime scene protection, and crowd control</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Suspicious odor</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Aircraft accident/crash</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Aircraft hijacking</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Chemical agent</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Civil unrest/riot</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Cyber-attack/disruption</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Hazardous materials (HAZMAT) spill</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Nonspecific threat of damage to people or terminal</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Radioactive agent</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Usurpation/pre-emption of terminal facilities for regional disaster</td>
<td>11</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Baggage system failure</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>False fire alarm</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Heating, ventilation, and air conditioning (HVAC) failure</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Flood/sprinkler use in building</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Picketing/protests/labour actions</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Probability and Consequence estimations have been made for each of these incidents as follows:
The approach described in the risk assessment process is based upon consideration of how the cultural behaviours identified in the Cultural Risk Assessment Methodology Report impact upon the hazardous incidents.

The key challenge is to be able to link the behaviours to incidents. The incidents describe the outcome whereas the behaviours describe actions which people do or do not take and which therefore affect the outcome. The methodology proposed to address this is to construct a generic fault tree for the occurrence and management of the incidents. This will allow the identification of where the behaviours could affect the risk arising from the incident.

The failure modes in the fault tree are as follows:

- Initiating incident occurs
- Incident not detected/alarm not raised
- Passengers do not move from area of danger
- Appropriate Incident response plan not put in place
- Incident response plan not successfully implemented by staff
- Incident response plan not successfully complied with by passengers

At this level of detail, it is possible to assign the relevant hazardous cultural behaviours to the incident. This is shown in the worksheet “elicitation” in the spreadsheet attached, where two of the cultural behaviours have been associated with the incident “Structural fire”.

It is also possible to classify the hazard in terms of likelihood and consequence, using the matrices described below. This can be done against the base likelihood given for the incident where the effect is assessed as follows.

**Effect on Likelihood**

- 3 = High
- 2 = Medium
- 1 = Low
- 0 = None

**Effect on Consequences**

- 4 = Very High
- 3 = High
- 2 = Medium
- 1 = Low
- 0 = None

It is recognised that there may be uncertainty in the estimates and hence the classifications will be estimated as a range of Minimum, Most Likely and Maximum.
These classifications are then applied to the weightings for the contribution of each of the failure modes to the incident (shown in the “Incidents” spreadsheet) to give a risk for the incident which is revised for the effect of the hazardous cultural behaviour.

Note that it is also possible to assess the absolute likelihood and impact using the classifications described in the Cultural Risk Assessment Methodology Report. If this approach is applied, then the resulting risk can be validated against the risk given.

The likelihood of a hazard identified occurring is a function of probability of the resulting consequences being materialised, and the possibility of the subject being exposed at a given location and time.

Table 17 - Example of a likelihood scale

<table>
<thead>
<tr>
<th>Scale of Likelihood</th>
<th>Likelihood of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly probable/Likely</td>
<td>10</td>
</tr>
<tr>
<td>Medium/Possible</td>
<td>5</td>
</tr>
<tr>
<td>Low/Remote</td>
<td>2</td>
</tr>
<tr>
<td>Negligible/Unlikely</td>
<td>1</td>
</tr>
</tbody>
</table>

1 per day - Very likely target
1 per week - Possible target
1 per month - Remote target
Unexpected - Unlikely target

The consequences as result of a hazardous event can be different depending on organisation and transport hub activities. The consequences from any threat can be estimated using the scale presented in Table 2.

Table 18 - Consequence table

<table>
<thead>
<tr>
<th>Level</th>
<th>Consequence on assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/Severe</td>
<td>Irreparable harm to the company (1) may result in the highly costly loss of major tangible assets or resources; (2) may significantly violate, harm, or impede an organization’s mission, reputation, or interest; or (3) may result in human death or serious injury</td>
</tr>
<tr>
<td>Medium/Major</td>
<td>Significant harm (1) may result in the costly loss of tangible assets or resources; (2) may violate, harm, or impede an organization’s mission, reputation, or interest; or (3) may result in human injury.</td>
</tr>
<tr>
<td>Low/Moderate</td>
<td>Moderate harm (1) may result in the loss of some tangible assets or resources or (2) may noticeably affect an organization’s mission, reputation, or interest.</td>
</tr>
<tr>
<td>Minor</td>
<td>Very unlikely to cause any harm to the company or caused injuries</td>
</tr>
</tbody>
</table>
Figure 30 - Elicitation sheet

<table>
<thead>
<tr>
<th>Probability</th>
<th>Consequence</th>
<th>Risk</th>
<th>Initiating incident occurs</th>
<th>Min</th>
<th>Most Likely</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural fire</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relevant natural behaviour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active shooter</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bomb threat</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FAA navigational system failures</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency (e.g., ROPS)</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Security breach</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Security equipment malfunction</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic blockage (access roads)</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transit system failure (trains, people movers, access and functional needs transport, etc.)</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical outage/power failure</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspicious package or bag</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biological agent</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
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<tr>
<td>Bomb explosion</td>
<td>1</td>
<td>4</td>
<td>4</td>
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</tr>
<tr>
<td>Heritage, host cities</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pandemic/quarantine</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural failure of building</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aircraft diversion (pre-investigatory center)</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flight cancellations (local or distant)</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other criminal act requiring investigation, crime scene protection, and crowd control</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspicious odor</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aircraft accident/crash</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aircraft hijacking</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical agent</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drill/exercise</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyber attacks/disruption</td>
<td>1</td>
<td>3</td>
<td>3</td>
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<td></td>
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</tr>
<tr>
<td>Hazardous material [HAZMAT] spill</td>
<td>1</td>
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<td>3</td>
<td></td>
<td></td>
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<tr>
<td>Nonspecific threat of damage to people or terminal</td>
<td>1</td>
<td>3</td>
<td>3</td>
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<tr>
<td>Radiation</td>
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<td>3</td>
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<td></td>
</tr>
<tr>
<td>Seizure/occupation of terminal facilities for regional disaster</td>
<td>11</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baggage system failure</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>False fire alarm</td>
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<td>1</td>
<td>3</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Heating, ventilation, and air conditioning (HVAC) failure</td>
<td>1</td>
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<td></td>
</tr>
<tr>
<td>Flood sprinkler use in building</td>
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<td>2</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Protesting protest/labor actions</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiating Incident Occurs</td>
<td>Probability</td>
<td>Consequences</td>
<td>Risk</td>
<td>Incident Not Detected/Alarm Not Raised</td>
<td>Passengers Do Not Move from Area of Own Accord</td>
<td>Appropriate Incident Response Plan/Evacuation Not Put in Place</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------</td>
<td>--------------</td>
<td>------</td>
<td>----------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Structural Fire</td>
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<tr>
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<td>3</td>
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<tr>
<td>Bomb Threat</td>
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<td>6</td>
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<td>0.02</td>
<td>0.02</td>
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<tr>
<td>FAA navigation system failures</td>
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<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Irregular operations (HIMP)</td>
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<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Security breach</td>
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<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Security equipment malfunction</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Traffic blockage (access roads)</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Transit system failure (trans, people movers, access and functional needs transport, etc.)</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Structural failure (building)</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Structural failure (offbuilding)</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Airline diversion (non-signatory carrier)</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Flight cancellations (local or distant)</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Other criminal act requiring investigation, crime scene protection, and crowd control</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Suspicious package or bag</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Biological agent</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Bomb explosion</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Hazardous materials (HAZMAT) spill</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Pandemic/influenza</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Chemical agent</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Civil unrest/riot</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Cyber-attack/disruption</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Nuclear materials (HEU/LEU)</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Nonspecific threat to damage to people or terminal</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Pandemic or agent</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Suspension/performance of terminal facilities for regional disaster</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Ransom:勒索者</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>False fire/alarm</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Heating, ventilation, and air conditioning (HVAC) failure</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.9</td>
<td>0.02</td>
<td>0.02</td>
</tr>
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</table>
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