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PROJECT DELIVERABLE

D3.2.1 – HAZARDS IDENTIFICATION REPORTS

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List of Abbreviations / Glossary

IMO: International Maritime Organization

FSA: Formal Safety Assessment

QRA: Quantitative Risk Analysis

HAZID: Hazard Identification

PHA: Preliminary Hazard Analysis

FMECA: Failure Mode, Effects and Criticality Analysis

HAZOP: Hazard and Operability

TA: Task Analysis

1 Introduction

In the port area and its vicinity, hazards caused by the port operation - such as an explosion from dangerous goods at a container terminal - are counted as a severe situation for any port authority or port company. As those hazards do not normally only have an impact to the port operation and its financial issues but also possibly harm the environment and people in the area. To prevent such incidents, many institutions from both academic and practical world have developed diverse methodologies and tools to handle this kind of situation which are understood and categorised under risk management.

In EFFORTS the WP 3.2 aims at providing a fundamental of hazard concepts, hazard identification techniques and risk methodologies to enable the best possible way to the use of available knowledge and best practices. This should be presented in the easy-to-understandable way for anyone working in the port. It should be generic enough and easily accessible that any kind of port can deploy this information. Moreover it serves as a basic for a customized methodology in handling and implementing risk management in specific port corresponding to the requirement and area of usage.

This deliverable, therefore, delivers the available and well-known hazard identification methodologies and risk management which could be useful for later tasks of this WP. The most recognised risk management framework in the maritime area is the Formal Safety Assessment (FSA) model recommended by International Maritime Organisation (IMO).

Following the concept introduced in this paper, a catalogue containing possible hazards in the port area associated to the process map provided by WP 3.1 will be resulting from this task and used as the basis for further tasks in this WP.

2 Approaches to hazards and risk

2.1 Concepts and definitions

A Hazard can be simply defined as a potential to threaten human life, health, property or the environment.

Hazard is an event, process or condition that can cause harm, including loss of life, injury and loss of health, damage to property and/or the environment, business interruption (or performances decrease), increased liabilities and other tangible or intangible losses.

Harm is actually caused when a hazard is manifested after being triggered by an event or a condition. Accidents constitute one important class of such unintended triggering factors, in which case we refer to accidental hazards. However, we must note that there also exist other important classes of triggering events like natural phenomena, intentional human acts etc.

Some known hazards can, usually, be controlled by means of suitable safeguards, i.e. by adopting technical or other means to remove (or reduce) the likelihood of occurrence of the identified triggering event.

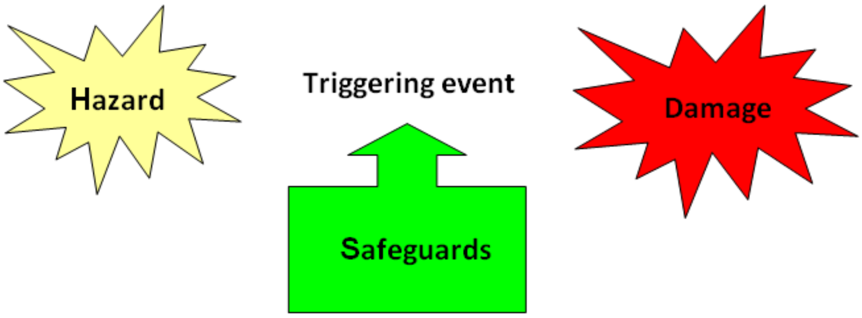

Figure 1: Risk analysis aims in safeguarding the plant / process / operation by reducing the probability of a damage triggering event.

An Accident is an unintended event involving fatality, human injury, ship loss or damage, other property loss or damage, or environmental damage. The Consequence is then the outcome of an accident [1].

Risk can be defined as the measure of the probable consequences (damage, loss) of a potential harmful situation. There is a number of definitions of risk in different disciplines and fields of practice. In general terms, risk can be expressed as a combination of frequency and severity of consequence:

Risk = Probability x Loss or (average) damage

However, risk can also be seen as the magnitude of the hazards faced versus the level of safeguards adopted:

Risk = Hazard / Safeguards

In the research and policy field of disasters, risk is seen as the outcome of the hazard faced multiplied by the vulnerability of the exposed elements (people, property, infrastructure, stocks etc) versus the level of existing capacity to tackle the potential negative consequences:

Risk = Hazard x Vulnerability / Capacity

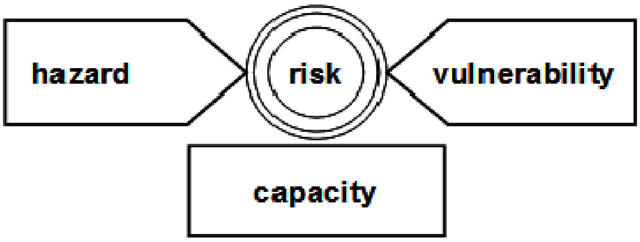

Figure 2: Risk analysis supports further actions to reduce the probability of loss

This approach can lead to more flexible policies to mitigate risk by allowing combinations of measures to minimize hazard (i.e. through land use planning), to reduce vulnerability (i.e. by strengthening lifelines and infrastructure) and to increase capacity (i.e. by improving emergency response and business contingency planning). Having mentioned policies and measures to mitigate risk one should bring up the issue of how risk is perceived and dealt with.

Risk perception is a complex matter studied by psychologists and sociologists because risk is perceived in different ways by different people, depending on several factors, among which the degree of involvement in the risk acceptability decision and the level of reward. Many factors affect the perceived risk e.g. involuntary exposure, lack of knowledge, lack of control, genetic effects, diffidence on authorities, low frequency - high consequence events. The perceived risk can also be defined as a "feeling of insecurity".

Risk acceptability is the level and the process to decide whether a certain activity can be accepted or not. This is another complex matter that requires the involvement of all interested stakeholders and the establishment of commonly recognised Risk Acceptance Criteria.

As an example, Figure 3 below shows the thresholds of the individual risk applied in the UK for chemical and petrochemical installations. In this field of applications, in the region between acceptable and unacceptable risk, the operator must adopt all reasonable practical means to reduce as much as possible the risk level.

In general, hazards and risks are very subjective matters[1]. What is perceived by someone as a threat may well be seen by others as an opportunity. This is a core issue for risk management. In fact, in complex environments, risk is a subject of governance.

[1] See section 2 on A citizen centred framework for hazard and risk

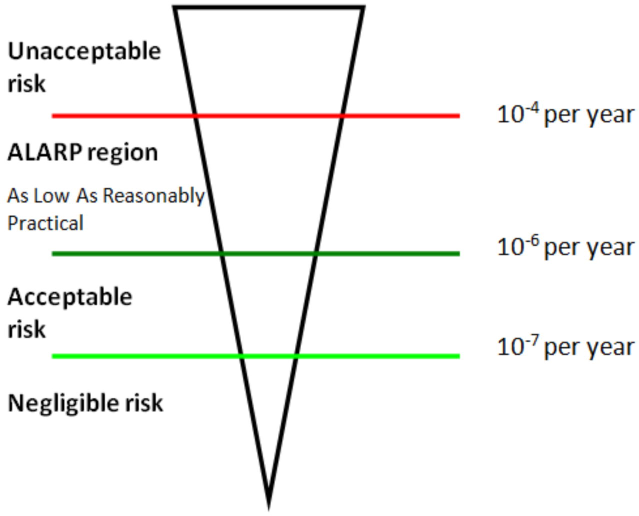

Figure 3: Individual risk thresholds for the UK chemical industry

Risk governance is a circular process integrating knowledge generation, decision making and implementation actions. It involves multiple agents and disciplines. Communication[2] is at the heart of the process (Figure 4).

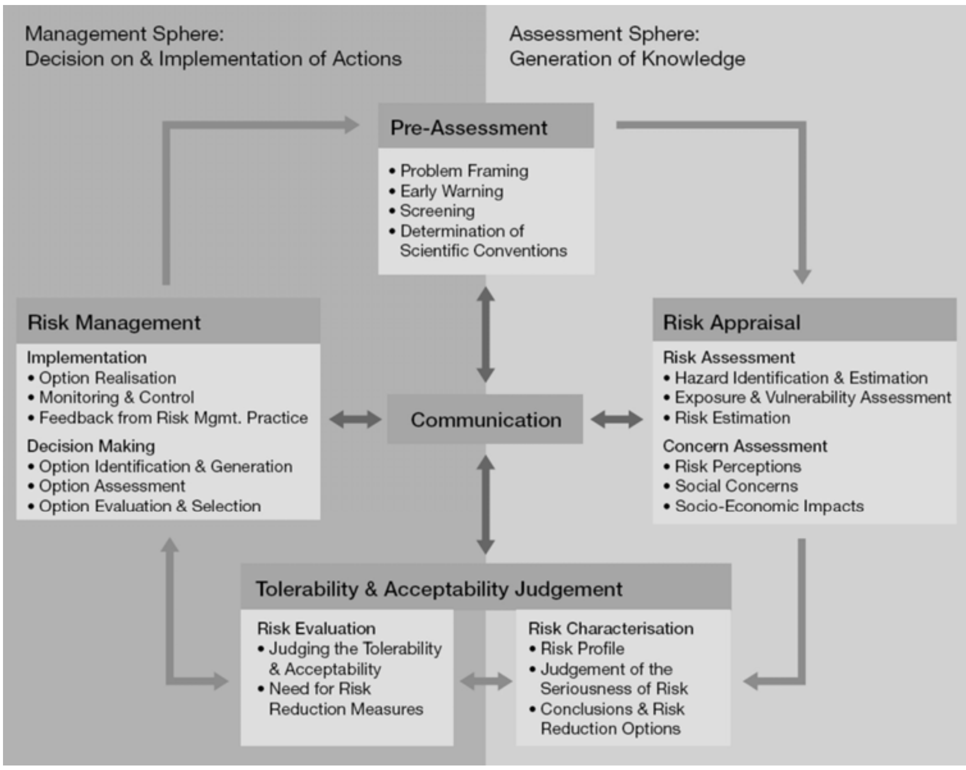

Figure 4: The risk governance process

[2] Communication is a generic term and does not refer only to information exchange. It includes more complex procedures such as negotiations, consultations, training and experience sharing.

Tasks that traditionally were seen as pure technical ones (such as hazard identification and risk assessment) are now considered as part of a multifaceted and usually long process from generating the technical knowledge towards decision making and implementation of actions. One should admit though that hazard identification and risk assessment were always subjected to further judgment based on the risk tolerability and acceptability before decision making and eventually implementation of measures were reached.

2.2 Process oriented risk quantification

In many human activities risk can be estimated through the statistical analysis of historical records of accidents occurred in the different industrial sectors. In other cases, however, the statistical theory is useless because of lack of significant data.

Consequently, the decision about the risk acceptability must be based on the application of systematic and consistent predictive procedure allowing estimating the risk level and the associated uncertainties. Such a procedure is commonly referred to as Quantitative Risk Analysis (QRA). QRA allows answering the following questions:

- What can go wrong in the plant/process/operation?
- Which are the consequences of malfunctions?
- How often will they occur?

Each of the above questions is dealt with a specific kind of analysis. More precisely, Hazard Identification (HAZID) analysis deals with the first question; models for the estimation of the damage to man, the environment and property are applied to answer the second question; probabilistic techniques are used to give the answer to the third question.

In alternative to the quantitative methods, the qualitative approach relies on experience, usually expressed in the form of check - lists and/or codes of practice.

The quantitative approach is obviously more sophisticated as it aims at producing a consistent and quantified picture of the risk induced by the operation of the plant. It is based on well established procedures in which systematic techniques for hazard identification, accident frequency and consequence estimation are applied.

Because of the uncertainties in data and models as well as the assumptions that the analysts must make to overcome the lack of information, the transparency (i.e. clarity) of the whole evaluation process is considered an essential requirement of any QRA procedure. The real value of a QRA resides in the critical examination of the plant/process behaviour in an iterative process of “design improvement” that, ultimately, leads to an acceptable level of safety. In other words, the QRA allows analysts to check the validity of the implementation of design rules and safety criteria, and to demonstrate that the design includes adequate safeguards actions for both preventing accidents from occurring and reducing their consequences.

2.2.1 Hazard identification techniques

On the QRA procedure the hazard identification phase represents a critical step: hazards not identified in this phase will almost certainly be hidden for a long period of time during which the plant/process/operation remains not adequately protected.

Consequently, these hazards can be recognised only after the accident has occurred, i.e. when it is too late! Considering man made activities, hazards are introduced during the whole plant life cycle, i.e. from the early design phase up to the plant dismantling. Figure 5 below shows the main phases of the plant life cycle from the conception to the operation.

Each phase presents a certain number of hazards due to the intrinsic dangerous properties of the substances used, the process used, the components, the operating procedures etc. Also the availability of plant information is different: it becomes more detailed as we pass from one phase to the next one.

To be effective, the hazard identification must be performed at each phase and the results become useful design prescriptions for the next phase. Hence each phase is a sort of filter that reduces the number and type of hazards that may pass to the next phase.

The identification of the hazards, or the reduction of the probability of their triggering events, requires suitable systematic techniques of analysis. This means that the methodology applied for the hazards identification strictly depends on the phase of the plant life cycle.

It has been recognised that in practice it is very difficult to eliminate all the potentially hazardous situations because e.g. of the complexity of the problem (think for instance to human factors), of the large number of ways in which the plant can behave, which forces the analysts to define sound “cut rules” in order to address the efforts to the significant accident scenarios. This means that it may be possible that some hazards remain hidden until the occurrence of their triggering events. The hidden hazards form what is known as residual risk.

The importance of performing the hazard analysis starting from the conceptual design is that the most suitable design improvements can be made at the lowest cost only in the design phase. Indeed, the cost for removing a hazard on the pilot plant or on the industrial plant may involve a lot of problems because of the presence of constraints on e.g. space and weight.

Hazard identification is usually performed by an interdisciplinary group of experts representing the different departments involved in the project. They brainstorm on the different aspects of the design using their experience and any available knowledge and documentation applying one or more of the following hazard identification methodologies:

- Process / system check - list;
- Preliminary hazard analysis;
- Failure modes and effects analysis;

- Hazard and operability analysis;
- Task analysis.

The choice of the technique(s) to apply depends upon the type of process (well known or new), the intrinsic hazard level, the phase of plant / operation, etc.

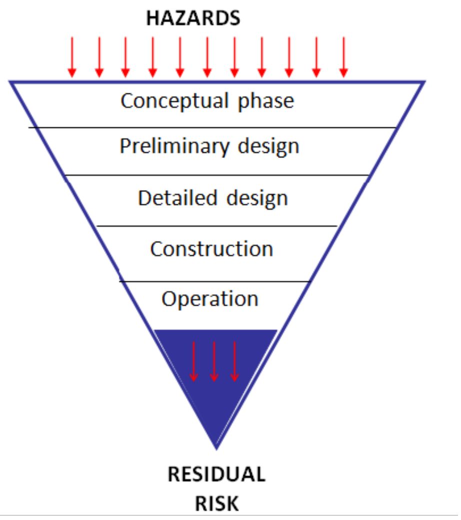

Figure 5: Risk propagation through the plant / operation life cycle

2.2.2 Check List

It is commonly used in safety and risk analysis to assist analysts and designers in their tasks. Check lists are extensively used e.g. in the hazard identification phase, risk review (auditing), inspections. It can be applied to small systems; large systems are broken down into smaller parts.

Learning from past failures or accidents is an important activity in order to improve the system safety/security by avoiding making the same mistakes in the future. Techniques applied to analyse records of information on past accidents allow improving guidelines / check lists / analysis methods i.e. to improve the tools for designing safer systems.

2.2.3 Preliminary hazard analysis (PHA)

It is a safety analysis methodology which is applied to address the main risk issues, identify hazards, causes, and consequences at the early stages of the design. As such it is useful to compare different design concepts. The result of a PHA is the set of the identified accident scenarios, which deserves attention during the later stages of the project, and safety recommendations for risk mitigation. In this phase use is made also of check list and past experience.

PHA is commonly applied to chemical and petrochemical plants. However, it can be used for any other type of (potentially dangerous) installation.

2.2.4 Failure Mode, Effects and Criticality Analysis (FMECA)

It is a procedure for identifying the consequences of potential components failure modes. For each component, questions to be answered by the group responsible for the analysis concern the modes of failure, the causes of failure and consequences, the detection means. The Criticality value allows the designers to classify the failure modes according to the severity of frequency and consequences. Then design changes most suitable to reduce the consequences are described.

FMECA is applied in different industrial sectors, e.g. off-shore, nuclear, transport, defence, aerospace, manufacturing, and in general for any system in which there is no chemical process.

2.2.5 Hazard and Operability (HAZOP)

It is applied by a team of expert to identify the potential hazardous situations starting from process variables deviations and to verify qualitatively the adequacy of existing protective and preventive measures. For each deviation of each process variable in selected points of the PHD, the team of plant's experts gives answer to questions about causes and consequences of the deviation, the existing means for detecting the deviation, the adequacy of the actions that are provided to avoid or to reduce the effects of the deviation. Hence the team decides about the modifications to apply to plant and procedure in order to improve the safety level of the installation. At the same time recommendations to improve the operability aspects are also recorded by the working team.

HAZOP has been developed for application in the chemical – petrochemical domain because of the presence of chemical reactions and process feed-back loops, but it has been successfully applied also to electric systems.

2.2.6 Task Analysis (TA)

It consists in the analysis of how a task, made up by a set of elementary actions of a given duration, is carried out by a human being in certain environmental conditions. In TA other factors can be taken into account e.g. clothing and equipment needed, psychological condition. In risk analysis, TA is applied by human error specialists.

TA is detailed and hence expensive. For some systems, where the human actions may become critical, the task analysis allows identifying where additional equipments are more effective to increase the safety level.

3 A citizen centred framework for hazard and risk

Ports are an extremely complicated environment, involving many operations by various actors, often with conflicting interests. When speaking about hazards, threats or risks, we must always refer to what kind of and for whom. What might be perceived as a hazard by a passenger transiting from the port may be perceived as an opportunity by a port operator. For example, the new chemical terminal to be located in the port is to be perceived as a danger for the residents living nearby, but for port this will mean to earn more revenue due to the new business activity. In what follows, we try to describe a framework as to what is understood as safety and security and classify the main port actors, final subjects of any safety or security considerations.

Any human actor can be considered at the centre of a set of values, like life, health, well being, property, environment, civil rights, privacy, knowledge, beliefs etc which constitute his/her personality. Each person perceives these values in a different way and gives a different importance / priority to each of them (personal scale of values). Often, the same person can, according to the circumstances, differentiate his scale of values. An individual would perceive as a threat anything that could compromise one or more of his personal values. The prioritized set of values common across a society of persons constitutes the collective / social scale of values of a given society. The term ‘citizen’, in distinction from the term ‘person’ or ‘individual’ refers to one or more ‘typical’ members of a society, i.e. adhering / sharing the collective scale of values. These values can be coded in the constitution and legislation or be embedded in the collective practices, consciousness, habits etc.

Thus, the actor *citizen* can be considered as one or more physical persons at the centre of a set of *common values*, i.e. values that are collectively recognized as such. Anything that can threaten any of these set of values constitutes a risk.

According to the value threatened we speak about risk to the life or physical existence, environmental risk, economical risk etc. Sometimes, risk can be quantified based on the probability of occurrence and the intensity of its negative consequences.

Safety is defined as the state of being free of risk or danger. The term ‘safety’, when used as an attribute, encompasses all measures, actions or systems aiming at ensuring the state of safety. It refers to threats / hazards against one or more items among the collective scale of values; hence the notions of physical, economical, environmental safety etc. It is important to note that the notions of safety and security are relative and can be perceived in a different way according to the prevailing scale of values across different societies or at different periods and conditions.

Security refers to a set of means through which safety is ensured, in particular against intentional threats. Thus, the term ‘security’ encompasses all measures, actions or systems aiming at preventing intentional (and therefore man-made) threats from compromising safety. The threatening human actor can use a variety of means (like weapons, infrastructure, specialised knowledge etc) to compromise one or more aspects of the citizen's safety. The *intending human actor* plus the necessary *means* for the execution of the threat constitute the *security threat*.

Security aims in preventing the materialisation of a security threat; it is therefore of preventive nature. Once a security threat materialises into a *security incident*, it becomes a safety concern and, therefore, a risk management issue.

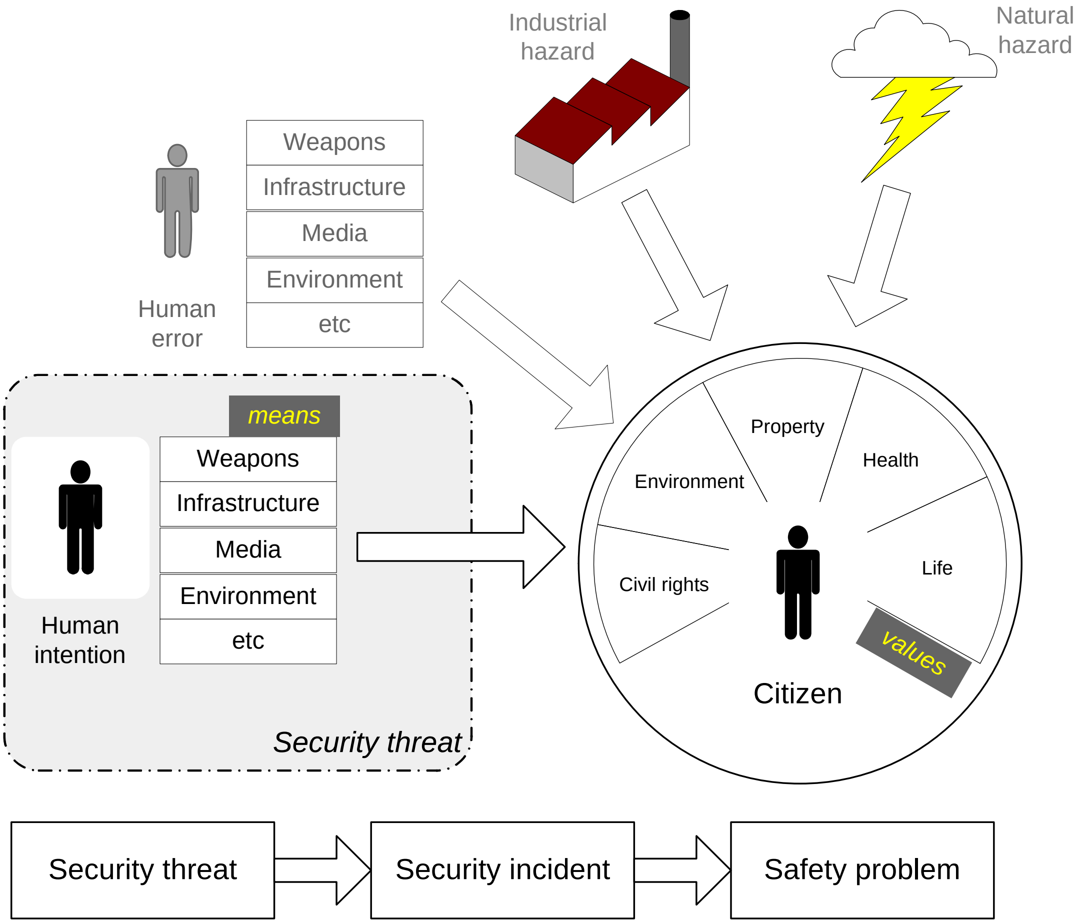

Figure 6: Citizen centered risk model.

4 Port specific context

4.1 IMO Guideline for Safety Assessment

The Maritime Safety Committee of the International Maritime Organization (IMO) approved the Interim Guidelines for the application of Formal Safety Assessment (FSA) to the IMO rule - making process [1].

The IMO FSA is a systematic process for assessing the risks associated with shipping activity and for evaluating the costs and benefits of IMO's options for reducing these risks. IMO FSA, schematically illustrated in Figure 7 below, comprises the following steps:

1. Identification of hazards;
2. Risk assessment;
3. Risk control options;
4. Cost benefit assessment and
5. Recommendations for decision making.

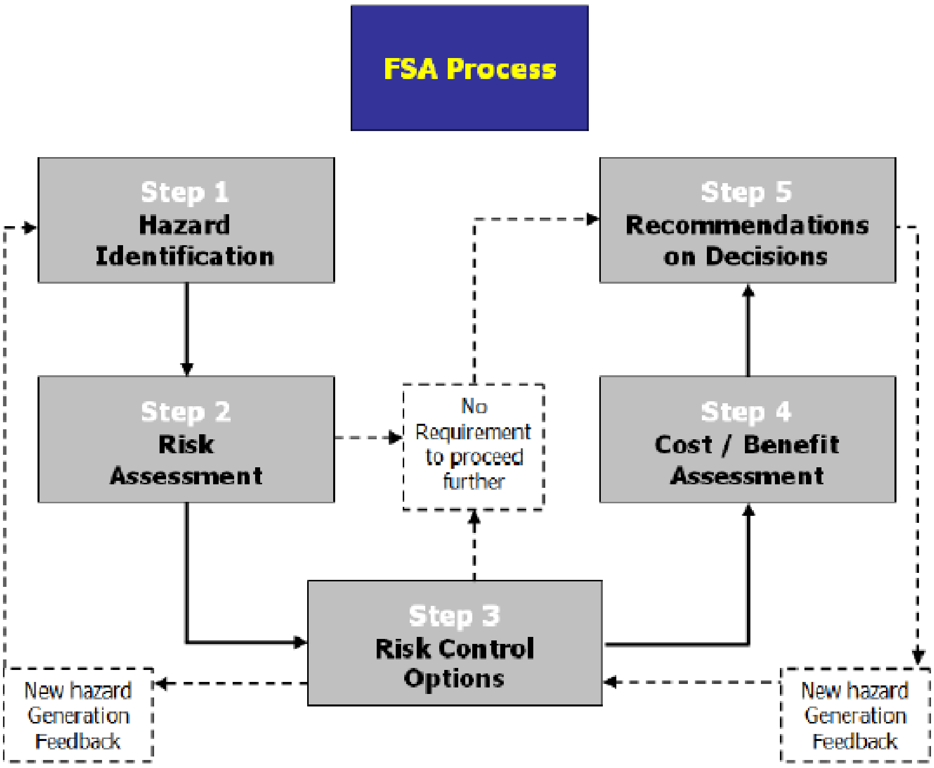

Figure 7: IMO Formal Safety Assessment Model

The report deals with step 1 of IMO FSA: the proposed approach not only provides for but, in the frame of a broader risk governance context, requires continuous communication with all the actors involved and hence, feedback, adaptability and reassessment. The main ideas for the Safety Assessment in port context are:

- to combine the IMO FSA model / approach with the port operation process
- to provide port operators with a comprehensive adaptable, flexible, extendible methodology
- to provide an initial hazard / risks identification and associate them to the port process model provided by WP3.1 according to the specific aims and requirements

4.2 Categories & subject of risk

In order to apply the methods and models described in the previous sections to the context of ports, two first questions must be answered:

1. What are the values at risk?
2. Who are the subjects / recipients of risk?

In what concerns safety in port operations, the following human values are of particular importance and need to be included in the subsequent analysis:

- Health & Human safety;
- Human comfort;
- Economy, market, property, material & labour;
- Environment

Consequently, the following categories of risk are considered:

- Physical: risk to the physical existence or to the health;
- Economical: risk to property, assets or income;
- Environmental: risk to the environment and the quality of life.

We can consider the following classes of port actors[3], subjects of the above hazards or threats:

- Operator: any physical person or group of persons (i.e. company, entity, trade category etc) who have professional activities directly linked to the port[4]

[3] The Citizens in Figure 6

[4] The 'regulator' class is implicitly included here; it includes all physical persons or bodies, usually public, that have an important role in the port decision making process, although their income is might not directly linked to the port.

- User: any physical person or group of persons, beneficiary of port services (passengers, traders, public)
- Neighbour: any physical person living at the vicinity of the port

Each port actor has a different perception of risk. It is clear that an analysis covering all kinds of risks for all possible actors, even in a simplified form, would be quite complicated and, in any case, out of the scope of EFFORTS. In practice, it is seen that the quasi totality of risk assessment exercises, especially those for industrial plants, focus on the operator class of actors. It is also true that at the end everything ends-up in money[5].

For that reason, in the analysis that follows we will focus exclusively on economical risks as perceived by the port operator class of actors. This choice has the advantage that, among other things, it somehow incorporates a significant part of environmental and physical safety concerns through their economic impact[6].

4.3 Port categories considered

The second issue that arises regards the complexity and extreme diversity of ports. There are ports that are much larger than their host cities, sometimes hosting industrial important plants while others that are just a part of an industrial plant or serve just a local community. Parameters according which ports can be classified include:

- Freight type: passenger, Ro-Ro, bulk, oil, gas, container, poly-functional etc.
- Level of service activity: local, regional, national, continental, global
- Geographic location: Mediterranean, Atlantic, Baltic etc.
- Freight (passenger) origin and destination: national, international, Schengen etc.
- Sea access: sea, river, canal etc.
- Land access: rail, road, inland navigation etc
- Urban aspects: city within a port or vice-versa
- Administration model: public, private, mixed

However, in their extreme diversity, ports have some fundamentally common characteristics when considering their processes. Thus ports can be seen as intermodal points of convergence between two key components of freight (or passenger) circulation: the land and maritime side. A port is a maritime but also as a

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5 IMO FSA also requests a cost / benefit assessment (see Figure 7) that implies a monetary mapping of any other tangible effect / value of relevance.

6 For example: the comfort or the environment around the port area is reflected to the property prices around the port area; the regulations on safety and environment as well as the various insurance schemes translate, through fines, premiums or operational restrictions, environmental, health and safety values to economical values.

land terminal, where inland traffic originates or ends. Besides being intermodal nodes, ports have a second function: that of servicing the maritime vessels.

Therefore, according to the port process domain derived from WP3.1, there are 5 common domains which are applicable to all kinds of ports and to be considered here: marine, infrastructure, logistics, public and interface to periphery (Figure 9).

4.4 Definition of generic port model for hazard identification

An extensive bibliography exists on the analysis of ports, generic or of particular type. According to the pursued aims of the specific study, ports have been analysed in terms of type, sequence or location of the performed operations / processes, spatial planning / distribution, infrastructure etc.

In general, process mapping serves, usually in the frame of the port enterprise activities, to a specified objective, e.g. re‑engineering. Identification, capturing and management of processes are purpose‑oriented, cutting off all peculiarities not needed for the terms of reference.

From the other hand, most port risk studies have focused either on the physical risk of port process / operations or on the environmental impact of port activities.

They have mostly used spatial distribution or infrastructure location models, often supported by sophisticated GIS tools.

Within the EFFORTS project, the port process domain model, illustrated in Figure 9 below, has been proposed to provide a generic “purpose free” taxonomy that can capture process-related information relevant to enterprise, environmental impact or socio‑economic relevant purposes.

In what regards the specific needs of the WP 3.2 and, in particular, the need to provide a simple but comprehensive mapping of hazards, various options were considered:

- The process domain model described above
- Location / infrastructure based model
- Port process model
- Main port operations breakdown

EFFORTS will provide a generic methodology that introduces the issue to all its breath and complexity in a systematic way with simple, practical and well understood terms. Such a generic methodology could, subsequently, be used by the ports focusing to their specific cases and priorities without losing the overall general context.

To achieve this goal and provide such a generic methodology, it was decided, to apply a process model approach derived from EFFORTS WP 3.1, to which a set of generic hazards[7] will be mapped.

[7] Not port specific

To achieve an optimized solution the process model approach from WP 3.1 will be enhanced/amended/adapted wherever it does not fully match the taxonomy requirements from WP 3.2.

It is remarkable that the final goal of WP 3.2 is not to develop a new risk assessment method additionally to large number of the already existing ones but to provide:

- The understanding of the risk management concept;
- A quick risk reference related to port and terminal processes;
- The access to relevant knowledge in order to support risk assessment and management in ports;
- The input to draft contingency plans;
- The opportunity to compare to other ports (benchmarking);
- Sources of risk studies, methodologies, tools and best practices.

in a comprehensive and easy-to-understand manner.

Thus the terms of reference for this work package can be summarised as follows:

- Explain risk assessment and management philosophy to port and terminal operators;
- Draft an introduction into safety science for port and terminal operators
- Provide a qualified list of relevant sources (abstracts, assessment of content);
- Provide a port process structure delivered by WP 3.1;
- Associate available risk assessments, casualties, contingency plans, best practices and other relevant material to port processes;
- Provide an overview of relevant methodologies and tools;
- Provide a risk assessment and management methodology for ports based on FSA (Formal Safety Assessment as recommended by IMO);
- Provide recommendations for standardization of port risk assessment and management.

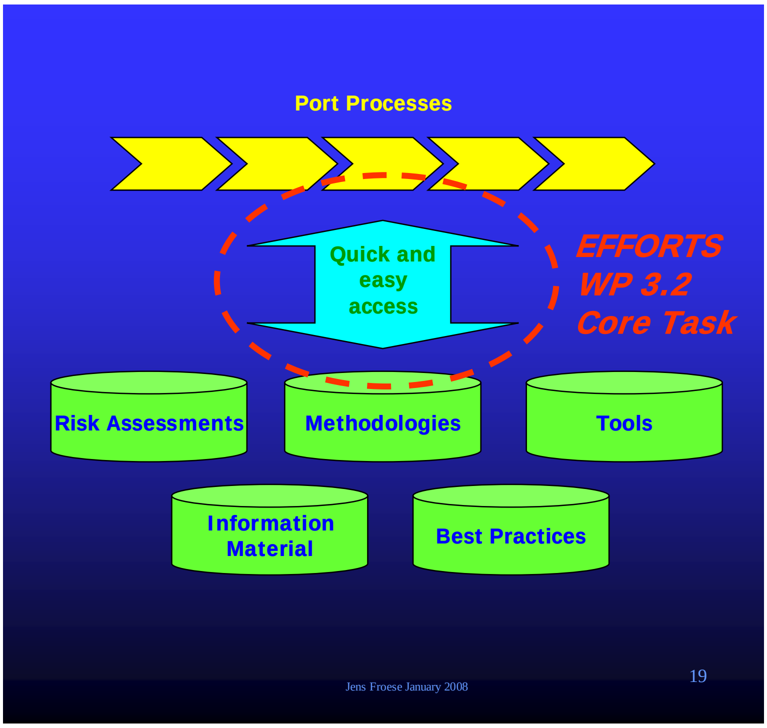

Figure 8: WP 3.2 Core Task

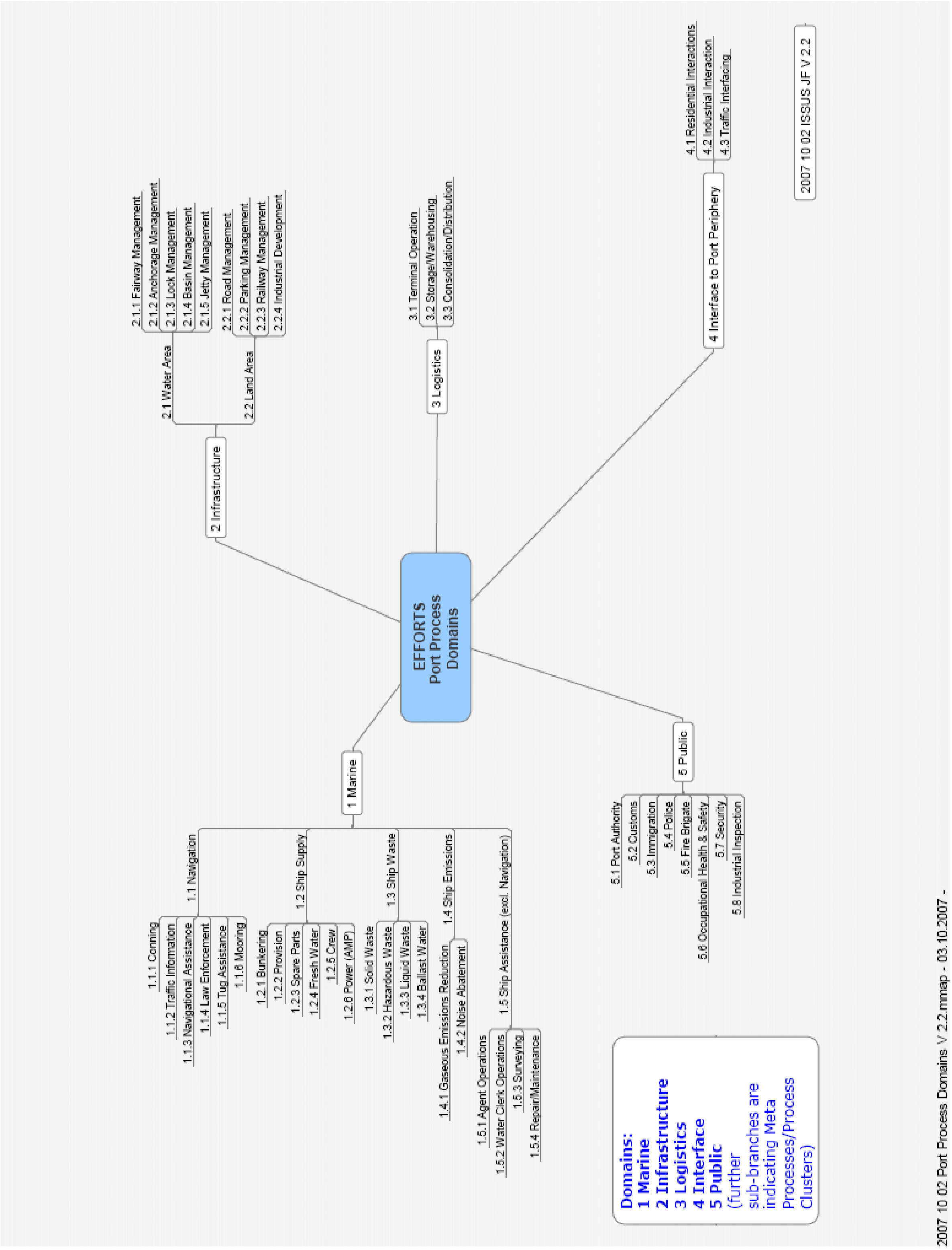

Figure 9: Port Process Domains

5 Hazard classification

5.1 Aims

EFFORTS aims at providing an easy to use risk identification tool for ports embedded in a logical classification system (taxonomy). Users of the project results commonly will not be risk experts. It is therefore essential to explain results in a transparent and easy - to - understand way without being very analytic.

EFFORTS WP 3.2 aims at providing a generic methodology that introduces the issue to all its breath and complexity in a systematic way with simple, practical and well understood terms. Such a generic methodology could, subsequently, be used by the ports focusing to their specific cases and priorities without losing the overall general context.

For this reason, it was opted to proceed by carefully selecting a list of generic[8] hazards and map them to the port process domains as described in section 4.4 above.

5.2 Strength and limitations of the process oriented approach

The hazard categorization based on a process oriented approach is convenient for two reasons:

(a) It can use established risk management methods and tools developed for other sectors (primarily for nuclear and chemical industry) and

(b) It deals with processes and context that are familiar to port managers / operators Indeed, if one focuses to sole port process hazards, long - established approaches developed primarily for technological accidents can be applied for hazard identification (see for example [2]). Table 1 below depicts one such list of specific hazards associated with port operations.

The main hazard identification in the WP3.2 will therefore mainly focus on the possible hazards on port operations associated to the port process domains defined from WP3.1. The result will enable each port to use such kind of hazard catalogues (associated with processes domain or process clusters, tools, methodologies to tackle the hazards, best practices) for their specific usages and analysis in the area of interest.

There are also some examples of a hazards not mapped in typical process oriented risk analysis of ports are earthquakes as well as the security threats (criminal activities or terrorism).

[8] Having in mind the commercial port sector but not depicting any particular port type specificity

Even if not fully in line with the process taxonomy both of these cases are treated in the next two sub - sections. The earthquake case is given as an example of such an extreme event, not related either to port or maritime operations, which can cause important damage to port facilities.

Table 1: Hazards for incidents in ports [2]

General hazard	Description	Specific Hazard
Impacts and collisions	Interaction with moving or a stationary object or a collision with vessel	Vessel collision
		Berthing impacts
		Striking while berth
Ship related failures	Hazards related to ship specific operations and/or equipment	Flooding
		Loading/Overloading
		Mooring failure
		Anchoring failure
Navigation failures	Potential for a deviation of the ship from its intended rote or designated channel	Navigation error
		Pilotage error
		Vessel not under command
Manoeuvring failures		Fine manoeuvring error
		Berthing / Unberthing error
Fire / Explosion	Fire or explosion on vessel or in the cargo bay	Cargo tank fire / Explosion
		Fire in engine room
		Fire in accommodation
		Other fires
Losses of containment	Release and dispersion of dangerous substances	Release of flammables
		Release of toxics material
Pollution	Release of material that can cause damage to the environment	Crude oil spill
		Other cargo release
Environmental barriers	Weather exceeds vessel design criteria, on harbour operation criteria	Extreme weather
		Strong current
		Earthquake

5.3 An example of extreme event induced hazards: earthquake

Although earthquakes are not usually considered as hazards in risk analysis for port operations, they have been the cause of significant damage and disruption of port operations in several cases. The most notable recent example is that of Kobe, Japan.

In 1995, a magnitude 7.3 Richter scale earthquake occurred north of the Awaji Island in Kobe. About 4.500 people were killed and 55,000 buildings collapsed.

Fires following the earthquake destroyed large parts of the city. The port of Kobe was severely damaged, mainly due to liquefaction and completely out of use (Figure 10). Although the port was reconstructed efficiently and rapidly it never fully recovered. In

2004 it ran at about 70% of its capacity before the earthquake in terms of containers and bulk.

Other examples of earthquake induced damage in ports include that of the Golcuk naval base in Turkey on August 1999 following a 7.4 Richter scale earthquake: several hundred military personnel were killed while the main docks and the 2 large cranes were heavily damaged. Numerous other port facilities along the Gulf of Izmit suffered severe damage (Figure 11 and Figure 12).

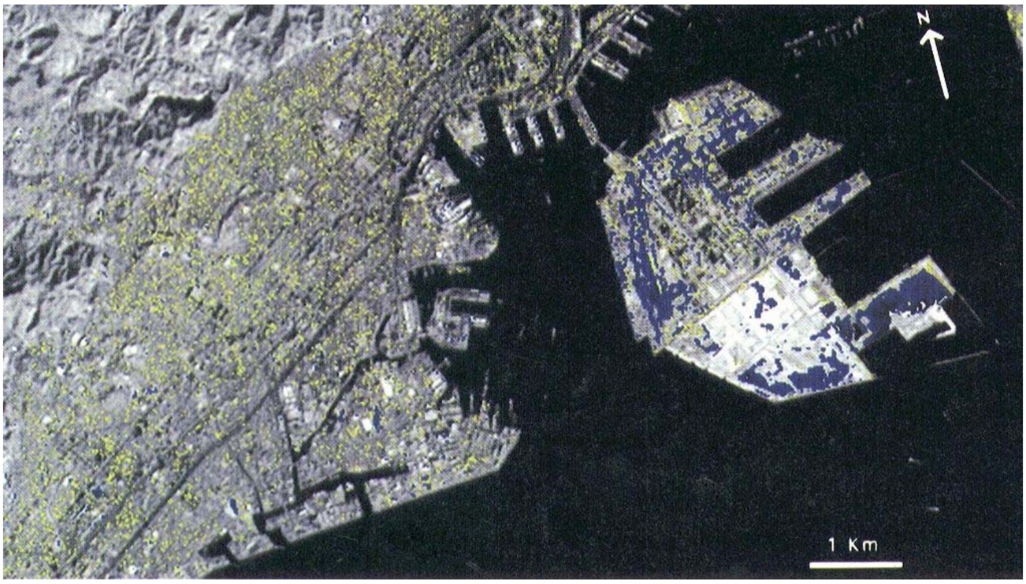

Figure 10: Areas of liquefaction in Kobe port after the 1995 earthquake (marked in blue)

Figure 11: Damage to the main pier and seawall at the Gulcuk Naval Base

Figure 12: Damage to a bridge to the pier at SEKA paper mill in Izmit

5.4 Security threats

Less known present-day hazards such as intentional threats possibly leading to human-conceived disasters (i.e. crime or terrorism) pose a difficult methodological and policy problem. Such hazards are believed to be unpredictable or even unthinkable, LAGADEC, thus making a reliable hazard identification an impossible task. Yet even in this case employing conventional methods for hazard identification and risk assessment cannot be avoided. Established knowledge from natural and technological disasters is used, DEMOUTH. In the case of security scenario approaches are currently broadly in use and serve as a base to hazard identification, risk assessment and security planning (see for example Port Facility Security Tool kit, AON RISK CONSULTANTS).

5.5 Alternative approaches

Hazards (and risks) can be categorized in many ways, according to many parameters. Various hazard categorisations are employed for example for the purpose of protection from natural hazards. Such generic hazard categorisation for the agricultural sector can be seen in Figure 13.

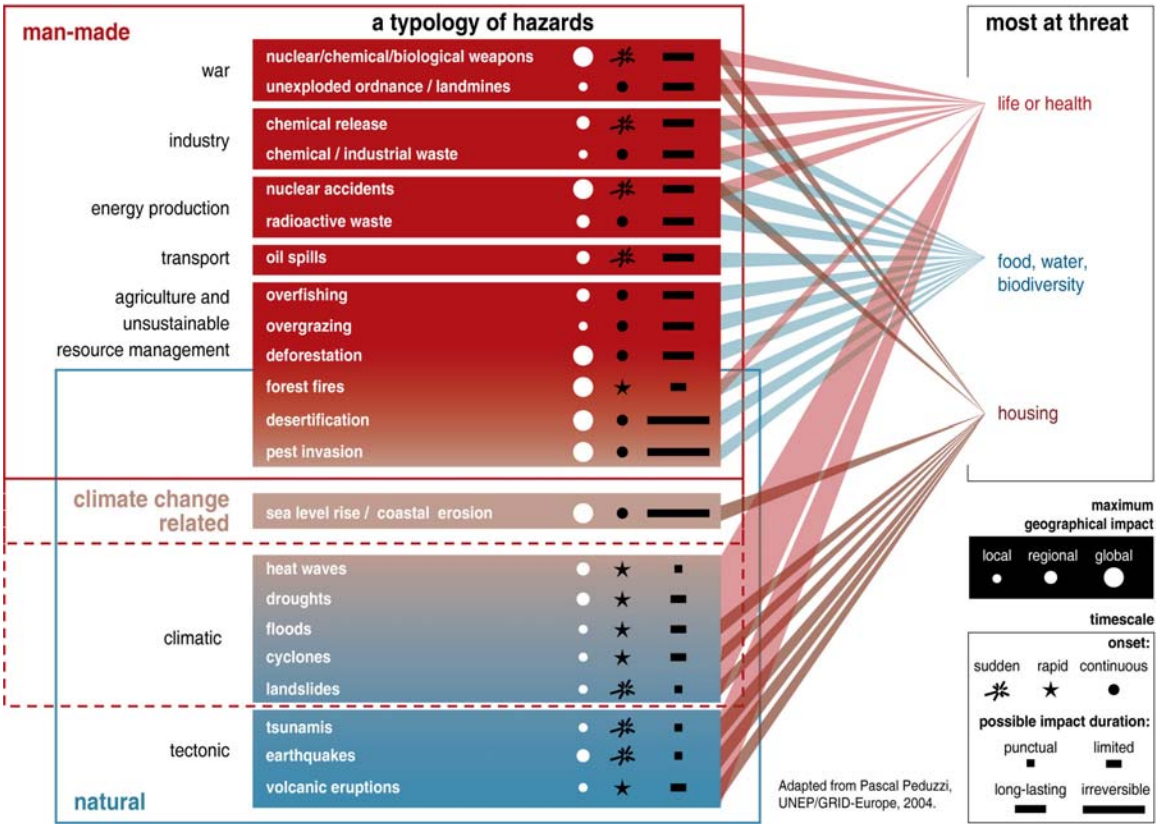

Figure 13: Typology of hazards according to UNEP/GRID - Europe

Other categorisations are applied for business contingency planning and crisis management. Such categorisations typically take into account hazards associated with the socioeconomic context i.e. strikes and union demands.

One should bring up also the issue of geopolitical hazards especially relevant in environments strongly connected with the global context.

As a conclusion, process oriented approaches can contribute to monitoring and quantification of risk related with specific, well defined operations of interest. Nonetheless, one should seek other approaches to hazard identification and assessment if hazard is to be treated in a broader, more comprehensive manner.

5.6 Governance approach

Ports are a unique hazard context in the sense that they are local and at the same time part of a global system (Figure 14).

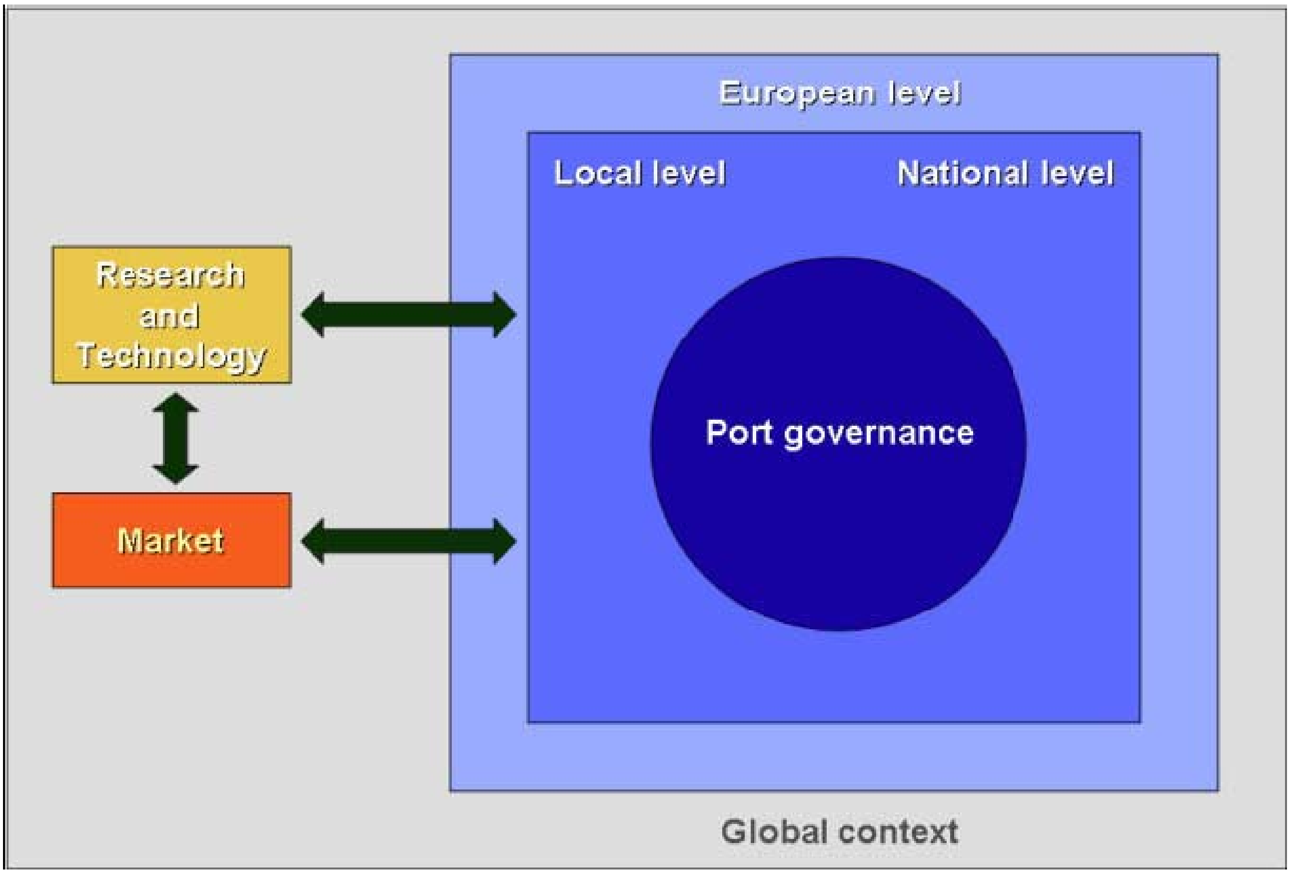

Figure 14: Port governance of a global system

To be useful, hazard identification and prioritisation should be seen in the framework of port governance. This means that in order to obtain viable and applicable risk management in a port, the different port actors should contribute to the identification and assessment of hazards according to their perception and acceptability of risk. For this, appropriate procedures should be set up exceeding by far the conventional hazard identification and assessment and making ample use of risk communication.

Matters become even more complex if the intangible effects of a hazard are to be taken into account (Figure 15). These effects such as the loss of reliability for business can be significant in environments where competitiveness is a core issue. Yet, the quantification and even the prediction of these intangible losses due to a hazard are both difficult and subjective.

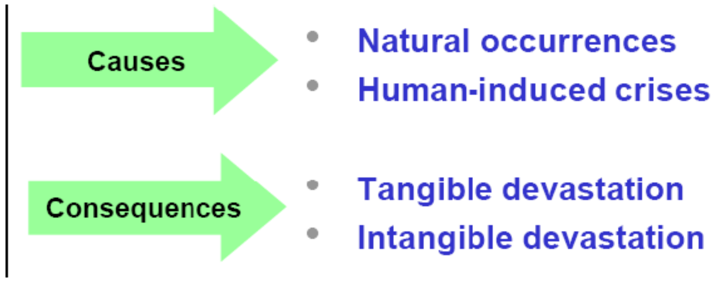

Figure 15: Risk from the point of view of crises

(Source: Mautner 2006)

In what follows we attempt to draft a list of generic hazards, having the ports in mind. The hazard spectrum is vast: environmental, man‐made, contextual, geopolitical hazards and threats etc. Some hazards, such as earthquakes, have a distinct location aspect while others, such as climate change, are global.

A number of criteria can be used in order to rank hazards, all having to do with what aspects of hazard are of interest for the purpose the categorisation serves. One obvious criterion is the geographical impact of hazard manifestation. It is not always easy to predict or even define the maximum geographical impact in current conditions of interdependencies and the globalisation. This is especially valid if intangible and long term effects are taken into account. Nonetheless one could attempt to roughly categorise hazards to local, regional and global hazards according to their possible geographical impact.

Furthermore the impact duration should be taken into account. This is also a complex assignment because some effects of a hazard might be more persistent then others. At any case the overall assessment of impact duration might be different to different actors.

Hazard onset is of significance also as it affects both hazard perception and risk management. Hazard onset can be sudden (instantaneous), as in earthquakes or explosions, quite rapid, as in floods and cyclones, or continuous such as sea‐level rise due to climate change.

5.7 Generic port hazards

In what follows a selected list of hazards that could be used to initiate a comprehensive port risk analysis following, in the frame of a broader risk governance approach, is presented (Table 5). It includes both the generic hazards, man‐made and natural, as well as hazards related specifically to port operations (port process domain in Table 5). The following parameters, important for the hazard and, subsequently, the risk management are generally associated with each hazard category:

- The onset velocity: the rapidity with which the hazardous event manifests itself; it can be sudden, rapid or quasi continuous.
- The expected geographical area impact: the expected extend of the area directly affected by the event; it can be local, regional or global.
- The possible impact duration: the duration of the direct consequences of the hazardous event; it can be short, long - lasting or irreversible.

These parameters are mapped in Table 2, for each one of the hazards considered. A first indicative approximation of the magnitude of each parameter is inserted. Emphasis should be given in the methodology to approach the problem and not to the specific hazard breakdown or the estimated values entered. These parameters, as well as the hazard categorization, could be different also according to the scope and the aims of the specific risk analysis exercise.

Table 2: Example of Port hazard categorization; indicative[9] estimations of the onset velocity as well as the impact area and duration of each hazard

class	category	hazard	onset	impact: area	impact: duration
generic man-made	geopolitical problems	global market, international context	000	AAA	==
	contextual problems	union problems/strikes	000	A	=
		external access disruption	00	A	=
		external services disruption	00	A	=
		media / public image	000	AA	=
	security	crime	00	A	=
		terrorism	0	A	=
		war	00	AA	==
	industry	chemical contamination	00	AA	==
		biological contamination	00	AA	==
	energy	nuclear / radiological	00	AA	===
		oil spills	00	AA	=
generic natural	climate change	sea level rise	000	AAA	===
		coastal erosion	000	AA	===
	extreme weather	heat wave	00	AA	=
		flood	00	A	=
		storm	00	AA	=
	tectonic	landslide	00	A	=
		earthquake / tsounami	00	AA	=
		volcanic eruption	00	AA	=
port specific	on-board	fire, explosion	0	A	=
		loss of containment	00	AA	==
		failure of equipment	0	A	=
	sea-side infrastructure	navigation, pilotage error, collision	00	A	=
		waterway blockage / obstruction	00	A	=
	sea to land interface	colision, grounding, berthing etc	00	A	=
		radar, communication failure	00	A	=
	land-side infrastructure	fire, explosion	0	A	=
		loss of containment	00	AA	==
		failure of equipment	00	A	=

legend

onset		impact area		impact duration	
0	sudden	A	local	=	short
00	rapid	AA	regional	==	long-lasting
000	continuous	AAA	global	===	irreversible

Of course, in order to proceed further with the risk analysis, the expected probability of occurrence must be somehow quantified. However, this parameter is strongly case specific. A first estimation of the expected occurrence probability can be extrapolated, for each specific case, using the

[9] Estimations may strongly vary from case to case or according to the interpretation. They are presented here just to indicate the methodological approach.

Table 3, as outlined in section 6 below.

6 Conclusions – the way ahead

This document constitutes the final report of Task 1 of WP 3.2.

It documents the work performed during the period July 2007 – January 2008. It presents the view of the authors on a methodological approach on the problem of the identification of hazards in ports as a basis for a consistent risk governance framework. Indeed, the authors firmly believe that the risks in such complex and diverse realities such as ports cannot be seen solely as a technical matter but as a governance issue. In this context, communicating with and involving all actors is fundamental for risk assessment and management.

It is obvious that all stakeholders in port operation must play an active role in appropriate risk assessment and risk mitigation. European ports in general do so already, what is lacking there is a more standardized approach. Standardized methodologies will allow for improved benchmarking between ports and the development and implementation of generic tools.

Furthermore all stakeholder not contributing to the operation of ports but might become effected by accidents need to be addressed too. Amongst those stakeholders are residents living in the vicinity of a port, administrations dealing with strategic planning and infrastructure and operation rules and guidelines, communities and other political bodies providing the framework for administrational and industrial activities.

They all need to understand risk-related implications to enable them to include those into their considerations and activities.

Traditionally industrial risks are being treated in a rather re-active manner by mainly responding to external pressure, maintaining a low profile. The lack of transparency and completeness causes suspicion amongst the stakeholders followed by resilience to agree to infrastructure and industrial projects. Amongst the big investment projects having been delayed or even stopped by stakeholders are also ports. The causes in most cases are environmental issues and not always restricted to the port vicinity. In case of the Port of Hamburg, dependent on further dredging of the river Elbe providing access from the sea which is 100 kilometres distant, concerned stakeholders are living all along the river often far away from the port. In this case the main hazard discussed is that of disastrous floods potentially killing hundreds of people as it happened in 1962.

Communicating risks to concerned parties needs to involve the benefits of operating a port. This adds a new dimension to the traditional cost-benefit consideration in risk management by not only describing the benefits of measures to mitigate risks but also elucidating the overall benefit of the related operation. This aspect, however, is not a core issue of EFFORTS but the recommended procedures need to provide links to general operational benefits. Those who have to live with hazards need to balance those against individual and community benefits.

The taxonomy of generic port hazards provided in Table 3 below includes both port induced hazards, typically mapped in process oriented methods, as well as hazards that originate outside the port domain. We note that the latter category becomes increasingly important.

The present analysis must be followed, within the context of the subsequent WP 3.2 tasks, on a case by case basis, by:

(a) The estimation, as better as possible, of the probability of occurrence of each of the hazards in Table 3 below.

(b) The mapping of the generic port hazards outlined to the port domains or the port functionalities, as these have been outlined in section 4.4, Figure 9.

Both such processes are case specific; they are strongly related to:

- The specific port (typology, location etc)
- The final aim of the risk analysis

Furthermore, under a risk governance approach, it is necessary to implicate various actors[10] and external experts[11] in a process that can result quite complex.

To develop a framework which covers a general understanding of risk-related issues, methodologies and tools to deal with it, which further provides access to relevant information including best practice solutions, is the main focus of EFFORTS. This means a comprehensive approach but wherever possible existing methodologies and tools should also become enhanced.

[10] Within the 'operators' class of actors (see Section 3.1); the most relevant

[11] Especially for the hazards originating outside an independently from the port processes

Table 3 provides a simple template for an initial, qualitative evaluation of the hazards that a particular commercial port may face, in each of the port domains or for the fulfilment of each one of the essential port functionalities. It aims to:

- Provide an initial, broad picture/evaluation of all possible hazards faced by each of the main functionalities of a particular port and capture hazards that are not mapped through a process‐oriented approach;
- Filter‐out non pertinent hazards and point out cases of particular interest;
- Identify the actors, internally and externally to the port, necessary to be implicated in the subsequent risk governance process;
- Identify the addressees of a transparent and understandable risk policy of ports.

Those stakeholders passively affected by port operations like e.g. residents usually do not distinguish between "hard" risks and other nuisances which bothers them. Port and terminal operators are under continuous pressure to defend operations resulting in noise, dust or even visual impacts. An owner of a sea-side apartment purchased for a fortune would rather prefer ancient sailing ships as the only significance of logistics but not huge container cranes. It seems that all port impacts can be treated in the same logical way as we now from risk assessment and management. It is one of the EFFORTS goals to demonstrate this in order to support port managers to "sell" their industry to concerned stakeholders.

According to the case and the scope of the analysis, a general, systematic starting point for the subsequent risk analysis / management activities needs to be provided.

This table is meant to be filled‐in, perhaps after suitable modifications, by a high level port operator[12] and/or as many as possible diverse port actors. The relevance of each hazard to each port domain / function could be marked as follows:

XXX → very relevant

XX → moderately relevant

X → weakly relevant

Void → not relevant – not applicable

Here again, the value is on the methodology and not in the specific estimations that can differ a lot from case to case. The table, dully filled‐up, should provide a comprehensive qualitative overview of the hazards faced by the ports in the fulfillment of their basic functions.

It should serve not only as a basis for further work within the EFFORTS WP 3.2 but also as a first tool for the ports to identify, in a systemic way, the hazards faced by specific ports in the fulfillment of their basic functions. Consequently, according to

[12] i.e. having a broad picture of the port activities; could be the port authority

their needs and priorities, they could launch more elaborate, targeted risk analysis / management activities.

Table 3: Mapping the generic port hazards to the port process domain

class	category	hazard	marine: navigation	marine: ship supply	marine: ship waste	marine: ship emissions	marine: ship assistance	infrastructure: water area	infrastructure: land area	logistics: terminal operations	logistics: storage / warehousing	logistics: consolidation / distribution	interface: residential	interface: industrial	interface: traffic	public: port authority	public: customs	public: immigration	public: fire brigade	public: health & safety	public: security	public: industrial inspections
generic man-made	geopolitical problems	global market, international context																				
		union problems/strikes																				
	contextual problems	external access disruption																				
		external services disruption																				
		media / public image																				
	security	crime																				
		terrorism																				
		war																				
	industry	chemical contamination																				
		biological contamination																				
		nuclear / radiological																				
	energy	oil spills																				
generic natural	climate change	sea level rise																				
		coastal erosion																				
	extreme weather	heat wave																				
		flood																				
		storm																				
	tectonic	landslide																				
		earthquake / tsounami																				
		volcanic eruption																				
port specific	on-board	fire, explosion																				
		loss of containment																				
		failure of equipment																				
	sea-side infrastructure	navigation, pilotage error, collision																				
		waterway blockage / obstruction																				
	sea to land interface	colision, grounding, berthing etc																				
		radar, communication failure																				
	land-side infrastructure	fire, explosion																				
		loss of containment																				
		failure of equipment																				

legend

onset	impact area	impact duration
O sudden	A local	= short
OO rapid	AA regional	== long-lasting
OOO continuous	AAA global	=== irreversible

void ->	not relevant/applicable
X ->	weakly relevant
XX ->	moderately relevant
XXX ->	very relevant

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