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Application of HFACS tool for analysis of investigation reports of accidents involving containerized dangerous goods

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APPLICATION OF HFACS TOOL FOR ANALYSIS OF INVESTIGATION REPORTS OF ACCIDENTS INVOLVING CONTAINERIZED DANGEROUS CARGOES

By

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China

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DECLARATION

I certify that all the material in this dissertation that is not my own work ahs been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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There are many ways to write acknowledgement since this part is the only one without need to abide by the academic requirements from university. That means the author can address his thanks in a way from one extreme, addressing as many persons, to the other extreme, addressing only one person as he wants. In this sense the author takes the risk of choosing the latter way to express his heart. The author hopes, in this way and with this paper, he can repay the debt that he owes to his beloved wife:

Yeshu Wang

ABSTRACT

Title of dissertation: **Application of HFACS Tool for Analysis of Investigation Reports of Accidents Involving Containerized Dangerous Cargoes**

Degree: **MSc**

The dissertation is a study of applying HFACS tool into analyzing investigation reports of accidents involving containerized dangerous cargoes, with the purpose of examining the human and organizational factors within this context.

Twelve investigation reports of accidents involving containerized dangerous cargoes were retrieved from different international sources. The HFACS framework and taxonomy were chosen to analyze and classify the human factors contained in the collected investigation reports. By examining the results of it, the utility of HFACS tool in this domain was tested and ultimately proved to be positively useful. There are no meaningful statistical trends revealed in the result, especially those associated with the shipper, even though it was proved in this research that the shipper's factors had made an important contribution to the accidents involving containerized dangerous cargoes. Additionally, shipper's "barrier" functions in the container shipping safety system were examined with the use of barrier classification concept. The limitation of the research was discussed in the last chapter with the hope of inspiring future research.

KEYWORDS: Accident Investigation, Human Factor, HFACS, Containership, Dangerous Goods, Shipper

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List of Abbreviations

HFACS Human Factors Analysis and Classification System

CDG Containerized Dangerous Cargoes

GHS Globally Harmonized System of Classification and Labeling of Chemicals

IMO International Maritime Organization

IMDG International Maritime Dangerous Goods

GISIS Global Integrated Shipping Information System

Chapter 1 Introduction, Purpose and Scope

1.1 Introduction to Maritime Transportation of Containerized Dangerous Cargoes from a safety point of view

Maritime transportation can be regarded as a separate transportation system, compared to air, rail and road transportation systems from a safety point of view, even though it closely interacts with other kinds of transportation systems. Take the maritime transportation of containerized dangerous cargo as an example. To control the hazards from amounts of packaged dangerous goods in a container, the whole transportation process from the shore-based process, like packing, marking, labeling, placarding declaration, to ship-based process, like loading, unloading, stowage, segregation, securing, sea-transport, has been addressed and harmonized by a set of international regulations as follows.

The United Nation's Economic Commission has developed a Globally Harmonized System of Classification and Labeling of Chemicals (GHS) concerning the classification of dangerous goods by the types of hazards they pose in order to improve the protection of human safety, health and the environment, and facilitate the trade and transport of chemicals on the basis of harmonization of the regulations on chemicals at various levels – national, regional and worldwide.(Hollnagel, 2008)

To regulate dangerous cargo transportation within the maritime sector under the umbrella of GHS, International Maritime Organization (IMO) has developed the chapter-VII of International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS 74) and annex-III of International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) with which the International Maritime Dangerous Goods (IMDG) Code is incorporated to provide detailed compliance standards covering each relevant process mentioned above.

Domestically, contracting governments are obliged to implement the above international requirements into the national domain.

It is necessary to clarify here the definition of containerized dangerous cargo (referred to CDG hereinafter) which is relevant to the scope of this research. It means the packaged form of dangerous cargo transported within a freight container. Obviously, this definition combines the meaning of two definitions from IMO conventions, the definition of packaged dangerous cargo and the freight container, which are separately stipulated in IMDG Code.

1.2 Safety Concerns of Containerized Dangerous Cargo Transportation at Sea

One of the major changes which has emerged from the globalization of trade has seen the tonnage of IMDG cargo soar, so that the amount of hazardous cargo on board a single post-panamax vessel on a voyage from the Far East to Europe could amount to 10,000 tones and upwards (Mullai Arben & Larsson Everth, 2008). Generally, it is estimated that between 10% to 15% of the cargoes transported in packaged form are dangerous or hazardous from a safety point of view (IMO, 2006).

As an intermodal freight container is sealed when loaded, its contents are not visible unless the container is inspected. IMO has carried out container inspection programme since 1996 among its member States. The consolidated results of 1996-2001 inspection revealed that the deficiency rate amounted to 30% (IMO, 2002). Even after 13 years until 2008, the deficiency rate still disappointedly amounted to 18% (IMO, 2008a).

There is some research trying to analyze the risks of CDG transported by sea from different points of view. Ellis and Lumsden (2009) have carried out the investigation on risk associated with the marine transport of undeclared dangerous goods, and found that: "there is the potential for serious incidents to occur. If undeclared dangerous goods are released during transport, consequences can be as severe as loss of life, extensive cargo losses, and vessel damages (Ellis Joanne & Lumsden Kent, 2009)." Günter Wichmann (2006) from Munich Re Group pointed out: "The safe transportation of dangerous goods is one of the greatest challenges in container shipping. Even if fires on container ships are much less common than other types of loss in the marine sector, the damage is usually immense (Günter Wichmann, 2006)." EMSA (2008) expressed its concern on expensive insurance claims resulting from containership accidents, and explained the reason: "ton for ton,'box ships'carry the cargoes with the highest value of any category of cargo ship, and they are also rapidly increasing in size. Indeed, some individual containers carry millions of Euros worth of goods each (European Maritime Safety Agency, 2008)."

The past half century has seen lots of maritime accidents involving CDG, some resulting in serious losses, such as the "Sealand Mariner" accident in 1998 causing two fatalities, the "Sea Elegance" accident in 2003 causing one fatality, and the

“Hyundai Fortune” accident in 2006 causing US$ 300M insurance claims.

Fire/explosion casualties in container cargo spaces have been increasing in the recent years (IMO, 2007). Most of these accidents involved containerized dangerous cargoes. This trend of fire/explosion in container cargo spaces has also been proved by the analysis result of data from Lloyd’s MIU casualty database combined with the data retrieved from English publications from maritime accident investigation website of different countries (see figure 1). In the past 20 years, there have been 55 fire/explosion accidents emanated from container cargoes on board containerships (see appendix 1).

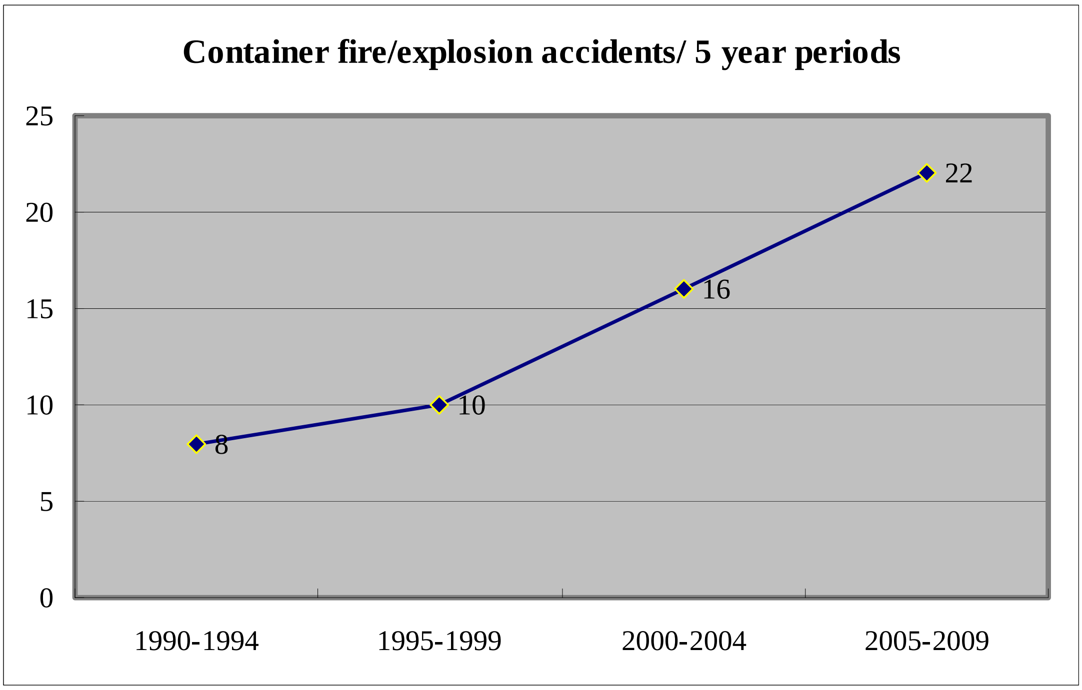

Figure 1 -Container fire/explosion accidents on board containerships in 1990-2009

Source: retrieved from the Lloyd’s MIU casualty database and English publications from maritime accident investigation website of different countries

1.3 Importance of Investigating and Analyzing Human and Organizational Factors of Maritime Accidents Involving CDG

The industry would benefit more had the day-to-day generated data be analyzed rather than waiting for an accident to happen (Schroder, 2004). Accident investigation is one of the tools for improving controls over hazards in the working environment (Energy Institute, 2008). In the case of a marine event, packaged dangerous goods may be involved and release their hazards by exposing one or a combination of the risk receptors, and consequently cause the accident. Accident investigation and analysis could help us to search below the surface to catch up the contributing causes/latent conditions, in particular those associated with human and organizational factors, which could be prevented later on.

Latent conditions are system deficiencies that lead to poor competence, procedures and equipment. They hide away from the “sharp end” with which they can always link themselves. To prevent further accidents, it is important to understand these systems and identify the deficiencies locating inside to develop the solutions. Human errors occur because the systems for preventing them have failed in some way. An incident, then, is not a person failure but a system failure. Thus in this sense, an organization’s safety management system can be thought of as the organization’s integrated set of processes that support human performance (Energy Institute, 2008).

Human errors make a significant contribution to maritime accidents according to a wide range of sources of research. Baker and McCafferty (2004) revealed that: “approximately 50% of maritime accidents are initiated by human error, while another 30% of maritime accidents occur due to failures of humans to avoid an accident. In other words, in 30% of maritime accidents, conditions that should have been adequately countered by humans were not (Baker & McCafferty, 2004)." Reason (1997) also expressed his concern with the human and organizational contribution to systems accidents, because accident analyses reveal that these factors dominate the risks to complex installations. "Even what appear at first sight to be simple equipment breakdowns can usually be traced to some prior human failure. Major accidents arise from the unforeseen interactions of human and organizational factors (Reason, 1997)."

1.4 Purpose and Scope

The principles can be assembled by combining the knowledge obtained from case studies with a more adequate theory (or theories) of error production, and applied to the design and operation of high-risk technological systems to reduce either the occurrence of errors or their damaging consequences (Reason, 1990).

As the importance of human and organizational factors in terms of contribution to maritime accidents, the author has decided to investigate them through the application of a specific analysis tool for the analysis of investigation reports of maritime accidents involving CDG, with the purpose of revealing any meaningful trends in the types of human and organizational errors associated.

The author has chosen the adapted Human Factors Analysis and Classification System (HFACS) for ship's machinery space fires and explosions by Ghirxi and his corresponding adapted taxonomy as the analytical tool(see appendix 3). The rationale for this choice will be explained further in the next section.

The specific objectives for this research are twofold: one is to examine the utility of Ghirxi's adapted HFACS framework and taxonomy in recognizing and analyzing the human factors contained in the investigation reports of maritime accidents involving containerized dangerous cargo; the other is to examine the thoroughness of the relevant accident investigation reports, with purpose of determining any meaningful trends and useful findings in the types of human factors, especially those associated with the shipper, after the adoption of "Guidelines for the investigation of human factors in marine casualties and incidents" by Resolution A.884(21)(IMO, 2000) .

To fulfill the above objectives, I will try to find as many investigation reports associated with the CDG cargo accident by approaching variable international databases, especially those accidents happened after 2000 year. After retrieving enough data (investigation reports), detailed analysis will be carried out on these reports with the use of adopted HFACS tool to find out the contained human factors. The retrieved human factors will be analyzed and coded against adapted Ghirxi`s taxonomy with the hope of releasing some useful findings. The last two chapters (chapter 4 & 5) will further discuss the findings and the limitation of the research.

Chapter 2 Methodology and Data Resources

2.1 Introduction to Ghirxi's adapted HFACS framework and taxonomy

The Human Factor Analysis and Classification System (HFACS) was originally developed by the US Department of Defense to investigate aviation mishaps. Later it was expanded to be seamlessly applied across all services, and is used to investigate aviation, ground, weapons, afloat, space and off-duty mishaps and events (Shappell & Wiegmann, 2000). A corresponding comprehensive and open taxonomy was created to fulfill this achievement.

The value of the HFACS framework is that it can provide a systematic view of the whole system. A system is a network of many variables in causal relationships to one another. Thus, it is usually wise when correcting a deficiency to consider it within the context of its system. Otherwise, we may treat only the symptoms and not the source of the trouble. We may also overlook the unpleasant side effects of our actions and do more harm than good in the long run (Doerner Dietrich, 1996). The HFACS framework can force the analyzer or investigator to go back from the front line, through the whole system, to the organizational level, which always embody the root causes.

However the HFACS framework only provides most of the possible human factors in general categories. A more detailed taxonomy is required for further analysis and classification in a specific domain. A taxonomy is usually made for a specific purpose, and no single scheme is likely to satisfy all needs (Reason, 1990). Thus, the original HFACS framework and its corresponding taxonomy were adapted by Ghirxi for a case-base analysis of a number of accident investigation reports into ship machinery space fires and explosions, considering that the original framework did not take into account the maritime transportation sector. (Ghirxi, 2008).

The HFACS framework shares the same theoretical basis, Reason’s model, with the IMO`s Code for the investigation of maritime accidents (IMO, 2000). The choice of HFACS as the analytical tool can ensure the compatibility of analysis with the information contained in the investigation reports.

The adapted HFACS framework and taxonomy by Ghirxi (Ghirxi, 2008) is used as the basic analysis tool. There was a need for some slight modifications to be made to fit into this research domain. These modifications will be discussed in the next chapter. The literature review has not shown any other taxonomy developed on the basis of HFACS framework in the maritime sector.

Since the purpose of this research is not to study the theoretical background of the HFACS framework, details about the HFACS framework and taxonomy adapted by

Ghirxi will not be discussed in this paper. Rather, only those necessary topics related to the later analysis and discussion (chapter 4 & 5) will be introduced in this part.

The HFACS framework as adapted expands Reason's four levels into thirteen causal categories as shown in table 1.

Table 1- The HFACS Framework as adapted for CDG accidents

	First Tier	Second Tier	Third Tier	
Latent conditions	**Organizational influences**	**Resources**	• **Human Resources** • **Technological environment** • **Equipment/facility resources**	**Remote from the ship**
↑		**Organizational climate**	• **Structure** • **Policies** • **Culture**	↑
		Organizational Process	• **Operations** • **Procedures** • **Checks & balances**	
		Statutory	• **International standards** • **Flag state implementation**	
	Unsafe supervision/ workplace factors	**Inadequate supervision**	• **Shipborne and shore supervision**	
		Planned inappropriate operations	• **Shipborne operations**	
		Failed to correct known problems	• **Shipborne related shortcomings**	
		Supervisory violations	• **Shipborne violations**	
	Preconditions for unsafe acts	**Environmental**	• **Physical**	
			• **Technological**	
		Crew	• **Cognitive factors** • **Physiological state**	
		Personnel	• **Crew resource management** • **Personal readiness**	
Active failures	**Unsafe acts**	**Error**	• **Skill-based** • **Decision** • **Perceptual**	**Front line**
		Violation	• **Routine** • **exceptional**	

Macro-perspective → **Micro-perspective**

Source: Kevin T. Ghirxi. (2008). *Application of scientific tools for the analysis of accident investigation reports about engine room fires.* Unpublished WMU, Malmo, Sweden.

Unsafe acts are defined as active actions leading to an error or an unsafe situation. Reason emphasizes that unsafe acts should happen in temporal and spatial proximities of a hazard (Reason, 1990), while in the accident cases relating to CDG, the unsafe act of the operator is usually quite far from the hazard, or to say the hazard has been existing for quite some time. A typical example is the mistaken stowage of dangerous cargo by the stowage planner. Thus, in the context of CDG accidents, the operators of unsafe acts are not limited to crew on board the vessel, but also could include the front line individuals working on shore as long as they have made the active failures leading to the accident.

It is important to identify unsafe acts as the first step, so that from where the investigator could trace backwards until to the highest management level. However sometimes the investigator should be aware that there could be several unsafe acts acted by different operators leading to one accident. These operators may locate in different departments belonging to the same management level, the front line, within the analyzed organization. Taking the "Sealand Elegance" accident for example, the chemical dangerous cargo, Calcium Hypochlorite, was mistakenly stowed near the heat resulting in emanating flammable gas. The flammable gas contained in the cargo hold later became ignited by the welding slag falling from the hot working by the ignorant maintenance crew, finally leading to the fire/explosion accident. In this case, both the wrong stowage by the stowage planner of the shipping company and the mistaken welding work by the ignorant maintenance crew are regarded as unsafe acts.

Unsafe acts, in the HFACS framework, are categorized into two groups: errors and violations, according to whether individuals make them intentionally or unintentionally (See figure 2). However this does not mean that errors are either intended or unintended because individuals do not set out to make an error. Rather it is the act or the underlying decision process that are intentional or unintentional.

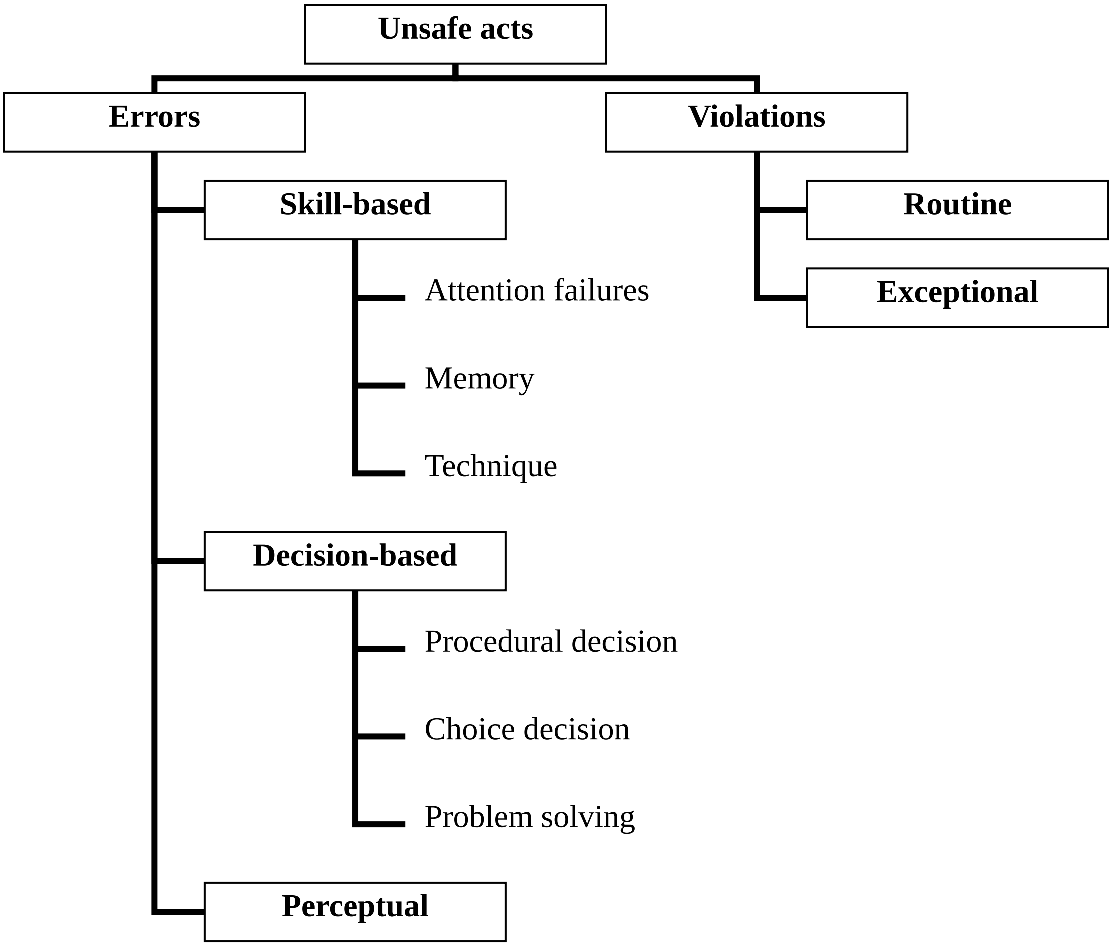

Figure 2 - Unsafe acts categorization

Source: Kevin T. Ghirxi. (2008). *Application of scientific tools for the analysis of accident investigation reports about engine room fires.* Unpublished WMU, Malmo, Sweden.

The Preconditions for unsafe acts are defined as factors in a mishap if active and/or latent preconditions such as conditions of the operators, environmental or personnel factors affect practices, conditions or actions of individuals and result in human error or an unsafe situation (Shappell & Wiegmann, 2000). Two areas of factors are considered in this level, the individual and the environmental factors. The individual factors cover not only physical condition but also the interaction of human. The environmental factors have a wide range covering the physical and the technological environmental factors. Barrier systems are usually categorized in this level as the technological environmental group. For example, the information of CDG should be declared on the document by the shipper (the requirement of declaration is regarded as incorporeal barrier function). If the shipper fails to implement the declaration requirements, the missing technical information of CDG, regarded as the precondition factors for the stowage plan, will probably cause the wrong stowage leading to the accident.

The precondition factors are categorized into three groups: environmental factors, crew condition, and personnel factors (see figure 3). Environmental factors can be subcategorized as physical environment and technological environment groups. Crew conditions can be subcategorized as cognitive factors and physiological state groups. Personnel factors can be subcategorized as crew interaction and personal readiness groups.

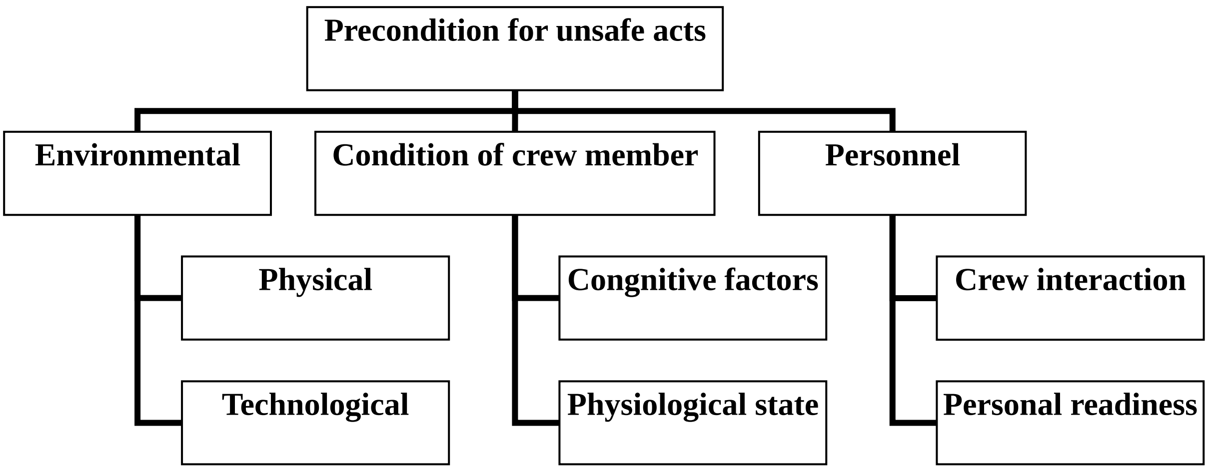

Figure 3 - Categorization of precondition for unsafe acts

Source: Kevin T. Ghirxi. (2008). *Application of scientific tools for the analysis of accident investigation reports about engine room fires.* Unpublished WMU, Malmo, Sweden.

Unsafe supervision factors are defined as factors in a mishap if the methods, decisions or policies of the supervisory chain of command (officers at management level over operational and support level) directly affect practices, conditions, or actions of individual and result in human error or an unsafe situation (Shappell & Wiegmann, 2000).

Four groups are categorized under the unsafe supervision level: inadequate supervision, planned inappropriate operations, failed to correct known problems, and supervisory violations (see figure 4)

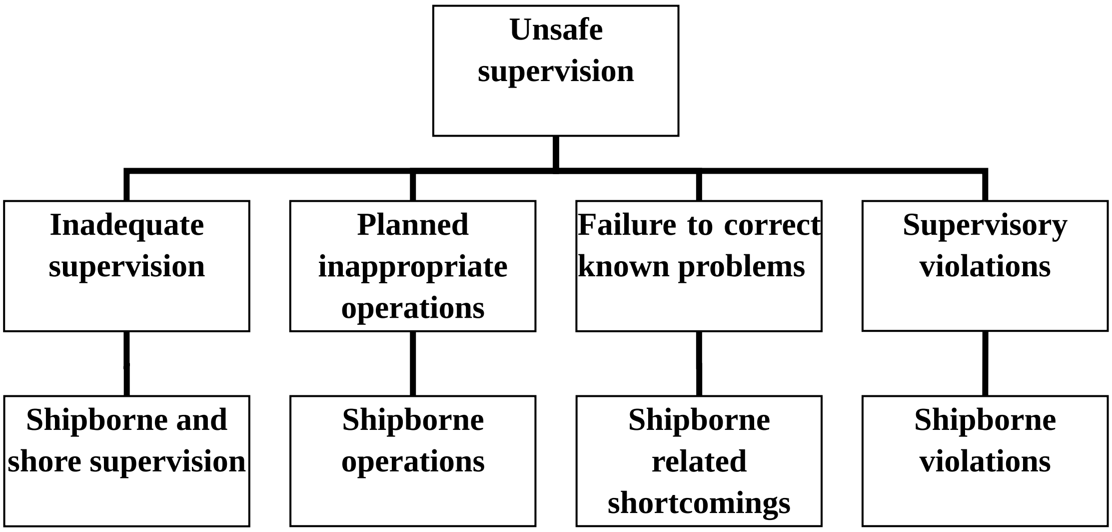

Figure 4 - Categorization of unsafe supervision factors

Source: Kevin T. Ghirxi. (2008). *Application of scientific tools for the analysis of accident investigation reports about engine room fires.* Unpublished WMU, Malmo, Sweden.

Organizational factors are factors in a mishap if the communications, actions omissions or policies of upper-level management directly or indirectly affect supervisory practices, conditions or actions of the crew member(s) and result in system failure, human error or an unsafe situation (Shappell & Wiegmann, 2000).

Four groups are categorized under the organizational level: resource management, organizational climate, organizational process and statutory. Resource management is subcategorized as human resources, technological resources, and equipment/facility resource groups. The organizational climate is subcategorized as operations, procedures, and oversight groups. The organizational climate is subcategorized as structure, policies, and culture; Statutory, as the new added category by Ghirxi, is subcategorized as international/national standards, and flag state implementation.

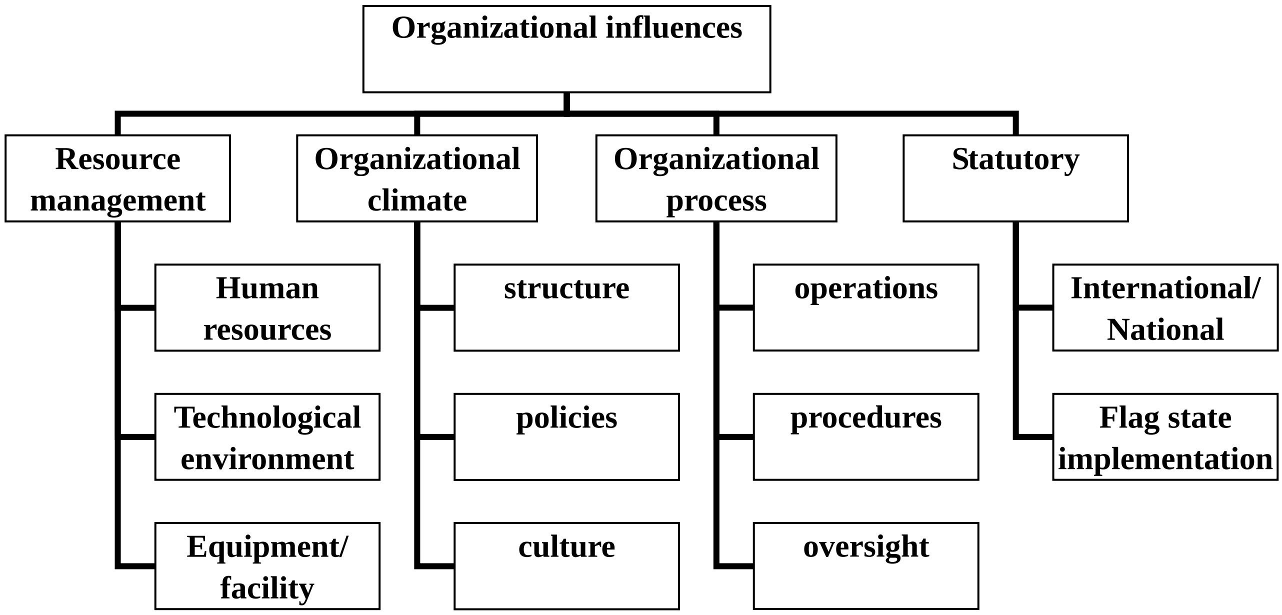

Figure 5 - Organizational influences categorization

Source: Kevin T. Ghirxi. (2008). *Application of scientific tools for the analysis of accident investigation reports about engine room fires.* Unpublished WMU, Malmo, Sweden.

2.2 Retrieving and Coding of Human Contributing Factors into Adapted HFACS Taxonomy

In order to indentify the human factors contained in the investigation reports and classify them into the right plane of the HFACS framework, it is important to understand the relationship between different factors. As the HFACS framework does not provide tools for identifying this relationship or failed path, other helpful tools should be adopted for this research.

Figure 6 shows that an event involves hazards coming into damaging contact with targets (people, assets, environment) as the result of a defensive failure. If starting with the end result, the analyst is capable of tracing backwards to determine the nature of the failed defence(s) and the hazard (Reason, 1997).

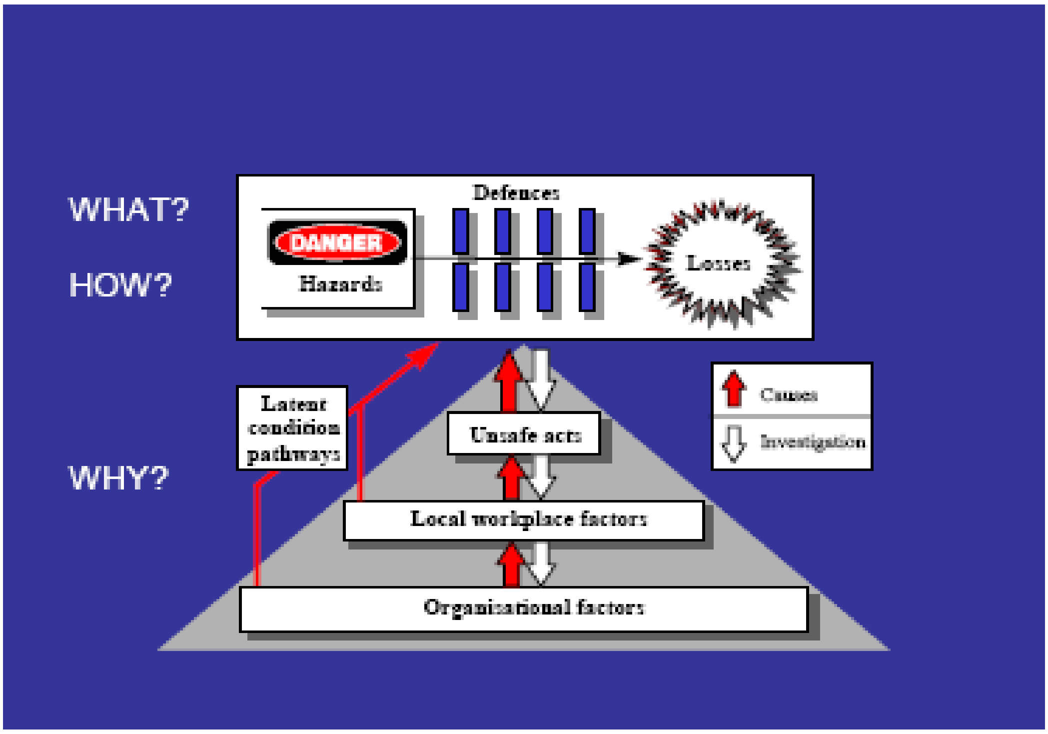

Figure 6 - Reason's human factor model

Source: Reason, J. (1997). *Managing the risks of organizational accidents*. Aldershot: Ashgate.

For this research, the author chose the barrier analysis combined with time-lines as the description tool. The concept of barrier provides one of the few opportunities to model interactions and complexity in high risk domains (Reason, 2006). Due to their nature, barriers must always be seen in relation to a potential flow of mass, energy, and information or control. It is therefore natural to base barrier analysis on a representation of possible sequences of functions or successions of events such as time-lines or tree diagrams (Hollnagel, 2004).

It is important to point out that the contents to be analyzed are all from the analysis part of the investigation reports. From that part of each report, the mentioned contributing factors are retrieved and analyzed in this research paper. This approach avoided the “re-investigation” of the accident, which would have otherwise led to subjective interpretations (Ghirxi, 2008).

After finishing the analysis and description of all the accidents, all of the found human factors are coded manually by the author against the Ghirxi`s adapted taxonomy (see appendix 3). If one factor can not be fitted into any nanocode, then consideration should be given to create a new one. Totally there are two new nanocodes created to suit this research. They are explained in the analysis chapter.

Much time and great attention were paid to verifying the final coding results and the adapted modifications to be consistent with the original HFACS framework and taxonomy.

2.3 Data

A comprehensive international review of the investigation reports of accidents involving CDG has been carried out on the web-base. The IMO Global Integrated Shipping Information System (GISIS), IMO`s DSC sub-committee section of IMO document website, the casualty database of Lloyd’s MIU, English publications from maritime accident investigation website of different countries were examined to retrieve qualified investigation reports. Two Chinese investigation reports were obtained through the China Maritime Safety Administration. The sources of the retrieved investigation reports are illustrated in appendix 2 respectively.

Only investigation reports investigating ships falling under SOLAS 1974 were retrieved to ensure compliance with the IMDG Code and other international regulation. This can also ensure that the master and the crews being investigated show the minimum quality standard as required by the International Convention on Standard of Training, Certification and Watchkeeping for Seafarers,1978, as amended in 1995(STCW 1978).

There is one exceptional case, Wing On No.1, 1999, which is a local ship in Hong Kong. This case is included in this analysis data because of two reasons. One is that it shows a valuable lesson to the world with regard to the transportation of fuelled used motor vehicles/cycles and related spare parts. The other is that after this accident, the Hong Kong government carried out an investigation on the local regulatory scheme concerning this issue. This report, which could be regarded as the supplement to the casualty investigation report, gives us valuable information with regard to human factor analysis.

Finally, 12 investigation reports have been collected. Of these, 7 are attributed or partly attributed to human causes. The remaining 5 are of unknown origin causes (see table 2).

Table 2- Accidents Involving Containerized Dangerous Cargoes

Ship name	**Type/country**	**year**	**Accident type**	**Main Contributing Factors**
MOR UK	Containership/Cyprus	1995	DG leakage	Unknown
SEALAND MARINER	Containership/ Marshall Islands	1998	Explosion, two fatalities	Shipper's Misdeclaration
WONG ON NO.1	Container lighter/HK	1999	Explosion, one fatality	Shipper's Undeclaration
KITANO	Containership/Japan	2001	fire	Unknown
DUTCH NAVIGATOR	Container feeder/ Netherlands	2001	Shift of containers / DG leakage	Multiple
SEA ELEGANCE	Containership/Singapore	2003	Fire, one fatality	Shipper's Undeclaration
LT UTILE	Containership/Panama	2003	Fire	Unknown
CSAV ITAJAI	Containership/Marshal	2004	Fire	Wrong stowage
PUNJAB SENATOR	Containership/Germany	2005	Fire, explosion	Wrong stowage
KOTA PAHLAWAN	Containership/Liberia	2006	DG leakage	Shipper's Wrong package
CMA CGM FIDELTO	Containership/France	2007	Explosion/ DG leakage	Unknown
HANJIN LONDON	Containership/ South Korea	2007	DG leakage	Unknown

Total number: 12 cases

Chapter 3 Findings of the Accident Investigation Reports Analysis

The human and organizational factors retrieved from the accident reports were coded against Ghirxi's taxonomy (see appendix 3). Some slight modifications have been adapted to suit the research domain and will be explained in this section.

3.1 Identification of Contributing Factors

Totally 32 contributing factors were retrieved from 7 reports with the use of the modified HFACS framework. No contributing factor was found in the other 5 reports due to the insufficient investigation (the coding result is illustrated in Table 3).

Table 3- Classified Contributing Factors Against Ghirxi's Taxonomy

		Sealand Mariner	Wing On No.1	Dutch Navigator	Sea Elegance	Csav Itajai	Punjab Senator	Kota Pahlawan
Total	**32**	**6**	**4**	**5**	**4**	**5**	**7**	**1**
Unsafe acts	**8**							
AE 103	7	1	1	2	1	1	1	
AE 201	1	1						
Preconditions	**4**							
PE 202	1					1		
PE 205	2	1			1			
PE 214	1						1	
Supervision	**13**							
SI 001	5	1		2		1	1	
SI 004	1	1						
SI 007	7	1	1	1	1	1	2	
Organizational	**7**							
OR 003	1		1					
OR 205	1						1	
FS 001	5		1		1	1	1	1
The other 5 cases, Mor UK, Kitano, LT Utile, CMA CGM Fidelto, Hanjin London are not attributable.								

Remark: Detailed coding results are illustrated in appendix 2.

Among these factors, the supervision factors take the largest number compared to others. On the contrary, the precondition factors amount to the lowest number group.

There are also 7 other contributing factors identified, but hard to be categorized into any category of Ghirxi's taxonomy (see table 4). For example, in the "Sea Elegance" case, the undeclaration of CDG by the shipper has contributed to the accident, but there is no enough information contained in the investigation report addressing the relationship between the shipper and the shipping company. It is still not clear how and where this shipper's failure has influenced the individual and organization behavior of the shipping company.

Table 4- Summary of the uncoded contributing factors

Ship name/actor	Contributing factors
Mor U.K./ shipper	The suspect tank containing between 20 and 80 percent of its capacity, which should not be offered for transport by ship, resulted in a liquid surge and increased the vertical loads at one end.
SEALAND MARINER/ Shipper	Failure to properly declare and document the hazard class on the shipping papers presented to the vessel's agent.
SEALAND MARINER/ Shipper	Failure to mark and placard the container.
SEALAND MARINER/ Shipper	Failure to pack the cargo in accordance with the IMDG Code requirements.
SEA ELEGANCE/ Shipper	Failure to declare the dangerous goods
KOTA PAHLAWAN/ Shipper	The xanthates carried by "KOTA PAHLAWAN" were not hermetically sealed strictly by the shipper in accordance with the IMDG Code.
DUTCH NAVIGATOR/ Maintenance company	The framework and the liner integrity of the tank container were impaired due to the improper repair by the maintenance organization, contributing to the collapse of the framework and the leakage of the content.

3.2 Identification of Unsafe Acts

There are only 8 unsafe acts identified from 6 of total 12 accidents. The identification percentage is 50%. This shows that only half of the investigations can conclude with direct failure.

Seven of 8 unsafe acts are fitted into AE 103, failure to see or avoid. Among these 7 factors, 5 are associated with the stowage planner of the company who failed to scrutinize the undeclared dangerous cargo, or stow the dangerous cargo correctly, leading to an unsafe situation. Two are associated with the chief mate failing to stow the dangerous goods correctly.

3.3 Identification of Precondition Factors

There are only 4 preconditions identified. There is a very little identification rate compared to other category's, but this does not mean that precondition is not important in terms of contribution to the whole event. For instance, the cargo information in the vicinity of the location where a fire accident happens is the precondition for the firefighting activity to mitigate the consequence. This information is vitally important for the fire fighter to be able to decide which fire extinguishing strategy, such as water or carbon dioxide, should be adopted to fight against the fire (to mitigate the consequence of the fire accident) in the cargo hold.

This can explain the insufficient investigation of some reports where only unsafe acts were identified, but not the precondition factors. Finally, the investigator failed to trace back the events from the unsafe acts, and lost valuable information at the precondition level.

The nanocode of PE 214, machinery space system knowledge, was adapted as illustrated in the following to suit the research domain:

PE 214 CARGO HOLD/MACHINERY SPACE SYSTEM KNOWLEDGE
A factor when the individual has no adequate or suitable knowledge of the cargo hold or the machinery space schematics and line/electrical installations.

3.4 Identification of Supervision Factors

Thirteen supervision level factors were identified and all fell into 2 groups. Five factors are categorized as SI 001, leadership/supervision/oversight inadequate, associating with failure to oversee the wrong stowage carried out by the stowage planner. Another 7 factors are fitted into SI 007, failure to provide current public/adequate technical information or procedure, associating with failure to provide adequate technical information related to the designated task, like cargo information in the vicinity of hot work, cargo information inside the container to be shifted, cargo hold information related to the cargo stowage operation.

To suit this research domain, the nanocode SI 007, failure to provide current public/adequate technical data or procedures, has been slightly modified as illustrated in the following:

SI 007 FAILED TO PROVIDE CURRENT PUBLIC/ADEQUATE TECHNICAL DATA OR PROCEDURES

A factor when current technical information related to the cargo to be operated, or the running of the machinery space, or maintenance of machinery in the machinery space is not provided to other crew members at management level and/or at operational and support level leading to a dangerous error in judgment/decision.

3.5 Identification of Organizational Factors

Seven organizational factors were identified in 5 of total 12 accidents. Five were categorized as FS 001, rule-making process, associating with failure to anticipate the potential risks involved, resulting in a loop-hole/weakness in the international regulations, i.e. in “Sea Elegance” case, the investigator suggested that “Serious thought should be given to carrying Calcium Hypochlorite in refrigerated containers, especially where the transit takes place in or through the tropics, which addresses a higher risk of carriage of Calcium Hypochlorite in or through the tropics than IMDG Code does.” The similar suggestions were also given by the investigators in “CSAV Itajai”, “CMV Punjab” and “Kota Pahlawan” cases (details referred to Table 8 on page 36).

Chapter 4 Discussion of the Findings

4.1 The Utility of Ghirxi`s Adapted HFACS Framework and Taxonomy for the Analysis of Accidents Involving Containerized Dangerous Cargo

It always turns out that the very rare accidents are not due to unique causes, but rather are due to the unexpected, and therefore in this sense, unique combination of common factors (Hollnagel, 2004). The human factor, especially the causal factors should not vary so much from different mishaps. In fact, most mishaps have very similar causes (Shappell & Wiegmann, 2000). Ghirxi`s research focuses on the engine room fire domain, which belongs to the same maritime sector as this research. That is why theoretically his work can be trusted here. This also proves one of the purposes of Ghirxi's study: to provide a platform, which will serve as the foundation for more detailed studies (Ghirxi, 2008).

The analysis result has shown that 7 reports yielding out 32 findings, while the remaining 5 reports yield nothing. This is not because of the potential disutility of the

HFACS framework, but for the following reasons. One is that accident proof was hard to be collected for analysis after a fire or explosion, especially after long-time fire extinguishing efforts. Almost all the proof such as the source of the fire was either consumed or washed or jettisoned. The other reason is because of the complicated chemical reaction of the dangerous chemical cargoes which usually emanate heat and/or flammable gas in the onset of an accident resulting in fire/explosion. It is difficult to artificially replicate the same chemical reaction in the laboratory for the proof reason. Like the “LT utile” accident of which the investigation did not come to a conclusion, the biggest possibility for the cause of the fire which the investigator can hypothesize is the dangerous chemical cargo leaking from the package released the heat from the chemical reaction with the scrap iron inside the container such as the reducer agent. However this hypothesis was never proved during the investigation.

4.2 The multiplicity of unsafe acts involving the stowage planner and the shipper

Active failures are committed by those at the “sharp end” or front-line of the system . The complexity of the system will contribute to the multiplicity of unsafe acts. All unsafe acts can be lumped into a single category, but errors take different forms, have different psychological origins, occur in different parts of the system and require different methods of management (Reason, 1997). In order to figure out who was located at the “sharp-end” of an accident, the investigator has to understand the system, especially the function of each part of it. The role of a system model is essential in considering how systems can malfunction, or in other words in thinking about accidents. The structure of a system is often less important than the function, and the latter may require a breakdown that does not map easily onto the structure (Hollnagel, 2008).

Even though the stowage planners are not on board the ship, they are located in the front line of the management. In a modern containership company, the stowage planner takes the function of the cargo stowage from the chief mate on board the ship, while the master and the mate play the supervision role comparatively. This can explain why there are not so many precondition factors revealed in the reports, since the stowage planner is on the shore side, far away from the investigator.

The shipper's relationship with the container shipping company is not fully investigated in the investigation reports. Consequently there is no enough information revealed about the shipper's failures, such as why the shipper neither declared the cargo as dangerous, nor packed the dangerous cargo in compliance with statutory requirements. In this sense, this research was not able to reveal any findings associated with shipper. The next sub-section 4.3 will try to analyze the functions of the shippers from a systematic point of view, hoping to provide the basis for future research.

4.3 Tentative Analysis of Barrier Functions of Shipper Regarding the Safety Transportation of Containerized Dangerous Cargo

Shippers are closely involved in the transportation service. They are in charge of the packing, marking, placarding, labeling and declaring dangerous cargo according to the relevant statutory requirements such as the IMDG Code. All these requirements are designed to achieve specific safety functions. Identification of these functions will provide useful cues in understanding the whole system, which is the prerequisite for the accident investigation.

Defenses are measures designed to protect the hazard or to mitigate the consequences of equipment or human failures, compromising both technical and human elements. Reason’s model (illustrated in figure 6 on page 18) describes how latent failure conditions coming from the organizational processes could degrade the defences, thereby leaving the way open for unsafe acts to become accidents. In order to identify the human factors, we have to know which attributed defence has failed.

Based on the nature of barriers, the barrier system is classified into the following four categories (Hollnagel, 2004): physical or material barrier system, functional (active or dynamic) barrier systems, symbolic barrier systems, and incorporeal barrier systems.

The shipper, who has the same meaning as “consignor” for the purpose of the IMDG Code, means any person, organization or Government which prepares a consignment for transport (IMO, 2008b). Provisions are set forth for dangerous goods consignments relevant to authorization of consignments and advance notifications, packing, marking, labeling, documentation and placarding.

4.3.1 PACKING as physical barrier functions

When preparing dangerous goods, the shipper must comply with the IMDG Code requirements on packing, so as to ensure the barrier functions of packing are fulfilled during the whole transportation. Table 5 shows the examples of the physical functions of packing system.

Table 5 -Barrier functions for the shipper as the physical barrier systems

Barrier functions	**Examples**
Containing or protecting to prevent transporting something from the present location (e.g. release) or into the present location (penetration)	Containers, tanks, valves, etc.
Restraining or preventing Movement or transportation of mass or energy	Restricted physical movements of liquid (limitation of ullage)
Keeping together Cohesion, resilience, indestructibility	Components that do not break or fracture easily, e.g., safety glass.
Separating, protecting, blocking	Scrubbers, filters,etc.

Adapted from barrier functions and barrier systems (Hollnagel, 2004)

4.3.2 Documentation, Marking, Labeling, Placarding as symbolic barrier functions

Similar to the packing function, the shipper has to prepare the dangerous cargo in compliance with the requirements on documentation, marking, labeling and placarding. These belong to the symbolic barrier systems as illustrated in table 6.

Table 6-Barrier functions for the shipper as the symbolic barrier systems

Barrier functions	Examples
Countering, preventing or thwarting actions(visual, tactile, interface design)	Coding of functions (colour, shape, spatial layout such as marking or labeling on the packages and containers)
Regulating actions	Dangerous goods declaration procedure
Indicating system status or condition(signs, signals and symbols)	Maximum load signs on the container and package
Permission or authorization (or the lack thereof)	Authorization of dangerous goods
Communication, interpersonal dependency	Advance notification of dangerous goods

Adapted from barrier functions and barrier systems (Hollnagel, 2004)

4.3.3 Statutory Requirements as Incorporeal Barrier Functions

The shipper also undertakes the legal and moral obligation to ensure the safety standard of transporting CDG, just like the functions of the incorporeal barrier systems as illustrated in table 7.

Table 7- Barrier functions for the shipper as the Incorporeal barrier systems

Barrier functions	Examples
Complying, conforming to	Self-restraints of shipper, social pressure
Prescribing: rules, laws, guidelines, prohibitions	Rules stipulated in the bill of lading, international or domestic laws

Adapted from barrier functions and barrier systems (Hollnagel, 2004)

The quality of symbolic and incorporeal barriers is highly dependent on humans. Since incorporeal barriers depend on the user's willingness to enforce them, they are comparatively not as same efficient and robust as the physical and symbolic barriers. They are not applicable to safety critical tasks, and difficult for the evaluation. Their availability is also uncertain since it depends on whether the user remembers them in the situation. They also completely depend on the user's compliance. They may nevertheless be attractive because the resource needs are low, as is the delay in implementation. Unless the population of users has unusually high moral standards, incorporeal barrier systems are not recommended, except as a temporary remedy (Hollnagel, 2004). The above discussion about the shortcoming of incorporeal barriers systems explains to us the reason why the population of shipper is vital important for the implementation of IMDG Code, and ultimately responsible for the casualty. The classification of barriers is not always a simple matter, but the reward is worthwhile in helping us to understand the accident.

4.4 Identified organizational factors including the added up statutory factors

The various ways in which human, technical and organizational factors can combine to produce organizational accidents are still not fully known and are perhaps ultimately unknowable, since each major organizational accident seems to throw up a fresh set of surprises. Organizational factors are universally difficult to be investigated, because they have multiple causes involving many people operating at different levels of their respective companies (Reason, 1997). They are usually located remotely from the front-line, causing additional burdens, such as time and money, for the investigating body. Reason further explains this concern from the human resource point of view. This additional evaluative burden is not lightened by the fact that most regulatory staffs possess expertise in technical and operational matters rather than in human and organizational factors (Reason, 1997).

Organizational factors were found as not being adequately addressed in this research either. Only 2 factors were identified excluding the other 5 statutory factors. The links between what is perceived to be front-line failures and wrong organizational decisions are not significantly identified, conclusions that indicated such do not provide a supporting structure as to why it was perceived that the blunt-end individuals had failed in their duties.

It is surprising to see that 5 statutory factors were identified from 5 reports showing a high identification percentage compared to other organizational factors. This coincides with the concern that due to a lack of feedback or otherwise, the IMO rule-making process does not keep abreast with technological advances or modern designs. This may lead to situations where shortcomings in regulations only come to light following the onset of an accident or are revealed by an accident investigation (Ghirxi, 2008).

Regulators are uniquely placed to function as one of the most effective defences against organizational accidents (Reason, 1997). Just like the above analysis, IMO regulations such as the IMDG Code undertake the functions of incorporeal barrier systems. They are continually being amended to prohibit actions that have been implicated in some recent accident or incident. However regulations and procedures share with other feedforward control devices the problem of being insensitive to local conditions. From table 8, we can see that the regulator’s failure to identify and react to specific dangerous goods contributed to the accident.

Table 8-Summary of the Statutory Contributing Factors

Ship name	**Statutory Contributing factors**
WING ON NO.1	The later investigation report on the regulatory scheme on this issue revealed that the existing legislation is inadequate in regulating the conveyance of ***used motor vehicles/cycles and their spare parts***. It further addressed that the deterrence from the safety guidelines for the transport of motor vehicles/cycles is insufficient and too indirect.
SEA ELEGANCE	After a number of incidents with ***Calcium Hypochlorite***, the Salvage Association and the International Group of P&I Clubs issued pertinent recommendations, which addressed higher risks of carrying Calcium Hypochlorite than IMDG Code does. Plus, the recommendations of this investigation report suggested that the IMO DSC sub-committee should be asked to further investigate the carriage requirements of Calcium Hypochlorite and amend the IMDG Code as appropriate. Serious thought should be given to carrying Calcium Hypochlorite in refrigerated containers, especially where the transit takes place in or through the tropics, which addresses a higher risk of carriage of Calcium Hypochlorite in or through the tropics than IMDG Code does.
CSAV ITAJAI	It is recommended that further precautionary measures should be considered by the IMO DSC subcommittee to control the temperature of ***Thiourea Dioxide*** throughout the carriage process, like stowage away from radiant heat or for carriage in reefer containers or ventilation.
CMV PUNJAB	It is recommended that further precautionary measures should be considered by the IMO DSC subcommittee to designate ***NiMH rechargeable batteries*** as dangerous cargo or cargo to be cooled.
KOTA PAHLAWAN	The ATSB has advised that ***xanthates*** have a recognized capacity to emit the odour of carbon disulphide even when packaged in accordance with the IMDG Code and an odour from xanthates shipments, similar to Kota Pahlawan`s, is commonplace according to their Australian importers. This suggests that the information for xanthates and requirements for their carriage, in particular the packaging, provided in the Code is not enough to address the hazard, and thus should be reviewed.

Of course it is fair to say that the regulators cannot foresee all the possible scenarios of failure in complex, tightly-coupled and highly interactive systems, so cannot universally prescribe particular types of human response. The regulator's position within the affected organization means that they are likely to attract blame from all directions. Since standing as they do on the organizational borders of all hazardous technologies, their sphere of responsibilities is bound to be implicated in a wide variety of contributing factors. However, if the regulators are to be other than convenient scapegoats, they will have to be provided with the legislation, the resources and the tools to do their jobs effectively (Reason, 1997).

Chapter 5 Limitations of Research, Conclusions and Future Research

The main motivation trying to understand accidents is to prevent them from happening again (Hollnagel, 2004). However there are always limitations to this objective from the reality or the theoretical world. This chapter will try to address these limitations from different points of views.

5.1 Limitation of data in revealing any statistical trend

The problem in accident analysis is mainly to get sufficient data and information about what took place (Hollnagel, 2004). In this research, the utility of the HFACS framework in identifying and classifying human factors from the reports is also limited by the data and information contained in the accident reports.

First, only 12 investigation reports were retrieved from global sources on the web-base. For the remaining relevant accidents involving CDG, the investigations were either not carried out or not revealed to the public or not available in English. Second, since a written account has the effect of "digitizing" what in the original was a complex and continuous set of "analogue" events, an accident report will always contain less information than was potentially available (Reason, 1990). Third, most importantly, the inquisition of the investigator is not thorough enough to discuss the organizational being of the system under investigation (Ghirxi, 2008). Only 2 organizational factors were identified in the analysis apart from the remaining 5 organizational factors which were all lumped into statutory category. For the investigation carried out after 2000 when the "Guidelines for The Investigation of Human Factors in Marine Casualties and Incidents" (Resolution A. 884(21)) was adopted to amend Resolution A.849 (20), the analysis result did not reveal any meaningful change in terms of human factors found compared to those carried out before 2000.

The retrieved human and organizational factors may be used for more general consideration of shipping, but are not enough to reveal any convincible statistical trend with the purpose of improving the safe transportation of CDG.

5.2 Limitation of HFACS framework in identifying Human Factors

The utility of the HFACS framework in identifying human factors / the weakness within the system has been tested and proved in this research, but its theoretical limitation is more worthwhile to be discussed here from an academic perspective. The HFACS framework is built on Reason's human factor model, which belongs to the group of epidemiological models. Thus, the HFACS framework inherits the shortcomings from it.

Epidemiological models are structurally and functionally underspecified but are valuable because they provide a basis for discussing the complexity of accidents that overcome the limitations of sequential models. Unfortunately, epidemiological models are never stronger than the analogy they use, and they are often difficult to specify in further detail, even though they have been instrumental in developing methods that can be used to characterize the general “health” of a system (Reason, 1997). In this sense, Reason` model is insufficiently specific regarding the nature of the holes in the cheese and their inter-relationships (Reason, 2006).

If a system is described using an epidemiological model type, then accident analysis becomes a search for known carriers and latent conditions. The underlying assumption is that defences and barriers can be strengthened to prevent future accidents from taking place, even though the detailed pathways may be uncertain (Hollnagel, 2008).

Rather than describing the accident and finally giving the clues for the solution, the HFACS framework concentrates on the classification of human factors in each level within the organization to give a data-driven basis for the analytical utility. Or like Reason declares: “we cannot prevent latent conditions from being seeded into the system since they are inevitable product of strategic decisions. All we can usefully do is to make them visible to those manage and operate the organization so that the worst of them, at any one time, can be corrected (Reason, 1997).”

In the realm of error management, HFACS tools can be regarded as the starting point or the basis to provide a discussion platform, and a communicating language for all parties involved in error management. However this utility is still far from the purpose of Karl Weick (1991): “to anticipate and forestall disaster is to understand regularities in the way small events can combine to have disproportionately large effects (Weick, 1991).”

In order to understand accidents it is necessary to describe them, and the description inevitably involves the use of an accident model. The three types of accident models, the sequential models, the epidemiological models and the systemic models, correspond to the gradual realization that accidents are due to complex coincidences rather than root causes (Hollnagel, 2004).

A more advanced model is needed to fulfill this task such as the systemic models. The overriding advantage of systemic models is their emphasis that accident analysis must be based on an understanding of the functional characteristics of the system, rather than on assumptions or hypotheses concerning interaction between structures or internal mechanisms as provided by standard representations of, e.g., information processing or failure pathways (Hollnagel, 2008).

5.3 Limitation of the “Stop Rules” of the Investigation in Revealing Shipper’s contributing factors

Ghirxi expanded the HFACS framework to regulator level by adding up statutory and flag state factors into the organizational level. It is found helpful in identifying relevant organizational factors in this research. Five statutory factors were recognized from 5 reports.

The efforts to identify the contributing factors associated with the shippers failed to reveal any results. This is because that compared to statutory factors, it is harder to blame the shipper who is usually located in another country/region different from the investigating state. Because of the sovereign rights, the investigating country can not go to another country to investigate the shipper. Consequently, information related to the shipper is not investigated and the links between the shippers and the shipping companies are not addressed.

Reason also observes this concern. He points out that leaving aside legal concern with responsibility, accident investigations are carried out for two main reasons: to establish what occurred and to stop something like it happening in the future. Both of these ends are best satisfied by limiting the scope of the analysis to those things over which the people involved, and most particularly the system manager, might reasonably be expected to exercise some control (Reason, 1997).

Our main interest must be in the changeable and the controllable. For these reasons, and because the quantity and reliability of the relevant information will deteriorate rapidly with increasing distance from the event itself, the accident causation model presented in figure 6 (page 19) must, of necessity, be confined largely to the manageable boundaries of the organization concerned (Reason, 1997).

This is why Reason's human error model stops at the production organization boundary (see figure 7). The raw material provider, like the shipper, is not addressed in this model; the philosophy behind it is that the hazard embodied in the raw material will be filtered out or controlled by the defences provided in the safety management system. For instance, the newly produced container should be examined and endorsed by the competent organization before being put into service to ensure it is safe enough for service.

Layout of the essential elements of the production organization

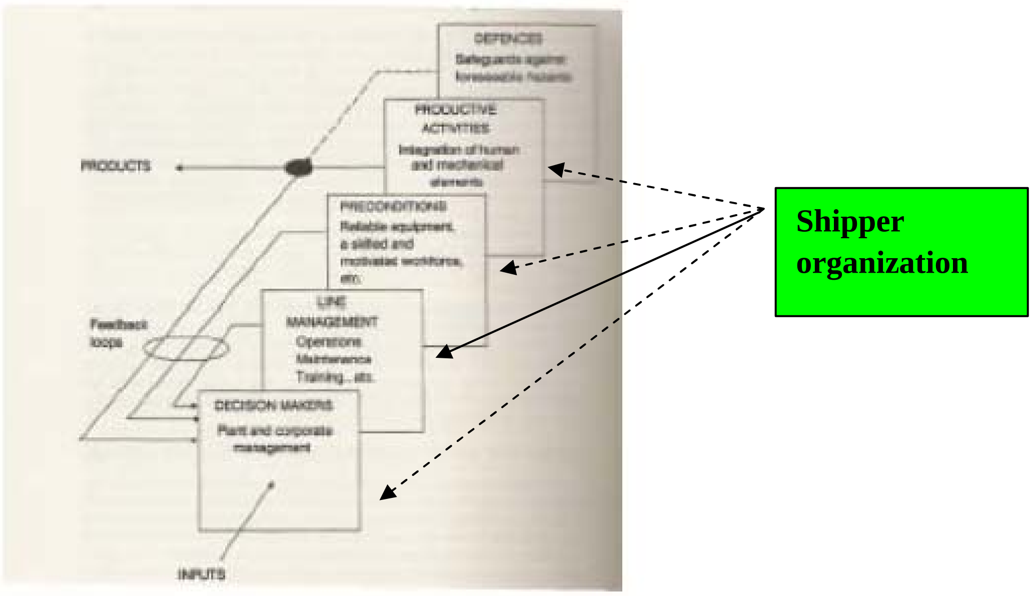

Figure 7- Interaction between the production and the shipper organization

Adapted from Human Error (Reason, 1990)

With globalization, the supply chain has changed so much that the supplier is regarded as part of the production system. Just like the shipper, they not only provide cargo for the shipping company, but also are responsible for the safety defense system of the cargo, e.g., packing, marking, placarding, labeling and declaring. In this sense, the production system defined in figure 7 has been expanded to the shipper. Consequently, the scope of the investigation should be expanded to the shipper as well.

Over the past 30 years, the search for the causes of a major catastrophe has spread steadily outwards in scope and backwards in time to uncover increasingly more remote contributions (Reason, 1997). Since time and causality are seamless, they have no natural breakpoints, only artificially imposed ones. Accident analysts, just like historians, are limited by their resources and by the availability of reliable evidence.

5.4 Conclusion and future research

The utility of Ghirxi's adapted HFACS framework and the corresponding taxonomy in the domain of accidents involving CDG was tested in this research. The testing result is positive when the scope is limited to shipping company. However it is doubtful when the scope is expanded to the shipper. Based on the collected data of this research, the HFACS tool is not able to draw both shipping company and the shipper into one conceptual framework. The reason of it has been discussed in the paper.

The relationship between the theoretical model and supporting database is interactive. The utility of the model is limited by the shortage of data in the real world. In the context of accidents involving CDG, the utility of HFACS framework is also limited by the insufficient investigation reports. The human factors retrieved from the investigation reports were not able to reveal any meaningful trends, especially those associated with the shipper. This is mainly because of the insufficiency of the investigation.

It has been proved by this research that the shipper of CDG plays a very important role in containership accident. Thus, it is important to examine the reasons which prevent the shipper from achieving safety goals in maritime domain. To fulfill this objective, specific theoretical model and database are necessary of being created to guide the future investigation and study.

There are two other available data sources related to incidents involving CDG apart from the collected investigation reports in this research. One is the inspection data coming from Container Inspection Programme launched by IMO since 1996 among its member States. The other is Hazardous Material Incident Reporting System (HMIRS) operated by Department of Transportation, U.S. Are there methods available to qualify the reliability of such data? What is the difference between data contained in the investigation reports and those provided in such sources? These raised questions are waiting to be answered by the future research.

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Appendix 1

Fire/explosion accidents emanating from container cargo areas in 1990-2009 periods

Ship name	Flag	Accident date
Ever Group	Taiwan	1990-6-14
Neptune Ruby	Singapore	1991-3-31
Bay of Bengal	Singapore	1991-3-31
Glorious Ocean	Panama	1992-4-17
Tokyo Senator	Germany	1994-4-28
President Washington	U.S.A.	1994-5-7
Contship Asia	Germany	1994-6-9
Norasia Susan	Germany	1994-6-12
California Luna	Panama	1995-4-16
Contship Pacific	Germany	1996-7-24
Contship France	Germany	1997-10-15
Sealand mariner	Marshall Islands	1998-4-18
Aconagua	Germany	1998-6-20
DG Harmony	Isle of Man	1998-11-9
Wong On No.1	HongKong	1999-5-25
CMA Djakarta	Antigua & Barbuda	1999-7-10
Ever Decent	Panama	1999-8-23
Uni Winner	Panama	2000-6-9
Saudi Jeddah	Bahamas	2000-6-11
Contship Champion	Germany	2000-6-24
Choyang Success	Panama	2000-9-19
CMA CGM Puget	Panama	2000-9-19
Kitano	Japan	2001-3-22
Wan Hai 161	Taiwan	2001-7-18
Hanjin Pennsylvania	Liberia	2002-11-11
Sloman Traveller	Antigua & Barbuda	2003-1-12
Ara J.	Antigua & Barbuda	2003-1-22
LT Grand	Italy	2003-2-17
LT Utile	Panama	2003-8-3
Sea Elegance	Singapore	2003-10-11
MSC Paraguay	Panama	2003-12-12
Csav Itajai	Marshall Islands	2004-2-28

NYK Argus	Panama	2004-10-19
Glory Bridge	Liberia	2005-3-14
Punjab Senator	Germany	2005-6-2
Norasia Taurus	Antigua & Barbuda	2005-7-16
Pac Makassar	Singapore	2005-8-5
Horizon Navigator	U.S.A.	2005-8-12
MOL Renaissance	Liberia	2005-12-29
Hyundai Fortune	Panama	2006-3-21
YM Green	Liberia	2006-8-6
YM Comfort	Taiwan	2007-3-10
Zim Haifa	Israel	2007-7-2
CMA CGM Fidelio	France	2007-7-4
MSC Roma	Liberia	2008-3-9
Chastine Maersk	Denmark	2008-8-13
Montreal Senator	Cyprus	2008-8-27
APL Peru	Antigua & Barbuda	2008-10-8
Maersk Itea	Liberia	2008-11-3
Tini From	Antigua & Barbuda	2008-11-27
YM Union	Liberia	2008-12-2
Hyundai Long Beach	U.K.	2009-2-5
Iran Ilam	Iran	2009-2-5
MOL Prosperity	Panama	2009-7-2
MSC Ines	Panama	2009-7-15

Total 55 accidents in 1990-2009 periods

Source: data retrieved from Lloyd’s MIU casualty database and English publications from maritime accident investigation website of different countries

Appendix 2

Coding of Human factor retrieved from investigation reports

Only factors within the scope of shipping company which is regarded as the main organization to be analyzed will be retrieved from the reports. The other human factors contained in the reports will be discussed in the remarks such as the unsafe acts by the shipper or the maintenance organization.

The “MOR U.K.” accident

(Source: retrieved from:
http://www.tsb.gc.ca/eng/rapports-reports/marine/1995/index.asp)

No human contributing factor revealed.
(Remark: there is one contributing factor of shipper indentified by the report. That is the suspect tank containing between 20 and 80 percent of their capacity should not offered for transport by ship. But the information provided in the report is not enough to trace other contributing factors back to the higher level of category.)

The “SEALAND MARINER” accident

(Source: retrieved from:
http://www.register-iri.com/content/maritimese/investigationreports.cfm)

UNSAFE ACTS:
AE 103 FAILURE TO SEE AND AVOID
The stowage planner of the charterer failed to perceive the undeclared dangerous

cargoes listed in the shipping paper, and mistakenly stowed them into cargo hold without ventilation which is contrary to the Code.

AE 201 RISK ASSESSMENT DURING OPERATION

The maintenance team failed to adequately evaluate the explosive risks associated with the hot work around the container. The concentration of explosive gas in the No.7 hold emanating from the dangerous cargoes container is not detected by the crew, and finally ignited by the falling hot slag.

PRECONDITIONS:

PE 205 BARRIERS

The placarding and marking of the container and the declaration of the dangerous cargo are regarded as preventive barriers. In this case, the shipper not declaring the dangerous cargo is regarded as a failed barrier.

SUPERVISION:

SI 001 LEADERSHIP/SUPERVISION/OVERSIGHT INADEQUATE

The chief mate failed to review the cargo documents for possible oversight on the part of the person preparing the documents (the stowage planner of the charterer).

SI 004 SUPERVISION-POLICY

Lacking of enough policy on guiding the hot work around the container area on board ships contributes to the ignorance of the maintenance crew, despite that several studies have shown that shippers do not always follow IMDG guidelines when packing containers, and as a result, the atmosphere in or around the container may present an unexpected explosive or flammable environment.

SI 007 FAILED TO PROVIDE CURRENT PUBLIC/ADEQUATE TECHNICAL DATA OR PROCEDURES

The current technical information related to the risk of container cargoes, especially dangerous containers, is not provided to the master and chief mate early enough before departure by the charterer.

(Remark: There are three contributing factors with regard to the shipper. One is failing to properly declare and document the hazard class on the shipping papers presented to the vessel`s agent; The second is failing to mark and placard the container; The last is failing to pack the cargo in accordance with the IMDG Code requirements. But the information provided in the report is not enough to trace other contributing factors back to the higher level of category.)

The “WING ON NO.1” accident

(Source: retrieved from: http://www.mardep.gov.hk/en/publication/ereport.html)

UNSAFE ACTS:

AE 103 FAILURE TO SEE AND AVOID

The stowage planner of the company failed to perceive the risk of hydrogen explosion, thus not provide ventilation to prevent the accumulation of hydrogen.

SUPERVISION:

SI 007 FAILED TO PROVIDE CURRENT PUBLIC/ADEQUATE TECHNICAL DATA OR PROCEDURES

The current technical information related to the dangerous cargo manifest is not possessed by the crew causing the non-awareness of the risk existing currently.

ORGANIZATION:

OR 003 TRAINING

As revealed in the latter investigation report on the regulatory scheme of this issue, it was found that little has been done in providing or facilitating the provision of practical training to operators and workers on the safety precautions and safe working practices.

FS 001 RULE-MAKING PROCESS

The later investigation report on the regulatory scheme on this issue revealed that the existing legislation is inadequate in regulating the conveyance of used motor vehicles/cycles and their spare parts. It further addressed that the deterrence from the safety guidelines for the transport of motor vehicles/cycles is insufficient and too indirect.

The "KITANO" accident

(Source: retrieved from:

http://www.tsb.gc.ca/eng/rapports-reports/marine/2001/index.asp)

(Remark: There is no cause and contributing factors identified in this accident investigation. The main reason is that the source of ignition could not be identified even though the source of fire has been identified as "activiated carbon pellet impregnated with potassium hydroxide (caustic potash)". The investigation further explained that "in spite of the fact that the carbon pellets showed signs of self heating", they were not required to be classified as a class 4.2, packing group III cargo, because they were transported in package with a volume of not more than 3 squre meters.")

The “SEA ELEGANCE” accident

(Source: DSC 10/INF.2, retrieved from IMO document website)

UNSAFE ACTS:

AE 103 FAILURE TO SEE AND AVOID

The stowage planner of shipping company failed to perceive the undeclared cargo, “Calcium Hypochlotire”, and mistakenly stowed it on the bottom tier, against the port H.O. service tank, with the engine room bulkhead in the front which are contrary to the Code.

PRECONDITION:

PE 205 BARRIERS

The placarding and labeling on the container and the declaration on the dangerous cargo document are regarded as preventive barriers. In this case, the shipper not declaring the dangerous cargo is regarded as failed barrier.

SUPERVISION:

SI 007 FAILED TO PROVIDE CURRENT PUBLIC/ADEQUATE TECHNICAL DATA OR PROCEDURES

After the accident happened, it took the ship more than 24 hours to present a full manifest of all cargo to the authority. This proved itself that the shipping company, in her organizational level, failed to provide adequate information of cargo which is necessary for the fire mitigation.

ORGANIZATION:

FS 001 RULE-MAKING PROCESS

After a number of incidents with Calcium Hypochlorite, the Salvage Association and the International Group of P&I Clubs issued pertinent recommendations, which addressed higher risks of carrying Calcium Hypochlorite than IMDG Code does. Plus, Recommendations of this investigation report has suggested that the IMO DSC sub-committee should be asked to further investigate the carriage requirements of Calcium Hypochlorite and amend the IMDG Code as appropriate. The serious thought should be given to carry Calcium Hypochlorite in refrigerated containers, specially where the transit takes place in or through the tropics, which addressed higher risk of carriage of Calcium Hypochlorite in or through the tropics than IMDG Code does.

(Remark: One contributing factor that the dangerous cargo is not declared by the shipper is identified, But the information provided in the report is not enough to trace other contributing factors back to the higher level of category)

The “LT UTILE” accident

(Source: retrieved from China Maritime Safety Administration)

No human factor revealed in the report.

(Remark: Even though the source of fire is identified, but the source of ignition is not because the whole cargo and container are destroyed by the fire, resulting in no proof to testify the contributing factor to the fire. But the investigator tried to identify the risk of self ignition of subject cargo especially when contacting with reducer agent surrounding it after leaking from the collapsed package during long time transportation.)

The “CSAV ITAJAI” accident

(Source: DSC 10/INF.2 , retrieved from IMO document website)

UNSAFE ACTS:

AE 103 FAILURE TO SEE OR AVOID

The stowage planner failed to perceive and react to the situation that the subject container was stowed under deck (contrary to IMDG Code requirements), which contains the temperature sensitive cargo inside. To make the situation even worse, the container is put adjacent to the engine room.

PRECONDITIONS:

PE 202 AUTOMATION

Reliance was placed on a computer program/disc input to highlight the problematic stowage, but the system failed to indicate the UN3341 Thiourea Dioxide requires “on deck” category D stowage only.

SUPERVISION:

SI 001 LEADERSHIP/SUPERVISION/OVERSIGHT INADEQUATE

The second physical check with the IMDG Code is overlooked by the captain since the first electric check carried out has shown no alarm. The supervision and oversight from shipping company and the captain was not enough to identify the stowage hazard, and finally created the unsafe situation.

SI 007 FAILED TO PROVIDE CURRENT PUBLIC/ADEQUATE TECHNICAL DATA OR PROCEDURES

After the accident happened, it took the ship more than 5 days to present the cargo manifest in No.6 hold to the authority. This proved itself that the shipping company, in her organizational level, failed to provide adequate cargo information to master or his representive in advance of loading, which maybe is necessary for proper stowage and safe carriage of the cargo.

ORGANIZATION:

FS 001 RULE-MAKING PROCESS

It is recommended that further precautionary measures should be considered, by the IMO DSC subcommittee, to control the temperature of "Thiourea Dioxide" throughout the carriage process, like stowage away from radiant heat or for carriage in reefer container or ventilation.

The "CMV PUNJAB SENATOR" accident

(Source: investigation report number:187/05, retrieved from the publication of the website : http://www.bsu-bund.de/)

UNSAFE ACTS:

AE 103 FAILURES TO SEE OR AVOID

The stowage planner failed to perceive the situation that the rechargeable batteries were stowed directly against the partition wall to the heavy oil settling tank in the cargo hold 6 for 14 days, resulting in the high temperature of carriage.

PRECONDITIONS:

PE 214 CARGO SPACE SYSTEM KNOWLEDGE

The stowage planner has no knowledge about ship's drawing, resulting in stowing temperature sensitive rechargeable batteries against the partition wall to the heavy oil settling tank in the cargo hold no.6.

SUPERVISION:

SI 001 LEADERSHIP/SUPERVISION/OVERSIGHT INADEQUATE

The supervision and oversight from shipping company and the captain was not enough to identify the stowage hazard, and finally created the unsafe situation.

SI 007 FAILED TO PROVIDE CURRENT PUBLIC/ADEQUATE TECHNICAL DATA OR PROCEDURES

The technical information, ship's drawing of cargo hold no.6, related to the cargo stowage is not provided to the charterer who is in charge of cargo stowage, resulting in stowing temperature sensitive rechargeable batteries against the partition wall to the heavy oil settling tank in the cargo hold no.6.

SI 007 FAILED TO PROVIDE CURRENT PUBLIC/ADEQUATE TECHNICAL DATA OR PROCEDURES

The information related to subject cargo containers is not directed to the vessel's command, who thus failed to direct his attention to the risk resulting from the mistaken stowage of the cargo.

ORGANIZATION:

OR 205 POOR SHIP DESIGN

The shipbuilding regulations should be reviewed in order to insulate cargo from sources of heat due to vessel operations.

FS 001 RULE-MAKING PROCESS

It is recommended that further precautionary measures should be considered, by the

IMO DSC subcommittee, to designate the NiMH rechargeable batteries as dangerous cargo or cargo to be cooled.

The “KOTA PAHLAWAN” accident

(Source: retrieved from:
http://www.atsb.gov.au/publications/safety-investigation-reports.aspx?mode=Marine)

ORGANIZATION:

FS 001 RULE-MAKING PROCESS

The ATSB has advised that xanthates have a recognized capacity to emit the odour of carbon disulphide even when packaged in accordance with the IMDG Code and an odour from xanthates shipments, similar to Kota Pahlawan`s, is commonplace according to their Australian importers. This suggests that the information for xanthates and requirements for their carriage, in particular the packaging, provided in the Code is not enough to address the hazard, and thus should be reviewed.

(Remark:The xanthates carried by Kota Pahlawan were not hermetically sealed strictly by the shipper in accordance with the IMDG Code. This is also regarded as commonplace that an odour coming out in the packing industry according to the investigation report. But the information provided in the report is not enough to trace other contributing factors back to the higher level of category.)

The “DUTCH NAVIGATOR” accident

(Source: investigation report number: 37/2002, retrieved from:
http://www.maib.gov.uk/publications/investigation_reports/2002/dutch_navigator.cfm)

UNSAFE ACTS:

AE 103 FAILURE TO SEE AND AVOID

The mate failed to be aware of the overstowage requirement from the IMDG Code and relevant UK regulation, and ultimately overstowed the tank container on top of each other.

AE 103 FAILURE TO SEE AND AVOID

The mate failed to see that excessive container stack masses has exceeded the recommendation from the cargo securing manual, maybe resulting in the excessive racking load.

SUPERVISION:

SI 001 LEADERSHIP/SUPERVISION/OVERSIGHT INADEQUATE

Master failed to recognize the overstowage by the mate of the tank container on top of each other.

SI 001 LEADERSHIP/SUPERVISION/OVERSIGHT INADEQUATE

Master failed to recognize the excessive container stack masses, maybe resulting in the excessive racking load.

SI 007 FAILED TO PROVIDE CURRENT PUBLIC/ADEQUATE TECHNICAL DATA OR PROCEDURES

It is found during investigation that the UK regulation relevant to the dangerous cargoes carriage was not provided on board ship.

(Remark: The framework and the liner integrity of the tank container were impaired due to the improper repair by the maintenance organization, contributing to the collapse of the framework and the leakage of the content. But the information provided in the report is not enough to trace other contributing factors back to the higher level of category.)

The "CMA CGM Fidelto" accident

(Source: retrieved from China Maritime Safety Administration)

No human factor revealed in the report.

(Remark: the investigation did not reveal the causes of the explosion, and failed to trace back to other higher level human contributing factors.)

The "Hanjin London" accident

(Source: investigation report number:304/06, retrieved from the publication of the website : http://www.bsu-bund.de/)

No human factor revealed in the report.

(Remark: the primary cause of the accident was no longer possible to be identified by the investigation.)

Appendix 3

Ghirxi's Adapted HFACS Framework and Taxonomy

Nanocodes for Phase I of the Research Study

Adapted from the Human Factors Analysis and Classification System *(HFACS)*

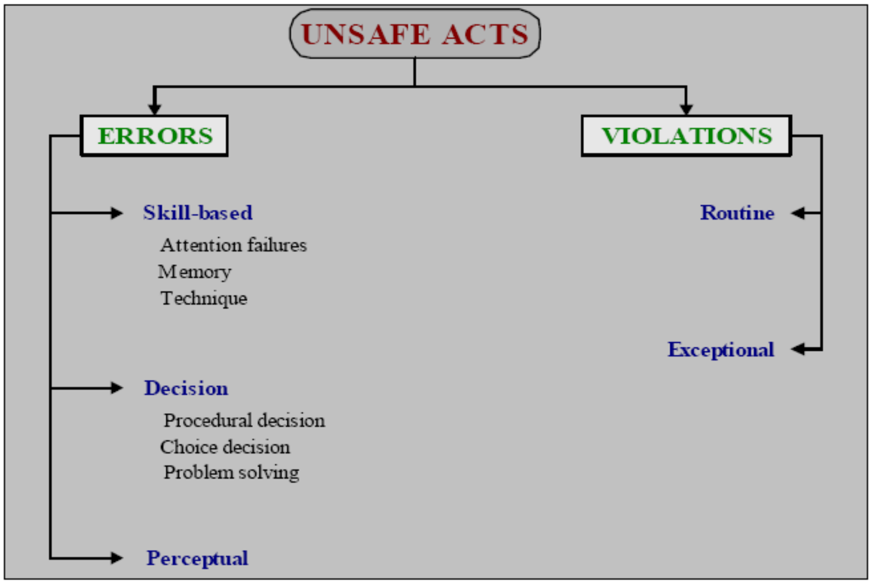
Guidelines for Accident Report Rating

in the use of a modified

for Ships' Machinery Space Fires and Explosions

UNSAFE ACTS

UNSAFE ACTS



ERRORS AE xxx

Skill-based errors AE 100

AE	101	Inadvertent use of equipment, control and switches
AE	102	Task overload
AE	103	Failure to see and avoid
AE	104	Distraction
AE	105	Poor techniques/seamanship
AE	106	Over/under-control of the system
AE	107	Over-reliance on automation
AE	108	Negative habit
AE	109	Checklist error
AE	110	Omitted step in procedure
AE	111	Procedures not used
AE	112	Failed to prioritise attention

Decision and judgement errors AE 200

AE	201	Risk assessment during operation
AE	202	Task misprioritisation
AE	203	Necessary action - rushed
AE	204	Necessary action - delayed
AE	205	Warning ignored
AE	206	Wrong decision making during operation

Perceptual errors AE 300

AE	301	Error due to misperception
AE	302	Error due to misjudged parameters

VIOLATIONS AV xxx

Routine AV 400

AV	401	Violation based on risk assessment
AV	402	Inadequate briefing for job
AV	403	Operated when unauthorised
AV	404	Violated training rules
AV	405	Failed to comply with manuals
AV	406	Violated standing orders and regs
AV	407	Failed to inspect after alarm

Exceptional AV 500

AV	501	Exceeded limits of system
AV	502	Accepted unnecessary hazards
AV	503	Not qualified as engineer officer
AV	504	Unauthorised to operate beyond design criteria

UNSAFE ACTS

Acts: Factors that have happened on board the vessel where the accident/incident has happened. Acts are active actions committed by the crew members, resulting in an error or an unsafe situation. Acts are not limited to marine engineers, irrespective of whether they form part of an engine-room watch system.

ERRORS: Factors in a mishap when mental or physical activities of the crew members fail to achieve their intended outcome as a result of skill-based, perceptual, or judgement and decision making errors leading to an unsafe situation. Errors are unintended. **AE xxx**

Skill-based errors (AE 100) – Factors in a mishap when errors occur in the crew member's execution of a routine, highly practiced (automated) task relating to procedure, training or proficiency and result in an unsafe situation.	
AE 101	A factor when the individual's movements inadvertently activate or deactivate equipment, controls or switches when there is no intent to operate the control or device. This action may be noticed or unnoticed by the individual.
AE 102	A factor when the individual fails to achieve his intentions because it is expected that a considerable number of cues be processed in a critical time period.
AE 103	A factor when an individual fails to perceive and react to a situation, resulting in an undesired outcome.
AE 104	A factor when an individual inadvertently fails to render the necessary attention to a particular detail due to the unfolding situation.
AE 105	A factor when an individual's techniques fall short of expected engineering techniques and good seamanship practices.
AE 106	A factor when an individual responds inappropriately to conditions by either over-controlling or under-controlling the machinery space system. The error may be a result of preconditions or a temporary failure of coordination.
AE 107	A factor when an individual relies on automation to the extent that he is unaware of the status of the system and is not able to deduce the corrective action to mitigate the unfolding situation.
AE 108	A factor when an individual aptitude reflects a regular negative overt expression of one's own personality.
AE 109	A factor when the individual, through an act of omission or commission, either makes a checklist error or fails to run an appropriate checklist and this failure results in an unsafe situation.
AE 110	A factor when the individual, misses critical step/s in a procedural activity due to memory failures when acting under stress.
AE 111	A factor when the individual does not make use of an established procedure.
AE 112	A factor when an individual inadvertently fails to prioritise attention due to memory failures when acting under stress.

Decision and judgement errors (AE 200) – Factors in a mishap when behaviour or actions of the individual proceed as intended yet the chosen plan proves inadequate to achieve the desired end-state and results in an unsafe situation.	
AE 201	When the individual fails to adequately evaluate the risks associated with a particular course of action and this faulty evaluation leads to inappropriate decision and subsequent unsafe situation. This failure occurs in real-time when formal risk-assessment procedures are not possible.
AE 202	When the individual does not organise, based on accepted prioritisation techniques, the tasks needed to manage the immediate situation.
AE 203	When the individual takes the necessary action as dictated by the situation but performs these actions too quickly and the rush in taking action leads to an unsafe situation.
AE 204	When the individual selects a course of action but elects to delay execution of the actions and the delay leads to an unsafe situation.
AE 205	When a caution or warning is perceived, understood but ignored by the individual, leading to an unsafe situation.
AE 206	When the individual, through faulty logic selects the wrong course of action in a time-constrained environment.

Perceptual errors (AE 300) – Factors in a mishap when misperception of an object, threat or situation (such as visual, auditory, proprioceptive, or vestibular illusions, cognitive or attention failures) results in human error.	
AE 301	When the individual acts or fails to act based on an illusion, misperception or disorientation state and this act or failure to act creates an unsafe situation.
AE 302	When an individual acts or fails to act appropriately due to degraded or unusual sensory input, leaving the individual to make a decision based on faulty information. It is the crew member's response to the illusion or disorientation that is classified as a perceptual error and not the illusion or disorientation per se.

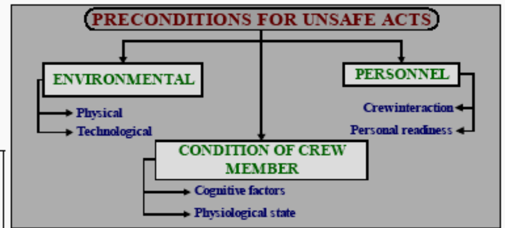
VIOLATIONS: Factors in a mishap when the actions of the operator represent wilful disregard for rules and instructions and lead to an unsafe situation. **AV xxx**

Routine violations (AV 400) – Factors in a mishap when violations are committed by crew members in a habitual manner and are often tolerated by line and organisational management.	
AV 401	A factor when the consequences/risk of violating published procedures were recognised, consciously assessed and honestly determined by the individual or crew to be the best course of action. Routine "work-arounds" and unofficial procedures that are accepted by the organisation on board as necessary for operations are also captured under this code.
AV 402	A factor when a crew member carries out a routine job without the adequate familiarisation required in the SMS of the company.
AV 403	A factor when a crew member wilfully operates or maintains a piece of equipment or auxiliary machinery without the necessary consent required by the SMS of the company. Consent may either be written in the form of permits of verbal instructions.
AV 404	A factor when a crew member wilfully operates or maintains a piece of equipment or auxiliary machinery without being provided with the necessary theoretical and practical training.
AV 405	A factor when a crew member wilfully operates or maintains a piece of equipment or auxiliary machinery without observing the instructions provided in the manufacturer's manual.
AV 406	A factor when a crew member wilfully operates or maintains a piece of equipment or auxiliary machinery without observing machinery space standing orders and regulations.
AV 407	A factor when following an alarm, a crew member wilfully fails to take corrective or remedial actions to safeguard the operation of the equipment or auxiliary machinery.

Exceptional violations (AV 500) – Factors in a mishap when violations have been committed in exceptional circumstances. These violations neither reflect the typical character of the crew member nor are condoned by the management of the vessel. Violations are exceptional not because they are extreme in nature but because they do not represent the typical behaviour of the crew member.	
AV 501	A factor when the wilful actions or inactions of the crew member result in the system operating beyond its limits.
AV 502	A factor when a crew member wilfully accepts unnecessary hazards to create an unsafe situation.
AV 503	A factor when a crew member takes over an machinery space watch without being qualified in accordance with the flag State regulations.
AV 504	A factor when the crew member wilfully sets the system to operate beyond its design parameters.

PRECONDITIONS FOR UNSAFE ACTS

PRECONDITIONS FOR UNSAFE ACTS



ENVIRONMENTAL FACTORS PE xxx

Physical environment PE 100

PE	101	Temperature - thermal stress
PE	102	Artificial light
PE	103	Vibration
PE	104	Ship movements and manoeuvres
PE	105	Toxins and cleanliness in machinery space
PE	106	Noise interference

Technological environment PE 200

PE	201	Controls and switches
PE	202	Automation
PE	203	Machinery space layout
PE	204	Communication equipment
PE	205	Barriers
PE	206	Faulty equipment
PE	207	Constrained tool use
PE	208	Complex fault
PE	209	Inaccessible maintenance area
PE	210	Machinery space configuration variability
PE	211	Parts unavailable
PE	212	Parts incorrectly labelled
PE	213	Easy to install incorrectly
PE	214	Machinery space system knowledge
PE	215	Procedure not understandable
PE	216	Procedure unavailable/inaccessible
PE	217	Incorrect procedure
PE	218	Too much/conflicting informatior
PE	219	Process/procedure update not carried out
PE	220	Incorrectly modified manufacturer's procedures

PERSONNEL FACTORS PP xxx

Crew interaction PP 100

PP	101	Machinery space leadership
PP	102	Cross-monitoring performance
PP	103	Team work delegation
PP	104	Rank gradient/power distance
PP	105	Assertiveness
PP	106	Communicating critical information
PP	107	Challenge and reply
PP	108	Maintenance plan
PP	109	Maintenance plan briefing
PP	110	Task-in-progress re-planning
PP	111	Miscommunication

Personal readiness PP 200

PP	201	Inadequate training
PP	202	Maintenance task knowledge
PP	203	Time constraints
PP	204	Pattern of poor risk judgement

CREW CONDITION PC xxx

Cognitive factors PC 100

PC	101	Inattention, repetitive and monotonous
PC	102	Channelised attention
PC	103	Confusion
PC	104	Distraction
PC	105	Checklist interference
PC	106	Emotional state
PC	107	Personality style
PC	108	Overconfidence
PC	109	Pressing
PC	110	Complacency
PC	111	Overagressive
PC	112	Excessive motivation to succeed
PC	113	Get-there-itis
PC	114	Response set
PC	115	Burnout
PC	116	Fatigue - mental
PC	117	Circadian rhythm desynchrony
PC	118	Misperception of operational condition
PC	119	Misinterpreted/misread instrument
PC	120	Expectancy
PC	121	Auditory cues
PC	122	Other cues
PC	123	Alertness (drowsiness)
PC	124	Peer pressure
PC	125	Technical/procedural knowledge
PC	126	Negative transfer

Physiological state PC 200

PC	201	Effects of PoM and OTC
PC	202	Operational injury/illness
PC	203	Sudden incapacitation/unconsciousness
PC	204	Physical fatigue
PC	205	Seasickness
PC	206	Hypoxia
PC	207	Hyperventilation
PC	208	Dehydration
PC	209	Physical task oversaturation
PC	210	Intoxication
PC	211	Nutrition
PC	212	Inadequate rest
PC	213	Unreported disqualified medical condition
PC	214	Overexcertion while off duty
PC	215	Misplaced motivation
PC	216	Inadequate motivation
PC	217	Pre-existing physical illness/injury/deficient
PC	218	Motor skill/coordination or timing deficient
PC	219	Insufficient reaction time

PRECONDITIONS FOR UNSAFE ACTS

Preconditions: Factors in a mishap if active and/or latent preconditions such as conditions of the operators, environmental or personnel factors affect practices, conditions or actions of individuals and result in human error or an unsafe situation.

ENVIRONMENTAL FACTORS: Factors in a mishap if physical or technological factors affect practices, conditions and actions of individual and result in human error or an unsafe situation. **PE xxx**

Physical environment (PE 100) – Factors in a mishap if environmental phenomena such as weather and climate affect the actions of individuals and result in human error or an unsafe situation.	
PE 101	A factor when the individual is exposed to heat resulting in compromised function, or interferes with the normal performance of duties.
PE 102	A factor when the absence, pattern, intensity or location of the light fitting prevents or interferes with safe task accomplishment.
PE 103	A factor when the intensity or duration is sufficient to adversely affect safe task accomplishment.
PE 104	A factor when acceleration forces or manoeuvres cause or contribute to damage, injury, prevent or interfere with the performance of normal duties.
PE 105	A factor when either exposure to chemical agents, fumes, fuels or oils is severe and interferes with the normal performance of normal duties or else machinery space lack of cleanliness contributes to the spread/intensity of a fire.
PE 106	A factor when any noise not directly related to the information needed for task accomplishment interferes with the individual's ability to perform that task.

Technological environment (PE 200) – Factors in a mishap if machinery space, engine control room and workshop design factors, automation or technical procedural/drawings affect the actions of individuals and result in human error or unsafe situation.	
PE 201	A factor when the location, shape, size, design, reliability, lighting or other aspect of a control or switch is inadequate and this leads to an unsafe situation.
PE 202	A factor when the design, function, reliability, use guidance, symbology, logic or other aspect of automated systems creates an unsafe situation.
PE 203	A factor when the design of machinery and layout has an adverse impact on the individual's performance.
PE 204	A factor when communication equipment is inadequate or unavailable to support machinery space job demands. This includes electronically or physically blocked transmissions. Communications can be voice, data or multi-sensory.
PE 205	A factor when other physical, functional and symbolic barriers are missing or inadequate, lead to an unsafe situation. Barriers functions captured include active, passive, preventive and reactive.
PE 206	A factor when the equipment is unsafe, directly leading to an unsafe situation or else may cause an individual to become distracted from the task due to concern for personal safety.
PE 207	A factor when the tools used are unsuitable or inadequate for the task performed and this leads to an unsafe situation.
PE 208	A factor when the fault isolation and detection is difficult, installation is error prone, multiple similar connections exist on the system or different sized fasteners can be installed in multiple locations, which can lead to an unsafe situation.
PE 209	A factor when it is a real contributor rather than an inconvenience. In such cases, the components or area to be maintained is surrounded by structure, no access doors exist in the maintenance area, there is a lack of footing space or handholds or the area is small or odd-shaped.
PE 210	A factor when similar parts on different machinery are installed differently, thereby leading to an unsafe act. This also applies to different machinery fitted on different ships.
PE 211	A factor when the part or tool is not owned or not in stock on board or is not available for procurement, even if the ship remains seaworthy.
PE 212	A factor when the hand marked labelling is incorrect or a wrong part number on the part leads to the selection of the incorrect part.
PE 213	A factor when the part can be easily installed with wrong orientation, there are no orientation indicators or connections are identical in size, colour or length, leading to an unsafe situation.
PE 214	A factor when the individual has no knowledge of the machinery space schematics and line/electrical installations.

PE 215	A factor when the individual finds the information provided problematic due to unfamiliar words, non-standard format, poor or insufficient illustrations, lack of detail or missing steps and poor writings, leading to an unsafe situation.
PE 216	A factor when a procedure does not exist, not located in a correct or usual place or near the worksite in the machinery space, leading to an unsafe situation.
PE 217	A factor when the individual finds that a procedure has missing pages, not revised, does not match machinery configuration, transferred from the source document incorrectly, steps are out of sequence or procedure does not work, leading to an unsafe situation.
PE 218	A factor when the individual finds similar procedures in different resources, which do not agree, too many references to other documents and configurations shown in different resources do not agree, leading to an unsafe situation.
PE 219	A factor when the individual uses procedures, which have been revised but not incorporated in the SMS, service bulletins by the maker not included in the SMS and document change requests are not submitted, lost or incorrectly filled, leading to an unsafe situation.
PE 220	A factor when the individual uses the procedures, which do not meet the intent of the manufacturer's procedures, non-standard steps or practices are added and the format does not match the rest of the procedure or procedures.

CREW CONDITION: Factors in a mishap if cognitive, psycho-behavioural, adverse physical state, or physical/mental limitations affect practices, conditions or actions of individuals and result in human error or an unsafe situation. **PC xxx**

Cognitive factors (PC 100) – Factors in a mishap if cognitive or attention management conditions affect the perception or performance of individuals and result in human error or an unsafe situation.	
PC 101	A factor when the individual has a state of reduction conscious attention due to a sense of security, self-confidence, boredom or a perceived absence of threat from the environment which degrades crew performance.
PC 102	A factor when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others of a subjectively equal or higher or more immediate priority, leading to an unsafe situation.
PC 103	A factor when the individual is unable to maintain a cohesive and orderly awareness of events and required actions and experiences a state characterised by bewilderment, lack of clear thinking, or (sometimes) disorientation.
PC 104	A factor when the individual has an interruption of attention and/or inappropriate redirection of attention by an environmental cue or mental process that degrades performance.
PC 105	A factor when an individual is performing a highly automated/learned task and is distracted by another cue/event that results in the interruption and subsequent failure to complete the original task or results in skipping steps in the original task.
PC 106	A factor when the individual is under the influence of a strong positive or negative emotion and that emotion interferes with duties.
PC 107	A factor when the individual's personal interaction with others creates an unsafe situation. Examples are authoritarian, over-conservative, impulsive, invulnerable, and submissive or other personal traits that result in degraded crew performance.
PC 108	A factor when the individual over-values or over-estimates personal capability, the capability of others or the capability of the machinery or equipment and this creates an unsafe situation.
PC 109	A factor when the individual knowingly commits to a course of action that presses oneself and/or one's equipment beyond reasonable limits.
PC 110	A factor when the individual's state of reduced conscious attention due to an attitude of overconfidence, undermotivation or the sense that others "have the situation under control" leads to an unsafe situation.
PC 111	A factor when an individual or crew is excessive in the manner in which one conducts a mission.
PC 112	A factor when the individual is preoccupied with success to the exclusion of other factors leading to an unsafe situation.
PC 113	A factor when an individual or crew is motivated to complete a task for personal reasons, thereby short cutting necessary procedures or exercising poor judgement, leading to an unsafe situation.

PC 114	A factor when the individual has a cognitive or mental framework of expectations that predispose oneself to a certain course of action, regardless of other cues.
PC 115	Also known as motivational exhaustion. A factor when the individual has the type of exhaustion associated with the wearing effects of high operations and personal tempo where one's operational requirements impinge on the ability to satisfy personal requirements and leads to degraded cognitive or operational capability.
PC 116	A factor when the individual's diminished mental capability is due to an inadequate recovery, as a result of restricted or shortened sleep or physical or mental activity during prolonged wakefulness. Fatigue may additionally be described as acute, cumulative or chronic.
PC 117	A factor when the individual's normal, 24-hour rhythmic biological cycle (circadian rhythm) is disturbed and degrades task performance. This is caused typically by night work or rapid movement (such as one time zone per hour) across several time zones.
PC 118	A factor when an individual misperceives or misjudges weight, volume, pressure, temperature, viscosity, density, flow rate and sea conditions within the performance envelope or other operational conditions and this leads to an unsafe situation.
PC 119	A factor when the individual is presented with a correct instrument reading but its significance is not recognised, it is misread or is misinterpreted.
PC 120	A factor when the individual expects to perceive a certain reality and those expectations are strong enough to create a false perception of the expectation.
PC 121	A factor when the auditory inputs are correctly interpreted but are misleading or disorienting or when the inputs are incorrectly interpreted and cause an impairment of normal performance.
PC 122	A factor when the inputs other than auditory are correctly interpreted but are misleading or disorienting or when the inputs are incorrectly interpreted and cause an impairment of normal performance.
PC 123	A factor when an individual exhibits lack of watchfulness and alertness leading to an unsafe situation.
PC 124	A factor when the individual is unwilling to use written information because it is seen as lack of technical skills/knowledge or has lack of individual confidence. In addition, this applies when the individuals do not question other's processes or does not follow safe operating procedures because others do not follow them.
PC 125	A factor when an individual was adequately exposed to the information needed to perform the task but did not absorb it. Lack of knowledge in this case implies no deficiency in the training programme, but rather the failure of the individual to absorb or retain the information[1].
PC 126	A factor when the individual reverts to highly learned behaviour used in previous situation but response is inappropriate or degrades performance.

[1] Exposure to information at a point in the past does not imply "knowledge" of it.

Physiological state (PC 200) – Factors in a mishap if the functioning of the body, including the physical and chemical process of cells, tissues, organs and systems and their various interaction is abnormal, resulting into a general or specific impairment, which leads to an individual making an error or leading to an unsafe act.	
PC 201	A factor when the individual takes a pharmaceutical intervention, prescribed or otherwise, that interferes with performance[2]. The effects may be direct or residual.
PC 202	A factor when due to an injury sustained during the job or a physical condition such as headaches and chronic pain, the senses and the ability to concentrate are affected and the time to react increases, resulting in a degradation of performance.
PC 203	A factor when the individual suffers abnormal loss of awareness of the self and of one's surroundings, resulting in an unsafe situation.
PC 204	A factor when the individual's diminished physical activity is due to overuse (time/relative load) during the job, degrading task performance[3].
PC 205	A factor when the symptoms of seasickness impair normal performance. Seasickness includes, nausea, sweating, flushing, headache, stomach awareness, malaise and vomiting.
PC 206	A factor when the individual has insufficient oxygen supply to the body leading to an impairment of function.
PC 207	A factor when the effect of ventilating above the physiological demands of the body causes the individual's performance capabilities to be degraded.
PC 208	A factor when the performance of the individual is degraded due to dehydration as a result of excessive fluid losses due to insufficient fluid intake.
PC 209	A factor when the number or complexity of manual tasks in a compressed time period exceeds an individual's capacity to perform.
PC 210	A factor when the acute or residual effects of alcohol or drug overdose impair performance or create an unsafe situation.
PC 211	A factor when the individual's nutritional state or poor dietary practices are inadequate to fuel the brain and body functions resulting in degraded performance.
PC 212	A factor when the opportunity to rest was provided but the individual failed to take the opportunity to rest.
PC 213	A factor when the individual intentionally operates machinery or engages in maintenance tasks with a known disqualifying medical condition that results in an unsafe situation.

[2] This includes nicotine or caffeine in sufficient quantities to cause impairment of normal function. This also includes chemical compound taken for purposes of prevention of disease, treatment of disease, weight management, mood alteration, birth control or sleep management *etc.*

[3] The effects of prolonged physical activity, or the effects of brief but relatively extreme physical activity, of which takes either an individual's physical endurance or strength beyond the individual's normal limits.

PC 214	A factor when the relative physical state of the individual, in terms of a regular rigorous exercise programme or a physical active lifestyle, is not adequate to support machinery space demands.
PC 215	A factor when an individual replaces the primary goal of a task with a personal goal.
PC 216	A factor when the individual's motivation to accomplish a task is weak or indecisive.
PC 217	A factor when a qualified crew member has physical problems either before joining the vessel or during his engagement on board but before the occurrence of the mishap.
PC 218	A factor when the individual lacks the required psychomotor skills, coordination or timing skills necessary to accomplish the task attempted.
PC 219	A factor when the individual is required to respond quickly but the reaction time available to process all the possibilities or choices thoroughly is critically short and exceeds one's ability.

PERSONNEL FACTORS: Factors in a mishap if self-imposed stressors or crew resource management affect practices, conditions or actions of individuals and result in human error or an unsafe situation. **PP xxx**

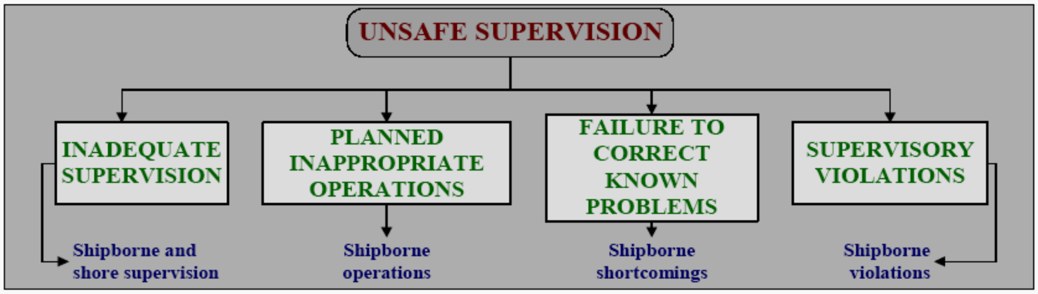
Crew interaction (PP 100) – Factors in a mishap if poor communication skills and team coordination affect the perception or performance of individuals and result in human error or an unsafe situation.	
PP 101	A factor when the machinery space leadership techniques failed to facilitate a proper crew climate, to include the establishment and the maintenance of an accurate and shared understanding of the evolving voyage and plan on the part of all crew members.
PP 102	A factor when crew or team members failed to monitor, assist or back-up each other's actions and decisions[4].
PP 103	A factor when the crew members failed to actively manage the distribution of mission tasks to prevent the overloading of any crew member.
PP 104	A factor when the difference in rank of the machinery space staff or ship caused the crew performance capabilities to be degraded. In addition, this applies to conditions where formal or informal authority gradient is too steep or too flat across a crew and this condition degrades collective or individual performance.
PP 105	A factor when individuals failed to state critical information or solutions with appropriate persistence.
PP 106	A factor when known critical information was not provided to appropriate individuals in an accurate or timely manner.
PP 107	A factor when communications did not include supportive feedback or acknowledgement to ensure that crew members correctly understood announcements or directives.
PP 108	A factor when an individual or crew member failed to complete all preparatory tasks associated with planning the job, resulting in an unsafe situation. Planning the job includes information collection and analysis, coordinating activities within the crew and with appropriate external agencies, contingency planning, and risk assessment.
PP 109	A factor when information and instructions provided to individuals, crews, or teams were insufficient, or participants failed to discuss maintenance jobs and strategies to cope with contingencies.
PP 110	A factor when crew members fail to adequately reassess changes in their dynamic environment during job execution and change their task plans accordingly to ensure adequate management of risk.
PP 111	A factor when correctly communicated information is misunderstood, misinterpreted, or disregarded.

[4] Factor '**PP102**' captures situations where 'team stability' collapses in the face of an emergency leading to chaos.

Personal readiness (PP 200) – Factors in a mishap if the crew member demonstrates disregard for rules and instructions that govern the individuals readiness to perform, or exhibits poor judgement when it comes to readiness and results in human error or an unsafe situation. This does not only include personal readiness failures because rules or regulations have been broken.	
PP 201	A factor when inadequate familiarisation training leads to human error or an unsafe situation.
PP 202	A factor when job is performed by individual for the first time or job is performed in the wrong sequence.
PP 203	A factor when frequent work interruptions, failure to perform preparation tasks first, too many tasks are scheduled for limited time period or task necessary for safety is not performed first, leading to a human error or an unsafe act.
PP 204	A factor when the risk-evolution exercise neither offers an advise on each of the identified hazards nor does it give a comprehensive judgement on whether the entire system is safe enough.

UNSAFE SUPERVISION

UNSAFE SUPERVISION



INADEQUATE SUPERVISION SI xxx

Shipborne and shore supervision SI 000

SI	001	Leadership/supervision/oversight inadequate
SI	002	Supervision - modelling
SI	003	Local training issues/programmes
SI	004	Supervision - policy
SI	005	Supervision - personality conflict
SI	006	Supervision - lack of feedback
SI	007	Failed to provide current public./adequate technical data or procedures
SI	008	Failed to provide adequate rest period
SI	009	Lack of accountability
SI	010	Perceived lack of authority
SI	011	Failed to track qualifications
SI	012	Failed to track performance
SI	013	Over-tasked/untrained officer at management level
SI	014	Loss of supervisory situational awareness
SI	015	Lack of communication with company representatives

PLANNED INAPPROPRIATE OPERATIONS SP xxx

Shipborne operations SP 000

SP	001	Ordered/led maintenance beyond capability
SP	002	Poor crew interaction
SP	003	Limited recent experience
SP	004	Limited total experience
SP	005	Proficiency
SP	006	Lack of risk assessment - formal
SP	007	Authorised unnecessary hazard
SP	008	Failed to provide adequate brief time / supervision
SP	009	Failed to provide adequate opportunity for crew rest
SP	010	Excessive tasking/loading

FAILED TO CORRECT KNOWN PROBLEMS SF xxx

Shipborne related shortcomings SF 000

SF	001	Failed to correct inappropriate/risky behaviour
SF	002	Failed to correct a safety hazard
SF	003	Failed to initiate corrective action
SF	004	Failed to report unsafe tendencies
SF	005	Failed to update manual
SF	006	Parts / tools incorrectly labelled

SUPERVISORY VIOLATIONS SVxxx

Shipborne violations SV 000

SV	001	Engaged unqualified crew
SV	002	Failed to enforce rules/regs
SV	003	Violated procedures
SV	004	Authorised unnecessary hazard
SV	005	Wilful disregard of authority
SV	006	Inadequate documentation

UNSAFE SUPERVISION

Supervision: Factors in a mishap if the methods, decisions or policies of the supervisory chain of command (officers at management level over operational and support levels) directly affect practices, conditions, or actions of individual and result in human error or an unsafe situation.

INADEQUATE SUPERVISION: Factors in a mishap when supervision proves inappropriate or improper and fails to identify hazard, recognize and control risk, provide guidance, training and/or oversight and results in human error or an unsafe situation. **SI xxx**

Shipborne and shore supervision (SI 000) – Factors in a mishap when the interaction between officers at management level and the ship's ISM managers has a direct bearing on the day-to-day running and operation of the machinery space, leading to an unsafe situation.	
SI 001	A factor when the availability, competency, quality, or timeliness of leadership, supervision or oversight does not meet task demands and creates an unsafe situation. Inappropriate supervisory pressures are also captured under this code[5].
SI 002	A factor when the individual's learning is influenced by the behaviour of peers and supervisors and when the learning manifests itself in actions that are either inappropriate to the individual's skill level or violate standard procedures and lead to an unsafe situation.
SI 003	A factor when one-time or recurrent training programmes, upgrade programmes, transition programmes or any other local training is inadequate or unavailable (*etc*) and this creates an unsafe situation[6].
SI 004	A factor when policy, guidance, or lack of a policy on guidance leads to an unsafe situation.
SI 005	A factor when crew members at management, operational and/or support levels experience a "personality conflict" that leads to a dangerous error in judgement/action.
SI 006	A factor when information critical to a potential safety issue had been provided to officers at management level without feedback to the source (*e.g.* DPA) *i.e.* failure to close the loop.
SI 007	A factor when current technical information related to the running of the machinery space or maintenance of machinery in the machinery space is not provided to other crew members at management level and/or at operational and support level leading to a dangerous error in judgement/decision.

5 Factor '**SI 001**' also captures lack of records on crew performance data.

6 The failure of an individual to absorb the training material in an adequate training programme does not indicate a training programme problem. Capture these factors under '**PC 125**'. The failure of an individual to recall learned information under stress or while fatigued despite attending an adequate training programme does not indicate a training programme problem. Capture these factors under '**PC 103**', '**PC 104**' and '**PC 126**'.

SI 008	A factor when officers at management level do not distribute breaks throughout work periods, particularly when things are routine, repetitive, long and/or monotonous.
SI 009	A factor when officers at management level do not make sure that crew members at operation and support level successfully fulfil their assigned responsibility.
SI 010	A factor when the officers in management level are not assigned the necessary resources to accomplish goals and objectives.
SI 011	A factor when officers at management level do not track a crew member's qualifications, resulting in that individual serving in a particular capacity or perform a particular function or task which is higher than that specified in his document[7].
SI 012	A factor when realistic, understandable, measurable, and achievable objectives are not set, leading to unclear and misunderstood objectives.
SI 013	A factor when the officer at management level is either untrained or else the situation demands exceed his ability to oversee the task performed by the other officers.
SI 014	A factor when for some reason other than lack of training and/or situation demands, an officer at management level does not oversee the task performed by other officers.
SI 015	A factor when officers at management level do not communicate safety critical information to the company representatives, leading to an unsafe situation or a situation not tackled in an adequate manner[8].

[7] An individual signing on a vessel without the necessary documents that the STCW Convention requires as evidence of having met (or achieved) all relevant Convention requirements, is also captured under '**SI 011**'.

[8] Company representatives refer to safety managers, superintendents and/or the DPA.

PLANNED INAPPROPRIATE OPERATIONS: Factors in a mishap when supervision fails to adequately assess the hazards associated with an operation and allows for unnecessary risk. It is also a factor when supervision allows non-proficient or inexperienced personnel to attempt tasks beyond their capability or when crew complement is inappropriate for the task. **SP xxx**

Shipborne operations (SP 000) – Factors in a mishap when the interaction between officers at management and operational levels and support levels has a direct bearing on the day-to-day running and operation of the machinery space, leading to an unsafe situation.	
SP 001	A factor when an officer at management level directs crew members to undertake a task beyond their skill level or beyond the capabilities of their equipment.
SP 002	A factor when the interaction of senior officers at management level and junior crew members at operation and support levels leads to poor communication and coordination problems.
SP 003	A factor when the officer at management level selects an individual who's experience for either a specific task, event or scenario is not sufficiently current to permit safe task execution.
SP 004	A factor when an officer at management level selects an individual who has either infrequently or rarely performed a task, or participated in a specific scenario.
SP 005	A factor when an individual is not proficient in a task or event.
SP 006	A factor when an officer at management level does not adequately evaluate the risks associated with a task or when pre-task risk assessment tools or risk assessment programmes are inadequate.
SP 007	A factor when management level authorises a task or a task element that is unnecessarily hazardous without sufficient cause or need. In addition, it includes **un**intentional scheduling of crew members for a task that they are not qualified to perform.
SP 008	A factor when due to the prevailing circumstances, offices at management level do not brief and/or supervise the subordinates.
SP 009	A factor when due to the prevailing circumstances management does not provide an opportunity for crew rest[9].
SP 010	A factor when due to the prevailing circumstances management authorises tasks and workload in excess of the capability of the individual.

[9] Factor '**SP 009**' captures instances during emergency operations, as compared to rest periods captures under '**SI 008**'.

FAILED TO CORRECT KNOWN PROBLEMS: Factors in a mishap when officers at management level fail to correct known deficiencies in documents, processes or procedures, or fail to correct inappropriate or unsafe actions of individuals, and this lack of supervisory action creates an unsafe situation. **SF xxx**

Shipborne shortcomings (SF 000) – Factors in a mishap when officers at management level do not comply with safety management practices, leading to an unsafe situation.	
SF 001	A factor when officers at management level fail to identify a crew member at operation or support level who exhibits recognisable risky behaviour or unsafe tendencies or fail to institute remedial actions when an individual is identified with risky behaviours or unsafe tendencies.
SF 002	A factor when officers at management level fail to correct a safety hazard or factors which might trigger off an accident.
SF 003	A factor when, following a safety analysis, decisions on corrective actions are not implemented.
SF 004	A factor when officers at management level fail to correct known hazardous practices, conditions or guidance that allow for hazardous practices within the scope of one's command.
SF 005	A factor when revised procedures have not been incorporated in the SMS, service bulletins by the maker not included in the SMS and document change made by the company are lost or incorrectly filed, leading to an unsafe situation.
SF 006	A factor when due to lack of management level oversight in the stock taking of spare parts or tools, hand marked labelling is incorrect or a wrong part number on the part leads to the selection of the incorrect part.

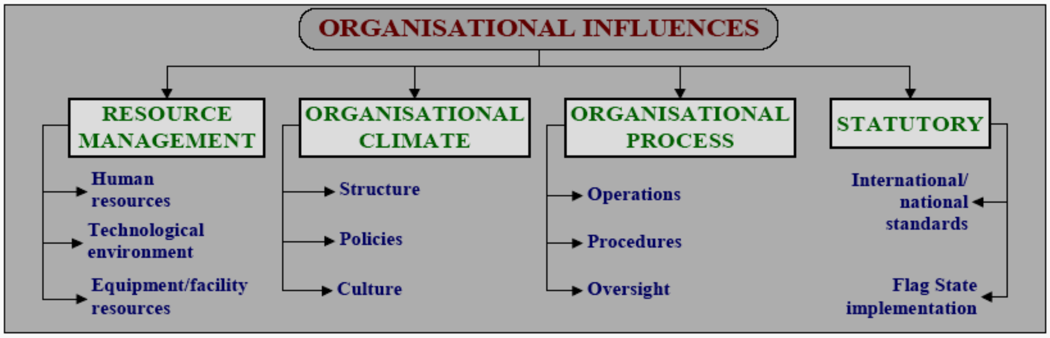
SUPERVISORY VIOLATIONS: Factors in a mishap when officers at management level wilfully disregards instructions, guidance, rules, or operating instructions whilst managing organisational assets and this lack of supervisory responsibly creates an unsafe situation. **SV xxx**

Shipborne violations (SV 000) – Factors in a mishap when violations committed by the operating and support level machinery space crew members are tolerated by officers at management level, leading to an unsafe situation.	
SV 001	A factor when a master inappropriately signs-on an individual on board his ship even though he is aware that the individual does not possess the necessary documents or has not met the necessary qualifications prescribed in the STCW Convention or the national requirements of the flag State of the ship.
SV 002	A factor when organisational and operating rules have not been enforced by the normally constituted authority.
SV 003	A factor when an officer at management level directs an officer at operation level and/or a crew member at support level to infringe existing regulations, instructions or technical guidance.
SV 004	A factor when an officer at management level directs another crew member to carry out a task, which does not necessarily violate a written procedure but nonetheless goes against established seamanship practices.
SV 005	A factor when rather than following formally established and constituted authority, an individual at management level follows unwritten and unofficial policy, which leads to an unsafe situation or else wilfully encourages disregard of authority in his subordinates[10].
SV 006	A factor when officers at management level allows for the use of inadequate/obsolete instructions or technical guidance.

[10] Factor '**SV 005**' is very closely related to factors captured under '**OC 004**'. Nonetheless, raters need to distinguish between an officer following an unwritten instruction or an unofficial policy and an officer exerting overriding authority, emanating from a resilient organisational system.

ORGANISATIONAL INFLUENCES

ORGANISATIONAL INFLUENCES



RESOURCE MANAGEMENT OR xxx

Human resources OR 000

OR	001	Inadequate safe manning
OR	002	Selection
OR	003	Training

Technological resources OR 100

OR	101	Excessive cost cutting
OR	102	Financial resources/support

Equipment/facility resources OR 200

OR	201	Engineer support
OR	202	Acquisition policies/design process
OR	203	Attrition policies
OR	204	Accession/selection policies
OR	205	Poor engine-room design
OR	206	Poor engine-room machinery design
OR	207	Purchasing of unsuitable equipment
OR	208	Failure to correct known design flaws
OR	209	Shortage of tools

ORGANISATIONAL CLIMATE OC xxx

Structure OC 000

OC	001	Chain-of-command
OC	002	Communication
OC	003	Accessibility/visibility of supervisor
OC	004	Delegation of authority/rigidity
OC	005	Formal accountability for actions

Policies OC 100

OC	101	Promotion
OC	102	Hiring, firing and retention
OC	103	Drugs and alcohol
OC	104	Accident and incident investigation

Culture OC 200

OC	201	Norms and rules
OC	202	Organisational customs, beliefs and attitudes
OC	203	Safety as a value

ORGANISATIONAL PROCESS OP xxx

Operations OP 000

OP	001	Operational tempo/workload
OP	002	Incentives
OP	003	Time pressure
OP	004	Schedules

Procedures OP 100

OP	101	Performance standards
OP	102	Clearly defined objectives
OP	103	Procedural guidance/publications
OP	104	Informational resources/support

Oversight OP 200

OP	201	Doctrine
OP	202	Established safety programmes/risk management programmes
OP	203	Monitoring and checking of resources, climate and processes to ensure a safe work environment

STATUTORY FS xxx

International/national standards FS 000

FS	001	Rule-making process
FS	002	Regulations

Flag State implementation FS 100

FS	101	Link with vessel/company
FS	102	Delegation of authority to RO
FS	103	Class and statutory surveys
FS	104	Communication

ORGANISATIONAL INFLUENCES

Organisation: Factors in a mishap if the communications, actions omissions or policies of upper-level management directly or indirectly affect supervisory practices, conditions or actions of the crew member(s) and result in system failure, human error or an unsafe situation.

RESOURCE MANAGEMENT: Factors in a mishap if resource management (and/or acquisition) processes or policies, directly or indirectly, influence system safety and results in poor error management or creates an unsafe situation. **OR xxx**

Human resources (OR 000) - Factors in a mishap when organisational decision-making regarding the allocation and maintenance of human resources results in human error or an unsafe situation.	
OR 001	A factor when the process of safe manning or manning resource allocations is inadequate for the voyage demands and the inadequacy causes an unsafe situation or excessive stress on the remaining crew members.
OR 002	A factor when the process of engaging crew members, either directly or through a manning agency, is inadequate for the voyage and/or company demands and the inadequacy cause an unsafe situation[11].
OR 003	A factor when the process allows for the assigning of responsibility to a crew member without the requisite training, resulting in an unsafe situation[12].

[11] Factor '**OR 001**' also captures situations where the engaging of multi-national crew members on board a ship leads to the erection of language barriers, causing an unsafe situation.

[12] Training captured under factor '**OR 003**' has two components. The first component is the initial training given to a crew member when he signs on a vessel *i.e.* the familiarisation training as required by the ISM Code. The second component is the in-house training or other on-going training, such as refresher courses, which is intended to keep the crew members abreast and fresh with the necessary knowledge to operate in a safe manner on board the ship.

Technological environment (OR 100) - Factors in a mishap when organisational decision-making regarding the allocation and maintenance of monetary assets results in human error or an unsafe situation.	
OR 101	A factor when excessive cost-cutting results in reduced funding for new equipment, the purchase of low-cost, lack of quality replacement parts and/or bunker oil.
OR 102	A factor when the vessel does not receive indirect financial resources to complete a task and/or allocation of training programmes is cut short and this deficiency creates an unsafe situation.

Equipment/facility resources (OR 200) - Factors in a mishap when organisational decision-making and policies regarding the selection of particular designs, resources and facilities result in human error or an unsafe situation.	
OR 201	A factor when support facilities and opportunities for recreation/rest are not available or adequate and this creates an unsafe situation[13].
OR 202	A factor when the processes through which the vessel, equipment, machinery or logistical support are acquired allow inadequacies or when design deficiencies allow inadequacies in the acquisition and the inadequacies create an unsafe situation.
OR 203	A factor when the process through which equipment is removed from service is inadequate and this inadequacy creates an unsafe situation.
OR 204	A factor when the process through which crew members and shore personnel are screened, brought into the service, or placed into specialties, is inadequate and creates an unsafe situation.
OR 205	A factor when the design of the machinery space contributes directly to either the initiation and/or propagation of an unsafe situation or else it does not assist the crew member's cognitive activities during the interception and interpretation of the overall system cues and creates an unsafe situation.
OR 206	A factor when the design of a particular piece of machinery, control or equipment contributes directly to the initiation and/or propagation of an unsafe situation or else visual and/or aurally information provided to the crew member is not presented clearly and properly and creates an unsafe situation.
OR 207	A factor when equipment is bought even if it does not meet internationally agreed specifications.
OR 208	A factor when design flaws which have been discovered in similar equipment through assessments or investigations have not been corrected, leading to an unsafe situation[14].
OR 209	A factor when tools either have not been made available on board or tools made available are of poor design, awkward to use or pose difficulties to the crew member, leading to an unsafe situation.

[13] Factor '**OR 201**' captures situations where leave from the vessel (signing off) is refused for reasons other than the individual's choice. Support facilities include dining, exercise, mess rooms, medical care *etc.*

[14] Factor '**OR 208**' captures also design flaws, which have been discovered in other companies and made public through accident and incident reports.

ORGANISATIONAL PROCESS: Factors in a mishap if organisational processes such as operations, procedures, operational risk management and oversight, negatively influence individual, supervisory, and/or organisational performance and results in unrecognised hazards and/or uncontrolled risk and leads to human error or an unsafe situation. **OP xxx**

Operations (OP 000) - Factors in a mishap when corporate decisions and rules that govern the day-to-day activities within an organisation create an unsafe situation.	
OP 001	A factor when the management company determines that it is necessary to increase the operational tempo to a point that it overextends the machinery space manning capabilities, leading to a human error or an unsafe situation.
OP 002	A factor when the management company discontinues or inhibits incentive (award) programmes, leading to under-reporting of hazards, incidents and lack of active participation in safety meetings.
OP 003	A factor when the management company allows for environmental demands to exceed the available resources, leading to stress (physiological, psychological, behavioural or social outcomes).
OP 004	A factor when the officers at management level have to resort to inadequate scheduling procedures that jeopardise crew rest or produce sub-optimal crew interaction, putting crew members at an increased risk of a mishap.

Procedures (OP 100) - Factors in a mishap when corporate decisions and rules that govern the day-to-day use of standard operating procedures create an unsafe situation.	
OP 101	A factor when written procedures are found to be flawed or faulty, leading to the application of non-standard procedures, resulting in the introduction of unwanted variability into the maintenance operations.
OP 102	A factor when the management company fails to establish or communicate the objectives for goals or the objectives are unrealistic, not understandable, immeasurable and unachievable, leading to misunderstanding by the crew members.
OP 103	A factor when written direction, checklists, graphic depictions, tables, charts or other published guidance are inadequate, misleading or inappropriate and this creates an unsafe situation.
OP 104	A factor when weather, intelligence, operational planning material or other information necessary for safe operations planning are not available, leading to human error or an unsafe situation.

Oversight (OP 200) - Factors in a mishap when corporate decisions and rules that govern the use of formal methods for maintaining oversight between the crew members and company management create an unsafe situation.	
OP 201	A factor when the doctrine, philosophy or concept of operations in an organisation is either flawed or accepts unnecessary risk and this flaw or risk acceptance leads to an unsafe situation or uncontrolled hazard.
OP 202	A factor when the company either does not have a safety/risk programme in place as it is seen as an overhead and a non-productive value or has a safety/risk programme without having an adequate understanding of the problem or actions needed to resolve safety critical issues[15].
OP 203	A factor when companies are missing official procedures in place to address contingencies and oversight programmes to monitor risks, leading to unawareness of problems before an accident occurs.

[15] Factor '**OP 202**' also captures instances such as when the company orders a generic safety management system manual and puts it on the shelf and/or when the management company blames a crew member whenever an accident/incident happens on board the ship.

ORGANISATIONAL CLIMATE: Factors in a mishap if organisational variables including environment, structure, policies, and culture influence individual actions are inadequate and result in human error or an unsafe situation. **<u>OC xxx</u>**

Structure (OC 000) - Factors in a mishap when the overall hierarchal structure of a company creates an unsafe situation.	
OC 001	A factor when the chain-of-command on board a ship or the management structure of the managing company is confusing, non-standard or inadequate and this creates an unsafe situation.
OC 002	A factor when a breakdown in the transfer of information between the managing company to the ship or between crew members results in correct information not reaching the crew member in a timely manner, leading to a human error or an unsafe situation.
OC 003	A factor when the representatives[16] of a managing company either is unable to take the opportunity or else the opportunity does not exist to listen and respond to crew members' questions and comments, leading to an unsafe situation.
OC 004	A factor when the managing company undermines the authority and interferes with the accountability of officers at management level, preventing them from effectively carrying out their assigned responsibilities, leading to an unsafe situation[17].
OC 005	A factor when the organisational structure does not include a specific accountability system, whereby managers and officers in management level are held accountable for the completion of assigned safety responsibilities resulting in substandard performance and an unsafe situation.

[16] Company representatives refer to safety managers, superintendents and/or designated persons ashore.

[17] Factor '**OC 004**' captures situations when the managing company fails to realise that company procedures do not necessarily capture all situations and therefore under the prevailing situation, the crew members at management level need to be allowed a certain degree of authority to override established procedures in the interest of safety and pollution prevention.

Policies (OC 100) - Factors in a mishap when ill-defined, adversarial, or conflicting policies or supplanted by unofficial rules and values result in confusion and lead to human error or an unsafe situation.	
OC 101	A factor when a crew member perceives that his/her performance on a task will inappropriately influence an evaluation, promotion or opportunity for upgrade and this pressure creates an unsafe situation.
OC 102	A factor when company policy on human resources issues does not indicate company's commitment to safety.
OC 103	A factor when company policy related to drugs and alcohol on board ships is not communicated and/or enforced on board, making it difficult for the crew member to choose the correct actions, resulting in human error or an unsafe situation.
OC 104	A factor when the company does not investigate accidents/incidents internally or else fails to appreciate that accident/incident investigation can be the starting point of a safety analysis, resulting in lack of understanding of the risk of the vessel, leading to an unsafe situation[18].

[18] Factor '**OC 104**' captures investigations conducting by managing companies with the purpose to apportion blame. Situations where notwithstanding the company's awareness of similar accidents, safety information is not passed to the fleet, are captured under factor '**OR 208**'.

Culture (OC 200) - Factors in a mishap when the unofficial or unspoken rules, values, attitudes, beliefs, and customs of a company contribute to human error or unsafe situation.	
OC 201	A factor when the expression of personal and organisational values demonstrates improper actions and are endorsed by the managing company.
OC 202	A factor when the managing company does not understand the underlying beliefs and/or philosophies of crew members resulting in inadequacies in the development of the safety management system.
OC 203	A factor when safety is considered to be a priority rather than a core value and operational principle, resulting in safety becoming redundant to other matters when priorities shift as a result of environmental demands.

STATUTORY: Factors in a mishap if the regulator's regime is either sub-standard or lacks the necessary depth, leading to an unsafe situation. **FS xxx**

International/national standards (FS 000) - Factors in a mishap when the process of setting international standards or part thereof contributes to human error or an unsafe situation.	
FS 001	A factor when the rule-making process fails to anticipate potential risks involved, resulting in a loop-hole/weakness in international regulations.
FS 002	A factor when regulations do not keep pace with technological changes, leading to an unsafe situation.

Flag state implementation (FS 100) - Factors in a mishap when the process of enforcement of regulations at national level is sub-standard and this situation contributes to an unsafe situation.	
FS 101	A factor when due to several constraints, the flag State Administration is unable to provide adequate oversight to a ship and its managers.
FS 102	A factor when the flag State Administration, which has delegated its authority to an RO, is not able to satisfy its responsibility by, *inter alia*, monitoring the performance of the RO's activity on its behalf.
FS 103	A factor when a class or statutory survey fails to capture a deficiency in the system leading to an unsafe situation.
FS 104	A factor when safety information (including safety lessons from accident reports) or other pertinent literature emanating from the IMO, NGOs or consultative bodies is not communicated to the ship owner, manager or master of the vessel, leading to inadequate dissemination of safety information[19].

[19] The inadequate dissemination must be a contributing factor to an accident.