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Maritime Transport
and Risks of Packaged
Dangerous Goods



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MARITIME TRANSPORT AND RISKS OF PACKAGED DANGEROUS GOODS

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ABBREVIATIONS

AAPA	– American Association of Port Authorities
ADG	– Australian Dangerous Goods Regulations
ADN	– European Provisions concerning the International Carriage of Dangerous Goods by Inland Waterways
ADNR	– European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways – Rhine River
ADR	– European Agreement concerning the International Carriage of Dangerous Goods by Road
ALARA	– As Low As Reasonably Applicable
ALARP	– As Low As Reasonably Practicable
CCPS	– Center for Chemical Process Safety of the American Institute of Chemical Engineers
CTU	– Cargo Transport Units
DG	– Dangerous goods
EC	– European Commission
ECOSCO	– UN Economic and Social Council
EMSA	– European Maritime Safety Agency
EU	– European Union
HCB	– Hazardous Cargo Bulletin
HSC	– U.K. Health and Safety Commission
HWN	– U.S. House of Representatives Web Site
IBC	– Intermediate Bulk Containers
IATA	– International Air Transport Association
ICAO	– International Civil Aviation Organisation
ICHCA	– International Cargo Handling Co-ordination Association
ILO	– International Labour Organisation
IMDG Code	– International Maritime Dangerous Goods Code
IMO	– International Maritime Organization
ISO	– International Standards Organisation
ISPS	– International Ship and Ports Facility Security
LMIS	– Lloyd’s Maritime Information Service
LNG	– Liquefied Natural Gas
LPG	– Liquefied Petroleum Gas
LRS	– Lloyd’s Register of Shipping
MAIB	– Maritime Accident Investigation Branch
MAIIF	– Maritime Investigators’ International Forum
MARPOL 73/78	– International Convention for the Prevention of Pollution from Ships 73/78
MEPC	– IMO’s Marine Environment Protection Committee
MoU	– Memorandum of Understanding for the Transport of Packaged Dangerous Goods on Ro – Ro Ships in the Baltic Sea
MSC	– IMO’s Maritime Safety Committee

OBO	– Oil/Bulk/Ore Carrier
OECD	– Organisation for Economic Co-operation and Development
PDG	– Packaged Dangerous Goods
PSC	– Port State Control
SMA	– Swedish Maritime Administration
SCB	– Statistics Centre Bureau, Sweden
SIKA	– Swedish Institute for Transport and Communications Analysis
SOLAS 74	– International Convention for the Safety of Life at Sea 1974
TEU	– Twenty foot Equivalent Unit
TSE	– Turku School of Economics, Logistics, Turku, Finland
U.S. BTS	– U.S. Bureau of Transportation Statistics
U.S. DOT	– U.S. Department of Transportation
U.S. TI	– U.S. Transportation Institute
ULCC	– Ultra Large Crude Carrier
UN	– United Nations
UNCTAD	– United Nation Conference on Trade and Development
UNECE	– United Nations Economic Commission for Europe
USCG	– U.S. Coast Guard
USEPA	– U.S. Environmental Protection Agency
VLCC	– Very Large Crude Carrier

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1 INTRODUCTION

1.1 Background

This report deals with the maritime transport system of packaged dangerous goods (PDG) and principles of risks of marine accidents/incidents involving dangerous goods. The report is part of the Safe and Reliable Transport Chains of Dangerous Goods in the Baltic Sea Region (DaGoB) project¹ and the author's² own research. The main aims of the DaGoB project include: a) improve co-operations at various levels among parties concerned in transport of dangerous goods in the BSR; b) provide up-to-date information on cargo flows, supply chain efficiency and risks related to transport of dangerous goods; and c) disseminate and transfer the knowledge gained from the project on local, national, regional and international levels (TSE 2006). The project involves numbers of partners from countries of the Baltic Sea Region (BSR), such as Finland, Sweden, Germany and the Baltic States. The leading partner is Turku School of Economics, Logistics, Turku, Finland.

The author's research work concerns the development of a risk analysis framework for readily application in the maritime transport system of PDG as well as the demonstration or validation of the framework in practice. One of the main parts of the thesis constitutes the "Frame of Reference", which provides relevant concepts, definitions and theoretical models in the essential interrelated research areas, such as: a) *the maritime transport system of PDG*; b) *risks of dangerous goods accidents/incidents*; and c) *the risk management system* (see Figure 1). The "Frame of Reference"³ serves as a theoretical platform for the development of the risk analysis framework. The framework development involves exploration of many relevant concepts and their relationships. The quality of the framework, which is the validity and reliability of the framework, and subsequently the quality of the results generated by it, depends very much on the unified understanding in the field and how well and precisely constituent concepts are defined and described.

¹ The DaGoB project is partly financed by the European Union (European Regional Development Fund) within the BSR INTERREG III B Neighborhood Programme.

² The author of this report is a PhD student at Lund University, Institute of Technology, Department of Industrial Management and Engineering Logistics, Sweden. Lund University is one of the partners in the DaGoB project.

³ The "Frame of Reference", which is Chapter 3 of the author's thesis, is a summary version of this and another report (see Mullai 2006).

Further, the research encompasses a number of very specialised and complex topics that require understanding of the central concepts. A basic premise is that one cannot make improvements to a system until one understands how the current system operates (Harrell and Tumay 1995). This report deals with the first two research areas, namely: a) *the maritime transport system of PDG* and b) *risks associated with it*⁴ (see the highlighted areas in Figure 1).

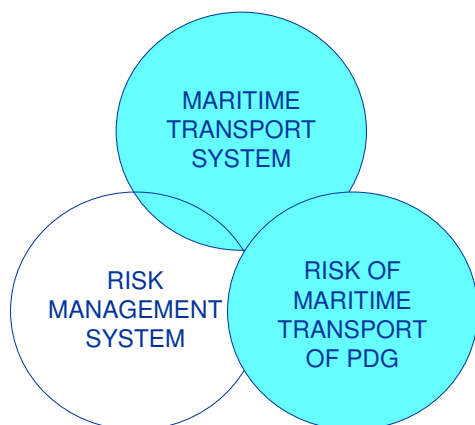


Figure 1: The Frame of Reference –key research areas

1.2 Purpose

In the context of the DaGoB Project objectives, the purpose of this report is to contribute to enhancing the understanding in the field by providing the state-of-the-art knowledge in the maritime transport system of dangerous goods and the principles of risks associated with the system. The contents of the report, which is part of the “Frame of Reference” of the author’s thesis, serves as a theoretical platform for defining and describing the system whose risks are to be analysed and managed.

⁴ Another report (see Mullai 2006) deals with concepts related to the third research area, which is the risk management system and its constituent elements.

1.3 Methods and materials

The report is based on the understanding gained through the library and field studies, including the extensive review of large amounts of different types of data and information collected from various sources. Personal research works (see Mullai and Paulsson 2002) and seafarer work experiences have also contributed to the contents of this report. For more details about the methods and materials used in this report, see Mullai 2007.

1.4 Report outline

The rest of the report consists of two interrelated chapters (see the highlighted areas in Figure 1). In Chapter 2, attempts have been made to explore, define and describe exhaustively the main components of the maritime transport system, focusing primarily on the technical and operational aspects of transport of PDG. The regulatory system governing maritime transport of PDG, which is a very important component of the system, is also described. Chapter 2 is mainly structured based on the relevant transport models (see Sjöstedt 1993 and others) and the structure of the IMDG Code. Risks of marine accidents/incidents involving dangerous goods are negative outcomes of the maritime transport system. Chapter 3 provides key relevant terms, definitions and concepts related to the main risk elements, including consequences, causes and contributing factors, dangerous goods hazards, and frequencies. For the purpose of illustration or demonstration, the report provides several illustrative examples – see boxes with the highlighted text. The report concludes (Chapter 4) with concluding remarks concerning topics and issues raised in this report. Based on inferences and understanding gained in this study, in this chapter some research areas and questions for future studies and recommendations of improving safety and health and environment protection in the BSR are provided. Attachments contain relevant information related to the contents of the report.

2 MARITIME TRANSPORT OF PACKAGED DANGEROUS GOODS

In this chapter the main components of the maritime transport system are defined and described, including objects of transport, means of transport, transport related activities, transport infrastructure and facilities, actors, the information system, dangerous goods traffic and the physical environment. The “state-of-the-art” regulatory system governing maritime transport of dangerous goods is also described. The chapter focuses on technical and operational aspects of maritime transport. It is mainly organised based on the transport model (see Figure 2) and the IMDG Code.

2.1 Transport system: modes of transport

The maritime transport system is a constituent component of the transport system or network, which, in turn, is an important constituent component of the physical distribution/logistics system or the supply chain.

The development of civilization is directly associated with the development of transportation systems (Coyle et al. 2000). Transport is a vital activity in moving both people and freight (Coyle et al. 2000) – it performs a change of positions of persons and goods. The positions before and after transport are identified as locations (A and B), in which A and B are modelled as two nodes in a network.

Viewed in historical, economical, environmental, social, and political terms, it is unquestionably the most important industry in the world (Coyle et al. 2000, p 19).

Transportation is the creation of place and time utility. When goods are moved to places where they have higher values than they had at the place from which they originated, they have place utility. Time utility means that this service occurs when it is needed. Time and place utility are provided to passengers when they are moved from where they do not want to be to places where they do want to be and at the demanded time (Coyle et al. 2000, p 20).

Transport also provides time and place utility for dangerous goods. Swedish Law (Ordinance1§) on the transport of dangerous goods states (Rosenberg 1998, pp. 11):

Transport means movement of dangerous goods by means of transport together with loading, unloading, safe keeping and other handlings of dangerous goods that facilitate movement.

Viewed from different perspectives, transport is categorised in different ways, where each category has its specific distinctions, including: a) *freight and people*: freight, passenger, freight and freight/passenger combined transport; b) *distance*: long and short haulage; c) *domestic and international transport*; d) the *environment or media* in which means of transport operate. From the media point of view, the transport system is divided into:

- I. Air transport
- II. Surface transport
 - 1) Land transport
 - a) Road
 - b) Rail
 - 2) Maritime transport⁵
 - 3) Pipeline

The “modal split” concept, which is often used as an analytical tool in transport studies, divides the entire transport system of passengers and/or freight according to the major modes of transport (Coyle et al. 2000). Air, road, rail, maritime and pipeline transport systems constitute five modes of transport forming the transport system (chain or network) (EC 1996a). Terms such as “transport system”, “transport network” and “transport chain” are frequently used interchangeably. PDG are carried by all modes of transport, except pipeline.

2.2 Concept of intermodal transport

The concept of intermodal is defined in different ways – including other quite similar terms such as multimodal or combined transport. Despite the variations, in essence the concept consists in the movement of goods and/or people by at least two modes of transport in succession between the point of origin and destination under one document and one contract of carriage. The concept has evolved over the years. The following definitions show distinctions among these terms: “intermodal”, “multimodal” and “combined”

⁵ Other similar terms include “sea transport”, “marine transport”, “shipping”, “merchant marine” or “waterborne transport”. The terms “transportation” and “transport” share similar meanings. The term “transportation” is commonly used in the USA. In this report, for the purpose of consistency, the term “maritime transport” is most frequently used.

transport. *Intermodal transport* consists in the movement of goods in one load unit or vehicle using several transport modes without handling goods themselves in changing modes (UNTAD 1995). *Multimodal transport* is transport activity involving the use of at least two modes in succession between origin and destination (UNTAD 1995). *Combined transport* represents intermodal transport where a major part of the journey is by rail, inland waterways or sea and any initial or final leg carried out by road is as short as possible (UNTAD 1995). The European Commission defines, with slight differences, combined transport as transport between the member states of road vehicles, containers or demountable bodies, without loading goods and using at least two modes of transport from among road, rail and inland waterways (EC 1995). In another document of the European Commission (EC 1996a), combined transport has been defined as transport of goods on intermodal transport equipment through at least two different modes without unloading the goods during the journey, in which the road leg should be as short as possible. The road is often the initial journey and terminal haulage, and rail or maritime transport accounts for the long distance part.

2.3 Maritime transport of packaged dangerous goods

The term “maritime” or “shipping” industry is often used to encompass many different maritime-related industries, sectors or activities, including transport, shipbuilding, insurance, classification, fishing, leisure or cruising, brokerage, shipping agencies and many more. Transport by water is described by different terms, such as “shipping”, “marine/maritime transport”, “sea transport”, “merchant marine” or “waterborne transport.” Although used to express different meanings in different contexts, these terms are often used interchangeably.

Maritime transport of dangerous goods constitutes a system or sub-system in its own right, in particular transport of bulk dangerous cargoes. Oil and oil products, liquefied gases, and many chemicals are carried in large quantities in a very specialized system. Tankers are specially designed to move bulk dangerous cargoes only. Although PDG are largely carried together with other non-dangerous goods in cargo ships and cargo/passenger ships, given its distinct technical and operational features the maritime transport system of PDG constitutes a specific element or sub-system of the maritime transport system.

2.3.1 Significance of maritime transport

Large amounts of different types of commodities, including dangerous goods/ cargoes varying from raw materials to manufactured goods supplying a vast and still growing volume of waterborne cargo, and passengers are moved by water.

Maritime transport affects society in many respects: economical, social, political, environmental and others. It is an important constituent part of the entire transport system. Maritime transport is linked to both the maritime industry and the overall transport chain (EC 1996b). Maritime transport is vital to the world economy. Shipping is involved in approximately 95 % of international trade (Wetzel 2004). It is a key sector playing a major role in the overall economy of many maritime countries and regions. For example, maritime transport is, in volume, the most important mode of transport in the EU, where over 90% of European Union external trade and around 35% of trade between EU countries is performed by water (EMSA 2004). Each year more than one billion tonnes of freights are loaded and unloaded in the EU Member State ports (EMSA 2004). For many countries and commodities shipping is the only alternative mode of transport in the international trade. For example, approximately 95 % of the Swedish imports and exports are carried by sea (SMA 2004). Maritime transport is also very important for the UK economy, as 77% of imports and 74% of exports by value are transported by sea (Donaldson 1994). This transport mode is also critical to the U.S. economy, as approximately 95 % of the nation's foreign trade by weight consists of waterborne cargo (Wetzel 2004) (AAPA 2004). Foreign trade accounts for more than 20 % of the U.S.'s gross domestic product (AAPA 2004).

Most citizens feel that benefits provided by transportation far exceed the costs associated with transport's environmental pollution and natural resource exploitations (Coyle et al. 2000). This is an important factor or input in risk evaluation and decision-making processes concerning transport of dangerous goods, in particular in selection and execution of the risk strategies and measures.

2.3.2 Different divisions of maritime transport

There are numbers of divisions of maritime transport or shipping viewed from different standpoints (Larsson 1993). Such divisions are often referred to as

the industry, sector, traffic or market. In addition, based on their distinctions, the constituent elements of the maritime transport system are classified in different ways. These distinctions are very important from both a theoretical and a practical point of view (Metaxas 1971).

From a service point of view, shipping is divided: *liner and tramp/bulk service* (shipping) (Kendall and Buckley 1990; Fink et al. 2002; Stopford 1988). The liner and tramp/bulk sectors differ in many respects, including technical, operating, management, relationships between service users and providers, ship employment, geographic areas and market operations. The liner service involves international water carriers that perform in fixed routes, tariffs and schedules (Coyle et al. 1994). Typically, liner carriers transport commodities with a higher industrial processing (Fink et al. 2002) – semi- and finished goods – using containers and other forms of packagings, including a wide range of chemical products. In contrast, tramp shipping involves international water carriers that have no fixed routes, tariffs and schedules (Coyle et al. 1994). Bulk shipping often refers to tramp shipping because bulk cargoes (e.g. oil, refined oil, iron ore, grain, coal, bauxite) are generally transported in tramp ships (Kendall and Buckley 1990). Tramp ships also carry general or packaged cargo. The bulk sector is typically divided into two categories: tanker (bulk liquid – e.g. oil and oil products) and dry bulk (including grain, iron ore, coal, bauxites and phosphates) (Fink et al. 2002).

Maritime transport is also divided into: *freight and passenger* (Coyle et al. 2000) and *combined passenger/freight* (e.g. ro-ro ferry ships) transport or market (Gordon et al. 1990). The movement of people by water is getting passengers to a wide range of destinations, including business travel, vocational or pleasure travel, personal trip, urban transit and many more. The water leg can be a part of the road or rail journey. Large amounts of PDG, including dangerous goods in “limited quantities” in the form of petrol in passengers’ cars or personal effects, are carried onboard passenger/ cargo ships and passenger ships.

A basic division of principal freight markets, which is based on the combination of ship types and freights/objects of transport, consists of (Gordon et al. 1990): a) the *dry cargo market*; b) the *tanker market*; c) the *reefer market*; d) the *car carrier market*; and d) the *passenger market*. Each division is further subdivided into sectors or sub-markets (see Table 1).

Table 1: Main and sub-divisions of the freight market (Gordon et al. 1990)

Main divisions - principal freight/ passenger markets	Sub-divisions - sectors or markets
<i>Dry cargo market</i>	<ul style="list-style-type: none"> • Bulker • Tweendeck • Container • Ro-ro • Liner • Small ship • Special ships <ul style="list-style-type: none"> - Heavy lift carrier - Barges and pontoons - Tugs - Barge carrier etc
<i>Tanker market</i>	<ul style="list-style-type: none"> • Oil and oil products • Chemicals • Other liquids • Liquefied gases (LPG and LNG) • Ore/oil and Ore/Bulk/Oil (OBO)
<i>Reefer market</i>	<ul style="list-style-type: none"> • Reefer • Container • Conventional general
<i>Car carrier market</i>	<ul style="list-style-type: none"> • Pure car carrier (PCC) • Other car carrier
<i>Passenger market</i>	<ul style="list-style-type: none"> • Cruising • Short-distance (ferry)

Form a cargo parcel point of view, shipping is divided into "*bulk cargo*" and "*general cargo*" (Stopford 1988). Bulk cargo is cargo, either dry or liquid, that is shipped unpacked in loose condition and that is of a homogeneous nature (U.S. TI 2001). Dry bulk trades comprise iron ore, coal, grain, timber, steel and other similar cargoes that are shipped in bulk. Dry bulk shipping refers to the movement of commodities carried in bulk, the so-called major bulks, together with ships carrying steel products (e.g. coils, plates and rods), lumber or log carriers and other commodities classified as the minor bulks (INTERCARGO 2002). Neo-bulk cargo includes commodities such as scrap iron, automobiles, forest products, and paper. Generally, bulk service is not provided on a regularly scheduled basis, but rather as needed. Specialised ships are designed to transport specific commodities.

Dangerous goods/cargoes are carried in both *bulk and packaged form*. Oil, oil products, liquid and solid chemicals, and liquefied gases (LNG and

LPG) fall in the "bulk" cargo division whilst packaged dangerous goods fall in the "general" cargo division. General cargo consists of consignments of less than ship load or hold size, which are often of semi-manufactured, manufactured and packaged commodities. General cargo is broadly defined as "anything other than bulk" or non-bulk cargo composed of miscellaneous goods (U.S. TI 2001). However, there are no hard and fast rules about what constitutes "general cargo" (U.S. TI 2001). Other similar terms for general cargo are "breakbulk" "packaged" or "bagged" cargoes (Kendall and Buckley 1990). The term "breakbulk" is often used to denote cargo that is loaded in unitized form, but not containerized, such as pallets, bags, crates, boxes and bales. "Breakbulk" has been defined as the separation of a consolidated bulk load into individual, smaller shipments for delivery to a consignee, where the freight may be moved intact inside a CTU (Coyle et al. 1994). Bagged cargo is cargo packed in sacks or bags (U.S. TI 2001) and many dangerous goods are carried as such. For example, the definitions of packaged and bulk dangerous goods are provided in the Australian Dangerous Goods Regulations AS3846-1998⁶ as follows:

Packaged dangerous goods are defined: *"the complete product of the packing operation, consisting of the packaging and its contents prepared for transport". Packaged dangerous goods include for example IBCs, LPG cylinders, freight containers etc.*

Bulk dangerous goods are defined: *"cargoes which are intended to be carried without any intermediate form of containment, in a cargo space which is a structural part of a ship, or a tank permanently fixed in or on ship."*

Based on the geographical area of operation, shipping is divided into: a) *deep sea or ocean shipping* and b) *short sea or coastal shipping*. Technically, coastal shipping is defined as transport that is conducted within coastal waters (IMO 1995a). The IMO defines coastal waters as waters that lie within 32 km (20 miles) of the shoreline (IMO 1995a). However, in practice, the shipping lanes often extend beyond this limit. In coastal or short-distance shipping special-purpose ships such as ro-ro ferry ships are often employed.

The term "waterborne" is used, for example, in EU transport project programmes (EC 1998-2002), to denote a broader concept of transport by water, including: a) *maritime transport* and b) *inland waterways transport* (i.e. rivers, canals, fjords and lakes). A large part of the world's shipping moves

⁶ Western Australian Dangerous Goods Regulations, 1998

through inland waterways usually employing smaller and lighter ships. However, large ocean-going ships navigate through many inland waterways, for example through rivers in the USA, European and Asian countries. In Europe, inland waterway transport, which is among the oldest transport modes, is considered as a constitute part of the combined transport system (Verhaar 1997). In the past, inland waterways in Europe have almost exclusively been used to carry bulk shipments, such as coal, crude oil and its products and chemicals. River and canal container traffic has been, for many years, very common and increasing. A large portion of containers arriving in the main sea/river ports are transloaded on the container barges. As part of intermodal transport, many chemical product shippers in Europe use barges on inland waterways for transporting road tank vehicles and tank container (HCB 1997).

Water transport is also divided into *domestic and international* (Coyle et al. 2000), where domestic water transport consists of all water movements where the origin and destination of shipments are of the same country. Shipments that have a foreign country as either the origin or destination are classified as international shipping. In the USA, domestic water carrier industry is classified by the waterway used. Carriers that operate within internal navigable waters (i.e. rivers, canals and lakes) are classified as internal water carriers. Coastal carriers operate along the coast. Domestic water carriers move raw materials in bulk (dry bulk: e.g. coal, gravel, grain and liquid bulk: e.g. crude oil and oil products, liquid chemicals) and manufactured goods (Coyle et al. 2000), including many different chemicals.

Box 1: The EU short sea shipping

From a European perspective, short sea shipping covers all sea transport that is not ocean going. It includes coastal shipping, transport between mainland coasts and inland, and sea-river transport by ship to and from river ports. Short sea shipping serves as a linkage to other transport modes and covers a wide range of diversified activities and services. Types of services provided by the short sea shipping include (ECOSCO 1996):

- *Bulk transport* – this constitutes 50% of the short sea shipping;
- *Ferry services* (including ro-ro service) is vitally important for certain countries and regions;
- *Feeder services*, which has been the fastest growing sector connecting hub ports with smaller ports not directly served by very large deep sea containerships;

Box 1: The EU short sea shipping

- *Liner services.*

Short sea shipping accounts for a large portion of transport in the European Community. Because of shifting trade from land transport to sea transport in a number of corridors (6-8 corridors), there have been growth opportunities for short sea shipping. Full integration of short sea shipping into the intermodal transport chain is one of the community transport objectives. There have been plans for developing "Fast Waterborne Transport Systems" (FWTS) for goods and passengers under intermodality aspects. The European Commission (EC 1996c) has supported research in improvement and development of new cargo containment units to serve intermodality, new sea-river operational concepts and sea-river ships. Ships engaged in short sea shipping spend a greater proportion of their time in port than do ocean-going ships, due to shorter sea distances and more frequent loading/ unloading of dangerous goods in ports.

2.4 Transport's constituent elements

This section defines and describes the main elements of the maritime transport system of PDG. The system is complex consisting of many interdependent elements. This section highlights the essential elements of the system. The structure is largely based on a transport (logistics) system model (Sjöstedt 1993) (see Figure 2) and the IMDG Code. Sjöstedt's (1993) model is a conceptual model describing the transport system. The model development has been inspired by other works, in particular the works of the Swiss Academy of Engineering Sciences, OECD, the European Council of Applied Sciences and Engineering. The model, which has a number of versions, is further developed by Sjöstedt himself and other authors, including Björnsson and Gadde (1993), Sjöholm and Lumsden (1992).⁷

⁷ KFS (2003) Kurskompendium: International Distributionsteknik: Distribution system, MTT045, Lund University, 2003 pp. 205-207. These sources are provided in this literature.

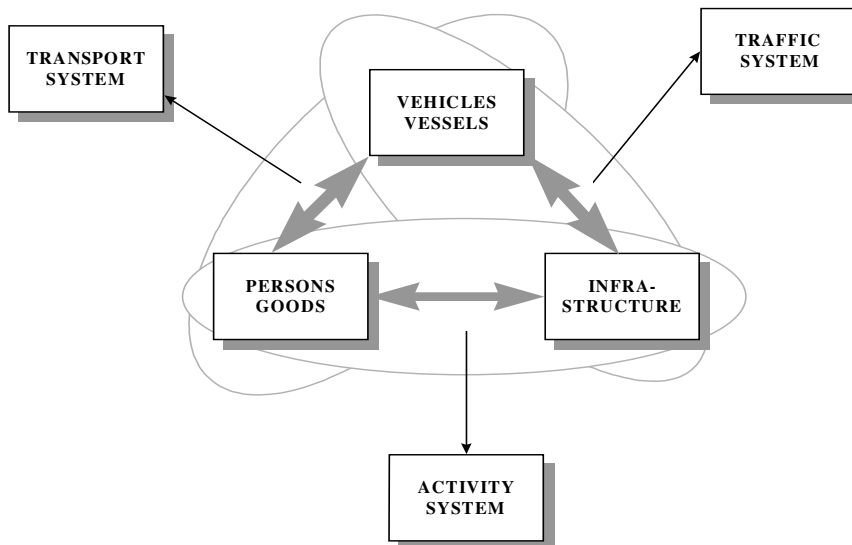


Figure 2: A conceptual model of the transport system (Sjöstedt 1993; others)⁸

The model is system oriented and organised around a number of the interrelated main elements that are subdivided into physical elements and activities or processes. Each main element consists of a number of constituent parts that can be identified at different levels, each of which, in turn, may be considered a system in its own right. The terms, definitions and concepts are gathered from numerous sources, including (SOLAS 1974) (MARPOL 1973/78) (IMDG Code 2002) (Sjöstedt 1993) (KFS 2003) (US TI 2001) and (Brodie 1994).

The main constituent elements of the transport system are (KFS 2003): a) *objects of transport*: i.e. persons/ passengers, goods/cargo and packagings and cargo transport units (CTUs); b) *means of transport*: i.e. road and rail vehicles, vessels and airplanes; c) *infrastructure and facilities*: i.e. roads, railways, terminals, ports and other transport facilities. These physical elements are related to each other through activities, which all linked together form the system. The main activities include: *transport, traffic and other transport related activities* such as cargo handling, storage, stowing, separation, segregation, securing, documentation, cargo caring etc.

The main constituent elements of the maritime transport system of PDG, which, in many respects, are specific for this transport, are described and

⁸ KFS (2003), Kurskompendium: International Distributionsteknik: Distribution system, MTT045, Lund University, 2003 pp, 205-207. The model and other versions are provided in this literature.

defined in the context of regulations governing this transport. This section also defines and describes some other important elements that are not included in the model mentioned (see Figure 2), such as the *human element*, the *physical environment* and the *regulatory system* governing maritime transport of PDG.

2.4.1 Objects of transport: goods/cargo – dangerous goods

The transported objects for the maritime transport system are cargoes/goods and people (passengers). Certain ship types, such as ro-ro ferries, carry both passengers and cargo. Ships carry many different cargo types, from raw materials, heavy and awkward cargoes, and unitized loads in containers or other forms of packagings, to high-value manufactured goods. Cargoes or goods are synonymous to *loads*, which, for the purpose of efficiency, are often consolidated into several *shipments* (KFS 2003). The nature of transport objects, including physical and commercial properties, (i.e. cargo/passenger, cargo value, cargo stowage factor and the cargo units) are of particular significance in relation to ship design and operation (Stopford 1993) and shipping divisions.

Table 2 shows the main groups and types of cargo classified by the UNCTAD (2001) for the purpose of world seaborne cargo traffic. As mentioned earlier, PDG fall largely into the general or liner cargo types of the dry cargo group.

Table 2: Seaborne cargo – the main groups and types (UNCTAD 2001)

Cargo group	Cargo types
<i>Bulk liquid</i>	<ul style="list-style-type: none"> • <i>Crude oil</i> • <i>Petroleum products:</i> naphtha gasoline, jet fuel, kerosene light oil, heave fuel oil, others. • <i>Liquefied gases:</i> Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG). • <i>Chemicals</i>
<i>Dry cargo</i>	<ul style="list-style-type: none"> • <i>Five main/major bulk:</i> iron ore, coal, grains, bauxite/alumina and rock phosphate. Grains, including: wheat, maize, barley, oat, rye, sorghum and soya beans. • <i>Minor bulk - heterogeneous mix:</i> agriculture products: sugar rice, soyameal and oil seed; fertilizers; forest products; steel products. • <i>Others:</i> cement, coke and petroleum coke, scrap, pig iron, salt and ore. • <i>General or liner cargo:</i> breakbulk, ro-ro, palletised, containerised cargo.

2.4.1.1 Dangerous goods

The SOLAS 74, regulation 1, (part A, Chapter VII), as amended, and the MARPOL 73/78, regulation 1, (Annex III), as amended, which are incorporated into the IMDG Code (2002, Chapter 1, pp 14-26), define dangerous goods for the purpose of the respective Conventions as follow:

- *Dangerous goods* classified under regulation 2 which are carried in *packaged form* or in solid bulk, in all ships to which the present regulations apply and in cargo ships less than 500 tons gross tonnage.
- *Harmful substances* are those substances which are identified as marine pollutants in the IMDG Code. *Packaged form* is defined as the forms of containments specified for harmful substances in the IMDG Code.

Regulation 2 (Classification) of SOLAS 74 describes 9 classes of dangerous goods, which are further defined and described in greater detail in the IMDG Code (2002).

2.4.1.2 Dangerous goods classification

In accordance with the principles set out in the UN Recommendations, the IMDG Code (2002, part 2, Chapter 2, pp. 48-49) divides dangerous goods into 9 classes according to hazards they pose, some of which are further subdivided into divisions. Detailed definitions and descriptions of dangerous goods are provided in each respective class. For example, class 5.2 (Organic Peroxides) is divided into five types and further sub-divided into solid or liquid with special entries for temperature-controlled organic peroxides. Organic peroxide does not have an individual UN number but a special UN type number (e.g. Organic Peroxide Type B, Liquid, and UN 3101). Dangerous goods classes, sub-classes and divisions are as follow (IMDG Code 2002):

Class 1: Explosives

Division 1.1: substances and articles which have a mass explosion hazard

Division 1.2: substances and articles which have a projection hazard but not a mass explosion hazard

Division 1.3: substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard

Division 1.4: substances and articles which present no significant hazard

Division 1.5: very insensitive substances which have a mass explosion hazard

Division 1.6: extremely insensitive articles which do not have a mass explosion hazard

Class 2: Gases

Class 2.1: flammable gases

Class 2.2 non-flammable gases, non-toxic gases

Class 2.3: toxic gases

Class 3: Flammable liquids

Class 4: Flammable solids; substances liable to spontaneous combustion; substances which, in contact with water, emit flammable gases

Class 4.1: flammable solids, self-reactive substances and desensitized explosives

Class 4.2: substances liable to spontaneous combustion

Class 4.3: substances which, in contact with water, emit flammable gases

Class 5: Oxidizing substances and organic peroxides

Class 5.1: oxidizing substances

Class 5.2: organic peroxides

Class 6: Toxic substances and infectious substances

Class 6.1: toxic substances

Class 6.2: infectious substances

Class 7: Radioactive materials

Class 8: Corrosives

Class 9: Miscellaneous dangerous substances and articles

Globally Harmonized System (GHS)

The Globally Harmonized System of Classification and Labelling of Chemicals (GHS), which is a new system introduced in recent years (first published in 2003), concerns classification of dangerous goods by types of hazards they pose (UNECE 2006). The GHS proposes harmonized hazard communication elements such as labels and safety data. In order to improve the protection of human safety and health and the environment, the purpose of the GHS is to ensure that information on hazards of chemicals is available. The GHS is also intended to facilitate trade and transport of chemicals. It provides a basis for harmonization of regulations on chemicals at various levels – national, regional and worldwide.

2.4.1.3 Marine pollutants and wastes

As a result of MARPOL (1973/78, Annex III), since 1st January 1991, items harmful to the marine environment, but not to people or ships have been included in Class 9. All marine pollutants, whether in Class 9 (because they do not fall under the criteria of classes 1-8) or one of the other classes, are required to carry the marine pollutant mark triangle. Based on the pollution severity, marine pollutants are divided into: *marine pollutants (P)* and *severe marine pollutants (PP)*. A full dot symbol in the IMDG Code (2002) list indicates that the substances, materials and articles “*can be a marine pollutant or a severe marine pollutant.*” Wastes are transported by water under the provisions of the class to which they belong. According to the Code, wastes that are subject to the Code provisions but covered under the Basel Convention are transported under class 9. The Basel Convention (1989) concerns the control of transboundary movements of hazardous wastes and their disposal.

2.4.1.4 Dangerous Goods List (DGL)

According to their hazardous properties, dangerous goods are assigned UN numbers and proper shipping names. The proper shipping name describes the goods in the Code. Dangerous goods that are transported by water are listed in the IMDG Code’s (2002) Dangerous Goods List (DGL) (part 3, Chapter 3.2). DGL entries are of four groups: single entries, generic entries, specific Not Otherwise Specified (N.O.S) entries and general N.O.S. entries. The DGL is divided into 18 columns containing the information for each entry, such as: UN number, proper shipping name, class or division, subsidiary risk, packing group, special provisions, limited quantities, packing and tank instructions and provisions, Emergency Procedures (EmS) in case of accident, stowage and segregation, properties and observations.

2.4.2 Packaging/cargo transport units (CTUs)

Cargo transport units (CTUs) are important because they present ship designers with the challenge of designing a ship that can handle and stow a particular type of cargo efficiently, which is because the same cargo can be transported in different ways (Stopford 1993). With regard to the form and

state in which they are carried by water, dangerous goods are divided into two main categories:⁹ 1) *packaged dangerous cargoes/goods* and 2) *bulk dangerous cargoes*, which are further subdivided into: a) *liquid bulk dangerous cargoes*, including liquefied gases and b) *solid bulk dangerous cargoes* (see Figure 3). Chapter VII of the SOLAS 1974 Convention, as amended, and Annex III of the MARPOL 1973/78 Convention, as amended, deal with the carriage of *dangerous goods/ harmful substances in packaged form*.

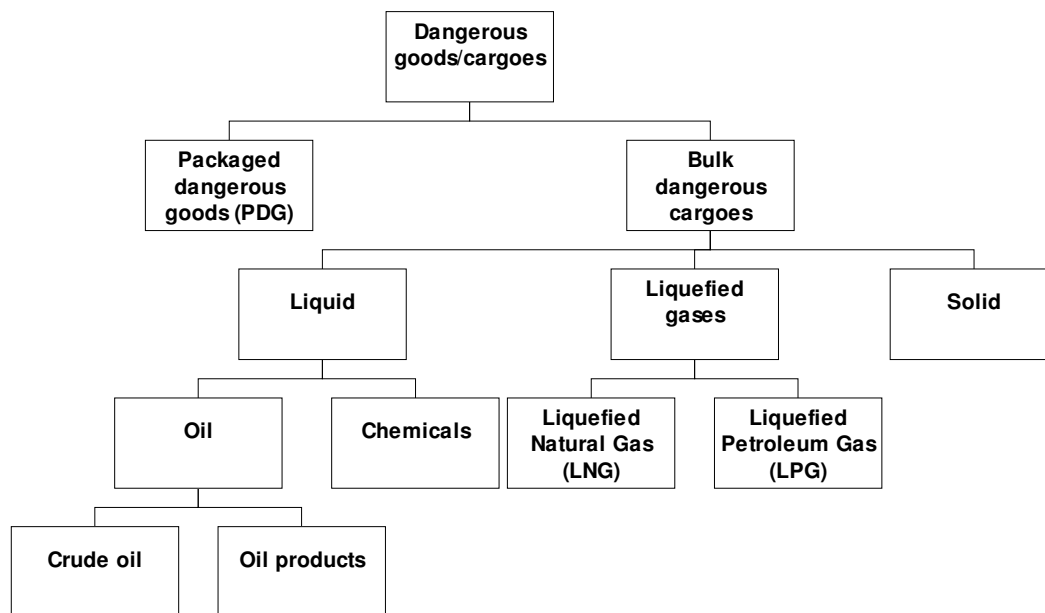


Figure 3: The form in which dangerous goods/cargoes are carried by sea

Some substances and materials are hazardous only when carried in bulk, because they are liable, for instance, to reduction of oxygen in the cargo space or the emission of toxic fumes, or may be prone to self-heating (e.g. coal and wood chips) (BC Code).¹⁰ Many bulk dangerous cargoes are carried in purpose-built ships, but, as the case histories have shown, they are also shipped in *packages or bulk packagings* (HCB 1986-2003).

Paine (1990) defines packaging as a means of achieving safe delivery in sound condition to the final user at a minimum cost overall. This is an important constituent element of the transport system. There are many different types of packagings or containments that are designed and constructed for the purpose of the carriage, storage, handling and use of a

⁹ With reference to sea transport and related activities in port areas regulatory framework.

¹⁰ With reference to the Code of Safe Practice for Solid Bulk Cargoes (BC) Code

vast range of dangerous goods. The IMDG Code (2002, Chapters 6.1-6.9) provides general and specific provisions for construction and testing of packagings, IBCs, large packagings, portable tanks and road tank vehicles.

Packagings vary in size, shape, capacity, strength and materials. They may be of single-use or one-way packaging and multiple uses or reused packagings. Some packaging materials (e.g. plastic materials) are recovered, cleaned and prepared for processing into new packagings. Some other types of packagings (e.g. metal or plastic drums) are put into the chemical distribution chain after reconditioning, including cleaning, restoring and inspection. Reused packagings are often filled with the same or compatible substances or materials.

The terms “packaging” and “package” are often used interchangeably. However, the IMDG Code (2002, Chapter 1, p 31) makes a distinction between these terms, where packagings are defined as receptacles and any other components or materials necessary for the receptacle to perform its containment function. Packages are defined as the complete product of the packing operation, consisting of the packaging and its contents prepared for transport.

2.4.2.1 Packaging levels

Packagings are divided into three main levels, namely: *primary packaging, secondary packaging or shipping container and tertiary or unit load* (Paine, 1990). In the shipping industry, there are more than three levels of packagings. In terms of packaging levels, the IMDG Code (2002, Chapter 1.2, pp 27-34) categorises and defines packagings into: *inner packagings and receptacles, intermediate packagings, outer packagings and composite packagings*. For example, inner receptacles (e.g. bottles or bags), which may require an outer packaging, are the smallest and simplest packaging types. On the other hand, the barge carried onboard barge-carrying ships is the largest packaging type. A ship may be considered a very large and complicated "packaging" in its own right.

2.4.2.2 Packaging types

Packaging terms and concepts assume different meanings in different contexts. In practice, one form of classifying different shipping commodities is

in terms of packaging/cargo transport units (Stopford 1993). The IMDG Code (2002) specifies a packaging type for each dangerous substance, article and material listed. Some dangerous goods containment types that are defined for the purpose of application in the IMDG Code (2002, Chapter 1.2, pp 27-34) are:

- *"Conventional" packagings* (e.g. drums, bags, fibreboard boxes) of up to 450 litres/400 kg are required to meet certain standards, pass specified performance tests, and bear UN packaging codes as evidence of this. The IMDG Code (2002) indicates a range of possible packages for every substance, which are all subject to the prime requirement that the packaging materials must be compatible with the proposed contents.
- *Intermediate Bulk Containers* (IBCs) are large rigid or flexible packagings of a capacity up to 3,000 litres and are designed for mechanical handling. Six types of IBC are specified, together with performance tests and details of which substances are allowed in which types of IBC, and with any special requirements (IMDG Code 2002, vol. 2 – DGL and vol. 1 - Chapter 4.1 and 6.5).
- *Large packagings*. Amendment 30, Chapters 4.1 and 6.6 of the IMDG Code (2002), introduces the concept of large packagings that consist of an outer packaging having a capacity between 400 kg or 450 litres up to 3,000 litres, but containing either inner packagings or articles that are designed to be handled by mechanical means.
- *Bulk packagings* are cargo transport units loaded with solid dangerous goods without any intermediate for of containments. Certain solid dangerous goods are transported in bulk packagings when indicated in the DGL by "BP" in column 8. Dangerous goods transported in closed cargo transport units (CTU's), closed road or rail vehicles are considered packaged dangerous goods.
- *Unit load* means that a number of packages are either: 1) placed or stacked on and secured by strapping, shrink-wrapping, or other means to a load board such as a pallet; 2) placed in a protective outer enclosure such as a pallet; 3) permanently secured together in a sling.
- *Portable tanks and road tank vehicles* range in size from 450 litres upwards. Different tank types (e.g. IMO type 4, 6 or 8 tanks) that are required to accommodate different requirements of various liquids and gases are described in detail in the IMDG Code (2002). Items such as maximum allowable working pressure, relief valves, filling ratios etc., are all dealt with, together with specific requirements for individual

substances (IMDG Code 2002, volume 1, Chapters 4.2, 6.7, 6.8 and 6.9 also in the DGL).

- *Freight container* is an article of transport equipment that is of a permanent character and strong enough to be used for repeated use; especially designed to facilitate the transport of goods, by one or more modes of transport, without intermediate reloading; designed to be secured and/or readily handled, having fittings for these purposes, and approved in accordance with the International Convention for Safe Containers (CSC 1972), as amended. This does not include vehicles and packagings. The term container is largely referred to as a box. There are various types and sizes of containers used worldwide, but the most common standard sizes are 20 foot (known as TEU) and 40 foot containers.
- *Cargo transport units (CTUs)* are freight vehicles, rail freight wagons, freight containers, road and rail tank vehicles/wagons and portable tanks.
- *Ship-borne barges* are independent and non-propelled vessels especially designed and equipped to be lifted in a loaded condition and stowed as a unit on board a barge-carrying ship or barge feeder vessel. LASH barges load about 400 tons cargo and Seabees load 600 tons (Stopford 1993).

Limited quantities of certain classes/packing groups, when packed as specified in the Code, may not be subject to the full requirements of the Code provided they meet the lesser requirements detailed (IMDG Code 2002, vol. 2, DGL column and 3.4).

2.4.2.3 Packaging groups

For packing purposes, substances, materials and articles of all classes, except classes 1, 2, 4.1, 5.2, 6.2 and 7, are assigned to three packing groups in accordance with the degree of danger they pose. The packing groups are (IMDG Code 2002, vol. 1, p 49):

- *Packing group I*: Substances presenting high danger;
- *Packing group II*: Substances presenting medium danger;
- *Packing group III*: Substances presenting low danger.

2.4.2.4 Packaging functions

Packaging functions derive from the basic needs for packaging. Jönsson (1998) and Paine (1990) describe packaging functions as follows: *containment, protection, distribution facilitation, information and communication, and recovery functions*. “Dangerous goods” packaging shares similar basic functions with other “ordinary” (or non-dangerous goods packaging) packagings, but the priorities are somewhat different. Due to the inherent hazardous properties of dangerous goods and the high risks they present, “dangerous goods” packagings are designed and constructed to meet more stringent requirements. In summary, the IMDG Code (2002, Chapter 1, pp 16-24, in accordance with SOLAS 74 and MARPOL 73/78 regulations) sets general and specific requirements for the packaging of dangerous goods, which shall be:

- Well-made and in good condition;
- Interior surface is not dangerously affected by the substance;
- capable of withstanding the ordinary risks of handling and transport by sea;
- Absorbent or cushioning materials, when used, shall be capable of minimizing the dangers and movements and ensure that the receptacle remains surrounded, of sufficient quantity to absorb the liquid in the event of breakage of the receptacle;
- Adequately constructed, tested, maintained and correctly filled.

2.4.3 Means of transport: ships

Ships are the operational means by which objects of transport are moved. “*Ship*” means a vessel of any type whatsoever operating in the marine environment, and includes hydrofoil boats, air-cushion vehicles, submersible, floating craft and fixed or floating platforms (MARPOL 1973/78, Art.1, p 8). PDG are carried onboard many different types of ships. In addition, many different types of ships and objects interfere with vessel traffic of PDG. Means of transport such as road vehicles, wagons, or barges carried onboard ships are considered as cargo transport units (CTUs) in maritime transport.

Swedish Law (Ordinance, 3§) on transport of dangerous goods defines the ship (Rosenberg 1998, p 12):

A ship that transports goods in packaged form, in containers, tanks or vehicles.

Ships have undergone considerable changes, not least in shape or design, construction, size, operation and management. Ships have grown bigger (O'Neil 1998). According to O'Neil (1998), the average age of ships has increased steadily in recent years to around 15 years, which has implications for the safety and the marine environment. Old ships may be more vulnerable to accidents. Poor maintenance and corrosion are some causes of ship's engine and structural breakdowns (O'Neil 1998).

The ship itself is a complex system in its own right constituting many different interrelated systems. The ship is made up of the following main sub-systems or components (Monioudis 1997): structure/hull, navigation, machinery and piping, power generation, fire-fighting, heating and ventilation, monitoring and control, communication, and lifesaving equipments and devices.

2.4.3.1 Types of ships

The classification systems used by international statistical organisations, such as Lloyd's Register of Shipping, recognise hundreds of ship types (Stopford 1993). Ships are categorised in many different ways, for example based on the type and amount of cargo carried, ship's services and properties. For statistical purposes, Lloyd's Register of Shipping (LRS 1996) categorises ships by structure, basic grouping and type, as shown in Table 3.

Table 3: Ship structure, grouping and types (LRS 1996)

Ship type	Basic grouping	BULK LIQUID CARGO	CARGO/PASSNGER CARRYING SHIPS	SHIP STRUCTURES
- Liquefied Gas Tanker - Liquefied Gas/Chemical Tanker	- Liquefied Gas			
- Chemical Tanker - Chemical/Oil Tanker	- Chemical			
- Oil Tanker	- Oil			
- Molasses Tanker - Fruit Juice Tanker - Water Tanker etc.	- Other Liquids			
- Bulk Carrier - Ore Carrier	- Bulk Dry	BULK DRY/LIQUID CARGO		
- Bulk/Oil Carrier - Ore/Oil Carrier	- Bulk Dry/Oil			
- Self-Discharging Bulk Carrier	- Self-Discharging Bulk Carrier			
- Cement Carrier - Wood Chips Carrier - Urea Carrier etc.	- Other Bulk Dry			

Ship type	Basic grouping		
- General Cargo Ship - Palletised Cargo Ship - Deck Cargo Ship	- General Cargo	ALL OTHER DRY CARGO	
- Passenger/General Cargo Ship	- Passenger/General Cargo		
- Container Ship	- Container		
- Refrigerated Cargo Ship	- Refrigerated Cargo		
- Ro-ro Cargo Ship - Container/Ro-ro Cargo Ship - Vehicle Carrier - Landing Craft	- Ro-ro Cargo		
- Passenger/Ro-ro Cargo Ship - Passenger/Landing Craft	- Passenger/Ro-ro Cargo		
- Passenger Ship	- Passenger		
- Livestock Carrier - Barge Carrier - Heavy Load Carrier etc.	- Other Dry Cargo		
- Trawler - Fishing Vessel	- Fish Catching	FISHING	SHIPS OF MISCELLANEOUS ACTIVITIES
- Fish Factory - Fish Carrier etc.	- Other Fishing		
- Offshore Supply Ship	- Offshore Supply	OFF-SHORE	
- Offshore Support Ship - Offshore Well Production Ship - Drilling Ship etc.	- Other Offshore		
- Research Ship	- Research	ALL OTHER ACTIVITIES	
- Tug - Pusher Tug	- Towing/Pushing		
- Dredger - Hopper Dredger	- Dredging		
- Motor Hopper - Sludge Disposal Vessel - Crane Ship - Cable Ship - Ice-Breaker etc.	- Other Activities		
- Barges - pontoons	- Non-propelled ships		
- Moored oil processing ship - Moored cement handling ship			
- Yacht - Sail training ship - Naval auxiliary ship	- Other ships structures		

In accordance with the order and terms used by respective sources, Table 4 shows two largely different classification systems of ship types. The United Nations Conference on Trade and Development (UNCTAD 2001) employs the classification system mainly based on the Lloyd's Maritime Information Service (LMIS), for the purpose of the review of maritime transport performance. The Swedish Maritime Authority (SMA 2002) uses the system for the purpose of marine accident statistics.

Table 4: Ship type classification systems (UNCTAD 2001; SMA 2002)

	UNCTAD 2001		SMA 2002	
	Group	Ship types	Category	Description
1	<i>Oil tanker</i>	- Oil tankers	<i>Passenger</i>	- Passenger (not ro-ro) - Passenger (ro-ro) - Road ferry - Passenger (seasonal) - Passenger, other
2	<i>Bulk carriers</i>	- Ore and bulk carriers - Ore/bulk/oil (OBO) carriers	<i>Tanker</i>	- Oil tanker - Gas tanker - Chemical tanker (one chemical) - Chemical tanker (more than one chemical) - Oil/ore - Bulk/oil - Tanker, other - Cob
3	<i>General cargo</i>	- Refrigerated cargo ships - Specialised cargo ships - Ro-ro cargo ships - General cargo ships (single- and multiple- deck) - General cargo/passenger ships	<i>General cargo</i>	- Reefer - Ro-ro/ auto/ container - Ore - Bulk carrier, other
4	<i>Container ships</i>	- Fully cellular ships	<i>Fishing</i>	- Fishing licensed by the National Board of Fisheries*) *) As of 1 September 1994 boats >5 m with special permit
5	<i>Other</i>	- Oil/chemical tankers - Chemical tankers - Other tankers - Liquefied gas tankers/carriers - Ro-ro passenger ships - Passenger ships - Tank barges - General cargo barges - Fishing vessels - Offshore supply ships - All other ship types	<i>Other</i>	- Tug/salvage - Barge/pontoon - Supply - Ice breaker and Accommodation platform - Other merchant vessels

In practice, many ship types do not operate in a separate and self-contained market. Despite specialisations, there are some degrees of

substitution among ship types (Stopford 1988). Some ship types move freely from one market to another, for example, OBO (oil/bulk/ore) and reefer ships. In addition, given properties and services abilities of the ship, there is no clear-cut distinction among certain ship categories or types (see categorisations in Tables 3 and 4). Case histories have shown that, in some cases, pallets, tank or freight containers with dangerous goods are reported to have been carried on the decks of small coastal oil/chemical tankers or barges (HCB 1986-2003).

The following is a description of some ship types carrying PDG and interfering with vessel traffic of PDG.

- *Container or cellular ship* is a ship in which containers are loaded below deck into specially designed slots giving permanent stowage of the container during sea transport. Containers loaded on deck are stacked and secured on special fittings (IMDG Code 2002, Chapter 1.2, p 27). Fully cellular container ships carry only ISO containers. The carriage of containers on board of containerships is referred to as lo/lo (lift-on/lift-off) when compared to the ro/ro (roll-on/roll-off) system. The size of container ships ranges from less than 100 TEU's to 5,000-6,000 TEU's, and the largest container ship today is 9,000 TEU.
- *General cargo ship* (or general dry cargo) is a ship designed to carry general cargo, often having several decks because of the number of ports served and the range of products carried (Brodie 1994). With some variations, Lloyd's Register of Shipping (LRS 1996), the Institution of Shipping Logistics (ISL 1997), and the Swedish Maritime Authority (SMA 2002)¹¹ include in the "general cargo" ship category these types of ships: single deck and multi-deck ships; reefer ships; special ships; ro-ro cargo ships; and lo/lo ships. Some other sources, for example, (LRS 1996) (IMO 1998-2000), and (SIKA/SCB 2001) of world marine casualty statistics and world/national fleet statistics, classify reefer ships and ro-ro ships as separate categories of ship type. In 2003, for the purpose of statistics, Lloyd's Register Fairplay (2003) has included in the "Other General Cargo Ship" category ships other than tankers, dry bulk and container ships. This category comprises: general cargo ship/ breakbulk ships, ro-ro ships, passenger ships, partial containerships, refrigerated cargo ships, barge carriers, heavy-lift ships, vehicle carriers, and specialized cargo ships. The sources mentioned have given the term

¹¹ Including these sources: Lloyd's Register of Shipping (LR) (1996), ISL Merchant Fleet Data (1997), and the Swedish Maritime Authority (SMA) (2002)

“general cargo ship” both the broad and narrow definition (i.e. breakbulk ships, single- and multiple- deck ships).

- *Ro-ro ship* (roll on-roll off) is a ship that has one or more decks, either closed or open, not normally subdivided in any way and generally running the entire length of the ship, carrying goods which are normally loaded and unloaded in a horizontal direction (IMDG Code 2002, Chapter 1.2, p 32). The ro-ro concept has undergone a process of evolution. Ro-ro ships vary in type and size. The main categories of ro-ro ships are: a) ro-ro cargo ships – carry cargo only, including drivers/personnel of freight vehicles; b) ro-ro passenger ships – carry passengers only, including their personal vehicles; and c) ro-ro cargo/passenger ships – carry combined cargo and passengers. A ferry ship is a ship, including other forms of vessels such as hydrofoil or air-cushioned vessels, for transporting passengers and usually vehicles/cargo across a short water crossing, especially as a regular service (Brodie 1994).
- *Reefer ship* is a specialised ship type that usually carries so-called “reefer cargoes”, such as food and agriculture products, for example fruits, vegetables, seeds, meat, fish and juice, which are usually packed on pallets. Many products carried as reefer cargo have inherent hazardous properties, while some others may turn from “non-dangerous” to dangerous cargo due to deterioration processes. In many circumstances, reefer ships also carry cargoes other than reefer cargoes, including many different PDG.
- *Passenger ship* is usually employed in cruising. Large ships accommodate over 3,000 passengers. Smaller and faster ships are employed in coastal (or short sea) and inland waterway passenger traffic. Combined cargo/ passenger ship types (e.g. ro-ro ferries) are in operation in many parts of the world, for example in the Baltic Sea, the North Sea and the Mediterranean Sea.
- *Barges*, which are divided into powerless and self-propelled barges, are commonly used in inlandwater and coastal traffic. A series of barges may be connected together to operate as a single unit, known as an integrated barge. Barges carry both liquid and dry cargoes. They vary in size from a few tonnes up to 60,000 tonnes carrying capacity (Coyle et al. 2000 p 159).
- *Barge-carrying ship* is a ship specially designed and equipped to transport ship-borne barges (IMDG Code 2002, Chapter 1.2, p 27). LASH (Lighter Aboard Ships) barges are barges that are loaded on

board sea or ocean-going ships. Barges may be carried to and from barge-carrying ships by barge feeder vessels.

- *Bulk cargo ship/carrier* (dry/liquid bulk) is a ship designed with specialized holds for carrying dry and/or liquid commodities, in unpackaged bulk form, such as oil, grain, ore, and coal. Bulk carriers are designed to carry a single bulk product (crude oil tanker), or accommodate several bulk product types (e.g. ore/oil and ore/bulk/oil carrier, known as OBO carrier) on the same voyage or on a subsequent voyage after the holds are cleaned. A dry bulk carrier (often known as "bulk carrier") is a ship specifically designed to transport vast amounts of dry cargoes in bulk. Based on their sizes, bulk dry carriers are categorised (Gorton et al. 1990) as follows: small size; "handy size" "handymax" described as large handy size and mostly equipped with good gears; "panamax" - this type represents the largest measurements allowed to pass through the Panama Canal – they are mostly gearless; "cape size" – the "large capes" are over 170,000 dwt. Modern bulk dry carriers with technically sophisticated equipment can, in addition to traditional bulk commodities, be used for transportation of unitized dangerous cargoes, such as paper, seeds, baled cotton, bagged fertilisers and many other containerised or packed dangerous goods.
- *Tanker ship* is a specifically designed bulk cargo ship that carries large quantities of bulk liquid cargoes, such as oil, oil products, liquid chemicals, other liquids, and LNG and LPG. The latter are specialised tankers, known as LNG and LPG carriers or tankers. Tankers have grown in size. For example, crude oil tankers are: Ultra Large Crude Carrier - 300,000 dwt plus; VLCC - Very Large Crude Carrier – 200,000-300,000 dwt; ULCC - Suezmax – 100,000-149,999 dwt; and Aframax – 50,000-99,999 dwt. Although they do not carry PDG, tankers interfere with traffic of ships carrying PDG. Case histories (see HCB 1986-2003) have shown that tankers have been involved in marine events, for example collisions, with ships carrying PDG.

2.4.4 Dangerous goods related activities or processes

There is a wide range of activities or processes related to maritime transport. One division is between activities performed during: a) *transit*, at sea, enroute or voyage time; and b) *port time*: c) *others*. Transit time is the time taken for goods to be carried from one place (i.e. port) to another (Brodie 1994). Port

time comprises the time that a ship requires for preparing and delivering/receiving goods. The “other” category comprises the time when the ship is neither in transit nor loading/discharging in port, for example, time at the shipyard, laid up or under arrest. Some activities are specific for each division (e.g. at sea: navigational operations and in port: loading and discharging operations), but some other activities are performed at sea and ports alike, for example, cargo caring and supervision, maintenance and repairs, and other activities – bunker or ballast transfers etc.

Operating activities of ships are also divided into: *main and supporting or auxiliary activities*. The main activities are those operations that are related to the main purpose of a ship i.e. transport of goods and/or passengers from one port to another. For example, the movement or the carriage, loading and unloading of cargo/passengers are the main activities while maintenance, dry-docking, and communication are examples of the supporting activities. Both groups are important and interrelated and it is difficult to draw a distinct line between them.

The main activities related to dangerous goods maritime transport that are governed by regulations include cargo handling – loading and unloading or filling (e.g. tanks), stowage, segregation, container/CTU packing, cargo securing, communication – marking, labelling, and placarding and documentation, cargo caring and carriage. *Cargo handling* is defined as the process of loading, unloading, packing or unpacking of goods in means of containment for the purposes of transportation including storing in the course of transportation (CTDG Act 2001). Many activities are performed by different actors at different locations ashore, which may be beyond the ship’s responsibility and control.

The regulations governing these activities are provided in the SOLAS 74 and MARPOL 73/78 Conventions, which are incorporated and amplified in the IMDG Code (2002). The following describes some of the main activities that are known in the IMDG Code as (requirements concerning) “Consignment Procedures”, Part 5, and “Transport Operations”, Part 7.

2.4.4.1 Marking, labelling and placarding

SOLAS 74, Regulation 4, specifies that packages containing dangerous goods shall be:

- durably marked with the correct technical name; trade names alone shall not be used,

- provided with distinctive labels or placards to make clear the dangerous properties of goods;
- information on labels or placards will still be identifiable on packages surviving at least three months' immersion in the sea.

Packages containing dangerous goods shall be marked and labelled except when: dangerous goods are of low degree of hazard or packaged in limited quantities or in packages that are stowed and handled in units that are identified by labels or placards.

MARPOL 73/78, Regulation 3, specifies that packages containing harmful substances shall be:

- durably marked with the correct technical name; trade names alone shall not be used;
- provided with distinctive labels or placards to make clear the dangerous properties of goods;
- packages containing small quantities of harmful substances may be exempted from the marking requirements.

Detailed specific requirements for specific types of dangerous goods and packages are provided in the IMDG Code (2002, pp 391-412), Part 5, Chapter 5: "Consignment Procedures." Each class is allocated a specific label or labels indicating the main hazard pictorially and showing the class number. Each package containing dangerous goods must bear the appropriate label. Freight containers, vehicles, etc., containing such packages are required to bear enlarged labels or placards. When dangerous goods have two or more hazards, the subsidiary hazards are indicated by means of additional appropriate labels/placards. The packages and CTUs containing marine pollutants shall clearly display the "Marine Pollutant" mark. Although CTUs containing dangerous goods in "limited quantities" do not have to be placarded, they shall be marked on the exterior as "limited quantities".

2.4.4.2 Documentation

SOLAS 74, Regulation 5, specifies that:

- on all documents, related to the transport of dangerous goods by sea, the correct technical name of the goods shall be used; trade names alone shall not be used;
- the shipping documents prepared by the shipper shall include, or be accompanied by, a signed certificate or declaration that the shipment

offered for transport is properly packaged and marked, labelled or placarded and in proper condition for transport;

- the persons responsible for the packing of dangerous goods in freight containers or road vehicles shall provide a signed container/vehicle packing declaration stating that goods have been properly packed and secured and that all appropriate transport requirements have been met;
- when requirements 2 and 3 are not met and the packing declaration is not available the freight container/vehicle shall not be accepted for shipment;
- ships carrying dangerous goods shall have a specific list or manifest setting forth (in accordance with regulation 2) dangerous goods on board and the location thereof; a detailed stowage plan may be in place of the list or manifest; a copy of these documents shall be made available to the person or organisation responsible.

Similar documentation requirements are provided in the *MARPOL 73/78, Regulation 4*, but concerning transport of harmful substances.

Specific requirements for dangerous goods, limited quantities, flashpoint, temperature, hazard etc are provided in the IMDG Code (2002). Information that has to appear on shipping documents (IMDG Code 2002, Part 5, Chapter 5.4, pp 412-421) falls into two categories:

- Invariably required – such as proper shipping name, class/division, UN number, Packing Group, number and type of packages, total quantity of dangerous goods and dangerous goods declaration signed by or on behalf of the shipper certifying that all the Code requirements have been complied with.
- Required only if applicable – such as flash point, marine pollutant and container packing certificate/vehicle declaration certifying that permitted dangerous goods have been properly packed and secured in a suitable container/vehicle. Special information is required for goods of classes 1, 2, 4.1, 5.2, 6.2 and 7 as mentioned in Chapter 5.4.

Multimodal Dangerous Goods Form (MDGF). The IMDG Code (Chapter 5, p 420) contains a MDGF that meets the requirements of the SOLAS 74, Chapter VII, Regulation 2, the MARPOL 73/78, Annex III, Regulation 4, and the IMDG Code, Chapter 5.4. This document is not mandatory.

2.4.4.3 Stowage, segregation and securing

SOLAS 74 Convention, Chapter VII, Regulation 6, requires that: Dangerous goods shall be loaded, stowed and secured safely and appropriately in accordance with the nature of the goods. Incompatible goods shall be segregated from one another.

MARPOL 73/78 Convention, Annex III, Regulation 5, requires that: Harmful substances shall be properly stowed and secured so as to minimize the hazards to the marine environment without impairing the safety of the ship and persons on board.

Stowage refers to where (on deck or under deck) and on what type of ship (cargo or passenger) different dangerous goods may be stowed or whether prohibited. Dangerous substances, materials and articles are required to be stowed as indicated in column 16 of the IMDG Code's Dangerous Goods List (DGL) (IMDG Code 2002, Vol.1, Chapter 7.1) in accordance with one of the specified stowage categories: Stowage Category A through E. The IMDG Code contains general and specific stowage provisions for specific classes (e.g. classes 1, 2, 3, 4, 5, 6, 7) and stowage in relation to:

- a) living quarters;
- b) undeveloped films and plates, and mailbags;
- c) marine pollutants;
- d) foodstuffs.

Segregation is concerned with keeping dangerous goods a safe distance from: a) dangerous goods in other classes (e.g. explosives from flammable liquids); b) dangerous goods in the same class (e.g. some acids from alkalis, both being in the corrosives class); c) non-dangerous goods (e.g. toxics from foodstuffs). According to the Code, two substances or articles are considered mutually incompatible if stowing them together may result in undue hazards in case of leakage or spillage, or any other accident. The IMDG Code (2002) specifies four levels of segregation utilizing a segregation table (IMDG Code 2002, Vol. 1, Chapter 7.2), together with specific segregation information in the Dangerous Goods List (column 1.6). The numbers, symbols and terms used are:

- 1 – “Away from”
- 2 – “Separated from”
- 3 – “Separated by a complete compartment or hold from”
- 4 – “Separated longitudinally by intervening complete compartment or hold from”
- X – The segregation, if any, is shown in the DGL

For the purpose of segregation, dangerous goods having certain similar chemical properties have been grouped together in segregation groups as listed in the IMDG Code (2002, Chapter 7.2, p 610).

The IMDG Code (2002, Chapter 7.2) contains general and specific segregation provisions, including segregation tables, terms, definitions, numbers and symbols, for various packaging levels, such as:

- segregation of packages;
- segregation of CTUs on board container ships;
- segregation of CTUs on board ro-ro ships;
- segregation in ship-borne barges and on board barge-carrying ships;
- segregation between bulk dangerous materials and packaged dangerous goods.

2.4.4.4 Transport, loading and unloading

Chapters 7.4, 7.5, 7.6, 7.7 and 7.8 of the IMDG Code (2002, pp 687-704) contain general and specific provisions concerning transport, loading and unloading of dangerous goods: in CTUs on board ships; packing of CTUs; in ship-borne barges on barge-carrying ships; temperature control; and transport wastes.

General provisions concern the applicability of the provisions and some general requirements, for example, examination of CTUs/packages prior to loading for any sign of damage, leakage or shifting of contents prior to loading, ventilation of cargo space and/or CTUs and heat protection of dangerous goods, if required. Specific provisions concerning specific packages/CTUs, classes and ships (e.g. ro-ro ships or barge-carrying ships) include:

- Design, strength, construction, equipment and fitting requirements for CTUs, barges, cargo spaces, ventilation systems, temperature control systems etc.
- Selection of suitable packages, freight containers or CTUs, handling equipment, and securing arrangements for the carriage of specific dangerous goods (e.g. class 1).
- Transport permission and rejection of packages/CTUs and exemptions.
- Loading and stowage arrangements not specified elsewhere in the Code.

- Packing of CTUs: visual examination of CTU; removal of irrelevant information; adequate packing, bracing and securing during the voyage; unpacking of CTU including cleaning of dangerous goods residues.
- Supervision of loading and unloading processes of packages/CTUs on board ships.
- Cargo caring: regular supervisions of packages/CTUs with dangerous goods during loading and unloading operations and during the voyage.
- Precautions during transport of dangerous goods, e.g., in ro-ro cargo spaces.
- Temperature control (refrigeration and heat control): procedures/monitoring, stowage, instructions, means and methods of temperature control, special provisions for classes 4.1 and 5.2, and vehicles transported on board ships.
- Ventilation procedures.
- Fire protection measures.

2.4.5 Transport infrastructure

Transport infrastructure consists of all man-made permanent facilities that make transport and transport-related activities possible, such as ports or terminals, man-made waterways, and other facilities. Ports are often large and complex entities (OECD 1996). As the link between sea and land, ports are the points where the different transport modes meet (EC 1996c) (Poza et al. 2003). Ports facilitate modal transfer (Coyle et al. 2000), i.e. the transfer of freights and/or passengers from one mode to another: land-water-land. They facilitate essential ship's activities (i.e. port time), such as loading and unloading, stowage, segregation and cargo securing. Ports provide a wide range of cargo handling systems: cranes, forklifts, etc. They also provide storage facilities for large amounts of many different types of cargoes, including PDG. In many countries, specialised warehouses are built and equipped to serve handling and storage of PDG.

Ports vary in type, size, management, specialization and technology. There are many different types of ports, such as ro-ro ports/terminals, deep sea and river ports, container terminals, passenger terminals, and conventional ports. Passenger terminals are points from which passengers can board and depart means of transport (Coyle et al. 2000). In many industrialised countries, the focus has shifted from "traditional" ports to ports serving different transport modes and logistics activities. Today, many

companies operating in ports can arrange a total logistics package, including pre-delivery inspection, delivery, documentation and stock control at the terminal of PDG.

There are too many ports of different sizes. However, only a few of the biggest ports handle the largest share of world cargo port traffic (by volume/amount/value). In the 1990s, the top 20 ports of the world handled approximately 52 % of total world container traffic.¹² Tables 5 and 6 show the total cargo (all types of cargo) volume (in metric tons) and container traffic (in TEU) handled in 2000 in each of the world's top 10 ports and the total for the top 40 ports (AAPA 2004). Estimations indicate that the top 10 ports handled (2000) 42.4% and 55.8% of the total cargo volume and container traffic respectively in the top 40 ports (see Table 5 and 6). In 2000, container traffic through the top 10 and 40 ports accounted respectively for 41.5% and 74.4% of the total world port container traffic of 192.3 million TEUs (UNCTAD 2001).

Table 5: World port ranking, 2000 – top 10 and 40 ports (total cargo volume) (AAPA 2004)

<i>Total cargo volume, metric tons (1000)</i>			
Rank	Port	Country	Tons
1	Singapore	Singapore	325 591
2	Rotterdam	Netherlands	319 969
3	South Louisiana	United States	197 680
4	Shanghai	China	186 287
5	Hong Kong	China	174 642
6	Houston	United States	173 770
7	Chiba	Japan	169 043
8	Nagoya	Japan	153 370
9	Ulsan	South Korea	151 067
10	Kwangyang	South Korea	139 476
Total of the world top 10 ports			1 990 895
Total of the world top 40 ports			4 690 884

¹² Containerization Year Book, 1992

Table 6: World port ranking, 2000 – top 10 and 40 ports (container traffic)
(AAPA 2004)

Container traffic (TEUs)			
Rank	Port	Country	TEUs
1	Hong Kong	China	18 098 000
2	Singapore	Singapore	17 090 000
3	Pusan	South Korea	7 540 387
4	Kaohsiung	Taiwan	7 425 832
5	Rotterdam	Netherlands	6 274 000
6	Shanghai	China	5 613 000
7	Los Angeles	United States	4 879 429
8	Long Beach	United States	4 600 787
9	Hamburg	Germany	4 248 247
10	Antwerp	Belgium	4 082 334
Total of the world top 10 ports			79 852 016
Total of the world top 40 ports			143 122 995

Through ports flow international and domestic dangerous goods in both waterborne and land traffic (OECD 1996). Almost every port in the world handles dangerous goods (Roos 1997).

2.4.6 Vessel traffic: PDG vessel traffic

Traffic is defined as the movement of means of transport in the infrastructure (KFS 2003, pp 205-207). Vessel traffic is measured in different ways, for example by the number/ tonnage/type of ships, amount/volume/value of cargo, and size/type of shipments per year (see Table 7 and 8).

Table 7 shows that world vessel traffic (by type of cargo in billion tons-miles) has increased significantly during the period 1970-2000 (Fearnley 2000). During this period, the total world cargo traffic has more than doubled, whilst the “other dry” cargo traffic category has almost tripled – from 2,118 in 1970 to 5,951 billion tons-miles in 2000.

Table 7: World shipping performance by types of cargo for selected years
(billion tons-miles) (Fearnley 2000)

Year	Oil		Dry cargo						World total
	Crude oil	Products	Iron ore	Coal	Grain	Bauxite & alumina	Phosphate	Other dry cargoes	
1970	5 597	890	1 093	481	475	n/a	n/a	2 118	10 654
1980	8 385	1 020	1 613	952	1 087	n/a	n/a	3 720	16 777
1990	6 261	1 560	1 978	1 849	1 073	205	154	4 041	17 121
1998	7 889	1 970	2 306	2 419	1 064	205	135	5 600	21 588
1999	7 975	2 010	2 317	2 350	1 186	204	133	5 753	21 928
2000	8 340	2 080	2 515	2 500	1 210	211	133	5 951	22 940

Table 8 shows in more detail cargo types and amounts (in million tons) of the “dry” and “other dry” cargo traffic (UNCTAD 2001), and PDG are carried as such.

Table 8: Dry cargo seaborne trade, in 2000 (million tons) (UNCTAD 2001)

Nr	Categories of dry cargo seaborne trade	Million Tons
1	Iron ore	455
2	Coal	520
3	Grain	225
4	Bauxite/alumina	55
4.1	Bauxite	31.4
4.2	Alumina	23.6
5	Rock phosphate	26.5
6	Minor bulk	700
6.1	Agriculture products: sugar rice, soyameal and oil seed	130
6.2	Fertilizers	66
6.3	Forest products	161
6.4	Steel products	187
6.4	Others: cement, coke, scrap, pig iron, salt and ore	161
7	General cargo: breakbulk, ro-ro and containerized goods	1750
Total dry cargo		4 491.5

Approximately 80% of the world tonnage carries dangerous cargo (Olsen, 1993), which includes bulk and packaged dangerous goods/cargo. Other sources (e.g. Gooley 1997; HCB 1997) indicate also that the amount of dangerous cargo shipped from plants to large population centres along fragile rivers and vulnerable coastlines continues to rise every year.

International and domestic waterborne transport of PDG is largely unknown. For commercial and other reasons, ports and responsible authorities do not always provide statistical information (Monnier and Gheorghe 1996). In addition, due to complicated situations in connection with dangerous goods traffic, statistics prepared by various parties are sometimes difficult to reconcile (Monnier and Gheorghe 1996).

The IMO (1996a) has estimated that between 10-15% of cargoes transported by water are dangerous goods that are carried in packaged form, including shipborne barges on barge-carrying ships, freight containers, bulk packagings, portable tanks, tank-containers, road tankers, swap-bodies, vehicles, trailers, immediate bulk containers (IBCs), unit loads and other cargo transport units. According to the editor of the Hazardous Cargo Bulletin (2000)¹³, this figure may be higher for some ports, countries and regions.

Transport patterns reflect the flow of people and commerce (Coyle et al. 2000). Transport affects society in that it simulates commerce and movements. On the other hand, the demand for commerce and movements influences transport. The demand for ships is derived from the demand for transport (Stopford 1993). The waterborne traffic is affected by many different factors, but the most influential factors include: world economy and trade, waterborne commodity trade, trade patterns, transport costs, political events, and technological developments. Any growth in the freight transport sector brings an increase in dangerous goods traffic (U.S. DOT 1997). In 1994, it was estimated that approximately 4 billion tons of hazardous materials were transported across the U.S., or about 500,000 shipments per day (Glenn 1994). In recent years, this figure has increased up to 800,000-1,000,000 shipments per day (Ross 2002) (HWN Archive 2001). Since 1990, U.S. exports and imports have more than doubled, and it is anticipated that they will double again by the year 2020 (Wetzel 2004). Approximately 95 % of U.S. imported and exported goods are carried by water (Wetzel 2004). Such an increase coincides with U.S. economic growth during this period.

Tables 7 and 8 show world dry cargo traffic including breakbulk, ro-ro and containerized goods traffic has increased significantly. Large amounts of different PDG are carried as “dry”, “other dry” and “general” cargo. According to UNCTAD (2001), world container port traffic has continued to expand, reaching up to 192.3 million TEUs in 2000. However, the volume of PDG

¹³ Telephone interview with the HCB editor (2000)

traffic cannot be readily and reliably identified from general vessel traffic statistics.

The world's major water routes have two main patterns, namely (Coyle et al. 2000): a) the routes of an *east-west pattern* among developed countries that have traditionally been the routes to/from Europe, North America and the Far East; and b) the routes of a *north-south pattern* among developed and developing countries that are the routes to/from Africa and South America. With regard to the world's major liner routes, Stopford (1993) specifies these main routes:

- *North Atlantic route* covers the trade between northwest Europe, East Coast Canada and the United States.
- *North America to Far East route* covers the trade between East and West Coast North America and the Far East, stretching from Japan to Singapore.
- *West Europe to Far East route* covers the trade between Western Europe and the Far East countries.

In addition to the above main routes, there are many other routes covering trades among countries within a region and countries of different regions, for example, the Mediterranean Sea area, Africa, South America, India and Pakistan, and the Middle East.

Box 2 presents an example of PDG vessel traffic in the Baltic Sea and the Öresund area.

Box 2: PDG vessel traffic in the Baltic Sea/Öresund area

In the absence of statistics, in order to map PDG vessel traffic in the Baltic Sea area a survey study was conducted in 1990 (MEPC 1993). Vessel traffic data were collected from all main ports in the area during a period of two months – October and November. Vessel traffic for the entire year was then estimated based on extrapolations of the survey results. For the purpose of the study, the Baltic Sea area was divided into 13 smaller areas, where the Öresund area was designated the number 4 area. Survey results on PDG vessel traffic in the Öresund area have shown (MEPC 1993):

- 259,296 tons of dangerous goods were moved per annum; an average of 710 tons were en route each day;
- 26,574 dangerous goods shipments were moved per annum; an average of 73 shipments were en route each day; on average 9.8 tons

Box 2: PDG vessel traffic in the Baltic Sea/Öresund area

per shipment;

- All dangerous goods classes were represented, including marine pollutants;
- Package types by which dangerous goods were carried consisted of bags, barrels, drums, cans, cases, boxes, packages, and cylinders, which were packed in containers or other CTUs;
- PDG were carried by different ship types including dry cargo ships, ro-ro ships, container ships, bulk carriers, and other ship types.

Table 9 shows PDG shipments per month, including information about the class, the UN number, the technical name, the number of shipments and quantities in tonnes, transported in the Öresund waters.

It has been estimated that over 300 million tons of dangerous goods, including all types of dangerous goods carried in bulk and packaged form, are transported every year in the Baltic Sea Region (BSR) (TSE 2006).

Table 9: Shipments of PDG per month in the Öresund area (MEPC 1993)

<i>Class</i>	<i>UN Number</i>	<i>Name</i>	<i>Number of shipments per month</i>	<i>Quantity in tons per month</i>
8	1789	Hydrochloric acid	50	1200
3	1263	Paint	150	1100
6	1935	Cyanide solution*	15	600
6	2312	Phenol, molten	15	600
8	1830	Sulphuric acid	25	600
3	1993	Flammable liquid	60	500
Total			2200	21600

*Cyanide solution:

- Class 6.1 – poison/toxic
- Marine pollutant – P
- Packaging group - I/II/III
- Subsidiary risk – none

2.4.7 Human element: maritime transport interests

The human factor is an important element of the system that designs, develops, builds, operates, regulates and interacts with other components of the system. Individuals and groups, their relations and communications within the organisation form organisational systems. In maritime transport, there is a wide range of interrelated different interests, which are categorised in different ways.

One common division consists of *transport users* (shippers), *transport providers* (carriers) and the *government* (Coyle et al. 2000). A carrier may be a person, organisation or government undertaking transport of dangerous goods by any means of transport. This includes both carriers for hire (known as common or contract carriers) and carriers on own account, known as private carriers (IMDG Code 2002). Many important interests are also directly linked with maritime transport, including third party service providers such as freight forwarders, third party logistics providers, shipping and port agents, and shipbrokers, pilots, port interests, class societies, maritime insurance organisations, shipbuilding, industry's associations and unions.

In the shipping chartering business, the main parties are (Stopford 1988) (Gorton et al. 1990): a) *the shipowner* – an individual or a company with a ship for hire; b) *the shipper* – an individual or company with cargo to transport by sea and c) *the charterer* – an individual or company that hires a ship. The term “cargo interests” is also used in shipping to define many different organisations involved or concerned with dangerous cargoes (IMO 1996e). The relationships (responsibilities, obligations and rights) among these parties are complex. They are generally regulated by rules, laws or contracts. For example, the charter party is a contractual agreement between a shipowner and a cargo owner, usually arranged by a broker, whereby a ship is chartered or hired either for one voyage or a period of time (U.S. TI 2001).

According to their responsibilities in connection with safety and health and the environment protection of the transport of dangerous goods, the U.S. DOT (1994) categorizes concerned parties into:

- *Individuals*: e.g. ship board and shore side personnel;
- *Companies*: e.g. consignors, consignees, shipowners, ship operation and management companies;
- *Responsible or competent authorities*: e.g. transport modes (road, rail, water, air, and pipeline) administrations or authorities including maritime administration, rescue and response service agencies, environment

protection agencies, port state control (PSC) authorities, police authorities, inspectorates or inspection authorities, coast guards etc.

The government's role, which may assume many different facets, is a very important factor in the maritime transport industry. The government influences and controls the industry in many different ways and to different extents, for example through legal, political and financial instruments. Governmental agencies issue, amend, promulgate and enforce regulations. Through the power of its agencies contained in the constitution, the government exercises its authority and has control over dangerous goods transport, safety and health and environment protection. The degree of independence/ interdependence, cooperation, and responsibility of competent authorities within their areas of responsibility, which is regulated by law, may vary among countries. In addition to the interests mentioned, shareholders, public interests, non-governmental organisations and associations are some other important groups interested in maritime transport of dangerous goods and issues concerning safety and health and marine environment protection.

Box 3 presents Swedish transport and competent authorities and their responsibilities.

Box 3: National authorities

Swedish authorities and their areas of responsibility

Swedish transport authorities

The Swedish law (Transport of Dangerous Goods Act 2006:263 and its Ordinance 2006:311, 2§) regulates questions concerning transport authorities designated by the government for each respective transport mode (SFS, 2006). The following authorities, which according to the Ordinance 2006:311, 2§ have specific responsibilities, are called "*transport authorities*":

- Land transport: Swedish Rescue Services Agency (SRSA)
- Air transport: Swedish Civil Aviation Safety Authority
- Sea transport: Swedish Maritime Administration (SMA)

SRSA is the transport authority for questions that are not related to any transport mode. The aforementioned transport authorities are responsible for issuing regulations concerning transport of dangerous goods in their own respective areas of responsibility. In their areas of responsibility, authorities also represent Sweden in regional (e.g. the EU and the Baltic Region) and

Box 3: National authorities

international organisations, bodies or working group meetings (e.g. ADR, RID, IMO, UN Committee of Experts on transport of dangerous goods) concerned with the transport of dangerous goods.

Swedish competent authorities

Swedish competent authorities, including their areas of responsibilities, are specified, with reference to 8§ - see below, in the Ordinance 2006:311, 7§:

- Radiation Protection Authority: in matters concerning transport of radioactive materials;
- Nuclear Power Inspectorate: in matters concerning transport of radioactive materials;
- Police Authority: in consultation with communal organisations for rescue services, in matters as specified in 8§ (Ordinance 2006:311) points 1 and 5, concerning permission and information of loading and discharging in public places;
- Swedish Rescue Services Agency (SRSA): in various matters as specified in 8§ (Ordinance 2006:311) points 1, 2, 5 and 6;
- Swedish Maritime Administration: in various matters as specified in 8§ (Ordinance 2006:311) point 3;
- Swedish Civil Aviation Authority: in various matters as specified in 8§ (Ordinance 2006:311) point 4.

Competent authorities in matters concerning supervision of transport of dangerous goods are provided in the Ordinance 2006:311, 10§.

According to Ordinance 2006:311, 8 §, competent authorities shall be responsible for specific tasks as specified in:

1. Annex of ADR
2. RID
3. IMDG Code
4. ICAO-TI
5. Council Directive 94/55/EG, 21 November 1994, concerning harmonisation of the member states' laws governing road transport of dangerous goods, as amended through Commission Directive 2004/111/EG;
6. Council Directive 96/49/EG, 23 July, 1996, concerning harmonisation of the member states' laws on rail road transport of dangerous goods, as amended through Commission Directive 2004/110/EG.

Swedish authorities responsible for the supervision

According to Ordinance 2006: 311, 10 §, the following authorities shall, within specified areas, have supervision over the observation of the law

Box 3: National authorities

(SFS 2006:263) on transport of dangerous goods and those directives that are communicated by means of the law:

1. Swedish Maritime Administration (SMA): sea transport;
2. Swedish Civil Aviation Authority: air transport;
3. Police Authority: land transport except rail transport;
4. Swedish Rail Administration: rail transport;
5. Swedish Coast Guard: goods in the land area of the port that are intended for further transport and, on request from the SMA for assistance, sea transport;
6. Radiation Protection Authority: transport of radioactive materials;
7. Nuclear Power Inspectorate: transport of radioactive materials;
8. Swedish Rescue Services Agency (SRSA): safety advisers for all transport modes and safe transport.

The responsible Swedish ministries (e.g. industry, employment and communication, defence, justice, sustainable development, foreign affairs, environment), authorities and other concerned parties regularly coordinate and cooperate with each other and other authorities and organisations at various levels – local, national, regional and international – in the matters concerning the transport of dangerous goods.

2.4.7.1 Shipping companies

In earlier days, shipowners were involved in all activities related to the ship only. Today, there is a diversity of situations. Ship-related functions are often divided into (Gorton et al. 1990):

- *Shipowning*: e.g. owning, purchasing or selling ships;
- *Ship management*: e.g. manning and technical supervision of ships;
- *Ship operation*: e.g. daily ship operations;
- *Commercial functions*: e.g. ship employment.

These functions are often divided among different companies located in different countries. On the other hand, shipping companies vary from companies involved in a niche market to companies conducting multiple shipping businesses. Some companies are even involved in activities or businesses that extend beyond the shipping industry. Shipping companies also vary in size, from a single small ship with a single owner or a minuscule organization where the owner has a total autocratic control of his “one ship”

company, sometimes referred to as an “over night” company, to “mega” carriers with hundreds of ships and very large staffs.

Shipping is largely a free market allowing a considerable scope for ship operators to determine their ships’ operating policy, including the level of expenditure on safety and pollution prevention, maintenance costs and the degree of compliance with internationally agreed rules (EC 1996b). Many shipowners have chosen to register their ships under other nations’ flags that offer conveniences in taxes, manning and safety requirements.

Crew

Personnel of a shipping company are often divided into: *ship personnel* (i.e. ship crew, personnel or seamen) and *shore-based personnel*. Depending on many different interrelated factors, such as ship type, size, age, service, management and nationality, the ship crew may vary in size, composition, specialisation, organisation, employment arrangements and quality or training. Over the years, crew size on cargo ships has fallen (Stopford 1988). Crew composition varies from a single nation to multiple nationalities, languages and traditions. Based on the ship’s main sectors, a traditional ship personnel categorisation consists of: *master*, *deck personnel* – chief officer or mate, deck officers (including radio officer), boatswain (bosun) and able-bodied seamen (AB) or ratings; *engine personnel* – chief engineer, engineers, electro-mechanics; and *other personnel* – e.g. catering personnel. Passenger ships and cargo/passenger ships (e.g. ro-ro ferries) have a large number of catering personnel.

Box 4 presents an example of categories and numbers of the ship personnel onboard Swedish merchant and fishing vessels.

Box 4: Personnel on Swedish merchant and fishing vessels

Tables 10 and 11 show main categories and numbers of ship personnel onboard Swedish merchant and fishing vessels (SMA 2002).¹⁴ An active seaman is a person who has worked in that capacity for at least 3 of the preceding 18 consecutive months. Personnel may have signed-on status on

¹⁴ Swedish Maritime Administration (SMA) 2002 Marine casualties and near accidents: Summary of marine casualties and near-accidents involving Swedish merchant and fishing vessels 2002. Ship personnel information is taken by SMA from the Swedish Seamen’s Register.

several vessels at the same time. Table 11 shows the categories and number of signed-on personnel registered in 2002 on merchant and special purpose vessels with a gross tonnage of 300 and over. In 2002, over 50% (or 2418 persons) of active catering personnel were women.

Table 10: Personnel status and numbers (SMA 2002)

<i>Number/year</i>	<i>2001</i>	<i>2002</i>
Active seamen	12625	13789
Whereof signed-on seamen	5843	5901

Table 11: Categories and numbers of signed-on personnel (SMA 2002)

<i>Nr.</i>	<i>Ship personnel</i>	<i>Number</i>	<i>As % of the total</i>
1	Masters	398	6.8
2	Mates	662	11.2
3	Deck crew	1217	20.6
4	Engineers	766	13.0
5	Engine crew	561	9.5
6	Catering	2297	38.9
	Total	5901	100.0

2.4.7.2 Dangerous goods training

The safe transport of dangerous goods and the marine environment protection rely very much on the appreciation by all persons concerned of the risks involved and detailed understanding of the regulations governing this transport (IMDG Code 2002, Chapter 1.3, p 45). The IMDG Code (2002) and STW Code, as amended, contain training requirements for both shore and ship (i.e. masters, officers and ratings) based personnel. The Code (2002) states that shore based personnel engaged in transport of dangerous goods by sea must receive training in the contents of the dangerous goods provisions. According to the IMDG Code (2002), shore based personnel include those who are engaged in dangerous goods transport related activities ashore such as: classification, marking, labelling, placarding, packing, preparing, loading/unloading, offering/accepting, enforcement, survey or inspection of dangerous goods shipments. Each person involved in

these activities is required to receive general, function-specific and safety trainings (IMDG Code 2002, Chapter 1.3, pp 45-46).

2.4.8 Information system – Information Technology (IT)

The information system is an essential element that facilitates the transport system, linking together all elements of the system into a single unit (KFS 2003). A broad range of diverse advanced information technologies (IT) is widely used, among other things, to enhance safety and environment protection and facilitate transport of dangerous goods. Some illustrative examples of IT applications in the field are described below:

- *The Electronic Data Interchange (EDI)* system is in place in many shipping companies and ports, which use it as a tool to facilitate documentary aspects of transport of dangerous goods.
- *The satellite tracing system* is an advanced IT application that allows tracing and monitoring the status and position of a container, ship or vehicle, including those loaded with dangerous goods, remotely via satellite. A tracing satellite device is affixed to the container or CTU, which receives and transmits data from/to satellites (GPS).
- *The bar-coding system* has been increasingly applied in dangerous goods and hazardous waste tracking. The system allows inventory managers to keep electronic tabs on many different types of dangerous goods. In combination with the bar-coding system, the Geographic Information System (GIS) technology is used to link an electronic map of a facility to dangerous goods databases.
- *The Operation Respond Emergency Information System (OREIS)* is a system designed in the USA to assist first responders such as firefighters, who are the first to arrive on the scene of dangerous goods accidents. The system accesses the mainframe databases of the participating carriers using an identification number. The system then verifies the cargo contents, converting hazmat information into a format that is easily understood and used by the first respondents. The system enables the first responders to make key decisions fast. OREIS has been used successfully in responding to dangerous goods accidents (Collins 1997).
- *Swedish marine accident related systems (SMA 2002)*. In order to enhance safety and marine environment protection and comply with international requirements (e.g. ISM Code), Swedish authorities in co-

operation with Swedish shipping interests have developed a number of integrated systems for reporting, recording and analysis of marine events and deviations. The Swedish Maritime Administration (SMA) has developed a computer system, known as the *Sea Casualty System* – in Swedish SjöOlycksSystemet (SOS) – for the purposes of registration and statistical analysis of marine accidents. Since 2002, the SOS has an Internet application. Information and data gathered from different sources are processed and codified according to a code scheme/manual (see SMA Database in Attachments). Information concerning the ship(s) involved in an accident is gathered from another system developed by the SMA, known as *Ship Inspection System*, in Swedish FartygsTillsyns Systemet (FTS). The Swedish Maritime Safety Inspectorate and the Swedish Shipowners Association have developed another system, known as the *Insjö system*. The system is used for reporting, recording and analysis of non-conformities or deviations and risks. The information generated from a combined analysis of accidents, near-misses and non-conformities or deviations is used in making decisions concerning safety at sea and marine environment protection. Serious marine accidents and lessons learned from them are reported to the International Maritime Organization (IMO).

2.4.9 Physical environment

The physical environment denotes the environment in which transport and other related activities take place. The maritime transport system of PDG is subject to a wide range of weather or atmospheric and navigational hazards. The basic elements of the physical environment are presented in Table 12. Either solely or in combination, they affect, in different forms and degrees of extent, different elements of the maritime transport system, including dangerous goods, packagings, means of transport (ships), infrastructure and equipment and risks associated with the system. The waterways (e.g. rivers, fjords, channels, straits, and canals) constitute the maritime transport infrastructure. Case histories (e.g. HCB 1986-2003) have shown that many marine accidents involving PDG have been attributed to these hazards. Further, a study concerning oil spills in the Öresund area (i.e. the sea water area between Sweden-Denmark) has also shown that a large portion (approximately 20%) of marine events (during the period 1985-1999) was attributed to weather and navigational hazards (Mullai and Paulsson 2002).

Table 12: Weather and navigation conditions

Category and sub-category		Elements
<i>Water</i> • Solid • Liquid • Vapour	• Oceans, seas, rivers, waterways, lakes • Fresh water • Mixture	• Waves, sea water spray • Current • Tide • Ice • Fresh water/spray • Precipitation: rain, snow • Fog • Condensation • Moisture/humidity • Sea/fresh water and vapour • Water/vapour contaminated, e.g. chemicals
<i>Air</i>		• Winds • Atmospheric pressure
<i>Sun</i>		• Temperature • Light
<i>Land/ water</i>		• Waterways: depths, air clearance, widths, lengths • Natural: oceans, seas, lakes, rivers, fjords, straits, channels • Artificial: canals, ports
<i>Other</i>		• Lightning

2.4.9.1 Marine environment – fauna and flora

The marine (water) environment is a constituent part of the ecosystem and the physical environment in which ships operate. The main elements of the system include: the body of waters – ocean, seas, inlandwaters (lakes, rivers, and canals); bottom or sediments; coastlines/ shorelines, beaches and banks, wetlands; marine/water habitants (fauna and flora); properties and the wide range of activities and values related to the marine/water environment.

Box 5 presents an example of the marine environment – the Öresund marine ecosystem.

Box 5: The Öresund marine ecosystem

The Öresund area is one of Europe's most sensitive and important from an environmental perspective. The Baltic Sea, which includes the Öresund waters, is the largest body of brackish water (i.e. slightly salty water) on Earth (Kocher 1995). The Baltic Sea's health has seriously deteriorated due to human activities, such as waste from industry, waste from urban areas and leftovers from fertilisers. The marine environment of the Öresund area has the following characteristics (Mullai and Paulsson 2002):

- Shallow waters;
- Slow water exchange processes;
- A relatively low level of biological activities;
- Beaches of great recreational value; they are vacation areas for many local and European residents, which provide service jobs in tourism and recreation;
- Contains 15 natural reserves (coastal and marine) – 12 Swedish and 3 Danish reserves;
- A number of areas of botanical and zoological interest on the Danish side; the coastal areas serve as feeding grounds for several species of marine and freshwater fish, and fishing is of economic importance for the area;
- EU areas of habitats: containing one “Baltic Sea protected” area, one “Convention on wetlands” area and a number of “EU bird directive” areas.

2.5 Regulatory system

The regulatory system governing transport is an important component of the transport system (Coyle et al. 2000). Regulations have been developed to control maritime transport, including all aspects: operational, economical, technical, safety and health, environmental and other aspects. Transport regulations have been a major force shaping the transport industry (Coyle et al. 2000). Regulations have continuously increased over the years. They vary across regions, countries or states, industries and sectors. Regulations overlap because of the overlapping jurisdictions of regulatory agencies developing and enforcing them.

Transport of dangerous goods is highly regulated. The forthcoming section describes the “state-of-the-art” regulations governing maritime transport of dangerous goods.

2.5.1 Introduction

There is a myriad of legal instruments and practices governing dangerous goods transport and transport related activities, encompassing conventions, resolutions, agreements, recommendations, codes, guidelines, legislation, acts, regulations, ordinances etc.¹⁵ Many different terms are used to describe this body of instruments, such as regulations, the system of regulations, the regulatory framework, the legal regime or standards. For the purpose of consistency, the term “regulations” is most frequently used in this report. Dangerous goods transport regulations may be categorised in different ways, including:

- *Geographical scope of application*: global/worldwide, international, regional (e.g. EU regulations), federal (e.g. USA regulations), national or domestic, local, organisational;
- *Legal effects*: mandatory or binding (e.g. rules or regulations) and non-binding (e.g. codes of practices);
- *Activities*: dangerous goods transport and transport-related activities such as activities in ports, packing, handling, stowage, segregation, documentation etc.;
- *Transport modes*: modal regulations - road, rail, waterborne, air and pipeline;
- *Form of carriage*: regulations concerning transport of *dangerous goods in packaged form* and in bulk.¹⁶

Regulations have various historical backgrounds of establishment and development. Some of the factors that, after the 1950s, contributed to the development of most dangerous goods transport regulations were:

- A rapid increase in dangerous goods traffic;
- New concepts of transport;

¹⁵ It should be noted that with respect to their legal status there is a distinction between regulations and recommendations, guidelines, codes. Regulations are of mandatory or legally binding nature, whereas recommendations and guidelines may be of non-binding nature.

¹⁶ With reference to the IMDG Code and the IMO’s definitions of “packaged form”, all dangerous goods carried by road, rail and air fall in the category of “packaged dangerous goods.”

- New technology and methods of cargo handling and transportation;
- Increasing numbers of accidents involving dangerous goods, which were subsequently associated with increasing public concerns about safety and the marine environment protection.

Regulations set out minimum standards for the carriage of dangerous goods dealing with different technical and operational aspects such as loading and unloading, packing, identification, marking, labelling and placarding of dangerous goods, documents, and stowage and segregation. However, many companies have established higher standards than those required (Coyle et al. 2000).

The regulatory system governing transport of dangerous goods and the transport system itself are interlinked with, as well as affected by, other regulatory systems concerning a wide range of systems, activities and aspects, for example transport and transport accidents in general, the environment, security, and safety and health in workplaces.

In the forthcoming section relevant regulations are described, including the UN Recommendations on Transport of Dangerous Goods, International Regulations and Codes of Practice concerning maritime transport of dangerous goods including Conventions (e.g. SOLAS 1974, MARPOL 73/78 and STCW Conventions), Codes of Practice (e.g. the IMDG Code 2002), and some examples of regional and national regulations. The description begins with the main UN organs, organisations and agencies responsible for development, amendment, revision and administration of the regulations concerning transport of dangerous goods.

2.5.2 The United Nations system and transport of dangerous goods

The United Nations (UN 2004) system consists of a number of bodies or agencies. The Economic and Social Council (ECOSOC), which is the largest UN organ, is responsible for many aspects concerning member states including economic, social and health problems. The ECOSOC coordinates the work of many subsidiary bodies, including 14 UN specialized agencies, 10 functional commissions and five regional commissions (UN 2004). The Council receives reports from 11 UN funds and programmes and issues policy recommendations to the UN system and to Member States. The Council also cooperates with a wide range of governmental and non-governmental organisations from different fields and sectors, academics and

businesses. Some of its subsidiary bodies are *responsible for transport of dangerous goods*.

The international work on the Transport of Dangerous Goods is focused on the United Nations Committee (UNCETDG) and Sub-Committee of Experts (UNSETDG) and various ad hoc specialist groups. The Committee of Experts, which has produced, issued and regularly revised the “*UN Recommendations on the Transport of Dangerous Goods*”, coordinates the work related to the transport of dangerous goods. The UN Recommendations cover the transport of dangerous goods, including hazardous wastes and substances. These recommendations serve as the basis for many national regulations and international instruments covering the transport of dangerous goods by sea, air, rail, road and inland waterways.

The United Nations Economic Commission for Europe (UNECE), which is one of five regional commissions of the UN, deals with many different aspects including the environment, statistics, sustainable energy, trade, industry and *transport*. The main activities of the Commission, which is coordinated with participants from many different international professional organizations and other non-governmental organizations, include development of conventions, regulations and standards, and technical assistance. The Commission has an ad hoc Group of Experts and seven principal subsidiary bodies. Each principal subsidiary body has its own permanent subsidiary bodies, i.e. the working groups established by the Commission. The UNECE subsidiary bodies dealing with *transport of dangerous goods*, which are subsidiary bodies of the Inland Transport Committee concerned with road, rail and inland waterway transport, are:

- The Working Party on the Transport of Dangerous Goods (WP.15), which is responsible for a) the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) and; b) the European Provisions concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN and ADN.R).
- The Joint Meeting of the Working Party on the Transport of Dangerous Goods and the RID Safety Committee (also called the RID/ADR Joint Meeting). The Joint Meeting is serviced jointly by the UNECE secretariat and the secretariat of the Intergovernmental Organization for International Carriage by Rail (OTIF).

The secretariat of UNECE is also responsible for the work of the ECOSOC Committee of Experts on the Transport of Dangerous Goods.

UNECE has developed more than 50 transport agreements and conventions that have become legally binding for countries that have ratified

them. These instruments cover many different aspects of transport safety, environment and facilitation including these categories: transport infrastructures, road traffic and road signs and signals, road vehicles, inland navigation, border crossing facilitation, transport of perishable foodstuffs, *transport of dangerous goods*, and other legal instruments related to road transport including working conditions, taxation, private law, and economic regulations. With respect to transport of dangerous goods, UNECE have developed and regularly update:

- European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR, 1957), including the Protocol;
- Convention on Civil Liability for Damage caused during Carriage of Dangerous Goods by Road, Rail and Inland Navigation Vessels (CRTD 1989);
- European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (AND 2000).

Important UN specialised agencies concerned with transport of dangerous goods include:

- The International Maritime Organization (IMO), responsible for maritime transport;
- The International Civil Aviation Organization (ICAO), responsible for air transport;
- The International Atomic Energy Agency (IAEA), responsible for nuclear technology including transport of radioactive materials and wastes.

The International Atomic Energy Agency (IAEA) is an autonomous organization under the United Nations (UN) (founded in 1957) that consists of 134 Member States (as per 2003) (UN 2004). It is an intergovernmental forum for scientific and technical co-operation in the peaceful use of nuclear technology. The Agency's broad spectrum of services, programmes, and activities also cover transport of radioactive materials and wastes. One of its purposes is to develop safety standards and promote the achievement and maintenance of high levels of safety and protection of human health and the environment in the transport of radioactive materials. The agency has produced the Regulations for the Safe Transport of Radioactive Materials and co-ordinates the work in transport of radioactive materials.

2.5.3 IMO and Conventions

In response to maritime safety concerns and the need for an international body in the maritime industry, the International Maritime Organisation (IMO)¹⁷ was formally established in 1948 after the adoption of a convention (known as the IMO Convention) by an international conference held in Geneva. The IMO consists of 166 member states whose combined merchant fleets represent more than 98% of world gross tonnage. The IMO's governing body is the Assembly, which meets every two years. A council, which consists of 32 member governments that are elected by the Assembly, acts as the IMO's governing body between sessions.

The IMO is a technical organisation where most of its work is carried out by a number of committees and sub-committees. The main committees, whose tasks are closely related to *the carriage of PDG by sea*, are the Maritime Safety Committee (MSC) and Marine Environment Protection Committee (MEPC). The Sub-Committee on Dangerous Goods, Solid Cargoes and Containers (DSC) is directly related to *the carriage of PDG by sea*. Three other committees are the Legal, Technical Co-operation and Facilitation Committees.

Transport of dangerous cargoes has been one of the IMO's main responsibilities. Since its inception, the IMO has convened many international conferences and developed many regulations, recommendations and codes of practice concerning the carriage of dangerous cargoes by sea. Thirty conventions and protocols and over 700 codes and recommendations concerning maritime safety, the prevention of marine pollution and other related matters have been adopted by the IMO (1995b).

International Conventions dealing with various aspects of maritime transport and environment contain provisions governing the carriage of dangerous goods, including PDG, by sea. Conventions adopted by the IMO fall into the following main categories (IMO 2004):

- Maritime safety;
- Prevention of marine environment pollution;
- Liability and compensation, especially in relation to damage caused by pollution;
- Other conventions dealing with facilitation, tonnage measurement, unlawful acts against shipping and salvage.

¹⁷The original name was the Inter-Governmental Maritime Consultative Organization (IMCO). The name was changed in 1982 to the IMO.

A detailed list of IMO's Conventions is provided in the Attachments to this report.

The most important International Conventions related to the carriage of *dangerous goods in packaged form by sea* are the SOLAS 74 and MARPOL 73/78 Conventions. Both Conventions provide the legal basis for international and national regulations.

2.5.3.1 The International Convention for the Safety of Life at Sea, 1974 (SOLAS, 74)

The International Convention for the Safety of Life at Sea (SOLAS 1974), as amended, is the most important of all international treaties dealing with shipping safety (IMO 1996b). The SOLAS 1974 sets the basic safety standards for all passenger and cargo ships, including ships carrying dangerous cargoes. Part A, Chapter VII, contains mandatory requirements for *the carriage of dangerous goods in packaged form* or solid bulk. It is stipulated that this part applies to dangerous goods classified under Regulation 2 that are *carried in packaged form* or in solid form in bulk. Part A contains mandatory requirements that are amplified in the International Maritime Dangerous Goods (IMDG) Code and the Code of Safe Practice for Solid Bulk Cargoes (BC Code). As at 31 July 2004, the SOLAS 1974 Convention has been ratified by 152 member states whose combined merchant fleets represent 98.5% of the world tonnage (IMO 2004).

2.5.3.2 International Convention for the Prevention of Pollution from Ships, (MARPOL, 73/78)

In 1973, the IMO convened a major conference to discuss the issue of marine pollution from ships, resulting in the adoption of the International Convention for the Prevention of Pollution from Ships (MARPOL 1973). In 1978, in response to a series of marine accidents, the IMO Conference adopted a Protocol to the MARPOL 1973. This combined instrument is known as MARPOL 1973/78, which entered into force in October 1983. The Convention has been amended several times since then.

MARPOL 1973/78 contains mandatory provisions for the prevention of pollution from ships. It consists of five Annexes dealing with:

- Annex I - Oil;
- Annex II – Noxious liquid substances in bulk;
- *Annex III – Harmful substances in packaged form*;
- Annex IV – Sewage;
- Annex V – Garbage.

Annex III contains mandatory provisions for the prevention of pollution by *harmful substances carried by sea in packaged form*. It stipulates (Regulation 1) that the carriage of harmful substances in packaged form is prohibited except in accordance with the provisions of this Annex (MARPOL 73/78, Annex III). Annex III entered into force on 1st July 1992. As of 31 July 2004, Annex III of the MARPOL 73/78 had been ratified by 113 member states whose combined merchant fleets represent 92.9% of the world tonnage (IMO 2004).

The SOLAS 1974 and MARPOL 1973/78 contain mandatory provisions concerning the carriage of PDG by sea that are incorporated and amplified in the IMDG Code.

2.5.3.3 ISPS Code

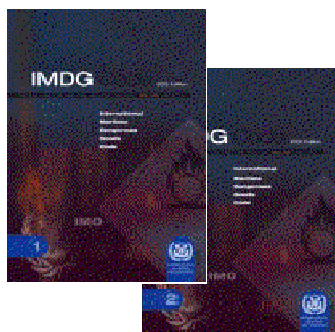
The International Ship and Ports Facility Security (ISPS) Code is adopted by the International Maritime Organisation (IMO 2004) as a security measure against terrorism in ports, ships and territorial waters. The implementation of the ISPS Code requirements, which took effect on July 2004, has become mandatory for all member states of the IMO. The European Union has adopted the ISPS Code in the EU Security Directive. The ISPS Code is mandatory for all ports/ terminals serving seagoing vessels of 500 grt and above on international voyages, including maritime transport and handling of dangerous goods. According to the ISPS Code, every port must carry out a risk assessment and design a port facility security plan, which describes the measures to be taken in enhancing the security in ports.

2.5.4 International Maritime Dangerous Goods (IMDG) Code

The principal international rules for *the carriage of packaged dangerous goods (PDG) by sea* are published in the International Maritime Dangerous Goods (IMDG) Code. The necessity for development and updating of the IMDG Code arises from the international seafaring community, maritime

trading interests and governments of maritime nations. The IMDG Code is based on the recommendations from the UN Committee of Experts on Transport of Dangerous Goods, SOLAS 1974 and MARPOL 1973/78.

For the IMO Member States that have ratified SOLAS 1974 and MARPOL 73/78 the IMDG Code requirements become indirectly mandatory. The IMDG Code serves as a basis for the national regulations in pursuance of the governments' obligations under Regulation VII/1.4 of SOLAS 1974 and Regulations 1(3), Annex III, of MARPOL 1973/78. In 1991, some 50 countries, whose combined merchant shipping fleets represented more than 84% of the world shipping, informed the IMO that they were applying the IMDG Code, which was going to be reflected in their national legislation (ICHCA 1992). In 1998, this number increased to 61% (IMO, 1998). Although it is primarily designed for the carriage of dangerous goods by sea, the IMDG Code affects directly and indirectly a wide range of parties and activities of the chemical supply chain or life cycle, including chemical and packing manufactures, packers, shippers, forwarders, carriers and terminal operators.



In order to keep pace with the rapid changes in the transport of dangerous goods and the shipping industry in general, regulations are further developed, modified or amended. Since its first appearance (1965), the IMDG Code has undergone considerable changes. Amendments originate from proposals submitted to the IMO by its Member States, and changes to the UN Recommendations (Orange Book). In the latter case, the Committee of

Experts makes appropriate amendments biennially. The IMDG Code is amended by the IMO's Sub-Committee on Dangerous Goods, Solid Cargoes and Containers (DSC).¹⁸

IMDG Code contents and layout

The IMDG Code (2002) is published in two volumes with a third volume entitled "Supplement".

- *Volume 1* contains parts 1, 2 and 4-7 of the Code.

¹⁸ Agreed amendments are approved before publication by the IMO's MSC and MEPC Committees

- *Volume 2* contains (part 3 of the Code) the Dangerous Goods List (equivalent to the schedules in previous editions of the Code), presented in tabular format.
- *Supplement (Volume 3)* contains numerous relevant IMO texts related to the IMDG Code.

The IMDG Code adopts a standard reference book format with the introduction, main contents, appendices and index. The Code's contents and layout have largely been harmonized with other modal regulations and the UN Recommendations.

The IMDG Code (2002) (Volumes 1 and 2) is divided into seven parts, each of which contains numbers of Chapters. The following is a brief summary of the main parts:

- *Part 1*: General provisions application and implementation of the IMDG Code; definitions units of measurements and a list of abbreviations; and training provisions for people engaged in transport by sea of dangerous goods.
- *Part 2*: Classification of dangerous goods: classes 1-9; definitions and properties of marine pollutants; and guidelines for the identification of harmful substances in packaged form.
- *Part 3*: Dangerous Goods List (DGL) and limited quantities exceptions: provides general information and specific provisions.
- *Part 4*: Packing and tank provisions: definitions; and general and specific provisions concerning the use of various types of packagings.
- *Part 5*: Consignment procedures: applications, general and specific provisions concerning the use, marking and labelling, documentation and identification of packagings and cargo transport units (CTUs).
- *Part 6*: Construction and testing of packagings and cargo transport units: general and specific provisions for construction and testing and inspection of packagings and cargo transport units.
- *Part 7*: Requirements concerning transport operations: general and specific provisions for (various types of packagings, CTUs and ships) stowage, segregation, carriage, packing, temperature control and transport of wastes; requirements in the events of an incident and fire.

Appendices

- Appendix A: List of generic and N.O.S proper shipping names
- Appendix B: Glossary of terms

Supplement volume

The "Supplement" volume to the IMDG Code comprises a number of separate IMO publications related to the Code concerning guidelines and

recommendations including these aspects: declaration of dangerous, dangerous goods packing and packing certificate, dangerous manifest, safety, emergency responses and procedures, reporting of incidents involving PDG, and inspection programmes.

The IMDG Code (2002) makes references to the applicability of the provisions of some of the above documents. For example, Chapter 7.4 (IMDG Code 2002, p 687) states that, unless otherwise specified, the provisions of the International Convention for Safe Containers (CSC) 1972, as amended, shall be followed for the use of any CTU.

Amendments to the IMDG Code

The amendments (May 2004) to the IMDG Code update several existing sections of the Code and include a new Chapter 1.4 (“Security Provisions”) concerning the security of the carriage of dangerous goods by sea (IMO 2004). These amendments, which take into account the introduction of a new IMO Code, i.e. the ISPS Code, entered into force in January 2006, but applied voluntarily from January 2005.

ISPS Code: The International Ship and Ports Facility Security (ISPS) Code was introduced by the International Maritime Organisation (IMO 2004) as security measures against terrorism in ports, ships and territorial waters. Implementation of the ISPS Code requirements, which took effect in July 2004, has become mandatory for all member states of the IMO.

Legal status

Amendments to SOLAS 1974, Chapter VII (Carriage of Dangerous Goods) adopted in May 2002, have made the IMDG Code mandatory from 1st January 2004 (IMO 2004). The IMDG Code (2002, Chapter 1.1, General Provisions, p 14) stipulates:

- Provisions are applicable to all ships to which SOLAS 74, as amended, applies and which are carrying dangerous goods classified under Regulation 2 of Part A of Chapter VII of that Convention.
- All ships, irrespective of type and size, carrying substances, materials or articles identified in this Code as marine pollutants are subject to the provisions of this Code.

- In the IMDG Code, the following parts are not mandatory:¹⁹ Chapter 1.3 (training), Chapter 2.1 (explosives, notes 1 to 4), 2.3.3 of Chapter 2.3 (determination of flashpoint), Chapter 3.2 (columns 15 and 17 of the DGL), Chapter 3.5 (transport schedule for class 7), 5.4.5 of Chapter 5.4 (multimodal dangerous goods form), and Chapter 7.3 (special requirements in the event of an incident and fire precautions involving dangerous goods).

Box 6 presents an example of regional regulations – the Memorandum of Understanding (MoU) concerning Transport of Dangerous Goods in the Baltic Sea.

Box 6: Regional regulations

Memorandum of Understanding (MoU) for Transport of Dangerous Goods in the Baltic Sea

The Memorandum of Understanding (MoU 2004) is an agreement among the member states of the Baltic Sea Region (BSR) concerning *maritime transport of packaged dangerous goods (PDG) on ro-ro ships in the Baltic Sea*. The member states of the MoU are Denmark, Estonia, Finland, Germany, Lithuania, Latvia, Poland and Sweden.

The MoU (2004) lays down the exemptions (Annex 1) in accordance with the IMO/MSC Circ. 1075, when transporting dangerous goods covered by the Regulations Concerning the International Carriage of Dangerous Goods by Rail (RID) and Annexes A and B of the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) onboard ro-ro ships in the Baltic Sea. According to the MoU (2004), the IMDG Code shall serve as basis for all technical and operational aspects of dangerous goods transport.

The MoU (2004) has replaced the MoU revised at the MoU Conference in Riga 2002 and Stockholm 2003. The MoU (2004) deals with technical, operational and other related aspects of maritime transport of PDG. The following is a summary of the contents of the MoU (2004):

Annex 1

- *Section 1: Application*

¹⁹ This implies that the rest of the Code is mandatory.

Box 6: Regional regulations

- Provisions of MoU applied on all ro-ro ships operating within the Baltic Sea, including the Gulf of Bothnia, the Gulf of Finland and the entrance to the Baltic Sea;
- Ro-ro ships having been issued with a Document of Compliance in accordance with the requirements of RID/ADR or IMDG Code;
- Dangerous goods which either fulfil the requirements of the IMDG Code or RID or ADR may be loaded together in the same CTU;
- *Section 2: Definitions*
 - With some exceptions, terms used in this MoU refer to the IMDG Code;
 - Low Wave Height Area (LWHA) is a sea area where according to the Agreement concerning specific stability requirements for ro-ro passenger ships – the significant wave height does not exceed 2.3 metres more than 10 % of the year.
- *Section 3: Transport of dangerous goods*
 - Dangerous goods classified, packaged, marked, labelled, documented and loaded in accordance with the requirements of RID, ADR or the IMDG Code may be transported in accordance with the provisions of the MoU.
- *Section 4: Loading and placarding of CTUs*
 - Packages shall be segregated from each other within CTUs in accordance with the provisions of the IMDG Code;
 - Placarding and marking shall be in accordance with requirements of the IMDG Code or RID/ADR;
 - CTUs containing marine pollutants have to be marked according to the IMDG Code.
- *Section 5: Transport of CTUs*
 - CTU packing certificate shall comply with the IMO/ILO/UN ECE Guidelines;
 - The consignor or his representative shall inform the master when dangerous goods are transport in accordance with specific requirements of RID/ADR;

Box 6: Regional regulations

- For mixed loading for traffic in LWHA, it has to be stated in the packing certificate: "Packed together according to the MoU" ;
- CTUs as referred to in 1.1.3.4 RID/ADR and 1.1.3.6 ADR shall display, on two opposite sides a neutral orange-colour plate.
- *Section 6: Stowage and segregation between CTUs*
 - Segregation between CTUs shall be in accordance with the provisions of the IMDG Code, except that for LWHA traffic no separation is required for segregation categories 1 and 2;
 - Stowage and segregation of class 1 shall be in accordance with the IMDG Code and the Document of Compliance (SOLAS 1974, II-2/19).
- *Section 7: Additional duties for the consignors*
 - The consignor shall ensure that dangerous goods are identified as "marine pollutant", if applicable;
 - The flashpoint range (61 °C or below) in accordance with the relevant packing group may be indicated.
- *Section 8: Requirements applicable to ships*
 - For ships constructed on or after 1 July 2002, regulation II-2/19 of SOLAS 74, as amended, shall be applicable;
 - The Document of Compliance shall include information specifying the classes of dangerous goods, which may be stowed in the individual cargo spaces of the ship;
 - A Letter of Compliance issued in accordance with the MoU is considered to be equivalent as being specified in the IMDG Code.
- *Section 9: Additional requirements*
 - CTUs containing dangerous goods shall be secured in compliance with the Cargo Securing Manual approved by the Administration;
 - The IMO/ILO/UN/ECE Guidelines for Packing of Cargo Transport Units (CTUs) shall be observed;
 - Ro-Ro vessels shall have on board current versions of the IMDG Code, RID, ADR;
 - Shipowners shall ensure that people who are involved in the transport

Box 6: Regional regulations

of CTUs are made familiar with the application of the relevant provisions.

- *Section 10: Transitional regulations*
 - On board cargo and passenger ships carrying not more than 1 passenger per 1m length of the ship, CTUs may be stowed under deck under the conditions according to the section 7 of the MoU, 1999.
- *Section 11: Entry into force*
 - Amendments to the MoU shall come into force not later than 1 January 2006.

Appendix of Annex 1 of the MoU includes:

- Competent Authorities
- Checklist for road transport
- Checklist for transport in ro-ro ships
- Report of competent Authorities

Annex 2

- Checklist for inspections in accordance with the MoU
- Checklist deficiency in accordance with the MoU

Annex 3

- Report for common controls

Annex 4

- List of competent authorities
- Appendix of the MoU provides guidelines for joint checks for the transport of PDG in ro-ro ships in the Baltic Sea. The checklist for inspections in accordance with the MoU is provided in the appendix of this report.

2.5.5 Federal and national regulations

Legally binding effects of international regulations derive from the obligation of states to adhere to an agreement to which they are contracting parties.

However, international regulations have no direct legal effect unless they are adopted into national or federal legislation and take the form of law. For example, when a convention is agreed, member states assume rights and obligations among themselves. But the convention signed by a government generally has no effect on national law until there has been an act of ratification or accession, and the convention has been incorporated by statute (Gaskell et al. 1992). In many countries, a Dangerous Goods Transport Act is passed by the parliament. The act creates the framework for establishing a national regulatory regime for transport of dangerous goods. Regulations are given legal effect by the act. In federal countries, the act is passed by the federal parliament and regulations are given legal effect by individual state and territory legislation.

Box 7 presents an example of the national regulatory system – Swedish legislation concerning the transport of dangerous goods.

Box 7: National regulatory system

Swedish legislation on the transport of dangerous goods

In principal, international or regional regulations or instruments, which are ratified by the Swedish government, become national laws or ordinances through legal procedures stipulated in the Swedish constitution. Based on these laws and their ordinances, Swedish responsible authorities adopt, issue and implement new international or regional regulations, including relevant derogations, in their areas of responsibilities. Prior to this, draft regulations are circulated to the concerned authorities, agencies and organisations for review and proposals for changes or amendments, in which implications and costs are considered.

In Sweden, except for maritime transport of bulk dangerous cargoes, all modes of transport of dangerous goods, including *maritime transport of PDG*, are regulated by the Swedish Transport of Dangerous Goods Act (SFS 2006:263)²⁰ and its Ordinance (SFS 2006:311)²¹ (SFS 2006). Maritime transport of bulk dangerous cargoes is regulated by the Swedish Maritime Vessels Safety Act (SFS 2003:438) (SFS 2006). Swedish regulations governing transport of dangerous goods are issued and come

²⁰ The original title in Swedish: "Lag (2006:263) om transport av farligt gods"

²¹ The original title in Swedish: "Förordning (2006:311) om transport av farligt gods"

Box 7: National regulatory system

into force through respective acts and ordinances. The regulatory system is further developed and amended on a regular basis by responsible transport authorities in cooperation with the relevant authorities, agencies and organisations.

The following are some important Swedish regulations (including acts, ordinance, regulations, directives, and directions) concerning transport of dangerous goods, safety, security and environment protection (SFS 2006; SMA 2006; TG 2006; Notisum 2006; SRSA 2006):

Dangerous Goods

- Swedish Transport of Dangerous Goods Act (2006:263).
- Swedish Ordinance (2006:311) on transport of dangerous goods.
- Swedish Rescue Services Agency regulations on the safety adviser for transport of dangerous goods (SRVFS 2006:9).
- Swedish Rescue Services Agency regulations on transport of dangerous goods on road and terrain (ADR-S) (SRVFS 2006:7).
- Swedish Rescue Services Agency regulations on transport of dangerous goods on rail (RID-S) (SRVFS 2006:8).
- Swedish Maritime Administration regulations on sea transport of packaged dangerous goods (SJÖFS 2005:15) (IMDG Code).
- Swedish Maritime Administration regulations and general directions on domestic sea transport of packaged dangerous goods in shipping areas D and E (SJÖFS 2004:18).
- Swedish Maritime Administration notification with regulations and general directions on transport of dangerous goods in port (SJÖFS 1991:8).
- Swedish Maritime Administration Regulations and general directions on compulsory registration, information obligations, and reporting obligations in certain cases (SJÖFS 2005:19).
- Swedish Maritime Administration regulations and general directions on transport of packaged dangerous goods on ro-ro ships in the Baltic Sea.

Maritime security

- European Parliament and Council Ordinance 725/2004/EC, 31st mars 2004, on enhancing ship and port facility security.

Box 7: National regulatory system

- Swedish Maritime Security Act (2004:487).
- Swedish Ordinance on maritime security (2004:283).
- Swedish Maritime Administration regulations on maritime security (SJÖFS 2004:13).
- Swedish Maritime Administration regulations (SJÖFS 2002:8) on ISM Code, the International Safety Management Code.

Seveso Legislations concerning major chemical accidents

- Swedish Act (1999:381) on measures to prevent and reduce consequences of serious chemical accidents.
- Swedish Ordinance (1999:382) on measures to prevent and reduce consequences of serious chemical accidents.
- Swedish Rescue Services Agency regulations (SRVFS 2005:2) on measures to prevent and reduce consequences of serious chemical accidents.
- Swedish regulations (AFS 2005:19) on prevention of serious chemical accidents.

Ship reporting system

- European Council Directive (2002/59/EC) on a supervision and information system for shipping.
- Swedish Maritime Administration regulations (SJÖFS 2005:19) on compulsory registration, information obligations, and reporting obligations in certain cases.

The Ordinance on the *maritime transport of packaged dangerous goods*²² contains: application; classification; packing; marking and labelling; documents; requirements concerning stowage; explosive substances in passenger ships; declaration of dangerous goods; regulations for stowage of liquids and liquid gases. A dangerous goods declaration form, transport emergency instructions and a container packing certificate are appendixes to the document.

Swedish responsible authorities keep the national regulatory system governing transport of dangerous goods up-to-date and in line or harmony with the relevant international and regional regulations.

²² The original title in Swedish: "Sjöfartsverkets kungörelse med föreskrifter om transport till sjöss av farligt gods i förpackad form."

Box 8 presents an example of the inspection programme for the transport of dangerous goods in Sweden.

Box 8: Inspections of the transport of dangerous goods

In Sweden, inspections of dangerous goods transport are regulated by the Swedish Transport of Dangerous Goods Act (SFS 2006:263). They are carried out on a regular basis.

In response to a request of the IMO Sub-Committee on Dangerous Goods, Solid Cargoes and Containers for providing information on the Member States national programmes of PDG inspections, Sweden submitted a report concerning “Inspection and Control of Dangerous Goods and Securing Cargo” in December 1996 (IMO 1996f).²³ The report is based on the inspection programme for cargo units, such as road vehicles, tank vehicles, trailers and freight containers, with dangerous goods during the period March 1994–September 1996. During this period, 4193 cargo units were inspected. The main purpose of the inspection programme was to investigate and identify to what extent people involved in the transport of dangerous goods, in particular shippers, were not complying with the regulations. The programme included the examination of cargo securing systems inside the cargo transport units.

The study was carried out in two (in 2 out of 3) districts, namely: district 1 (Stockholm) included all ports on the eastern coast of Sweden from Sundsvall in the north down to the south, including Norrköping and Västerås; and district 2 (Malmö) included the southern part of Sweden from the port of Oskarshamn to the port of Helsingborg.

According to the report, the inspection programme was inconsistent and this was reflected in the overall study results. With regard to deficiencies in compliance with dangerous goods transport regulations, because of differences in inspection methods, inspections in districts 1 and 2 reached to two different results. The differences in the number of cargo units with deficiencies between the two districts were significant. District 1 reported only units with dangerous goods, and district 2 reported the total number of units inspected.

²³ IMO (International Maritime Organisation) (1996f), “Reports on incidents involving dangerous goods or marine pollutants in packaged form on board ships or in port areas”, submitted by Sweden, December 1996, Sub-committee on Dangerous Goods, Solid Cargoes and Containers, Document DSC 2/INF. 13, 19. The report was collected during the field study at the port of Ystad.

Table 13, which provides the results of inspections of 885 cargo units with dangerous goods in both districts, shows that the number of cases of deficiencies was significant. In total, deficiencies in compliance with transport regulations were noted in 383 cases, which comprised 43.3% of the total number of units inspected (885) (see Table 13).

Table 13: Dangerous cargo transport units with deficiencies (IMO 1996f)

<i>Nr.</i>	<i>Dangerous goods</i>	<i>District 1</i>	<i>District 2</i>	<i>Total</i>
1	Number of units inspected	383	502	885
2	Number of deficiencies	219	164	383
	% of units with deficiencies	57.2%	32.7%	43.3%

The list of deficiencies (Table 14) shows that the majority of deficiencies (33.4%) were found in stowage and securing of cargo within transport units. Other significant deficiencies were: faults in declaration of goods (8.1%); marking and labelling of units (7.6%); faults in container packing certificate (5.7%); labelling of packages (5.5%); stowage/securing of transport unit on board ship (4.4%).

Table 14: The list of deficiencies (IMO 1996f)

<i>Nr</i>	<i>List of deficiencies</i>	<i>Number of units with deficiencies</i>	<i>Percentage</i>
1	Advance notification	6	1.6
2	Documentation	31	8.1
3	Ems/MFAG	11	2.9
4	Stowage plan	-	-
5	Segregation	2	0.5
6	Container packing certificate	22	5.7
7	Placarding, marking (units)	29	7.6
8	Labelling (packages)	21	5.5
9	Packagings	8	2.0
10	Stowage/securing of unit	17	4.4
11	Stowage/securing inside unit	128	33.4
	Total	383	100%

Table 15 shows statistics on dangerous goods inspections carried out by the Swedish police authorities during the period 1998-2001. Inspections, which include inspections of all vehicles trafficking in Sweden, are carried out on a regular basis. They are carried out at road checkpoints and terminals. During the period 1998-2001, the number of inspections has remained unchanged. Some categories of deficiencies have been repeated every year.

Table 15: Dangerous goods inspections during the period 1998-2001

	Inspections, deficiencies	1998		1999		2000		2001		Total	
		No	%	No	%	No	%	No	%	No	%
1	Inspections: deficiencies are found	2067	28.7 ²⁴	1742	26.7	1780	25.0	1500	24.0	7089	26.15
2	Reported to prosecutor	270	13.0 ²⁵	237	13.6	250	14.0	233	16.0	990	13.96
3	Prohibit/ban	267	12.9 ²⁶	220	12.6	265	14.9	184	12.2	936	13.20
4	Legal action, injunction ²⁷ or order	1397	67.6 ²⁸	1231	70.6	1243	69.8	957	63.8	4828	68.11
5	Total inspections	7208		6529		7123		6250		27110	

Table 16 shows the most common categories of deficiencies observed in dangerous goods inspections during the period 1998-2001. The deficiencies are ranked based on the number of incidences.

Table 16: The most common categories of deficiencies

<i>Nr</i>	<i>Categories of deficiencies</i>	<i>Deficiencies</i>	
		Number	As % of the total
1	Dangerous goods declaration	530	23.4
2	Fire extinguisher	469	20.7
3	Written instructions	325	14.3
4	UN number, marking of packages etc.	282	12.4
5	Vehicle marking	238	10.5
6	Protection equipment	153	6.7
7	Two warning lights	138	6.0
8	Vehicle certificate	135	6.0
	Total	2270	100.0

Deficiencies are observed in one-fourth of inspections carried out during 2001. The seriousness of deficiencies varied from reporting to prosecutor, prohibition or banning to legal actions, such as injunction or order. Notes or warnings were made in cases of deficiencies related to dangerous goods declaration, written instructions and fire extinguishers.

Similar dangerous good inspection programmes are in place in other countries, for example in the USA, European (e.g. Netherlands, Belgium, UK, Finland and Germany) and other OECD countries (e.g. Australia and New Zealand). All these inspections have shown that people responsible for preparing and packing CTUs often violate dangerous goods transport regulations.

²⁴ As % of the total inspections, where one or more deficiencies may have been found

²⁵ As % of the inspections with deficiencies

²⁶ As % of the inspections with deficiencies

²⁷ Injunction is the instruction or order issued by a court to a party to an action, especially to refrain from some acts.

²⁸ As % of the inspections with deficiencies

2.6 Summary

Maritime transport plays a vital role in the world's regions' and countries' economy and development. For many countries, it is the only international transport alternative. The maritime transport system of PDG, which is a constituent element of the transport system and the supply chain, consists of many different interrelated elements and sub-elements. This chapter has provided a systematic and exhaustive description of the system elements. Further, the essential concepts describing the system elements are defined based on the relevant and reliable sources. However, the distinction between concepts describing shipping divisions, markets or sectors, and elements and sub-elements of the system is not always watertight. There exist grey or overlapping areas among concepts. Undue consideration about these concepts and their relationships and respective definitions will have implications in validity and reliability of the research results.

The transport model (see Figure 2) shown in this chapter is used as a point of reference for defining and describing the components of the system. However, neither the model version presented in this chapter nor other versions adequately represent the transport system. The models lack certain essential components, including the human element and the regulatory system governing transport. Further, with reference to descriptions and definitions provided in this chapter, the relationships among constructs are not entirely complete and correct. For example, the maritime transport-related activities encompass a wide range of many different interrelated activities, such as loading/unloading, stowage, segregation, separation, securing, documentation, carrying, cargo care (e.g. temperature control) and many more. These activities involve all the system elements (e.g. means of transport, objects of transport and infrastructure). The "activity system" is not an exclusive relationship between the object of transport and the infrastructure as defined in the model (see Figure 2).

3 RISKS OF MARITIME TRANSPORT OF DANGEROUS GOODS

This chapter provides terms, definitions and concepts related to the main risk elements. It begins with description of different types of risks, and risk elements and how they are related to the concept of risks. The chapter also provides specific definitions and concepts of risks associated with transport of dangerous goods.

Maritime transport provides society with numerous benefits. However, positive aspects of transport are associated with costs (Coyle et al. 2000), including risks of loss of life and injuries, pollution and damage of the environment, exploitation of irreplaceable natural resources and land use. Protection of the marine environment from adverse effects of hazardous materials losses has been a growing concern (Coyle et al. 2000), in particular with increasing varieties and volumes of dangerous goods being shipped.

3.1 Types of risks

"What is risk?" There is no generally accepted definition of the risk. The following is a list of risk definitions commonly used in technical literatures, including those quoted in this report: "*risk is the probability of a loss*", "*risk is the size of possible loss*", "*risk is a function, mostly the product of probability and size of loss*", and "*risk is a function of probability and consequences of unwanted events.*" A common characteristic of these definitions is that they refer to the essential constituent concepts of the risks, which are: "*frequency/probability*" and "*consequences*" of "*unwanted or undesirable events.*" Examples of undesirable events are accidents and incidents involving maritime transport of PDG. The term "unwanted or undesirable" assumes various meanings in different contexts, but it is often used as a more neutral term. An "unwanted" event or situation for an individual or group of people may be a "wanted" event for another individual or group of people, for example, weather conditions or games. In some situations, this may also hold true for the same people, but at a different time.

Table 17 provides descriptions of some generic terms and their alternatives used in connection with the risk analysis of dangerous goods.

Table 17: Generic and alternative risk terms (CARAT 2001)

Generic terms	Alternative terms	Description – examples
<i>Sources of risks</i>	Risk producers: dangerous goods	<ul style="list-style-type: none"> • A configuration or an entity which has the potential to cause, or is specified to cause an adverse outcome, such as dangerous goods.
<i>Hazards: source having the potential to cause</i>	Hazards: dangerous goods hazards (DGH)	<ul style="list-style-type: none"> • Having the ability or capable of development into actuality and cause.
<i>Undesirable/ undesired outcome</i>	Consequence, effect, impact, harm	<ul style="list-style-type: none"> • Adverse consequences/effects such as fatality, injury, destruction, disruption of normal activity, or economic loss. • Results or final consequences judged to be adverse by the subject of concern.
<i>Subjects of concern</i>	Risk receptors: human, ecosystem, property/ assets and other	<ul style="list-style-type: none"> • Those beings, systems, or assets that are the targets of the potential to cause an undesired outcome. • Those subjects for whom there may be possible negative impacts from source of the potential to cause harm.
<i>Likelihood</i>	Probability Frequency	<ul style="list-style-type: none"> • The condition of being likely or probable • Percent occurrence per unit time e.g. year • Chance of an event

The term “risk” also assumes various meanings and it is used in different situations, senses and contexts by various people. The term is employed in many areas or activities, for example economic or financial risks, business risks, industrial risks, environmental risks, technical or operational risks, chemical risks etc.

Risks are categorised in different ways, for example *voluntary and involuntary risks* (Starr 1969; Starr et al. 1976; USEPA 1998), *statistically verifiable and non-verifiable risks* (Hammonds 1992), *natural risks, technological and human activities risks*. *Voluntary risks* are those associated with activities that people decide to undertake, for example, workers, stevedores or ship crews. *Involuntary risks* are those risks that are associated with activities that happen without prior consent or knowledge of, for example, members of public or community living adjacent to port or waterway areas. Acts of nature and exposure to environmental contaminants are examples of involuntary risks. Although exposed to involuntary risks, people may be aware of risks posed by dangerous goods related activities. They somehow accept these risks by trading off costs and benefits. In some countries, the level of individual risks for people who "voluntarily" expose themselves to risks (e.g. 1 in 10 000 per year for workers) is a factor of ten or more higher than the level of "involuntary" risk (e.g. 1 in 100 000 per year for members of the public) (OECD 2000).

Risks are divided into *statistically verifiable and non-verifiable risks* (Hammonds 1992). Statistically verifiable risks are risks that can be determined from direct observations. Hence, these risks can be compared with each other. Generally, risks from dangerous goods are statistically verifiable or determined risks. Statistically non-verifiable risks are those risks that are assessed based on limited data sets and mathematical models, for example risks of rare natural phenomena.

Risks are also divided into *natural and human activities risks*, where the latter are known as *technological or man-made risks*. In the second category also fall risks of dangerous goods-related activities, including maritime transport. Risks also take on various meanings for these activities, for example business risks, i.e. speculative risks arising from an enterprise. Risks of accidents involving dangerous goods are concerning issues for many countries and regions in the world. Transport of dangerous goods is a risk generator entailing possibilities of undesired outcomes (Scott 1996; HCB 1986-2003). Due to releases of dangerous goods, transport poses considerable threats to the public safety and health and to the environment (Weigkricht and Fedra 1993; HCB 1986-2003). However, technological and human activity risks should not be judged in isolation from the related benefits of these activities.

Natural and technological risks are often interconnected. For example, a natural disaster, such as a landslide, may be caused by human activities. If there is a chemical plant or storage facility in its path, this may, in turn, cause

an industrial disaster. Case histories (HCB 1986-2003; SMA 1985-1999) have shown that a large number of marine events are attributed to weather/sea hazards. These combinations of risks are known as "Na-Techs" ("Na" for natural, "Tech" for technological) risks (UNEP 1997).

Case histories (HCB 1986-2003) and the literature study have shown (see Figure 4) that risks are generated in any possible combinations of dangerous goods components, properties and their related activities. Dangerous goods related activities are considered "generators", "producers" or "sources" of risks. Usually, the expression risks "from or of" implies the source of risks, for example, risks from the carriage of dangerous goods by water. The exposed people, environment and properties are considered as the "risk receptors" (Ertugrul 1995). Risk receptors may also be parts of dangerous goods-related activities and systems. The expression risks "to" (at, on) is often used to indicate the risk "receptors", for example risks to people or the environment. However, there is no clearly defined line between risk generators and receptors, as the risk generators or sources may also become risk receptors in case of accidents. Dangerous goods hazards (DGH) have affected ships and packages as much as the human and the marine environment.

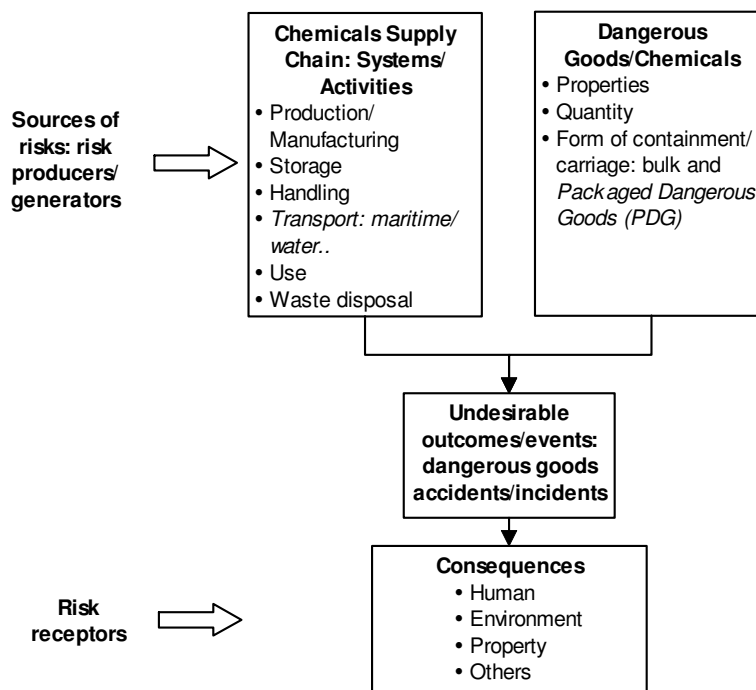


Figure 4: Types of dangerous good risks – risk generators and receptors

The list below, which is not exhaustive, shows that, in connection with events involving dangerous goods, the risk concept has a broad application, including:

- *Types of dangerous goods and activities*: e.g. risks from production or manufacturing, handling, storage (warehouse or fixed installation), and transport of oil and oil products, LPG, toxic chemicals, explosives, corrosives, or radioactive materials.
- *Location*: e.g. risks at (on) routes, ports, cities, countries, or regions.
- *The extent of hazards/accidents*: e.g. risks from major accidents during transport of dangerous goods (HSC 1991).
- *Quantities of dangerous goods*: e.g. risks of dangerous substances and materials produced, handled, stored or transported in large quantities. This is related to the amount of dangerous goods moved, for example over a certain period of time. Many risk studies deal solely with bulk dangerous goods/cargoes carried by sea in large quantities. Risks arising from the carriage of dangerous goods in “small” quantities may not be considered.
- *The form in which dangerous goods/cargoes are carried*: e.g. risks of dangerous cargoes carried in bulk (e.g. oil and oil products) by water. Another form of risks is risks of marine accidents involving *packaged dangerous goods*.
- *Categories of risk receptors or consequences*: e.g. human safety and health risks, environmental risks, property risks and other risks.

3.2 Constituent elements of risks

In order to have a more comprehensive understanding of the concept of risks, the essential constituent elements of risks are defined and described, such as *undesirable events (marine accidents/incidents)*, *dangerous goods hazards, causes, consequences and likelihood (frequency or probability)*. Risk definitions and concepts, marine accidents and incidents coding schemes and many formal and informal studies, which are quoted in this chapter, serve as a platform for defining and describing the mentioned elements.

3.2.1 Marine accidents/incidents

There is no generally agreed definition of what constitutes “accident”, “casualty” or “incident”. Terms such as “undesirable”, “unwanted”, “mishaps” or “misfortune” are also often used to denote events that cause or are likely to cause unwanted results or consequences. These terms, which are more neutral and do not indicate the scale or extent of consequences, may include all types of events, from catastrophic to incidents and near-misses. However, the most commonly used terms are “accident” and “incident”. Despite their distinctions, these latter terms are often used interchangeably.

Definitions vary across transport modes and countries. For statistical purposes, many organizations and institutions in different countries have designed their own definitions. For example, the U.S. Department of Transportation (U.S. DOT 1996) defines accident as any *unexpected event that disrupts or interferes with the orderly progress of a certain activity or process*. Accidents are associated with unwanted results, such as loss of life and injuries to people, loss and damage to goods, properties and environment, and other economic losses. In shipping, the terms "marine accident and incident" and "marine casualty" are used to describe undesirable events in connection with ship operations. With reference to the IMO (IMO 1996a), Lloyd’s Register of Shipping (LRS 1996) and other sources (U.S. BTS 2004; USCG 2004; SMA 2002; MAIB 2004; MAIIF 2004), the terms “marine accident” and “marine casualty” share common meanings. The IMO’s Code of Investigation of Marine Casualties and Incidents defines marine accident and incidents as follows (IMO 1996a):

- *Marine accident (casualty)* means an event that resulted in:
 - a) The death of, or serious injury to, a person that is caused by, or in connection with, the operation of a ship;
 - b) The loss of a person from a ship that is caused by, or in connection with, the operation of a ship; or
 - c) The loss, presumed loss or abandonment of a ship; or
 - d) Serious material damage to a ship; or
 - e) The stranding or disabling of a ship, or the involvement of a ship in a collision; or
 - f) Serious damage to the environment being caused by, or in connection with, the operations of a ship.
- *Marine incident* means an occurrence or event being caused by, or in connection with, operation of a ship by which the ship or any person is

imperilled, or as a result of which serious damage to the ship or structure or the environment might be caused.

For reporting purposes, with regard to the severity of events, the IMO (1996c) defines and categorises marine casualties as follow:

1. "Very serious" casualties are casualties to ships which involve total loss of a ship, loss of life, or severe pollution;
2. "Serious" casualties are casualties to ships which do not qualify as "very serious casualties" and which involve fire, explosion, collision, grounding, contact, heavy weather damage, ice damage, hull cracking, or suspected hull defect etc. resulting in:
 - a) structure damage rendering ship unseaworthy;
 - b) pollution, regardless of the quantity; and/or
 - c) a breakdown necessitating towage or shore assistance;
3. "*Less serious*" casualties are casualties to ships which do not qualify as "very serious casualties" or "serious casualties";
4. "*Hazardous incidents*".

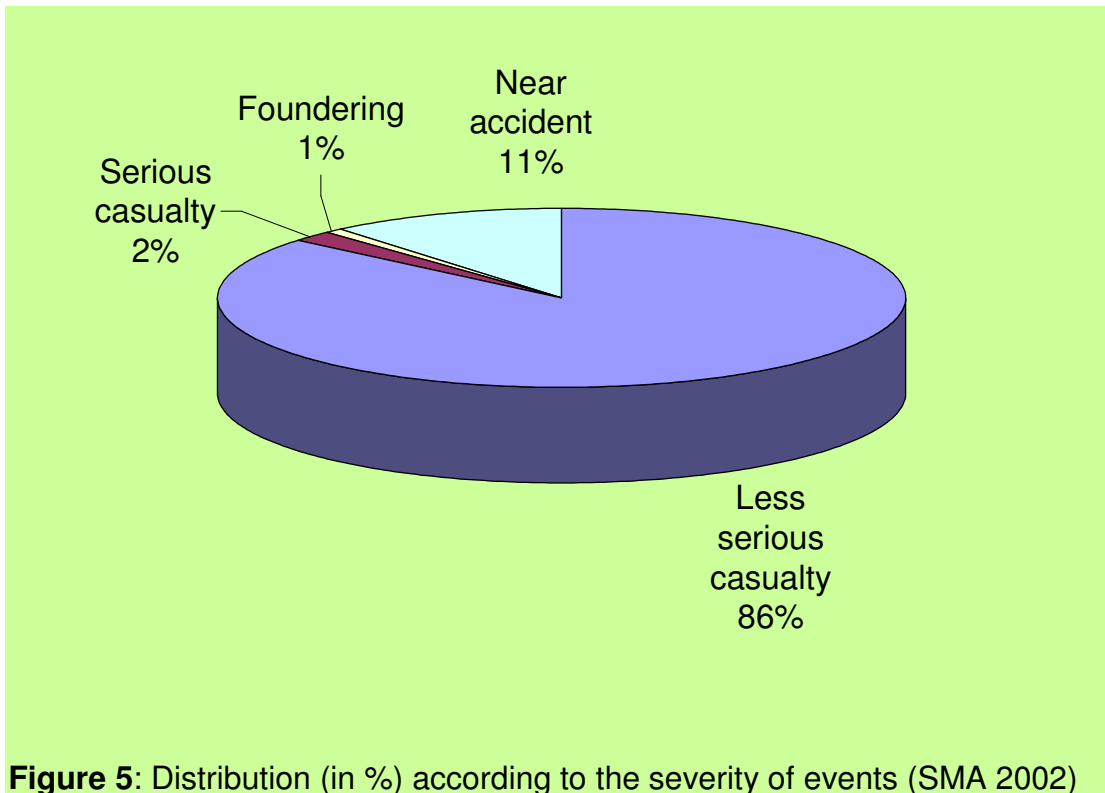
Box 9 presents the Swedish Maritime Administration classification system of marine accidents and incidents based on the severity of events.

Box 9: Marine casualties according to the severity of events

Figure 5 shows distribution (in %) according to the severity of marine casualties involving Swedish merchant and fishing vessels (SMA 2002). Based on their severity, marine events are divided into (SMA 2002):

1. *Marine casualties* including serious and less serious casualties;
2. *Near-accidents*.

The severity of events is determined according to the IMO's classification criteria, where: a) foundering includes ship total loss or constructive loss; and b) serious casualty includes events in which the ship is determined to be not seaworthy and/or that loss of life or seriously physical injury is the result of the accident.



3.2.1.1 Categories of marine accidents/incidents

For the purpose of statistics, the Lloyd's Register of Shipping (LRS 1996) and the IMO (1994) define types or categories of marine accidents (casualties) as shown in Table 18, according to the order, terms and definitions as provided by the respective sources. The IMO classifies marine events into *initial and subsequent events*. The "initial event" is defined as the event which has resulted in the casualty, or which started the series of events that resulted in the casualty (IMO 1994a). The initial event may be followed by one or strings of events, known as "subsequent events".

Table 18: Categories of marine events - Lloyd's Register of Shipping (1996) and IMO (1994b) classifications

LRS 1996			IMO 1994b		
	Category	Description/ definition		Category	Description/ definition
1	<i>Foundered</i>	Includes ships that sank as a result of heavy weather, springing of leaks, breaking in two, etc., but not as a consequence of categories listed below.	1	<i>Collision</i>	Striking or being struck by another ship, regardless of whether underway, anchored or moored.
2	<i>Missing</i>	After a reasonable period of time, no news having been received of a ship and its fate being therefore undetermined, the ship is posted as 'missing' at the Corporation of Lloyd's or reported as such from another reliable source.	2	<i>Stranding/ grounding</i>	Being aground or hitting/ touching shore or sea bottom or underwater objects (wrecks etc.)
3	<i>Fire/ explosion</i>	Includes ships lost as a result of fire/explosion where it is the first event reported - it therefore follows that casualties including fires and/or explosions after collisions, stranding, etc. would be categorised under 'collision', 'wrecked/stranded'.	3	<i>Contact</i>	Striking any fixed or floating object other than those included in collision or stranding.
4	<i>Collision</i>	Including ships lost as a result of striking or being struck by another ship, regardless of whether underway, anchored or moored.	4	<i>Fire or explosion</i>	Casualties where fire or explosion is the initial event.
5	<i>Contact</i>	Includes ships lost as a result of striking an external substance - but not another ship (collision) or the sea bottom (wrecked/stranded). This category includes striking drilling rigs/ platforms, regardless of whether in fixed position or in tow.	5	<i>Hull, watertight doors, port failure, etc.</i>	Not caused by nr. 1 to 4.
6	<i>Wrecked stranded</i>	Includes ships lost as result of touching the sea bottom, sandbanks or seashore, etc., and entanglement in underwater wrecks.	6	<i>Machinery damage</i>	Not caused by nr. 1 to 5, which necessitated towage or shore assistance.
7	<i>Other</i>	Includes war losses (including losses occasioned to ships by hostile acts), hull/machinery damage or failure that is not attributed to any other category, and losses, which, for want of sufficient reasons, cannot be classified.	7	<i>Damage to ship or equipment</i>	Not caused or covered by nr. 1 to 6.
			8	<i>Capsizing or listing</i>	Not caused by nr. 1 to 7.
			9	<i>Missing</i>	Assumed lost.
			10	<i>Other</i>	All casualties not covered by nr. 1 to 9.

Lloyd's Register of Shipping (LRS 1996) classifies ship losses into: a) *actual total losses*, which include mostly foundered casualties; and b) *constructive total losses* - this depends on costs of repair and the value of the ship. Constructive total losses are primarily ships broken up as a result of a casualty.

The Lloyds Maritime Information Service (LMIS, 1995) casualty database divides marine accidents into 9 categories, as follows:

1. *Foundered*: includes ships that sank as a result of heavy weather, leaks, breaking in two, etc, and not as a consequence of other categories such as collision etc.
2. *Missing vessel*: includes ships that disappeared without any witnesses knowing exactly what happened in the accident.
3. *Fire/explosion*: includes ships where fire/explosion is the first event reported, or where fire/explosion results from hull/machinery damage, i.e. this category includes fires due to engine damage, but not fires due to collision etc.
4. *Collision*: includes ships striking or being struck by another ship, regardless of whether under way, anchored or moored. This category does not include ships striking underwater wrecks.
5. *Contact*: includes ships striking or being struck by an external object, but not another ship or the sea bottom. This category includes striking drilling rigs /platforms, regardless of whether in fixed position or in tow.
6. *Wrecked/stranded*: includes ships striking the sea bottom, shore or underwater wrecks.
7. *War loss/hostilities*: includes ships damaged from all hostile acts.
8. *Hull/machinery damage*: includes ships where the hull/machinery damage is not due to other categories such as collision etc.
9. *Miscellaneous*: includes lost or damaged ships which cannot be classified into any of the categories 1 through 8 due to not falling into any of the categories above or due to lack of information (e.g. an accident starting by the cargo shifting (not as a consequence of events of any of the categories 1 through 8) would typically be classified as miscellaneous).

Box 10 presents the Swedish Maritime Administration (SMA) classification system of marine accidents/ incidents.

Box 10: SMA classification of marine accidents/incidents

The Swedish Maritime Administration (SMA 2002, p 6) (SMA 1985-1999) categorises marine accidents/incidents as follows:

1. Grounding
2. Collision with another vessel
3. Collision with other object
4. Leakage/capsize/weather damage
5. Shifting of the cargo
6. Fire and/or explosion
7. Engine failure
8. Spillage
9. Other
10. Near-accident

According to the SMA (2002), in recent years, numbers of changes have been made in the systems. Since 1998, the “shifting of cargo” event is reported as a new type of event, which appears in the database under a separate heading. Before 1998, this category of events had been recorded under the category “leakage/capsize/weather damage”. Starting in 1995, spillages are reported under “spillage” event when the spill has been an initial event, and not caused or covered by other types of events (e.g. spillage due to hose breakage). Events, which for want of sufficient reasons cannot be categorised, are reported under the “other” category of events. For example, this category includes incidents of container losses overboard due to bad weather and poor securing of containers in a trailer on board a ro-ro ship. Since 1999, near-accidents are presented in the annual accident report. The report (2002) does not clearly specify what constitutes a “near-accident.” Accidents to persons and illness are reported under the category “accidents to persons.” Non-conformities or deviations are reported, recorded and analysed in the Insjö system. For more information about the Insjö system see section 2.4.8.

3.2.1.2 Dangerous goods accidents/incidents

The above classification systems vary across industries and countries. They do not specifically define “marine accidents and incidents involving dangerous goods”. When considering risks of events involving dangerous goods, i.e. risks of dangerous goods by virtue of their inherent hazardous

properties only, most of the categories of events mentioned may be considered as "ordinary" marine events, as they may not necessarily involve PDG. Events involving dangerous goods, which may not be caused by any other category, may have been reported under the "other" category of events.

Table 19 provides some definitions of dangerous goods accidents/incidents that are extracted from a number of documents concerning transport of dangerous goods.

The MARPOL 1973/78 Convention deals with incidents involving "harmful substances" and losses or likely losses overboard of harmful substances in packaged form only.

The international regulations governing air transport of dangerous goods provide more complete and precise definitions. However, the definitions from the USA sources are the most comprehensive definitions found in national and international regulations governing transport of dangerous goods. The definitions of the USA Federal Railroad Administration (FRA), for example, include events involving dangerous goods. They make a clear distinction between accidents and incidents by means of the "monetary threshold" concept, for example, accident > \$6,300> incident. Because of side, unknown and long-term effects, it may be difficult to measure accurately accident consequences in quantitative terms, for example, in amounts of dollars. However, accidents are distinct from incidents in terms of consequences, as the extent of incident consequences is lesser (smaller) than accident consequences.

In summary, *PDG marine accidents/incidents can be defined as undesirable marine events involving or likely to involve PDG*. The term "accident" includes "very serious" and "serious" events, which are associated with one or more consequences, such as the loss of life, injury, damage to the ship, properties, the environment, and other effects. The term "incident" denotes a "less serious", "hazardous" or "near miss" event. Incidents may include unsafe situations or emergencies or losses that have involved PDG and marine pollutants (IMO 1995).

Table 19: Definitions of dangerous goods accidents and incidents

Documents/sources	Definitions
MARPOL 73/78, Appendix to Protocol I	<i>Incident</i> involves the loss or likely loss overboard of packaged dangerous goods, including those in freight containers, portable tanks, road and rail vehicles and shipborne barges, into the sea.
MARPOL 73/78, Annex III	<i>Marine pollutants incident</i> is the loss or likely loss overboard of harmful substances in packaged form including those in freight containers, portable tanks, road and rail vehicles and ship-borne barges, identified in the IMDG Code as marine pollutants.
MARPOL 73/78, Article II of Protocol I	<i>Incident</i> is a discharge or probable discharge of harmful substances in packaged form, including those in freight containers, portable tanks, road and rail vehicles and shipborne barges.
ICAO (1989) International Standards and Recommended Practice for Aircraft Accidents Inquiries, Cap.1. Annex 18, Convention on the International Civil Aviation. 16/11/89	<i>Dangerous goods accident</i> is an occurrence associated with and related to the transport of dangerous goods by air, which results in fatal or serious injury to a person or major property damage.
ICAO (1989) International Standards and Recommended Practice for Aircraft Accidents Inquiries, Cap.1. Annex 18, Convention on the International Civil Aviation. 16/11/89	<i>Dangerous goods incident</i> is an occurrence other than a dangerous goods accident associated with and related to the transport of dangerous goods by air, not necessarily occurring on board an aircraft, which results in injury to a person, property damage, fire, breakage, spillage, leakage of fluid or radiation or other evidence that the integrity of the packaging has not been maintained. Any occurrence relating to the transport of dangerous goods, which seriously jeopardizes an aircraft or its occupants, is also deemed to be a dangerous goods incident.
US Federal Railroad Administration (FRA)	<i>Train accidents</i> are collisions; derailment; fire; explosion; act of God or other events involving on-track equipment in which damage to railroad equipment and property exceeds a monetary threshold established and readjusted periodically by regulation. For instance, if a freight train transporting 50 cars of hazardous materials derails 5 cars with no release of product and damage to equipment and structure results in a cost of \$12,000, the event is considered an accident and must be reported to FRA, because the dollar amount exceeds the current \$6,300 threshold.
US Federal Railroad Administration (FRA)	<i>Train incidents</i> . As opposed to train accidents, the term "incidents" more broadly includes much smaller releases, releases from cars not involved in railroad accidents, and even releases from cars standing still, not part of the train. The releases may be small due to, for instance, improper requirement of tanks.

3.2.2 Dangerous goods hazards

Dangerous goods hazards (DGH) are inherent properties of dangerous substances, materials and articles including physical, chemical, biological, and radioactive hazards. In case of a marine event, packaged dangerous goods may get involved and realise their hazards by exposing one or a combination of the risk receptors. The extent or magnitude of effects due to DGH depends on the type, physical state, and quantity of dangerous goods and a wide range of other factors and conditions. Many substances and materials possess more than one hazard, while others share similar hazards. DGH that have usually been considered in the risk analysis are (Ertugrul 1995):

- *Acute toxicity* - due to toxic clouds;
- *Flammability* - flame impingement in flash fires due to flammable clouds;
- *Thermal radiation* - due to jet and pool fires and fireballs;
- *Blast wave* - from Vapour Cloud Explosions (VCEs), Boiling Liquid Expanding Vapour Explosions (BLEVEs), detonations, confined explosions;
- *Missile damage* - from flying pieces of metals or other objects due to blast waves.

Table 20 shows major hazards of liquid and solid bulk substances and materials carried in large quantities in Great Britain's waters, which were considered in the UK Health and Safety Commission (HSC) risk analysis project.

Table 20: Major hazards from bulk dangerous cargoes (HSC 1991)

<i>Substances and materials</i>	<i>Outcomes – hazards</i>
<i>1. Toxic liquefied gas</i>	1.1 Gas cloud
<i>2. Flammable liquefied gas</i>	2.1 Vapour cloud explosion (VCE) 2.2 Flash fire 2.3 Fireball
<i>3. Flammable liquid</i>	3.1 Explosion of vapour 3.2 Pool fire
<i>4. Bulk solid</i>	4.1 Explosion

3.2.3 Principles of cause: cause-effect relationship

The simplest generic notion of *cause* is that it may be a person, thing, event, state, or action that produces an effect (CED 1992). Subsequently, effect is something that is produced by a cause. The notion of effect or consequence is discussed in greater detail in section 3.2.4.

In sciences and many other human activities, people are often interested in establishing causal relationships among things or phenomena (Little 1991). In the field of risk management, people also tend to make various kinds of causal claims. One very important goal of accident investigations and risk studies is to uncover the conditions prior to events that were necessary and/or sufficient to cause or produce events. For example, in order to learn about and prevent accidents from happening in the future, accident investigations or studies attempt to identify and establish causes of accidents. Events that conveyed the state of the system (e.g. a package) at a given point (e.g. prior to breach of the package) to the new state of the system (e.g. breach of the package) are identified and reconstructed based on certain procedures.

The principle of cause-effect relationships, known as causality or causal mechanisms that link cause and effect, is that a cause always precedes one or more effects. Or, an effect may result from one or more causes. This refers to the principle that “nothing can happen without being caused” or “things happen for some reasons.” Little (1991, p 13) defines the meaning of cause and effect and their relationships as follows:

What does it mean to say that condition C is a cause of outcome E? The intuitive notion is that the former is involved in bringing about the latter, given the laws that govern the behaviours of the entities and processes that constitute C and E...There are three central ideas commonly involved in causal reasoning: causal mechanism connecting cause and effect, correlation between two or more variables and one event is necessary or sufficient condition for another.

With reference to the above notion, a series of events may connect condition (C) and the outcome (E). This series of events may constitute the causal mechanism linking C to E, and the laws that govern transitions among the events are the causal laws determining the causal relation between C and E (Little 1991). Events are causally related if and only if there are causal laws that lead from cause to effect (Little 1991).

There are three types of relationship functions (Ackoff et al. 1968, p 16): 1) *cause-effect* (or deterministic causality); 2) *producer-product* (probabilistic causality); and 3) *correlation*. When one thing or phenomenon X is said to cause (or be correlated with) another Y, several things may be meant (Ackoff et al. 1968, p 16):

1. X is necessary and sufficient for Y, i.e. deterministic causality.
2. X is necessary but not sufficient for Y, i.e. probabilistic or non-deterministic causality. In general, anything that is necessary but not sufficient for the subsequent occurrence of another thing (phenomenon) is the producer of the second thing (phenomenon).
3. X is neither necessary nor sufficient for Y, but they tend to be present or absent together. This is a condition of correlation that may not involve causality at all. For example, the value of two variables may tend to change together, and yet the variables may not be causally connected. In this case, variables are considered to be correlated.

Cause-effect relationships can vary from simple linear, or chain, to very complex networks or neural forms. One effect may become the cause for another effect. Many situations involve a host of causes and effects. The cause-effect chains are “opened” and “closed” chains. The circulation of water in nature is an example of a “closed” chain. Dangerous goods accidents may be considered an “opened” chain of events.

The above classification of functions indicates that causal laws are of deterministic or probabilistic character. A cause (deterministic or probabilistic) must be necessary for its effect(s). To establish that two things or phenomena tend to change or occur together is not to establish that they are related directly or indirectly by a cause-effect or producer-product relationship. One cannot infer causation or production from correlation alone.

The review of many formal and informal studies shows that the distinctions between a) cause-effect and producer-product relationship and b) causation (i.e. the relationship of cause and effect) and correlation, are seldom made in marine accident or risk studies. Further, many studies take a simplistic view, often failing to recognise that the relationships among variables describing the system elements and phenomena are very complex, interrelated and share large overlapping areas. According to the statistics literature (e.g. Joseph et al. 1998), the unique variance explained by each independent variable decreases and the shared prediction percentage rises as multicollinearity increases (Joseph et al. 1998). Multicollinearity refers to the relationships among independent variables (Joseph et al. 1998).

3.2.3.1 Classification systems of causes

In shipping, as in many fields of sciences and human activities, there is a wide range of classification systems, coding schemes or models of causes, which, in turn, are integrated parts of the marine accidents and incidents coding systems. The following are some systems that have, to a large extent, shaped many national and organisational coding schemes in the field of marine accidents reporting, recording and analyses. For example, as mentioned earlier, the Swedish Maritime Administration (SMA 2002), in cooperation with other relevant Swedish shipping, safety and environmental protection interests, has developed a series of coding schemes or systems that are largely based on the IMO and other relevant organisations, namely: "SjöOlycksSystemet" (SOS – The Sea Casualty System) and Insjö System.

For the purpose of constructing the IMO Casualty Database, harmonizing reporting procedures and mandatory and non-mandatory reporting of data/information on marine casualties, deficiencies and non-compliances, fatigue, fire casualty, stability casualty, and information from investigation of incidents involving dangerous goods or marine pollutants in packaged form, based on extensive experience of its member states, the IMO has developed detailed formats, coding schemes or classification systems (IMO 1995, 1994, 1996).

Table 21 presents the IMO (1994a) and US DOT (1995) classification systems of causes, which are based on the hierarchal order of relations or connections to marine casualties. The systems are not perfectly compatible.

Table 21: IMO (1994) and US DOT (1995) classification systems of causes

Hierarchy	IMO system (1994)		US DOT system (1995)	
	Category	Definition	Category	Definition
1	<i>Primary causes</i>	These are the immediate or main causes of marine events; this the first hierarchic level (layer or order)	<i>Apparent cause</i>	That cause or causes most directly related to the incident.
2	<i>Underlying causes</i>	This is the second hierarchic level of causes, i.e. the causes of the main or primary causes.	<i>Propagating cause</i>	That cause or causes closely related to the incident or aggravating the incident.
3	<i>Contributing factors</i>	This is the third hierarchic level – factors that contribute to the underlying causes.	<i>Originating cause</i>	That cause or causes more distantly related to the incident but still important in the chain of events leading to the incident.

Contributing factors are those factors or conditions that have contributed to development of the marine casualty (USCG 2001), i.e. factors that have contributed to the initial and subsequent events and their consequences. Contributing factors are considered as supplements to the primary cause of the initial events. Initial marine events (e.g. collisions) are often followed by one or more subsequent events (e.g. hull breach, listing/capsizing and foundering). Often, both underlying causes and contributing factors refer to contributing factors of the main or primary causes (IMO 1996a).

Root causes are the most basic causes of an event (USCG 2001). It is common for a marine casualty to have many underlying root causes. Root cause analysis provides a means to determine how and why something has occurred (USCG 2001).

From the own/other ship's point of view, causes are classified into (IMO 1994a):

- a) *Internal causes*: causes related to one's own ship involved in the accident including crew, structure, equipment, cargo and other internal causes associated with the ship itself, excluding pilot errors;
- b) *External causes*: causes for which one's own ship involved in an accident is not responsible. This category includes causes related to other ships actions, navigational infrastructure, pilots, weather and navigation hazards and other external factors that are not associated with the ship itself;
- c) The "*unknown causes*" category consists of causes for which there is no sufficient information.

The most extensive and complex parts of the IMO (1994, 1995, 1996) coding schemes are causes and contributing factors related to personnel and management. The main categories are summarized as follow:

- 1.1. *Personnel related*, including:
 - 1.1.1. Diminished ability: emotional, motivational, or physical causes.
 - 1.1.2. Inadequate ship environment.
 - 1.1.3. Knowledge, experience, or training causes.
 - 1.1.4. Mental action causes.
- 1.2. *Management related*, including:
 - 1.2.1. Faulty leadership: discipline, command, supervision, communication, co-ordination.
 - 1.2.2. Faulty management of physical resources: manning, manpower available, mismatch of personnel with job, poor job design.
 - 1.2.3. Faulty standards, regulations, policies, procedures, or practices: conflicting, inaccurate, inadequate, insufficient details, out of data.
- 1.3. *Related to the ship's design, structure, and equipment*: design error, propulsion, auxiliary, steering gear, closing arrangements or seals, structural failure, navigational equipment bilge pumping, electrical installation, fire detection and fighting, communication equipment, lifesaving appliances.
- 1.4. *Related to the cargo*: shifting, fire/explosion, stowage, securing.
- 1.5. *Related to criminal aggression or war*: war, terrorism, sabotage, arson.
- 1.6. *Related to sea and weather conditions*: sea, wind, currents or tides, icing.
- 1.7. *Related to navigation infrastructure*: aids to navigation, charts and nautical publications, and VTS error.

1.8. *Related to external sources, such as: tug boat, shore equipment or installation.*

1.9. *Not listed above.*

3.2.3.2 Human factor classification systems

Based largely on Bayers and Hill's (1991) human error taxonomy, the U.S. DOT (1995) defines and presents the percentage of dominant human errors cited in the analysis reviews from various sources (see Table 22).

Table 22: Human error taxonomy and percentage (U.S. DOT, 1995)

Main category	Examples	% cited in various sources
<i>Management</i>	Insufficient manning, inadequate communications or co-ordination, faulty standards, regulations, policies, or practices.	30%
<i>Operator status</i>	Fatigue, inattention, vision deficit, workload.	22%
<i>Working environment</i>	Errors caused by the nature and onboard working environments including: hazardous natural environment, poor human factors equipment design, poor maintenance, inadequate aids to navigation, markers, or information.	20%
<i>Knowledge</i>	Mariners and pilots knowledge and experience including: inadequate general technical knowledge, inadequate knowledge of own ship handling, unawareness of role or task responsibility.	14%
<i>Decision making</i>	Faulty understanding of current situation, decision based on inadequate information, imprudent seamanship.	14%

The IMO's classification scheme of human and organisational factors that shape human performance and contribute to the likelihood of human errors in

marine accidents, which is an integrated part of the marine accident classification system, consists of (IMO 1994c):

External bodies:

- Non-compliance with national and international standards and requirements;
- Failures, inadequacy and problems arising during communications with bodies which are not related to the ship/company;
- Manufacturer's equipment that is not designed for the required standards or has inherent faults;
- Standards of personnel competence, e.g. crew fail to meet international standards in certification;
- Non-compliance with standards governing all aspects of the working environment.

Company and organisational factors:

- Inadequate, insufficient or conflicting company policy and standards;
- Company makes use of conflicting, incorrect or inaccurate manufacturer's instructions;
- Communication problems between the company and the ship;
- Organisational pressures on the master and crew;
- Inadequate resources to complete the job;
- Failure of the company to provide its personnel with adequate training.

Equipment factors:

- Intentional and unintentional misuse of equipment;
- Equipment not available when needed;
- Equipment poorly designed;
- Equipment poorly maintained;
- Automation – increasing reliance on automation and crew not trained.

Working place environment: onboard the ship, including:

- Noise;
- Vibration;
- Temperature/humidity;
- Visual environment/visibility/lighting;
- Ship movements and weather effects;
- Poor housekeeping;
- Unsuitable layouts;
- Accommodation.

Social - crew factors:

- Interactions among the crew, internal organisation, the way in which the individuals work together as a team;
- Failures of all shipboard communications;
- Inadequate shipboard management and supervision;

- Inappropriate allocations of responsibilities to onboard personnel;
- Inadequate procedures; insufficient or improper manning or poor crew composition;
- Deficient crew training; lack of discipline of ship personnel and passengers.

Individual:

- Problems in communication on the part of the individual (e.g. language);
- An individual is incompetent to carry out duties;
- An individual is not adequately trained for the task;
- An individual does not have sufficient skills and knowledge to carry out the tasks;
- Impaired health including alcohol, illegal and prescribed drugs;
- Domestic issues;
- Fatigue and lack of vigilance;
- Perception abilities (e.g. visual, auditory, tactile, smell etc.);
- Poor decision making;
- Risk perception and inappropriate risk taking behaviours.

Figure 6 presents in graphical format the above scheme.

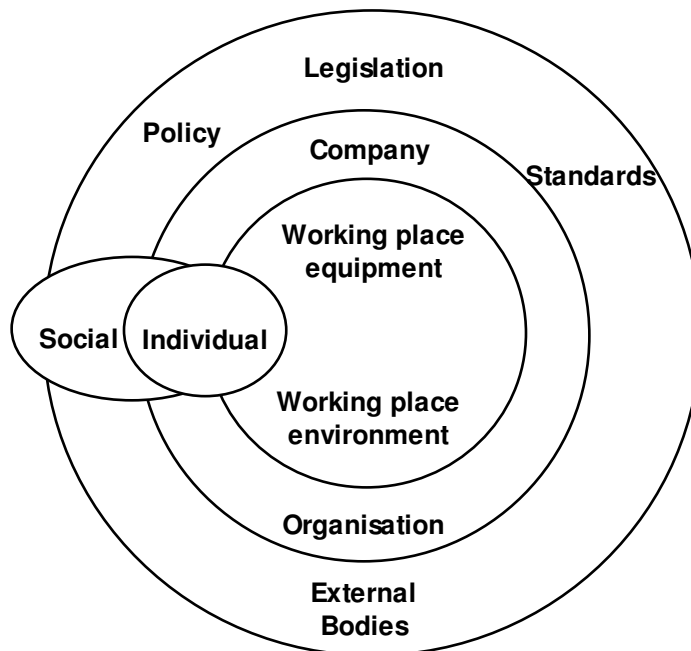


Figure 6: Influencing factors of human performance and errors (IMO 1994c)

According to the Norwegian government (IMO 1994a) and personal experience gained through the review and study of many accident databases, the coding process may be prone to errors and inconsistencies. The same data and information may be coded differently. Coding may be performed by different people with a variety of backgrounds blending together objective and subjective judgments. Further, in the coding process people may also be faced with the problem of determining the order of hierarchy with certainty. For example, in many cases it may be difficult to establish the primary cause and contributing factors with certainty. Many accident investigations have the tendency to look for something tangible, which can be somebody or something, to blame.

Box 11 presents an example of the classification system of causes of marine accidents/incidents – the Swedish Maritime Administration (SMA) coding system of causes.

Box 11: SMA coding system of causes

For the purpose of statistics, the SMA divides the casualty causes into seven main groups and sub-groups and other known causes and causes unknown (see Table 23) (SMA 2002).

Table 23: SMA coding of causes of marine casualties (SMA 2002)

Nr.	Main groups	Examples of sub-groups
1	External factors	Currents, winds, tides etc., causing drifting or other manoeuvring difficulties
2	Vessel's construction and placement of equipment	Stability problems caused by the construction of the vessel
3	Technical failure of on-board equipment	Technical failure of steering gear including steering machinery
4	Operation and design of equipment	Instruments/equipment improperly arranged
5	Cargo, securing of cargo and handling of cargo/bunker	Cargo inadequately or improperly secured
6	Communication, organisation and operational practices	Navigation bridge procedures not appropriate from a safety aspect
7	Onboard personnel	Miscalculations in navigating the vessel
8	Other known cause	
9	Cause unknown	

According to the SMA (2002), data and information gathered from marine casualty investigations are codified according to the coding scheme. Based on the scheme, established working procedures and investigator judgments, the primary causes and contributing factors of casualties are identified and codified. Casualty causes are divided and further sub-divided into (SMA 2002):

1. *Primary causes*

- 1.1 Human factor
- 1.2 Technical failure
- 1.3 External factor

2. *Contributing factors*

- 2.1 Human factor
- 2.2 Circumstances of operation and design of equipment
- 2.3 External factor

In 2002, the human and other factors, which include technical failures and external factors, accounted respectively for 74% and 26% of the primary causes of marine casualties.

In summary, the classification systems of causes (as shown above) share similarities, but they are not entirely compatible. They are mainly designed for marine accidents and incidents in general.

3.2.4 Consequences

Terms such as “results”, “aftermath”, “impacts” or “effects” are often used interchangeably to denote consequences of undesirable events (AHD 2000). The risk analysis of dangerous goods-related activities takes into consideration consequences that are due to dangerous goods hazards. They may be divided into realised and un-realised hazards. The consequences of marine events involving dangerous goods are the consequences of realised hazards. The examples from the HCB database (1986-2003) (see Box 13) and Figure 7 illustrate this point.

Box 12: Dangerous goods hazards and consequences

Due to poor lashing, a tank container loaded with flammable substance onboard the ship breaks free. The following may be two possible scenarios:

1. The tank remains intact and its content may not be spilt. In this case, dangerous goods hazards are not realised. However, from the moment that the tank is loaded onboard the ship, its content has the potential for spilling, ignition or explosion. Although intact, the tank may still have caused fatalities, injuries and damages, but not due to dangerous goods hazards properties, such as fire or explosion.
2. The tank is damaged (puncture or rupture) and its content is spilt, ignited and exploded. In this case, dangerous goods hazards are realised causing fatalities, injuries and/or damage to the ship. The ship may even sink, causing marine environmental pollution.

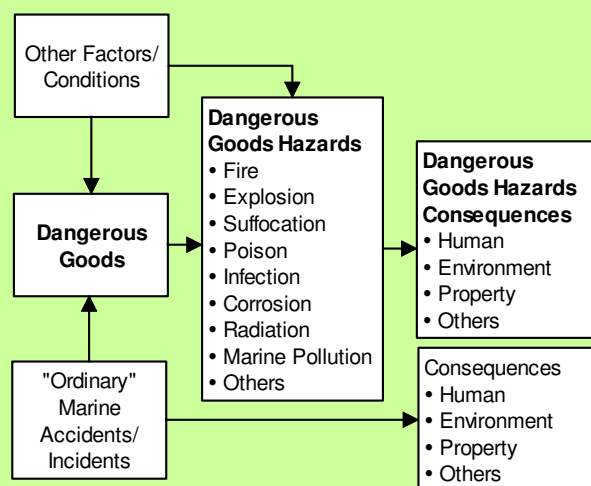


Figure 7: Examples of dangerous goods hazards and their consequences

Realization of dangerous goods hazards is necessary, but not sufficient to cause harms to risks receptors, because there are many different influential factors and conditions, including hazard energy, concentration and density, the distance from the release of dangerous goods, media of hazard transportation, the number and features of the risk receptors exposed and many more.

Consequences of marine accidents are classified in different ways. One common classification system, which is based on the main categories of risk receptors, consists of:

1. *Human*: individual, groups and society, including physical and psychological effects;
2. *The environment*: air, land and water, including their habitats; and
3. *Properties*: man-made, for example means of transport, cargo and packages, equipment, facilities and buildings.

"Life" or "creature" consequences are sometimes referred to as consequences to human beings and air, land and water habitats. Accidents are often associated with combined consequences.

In terms of time, consequences can be divided into: a) *short-term*, b) *medium* and c) *long-term effects*. However, it may be difficult to determine and make a distinction among these categories, as dangerous goods releases have a wide range of possible effects on human beings, the environment, properties and human activities. In many cases, risk analyses concentrate only on the direct and immediate effects, disregarding indirect and long-term effects, which may have a larger portion of problems and costs than the former.

Consequences, and subsequently the accidents themselves, are classified or scaled based on the severity of events. For the purpose of risk analysis in the transport of dangerous goods, the severity of accidents is often expressed in terms of the number of fatalities and injuries. Table 24 shows examples of two subjective classifications of consequences.

Table 24: Subjective classifications of consequences (Bell 1996; HSC 1991; USCG 2001)

Rank	Bell 1996; HSC 1991	USCG 2001	
	<i>Description</i>	<i>Description</i>	<i>Definition</i>
1	Insignificant	Negligible	Passenger inconvenience, minor damage
2	Minor	Marginal	Marine injuries treated by first aid, significant damage not affecting seaworthiness, less than \$25000
3	Major	Critical	Reportable marine casualty (US, 46 CFR 4.05-1)
4	Catastrophic	Catastrophic	Death, loss of vessel, serious marine incident (US, 46 CFR 4.03-2)

The IMO and other organisations classify accidents somewhat differently. As mentioned earlier, based on the severity of consequences, marine events are classified into: "very serious", "serious", "less serious" and "hazardous incidents."

Consequences can also be divided into (CCPS 1989) a) *direct effects* – for example, direct effects of toxic spill, fire or explosion events; and b) *indirect effects* – for example, "domino" effects on adjacent means of transport or

industrial facilities. A "domino accident" is defined as an accident on one ship that either has caused or is caused by an accident on a nearby ship, storage or process plant ashore (HSC 1991).

The consequences of dangerous goods by virtue of their inherent hazards only are the risk element that largely distinguishes risks of dangerous goods from other types of risks.

3.2.5 Likelihood: frequency/probability

The term "likelihood" is used to express the chance of something happening, leaving it open as to whether a probability or frequency should be used depending on circumstances (Monnier and Gheorghe 1996). Sprent (1988) provides a theoretical interpretation of frequency and probability:

The interpretation is based on a sequence of repetitions of the same experiment, activity etc. An experiment is repeated n times. The nA is the number of times a certain event A occurs. The ration nA/n is called the relative frequency of A . According to the frequency interpretation of probability, $P(A)$ is the probability for A if the ration nA/n tends to $P(A)$ as the n gets large. The relative frequencies tend to stabilise with increasing numbers of repetitions.

The frequency of events involving PDG is the chance that a package (e.g. a container or CTU) carrying dangerous goods will be involved in an accident (Monnier and Gheorghe 1996). It is expressed in many different terms. Often, the frequency is expressed in terms of a specified period of the time interval, for example, one year. The frequency applies to all risk elements including events, causes or failures, and consequences. In dangerous goods risk studies, the frequency is generally estimated based on historical accident data (HSC 1991). However, when quantitative estimation of the frequency is neither possible, for example in the absence of statistical data, nor necessary, the frequency is evaluated qualitatively or subjectively. Table 25 shows examples of subjective categorisations of the frequency.

Table 25: Subjective frequency classifications (Bell 1996; HSC 1991; USCG 2001)

Rank	Bell 1996	HSC 1991	USCG 2001	
	<i>Description</i>	<i>Description</i>	<i>Description</i>	<i>Definitions</i>
1	Remote	Remote	Not probable	So unlikely, it can be assumed occurrence may not

				be experienced
2	Rare	Unlikely	Very unlikely	Unlikely but possible to occur in the life of an item
3	Frequent	Infrequent	Not likely	Likely to occur some time in the life of an item
4	Very frequent	Frequent	May occur	Will occur several times in the life of an item
5			Likely	May occur as often as once in an operating year

3.3 The extended concept of risks

This section provides a more comprehensive concept of risks. Some definitions of dangerous goods risks include:

- *Risk* is defined as the *probability* of an *accident* that causes a release of dangerous goods times the *consequence* of such an event, for example, the number of fatalities (Weigkricht and Fedra 1993).
- *Risk* is the *likelihood* of a specified *undesirable event* occurring within a specific period or in specific circumstances. It may be either a frequency (the number of specified events occurring in a unit time) or a probability (the probability of specified event following a prior event) depending on the circumstances (HSC 1991).
- *Risk* is a measure of the *probability* and *severity* of harm to an exposed receptor due to potential undesired events (Ertugrul 1995).

In principle, similar definitions are used in risk assessment guidelines in a number of countries, for example, the UK (HSE 1989), the Netherlands (Versteeg 1988), the City of Toronto (Milward 1991), and the Industrial Accident Council of Canada (MIACC 1990). In summary, the risk of undesirable events involving dangerous goods is more precisely defined as:

$$\text{Risk} = (\text{Frequency of occurrence of the hazardous release events}) \times (\text{Estimated consequences of the hazardous release events})$$

The above definitions clearly show the essential constituent elements of dangerous goods risk. Risk is defined as a function of the frequency/probability and consequence. Judging by definitions and practices in the field, it would be a gross misconception to argue that risks have positive aspects. Aggregated risk is determined in terms of cumulative combination of frequencies and consequences (Sprent 1988). A simple mathematical model of risk estimation is:

$$R = f(FC)$$

Where:

R - Risk

F - Frequency

C - Consequences

f - Denotes risk as a function of the frequency and consequence.

Table 26 shows the concept of risks including frequencies and consequences with their respective scales.

Table 26: Risk matrix – the frequencies and consequences

Frequency (F)	Consequences (C)			
	Insignificant (i)	Minor (mi)	Major (ma)	Catastrophic (c)
Frequent (f)	(f) x (i)	(f) x (mi)	(f) x (ma)	(f) x (c)
Infrequent (if)	(if) x (i)	(if) x (mi)	(if) x (ma)	(if) x (c)
Unlikely (u)	(u) x (i)	(u) x (mi)	(u) x (ma)	(u) x (c)
Remote (r)	(r) x (i)	(r) x (mi)	(r) x (ma)	(r) x (c)

There are considerable numbers of possible combinations of frequencies and consequences, which in this case are sixteen. The values of risks vary considerably. For the purpose of illustration, the frequencies and consequences are given their respective numbers on the scale, for example:

- Insignificant (i) = 1 to catastrophic (c) = 4
- Remote (r) = 1 to frequent (f) = 4

By applying $R = f(FC)$:

$(r) \times (i) = 1$ - i.e. the minimal value or low risk

$(f) \times (c) = 16$ - i.e. the maximal value or high risk

Other values range in the scale from low to high risks.

The model (Figure 8) derives from understanding and interpretation of the risk concept. The model shows the concept of risk levels and the relation between the risk and safety concepts. Risk levels vary from low to high. Risks that lie on the top right part of the model are considered as very high-risk levels and they are considered intolerable. Risks lying on the bottom left part are considered low or negligible risks. Risks that are within the “As Low As Reasonably Practicable” (ALARP) or “As Low As Reasonably Applicable” (ALARA) region are considered tolerable risks. For example, an unlikely event with little or insignificant consequences has a low risk level. On the other hand, a likely event with severe or catastrophic consequences has a high risk level.

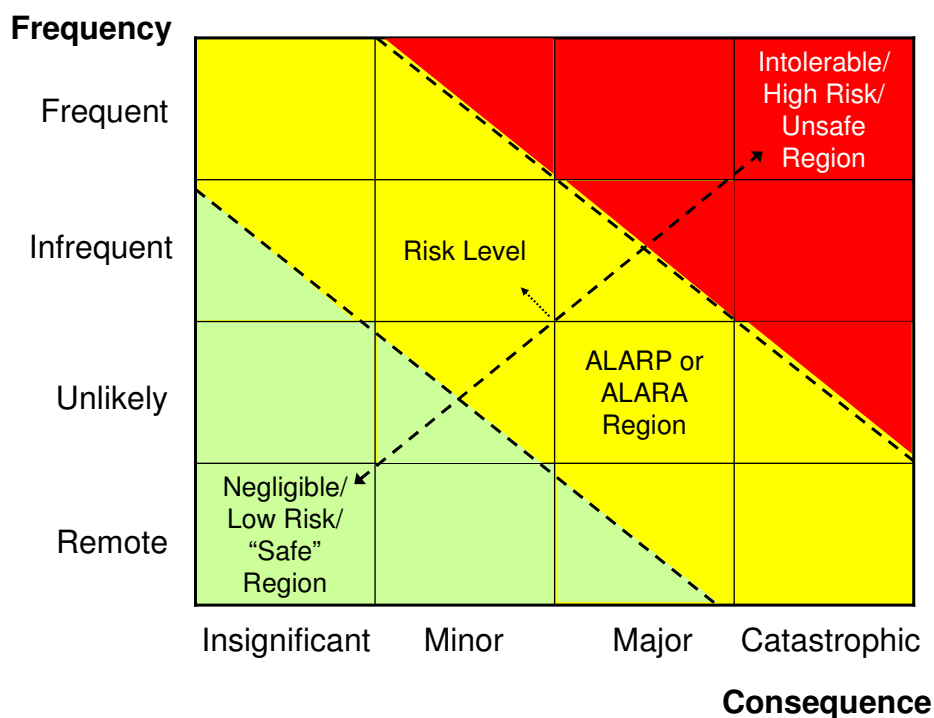


Figure 8: Risk elements and relations between risk and safety (adapted from HSC 1991)

Case histories (HCB 1985-2003) have shown that some catastrophic events have involved a large number of people. Frequent (f) events with insignificant (i) consequences (c) may be equal to remote (r) or unlikely events but are associated with catastrophic consequences. These risks may be expressed in quantitative terms as follows: $(f) \times (i) = (r) \times (c)$ or $4 \times 1 = 1 \times 4$.

3.3.1 Concepts of hazard, risk and safety

In common use, the terms *hazards*²⁹ and risks are often used interchangeably. However, in engineering science there is a distinction between them. *Hazards* are there defined as physical situations with the potential to cause human fatality and injury, damage to property and environment and some combination thereof (HSC 1991). Hazards are regarded as being continually present (Marshall 1987). Dangerous goods hazards are inherent properties of dangerous goods to cause harm to the risk

²⁹ According to Marshall V.C. (1987), the term 'hazard' seems to have originated in the name 'Castle Hasart' in Syria where Crusaders learned to play dice.

receptors. The risk concept incorporates the likelihood of experiencing hazards. *Risks* are characterized in terms of the likelihood and consequence, such as loss of life, injury, and damage to environment and property.

Safety is defined as the freedom from dangers or risks.³⁰ In a wide range of human activities, there is no absolute freedom from risk, and the term "safe" is applied relatively. Low or acceptable risks cannot be excluded even in a state of safety. In other words, a safe condition exists even when acceptably low risks prevail (Forberg 1997). Unsafe, hazardous or dangerous situations are associated with high risks.

This section discussed risks from a theoretical perspective. However, in practice, interpretations and applications of the risk concept are complicated and difficult. For example, it may become difficult to determine, both in qualitative and quantitative terms, what should be considered "low", "high", "negligible", "tolerable", "acceptable" or "intolerable" risks for a given individual, group of people, activity, country or time.

As mentioned earlier, based on the categories of risk receptors, risks are divided into: *risks to people, environment and properties*. The following section discusses risks to people and the environment, known as *human and environmental risks* respectively.

3.3.2 Human risks

A large number of people might be at risk from the transport of dangerous goods. Catastrophic events involving dangerous goods have caused thousands of fatalities (HCB 1986-2003). With respect to the categories of people exposed, risks are divided into: *individual and societal risks* (HSC 1991).

3.3.2.1 Individual risks

Risks to individuals (known as *individual risks*) are defined as the frequency at which an individual may be exposed to sustain a given level of harm from the realization of specified hazards (HSC 1991). Individuals at risk in maritime transport of dangerous goods include (HCB 1986-2003):

- *Workers* (employees);

³⁰ Oxford Dictionary, 1992

- Crew members or onboard ship personnel;
- Port workers;
- Other employees of the company
- *Members of the public:*
 - Passengers onboard ships
 - Other ship personnel and passengers
 - People ashore other than the company generating risks

3.3.2.2 Societal risks

Risks to society (known as *societal risk or collective risks*) are defined as the relation between the frequency and consequences, which is the number of people suffering from a specified level of harm in a given population from the realisation of specified hazards (HSC 1991). Compared to individual risks, the concept of societal risks is broader and much more complex. These risks may cover many situations and affect the population of a country or a region as a whole. The concept of societal risks is particularly important when considering the potential of events associated with hazardous activities that result in large numbers of fatalities and injuries. One example of such activities is the maritime transport of dangerous cargoes. In Europe, the concept of societal risks is extended to account for environmental damage as well (EC 1996). The societal risks are subdivided into (HSC 1991):

- a) *Local societal risk*: e.g. people living adjacent to a particular port area or waterways;
- b) *National societal risk*: e.g. total risks from maritime transport of dangerous goods and related activities including both international and national or domestic traffics.

The societal risks are presented as the sum of all risks measured, for example, as an annual fatality rate, adding together risks to the crew of the own ship, the crew of other ships, passengers and other people ashore. The estimated risk values are usually expressed as either chances of fatality and injury per year or chances per lifetime (i.e. assumed life expectancy) or working life (workplace risks).

3.3.3 Environmental risks

The marine (aquatic, ecosystem) environment is also exposed to marine accidents involving dangerous goods. Many risk studies have been confined

to assessment of immediate effects of dangerous goods hazards to human safety and health. Assessments of the marine environment risks have been confined to major spills of a limited number of dangerous substances and materials carried in large quantities in bulk by sea, in particular oil, oil products and a few chemicals. Knowledge about the environmental risks from a wide range of different types of PDG carriage water is underdeveloped.

For the purpose of reporting marine casualties, Greenpeace International has suggested the following categories of information to be provided by countries and inserted into the IMO Casualty Database for assessing environmental risks of marine events involving PDG (IMO 1996c):

- *Natural resource damages:*
 - Loss of wildlife: birds, marine mammals, non-commercial fish, other marine life;
 - Loss of fisheries: fin fish, shellfish, fish farming;
 - Habitat degradation: soft habitats (e.g. marshes, mangroves), shorelines (beaches), rocky coastal/reefs (e.g. coral reefs);
 - Geological and archaeological resources damages;
- *Local community effects:*
 - Human health and safety effects;
 - Terrestrial habitats;
- *Damages to tourism and recreation.*

Attempts have been made to characterise environmental risks by employing similar concepts to those used in human societal risks (Fryer 1996). The risks are proposed to be presented in the form of a frequency and consequence curve, where the horizontal axis represents measures of marine environment harms, which is known as the *Environmental Harm Index* (EHI) (Fryer 1996).

3.4 Reporting systems

The following section provides some relevant international, regional and national regulations concerning reporting or notification systems for marine accidents and incidents and the carriage of dangerous goods.

3.4.1 IMO Conventions

Under article 12(1) of MARPOL 73/78, for the purpose of reporting marine casualties, reports should be in accordance with SOLAS 74 arrangements. Under article 12(2) of MARPOL 73/78, a report should be made to the IMO whenever a party judges that information concerning the findings of casualty investigation will assist in determining what changes in the Convention might be desirable. This report should be in a form suitable to issues such as an MEPC information paper (IMO 1996d).

In accordance with guidelines and general principles adopted by the IMO by resolution A.648 (16) (IMO 1995), in cases of *marine accidents and incidents involving dangerous goods and marine pollutants in packaged form* on board ships and in port, information should be provided in the following cases:

- a) An accident involving dangerous goods in packaged form is associated with loss of life, injury or damage to a ship or property; or
- b) An accident/incident involving dangerous goods and marine pollutants in packaged form, where an unsafe situation, an emergency or loss has occurred.

The information from investigation of incidents involving dangerous goods or marine pollutants in packaged form should contain (IMO 1996d):

- Cargo involved: name, UN number, class, name and address of manufacturer or consignee or consignor, type of packaging/container, quantity and conditions of goods, stowage and securing arrangements;
- Pollution: goods lost overboard (yes/no), if yes: quantity of goods lost, lost goods floated or sunk, loss of goods released from packages;
- Brief account of the sequence of events;
- Extent of damage;
- Emergency response;
- Comments on compliance with applicable requirements;
- Comments on effectiveness of applicable requirements;
- Measures/recommendations to prevent recurrence;
- Further investigation.

3.4.2 EU Directives on notification system for ships carrying dangerous goods

Directive 93/75/EC, the Hazmat Directive adopted on September 1993, established a notification system for ships carrying dangerous or polluting goods, regardless of their flag, bound for or leaving EU ports (EC 1993). The directive sets out a range of duties for the parties involved in dangerous goods related activities. Thus, the shippers and ship operators are required to provide the relevant authorities with detailed information on cargoes handled and carried. Precise and available at all time information contributes to prevention, minimisation and mitigation of accidents and incidents at sea. Further, accurate information enables the relevant authorities to take the necessary precautions with regard to the existence of dangerous goods on board ships. This directive has been amended several times and it was repealed on 05/02/2004 through the adoption of Directive 2002/59/EC, part of the Erika II package (EC 2002 2004).

3.4.3 Swedish Maritime Code

In compliance with Chapter 6, paragraph 14 (formerly paragraph 70) of the Swedish Maritime Code, the master of a ship is legally obligated to report marine accidents to the Swedish Maritime Safety Inspectorate (SMA 2002). Based on the Swedish Act of 1990 and its appended regulations regarding the investigation of accidents, the Swedish Maritime Safety Inspectorate has broadened the mandatory-reporting requirement to include reporting of all types of accidents at sea (SMA 2002). Based on combined analysis of accidents, near-accidents, deviations or non-conformities, recommendations are prepared for the concerned parties including specific ships, shipowners and departments within the Swedish Maritime Safety Inspectorate.

3.4.4 Helsinki Convention

Since January 1st 2001, ships bound for or leaving a port of a Contracting Party to the Helsinki Convention and carrying dangerous or polluting goods must report dangerous goods to the competent authority of that Contracting Party.

3.4.5 UN Recommendations on reporting accident/incident

A new paragraph 19 concerning procedures for reporting accidents and incidents involving dangerous goods in transport was added (in 2005) to the UN Recommendations, which states (HCB 2005):

The relevant national and international organisations shall establish provisions for reporting of accidents and incidents involving dangerous goods in transport. Basic provisions in this connection are recommended in 7.1.8 of the Modal Regulations. Reports or summaries of reports that the States or international organisations deem relevant to the work of the sub-committee of experts on the transport of dangerous goods (e.g. reports involving packagings and tank failures, major release) should be submitted to the sub-committee for its consideration and action, as appropriate.

The following text has been agreed for the new Section 7.1.8 of the UN Recommendations (HCB 2005):

7.1.8 Reporting of accidents and incidents involving dangerous goods in transport

7.1.8.1 Accidents and incidents involving the transport of dangerous goods shall be reported to the competent authority of the state in which they occurred in accordance with the reporting requirements of that State and applicable regional/modal agreement.

7.1.8.2 Information reported shall include at least the description of the goods as provided in 5.4.1.4, description of the accident/incident, data and location, estimated loss of dangerous goods, containment information (e.g. packaging or tank failure that resulted in a release of dangerous goods).

7.1.8.3 Certain types of dangerous goods, as determined by the competent authority or established under applicable regional/modal agreements, may be excepted from these requirements for reporting of accidents or incidents.

3.5 Summary

Maritime transport of dangerous goods is associated with negative outcomes, i.e. risks. The term “risk” is used by many different people in different contexts. Risks are categorised in different ways, for example, voluntary and involuntary risks, statistically verifiable and non-verifiable risks, natural risks, technological and human activities risks. Risks of maritime transport of PDG may be generally considered as statistically verifiable technological or human activity risks.

In this chapter, the essential constituent elements of risks are explored, defined and accordingly described. The concept of “risk” is defined in different ways. This chapter presented a list of formal (theoretical) definitions collected from some of the most well-known sources. The most generic definition of the term “risk” comprises: the likelihood (frequency or probability) of consequences of accidents and incidents. Maritime transport of PDG is a risk generator or producer. Dangerous goods by virtue of their inherent hazardous properties only, such as fire, explosion, and toxic hazards, have been involved in marine accidents causing fatalities, injuries, damages to properties and marine environment pollution.

This chapter showed that there are many different and, to some extent, incompatible categorisation or coding systems of the risk elements. Some systems are very detailed and complex. For example, the classification of causes and contributing factors varies. However, causes and contributing factors, of whatever classification system, are related to: man, man-made, physical environment and products of their interrelations.

4 CONCLUDING REMARKS

In this report attempts have been made to enhance our understanding of the field of maritime transport and principles of risks associated with accidents and incidents involving dangerous goods. The essential constituent elements of the system and risks have been defined and exhaustively described.

The following section concludes with some key remarks concerning topics and issues raised in this report. Based on inferences and understanding gained in this study, some research areas and questions for future studies are suggested to the members of scientific communities, responsible and competent authorities, policy or decision-makers and other interested parties in the BSR. Some recommendations for enhancing safety and health and environment protection and reliability in the transport of dangerous goods in the BSR are also provided. The research areas and questions and recommendations provided in this and another report (see Mullai 2006)³¹ are interlinked.

³¹ Mullai A (2006) *Risk Management System – Risk Assessment Frameworks and Techniques*, Safe and Reliable Transport Chains of Dangerous Goods in the Baltic Sea Region (DaGoB) Project Publication Series 5:2006, Turku School of Economics, Logistics, Turku, Finland.

Nr.	Concluding remarks	Research areas and questions	Recommendations
		Consider and/or reconsider the following research areas and questions:	Consider and/or reconsider the following recommendations:
1	<i>Terms, definitions and concepts</i>		
	<ul style="list-style-type: none"> • Terms, definitions and concepts in the field are many, variable and complex. • Classification/coding systems of risk elements, including types of marine accidents/ incidents, causes and contributing factors, and consequences, are also many, variable and, to some extent, incompatible. • These systems vary across countries, industries, organisations or authorities. • Undue considerations may lead to faults or misconceptions that would render the results of the risk study invalid and unreliable. • Combining various data sources with 	<ul style="list-style-type: none"> • Study the classification systems of risk and system elements in the BSR. • Identify and study the best systems and practices in the BSR and other parts of the world. • What is the current state of the classification systems in the BSR? Are they in place in all the countries of the BSR? • If in place, explore discrepancies among systems. Are they compatible or harmonized? 	<ul style="list-style-type: none"> • Carefully select and employ the relevant, reliable and correct terms, definitions and concepts. • Some relevant sources are international and national organisations (e.g. IMO, USCG, LRS, SMA, etc.), and regulations texts concerning transport of dangerous goods (e.g. the IMDG Code). • Employ the same definitions and concepts, if necessary with some adjustments, used by the data source in which the risk study is based. • In cases when making use of data from various incompatible sources, design and employ operational definitions, if necessary. • Disseminate information on the best systems and practices in the BSR and

Nr.	Concluding remarks	Research areas and questions	Recommendations
	different and incompatible classification systems, definitions and concepts would be a problem for the risk study.		<p>other countries concerning classification systems.</p> <ul style="list-style-type: none"> • Harmonize classification systems in the BSR with relevant international and regional systems. • Provide financial and technical assistance and expertise to the countries, if necessary.
2	<i>The maritime transport system</i>		
	<ul style="list-style-type: none"> • The maritime transport system, which is an important constituent element of the transport and supply chains, plays a major role in the overall economy of many countries and regions, including the BSR. • For many countries and regions, maritime transport is the main, if not the only, mode of international transport. The vast majority (95 %) of Swedish imports and exports is carried by sea. 	<ul style="list-style-type: none"> • Study the current state of development in transport chains of dangerous goods including: <ul style="list-style-type: none"> ▪ Individual transport modes ▪ Intermodal or combined transport • Study the following elements and activities: <ul style="list-style-type: none"> ▪ Infrastructure – ports/terminals ▪ Cargo handling equipment ▪ Ships ▪ Packaging systems/CTU ▪ Information technology (IT) 	<ul style="list-style-type: none"> • Employ the best practices and technological solutions regarding safety, marine environment protection and facilitation of the transport of dangerous goods in the BSR. • Install remote sensing technologies for surveillance and monitoring of the marine environment of the BSR. • Enhance co-operation and co-ordination among parties regarding the transport of dangerous goods within each country and among countries in the BSR.

Nr.	Concluding remarks	Research areas and questions	Recommendations
	<ul style="list-style-type: none"> • Given certain specific properties of the system, maritime transport of PDG may be considered a sub-system on its own right. • The system consists of many different elements or sub-systems and related activities in complex and dynamic relationships. • The state of the system varies across regions, countries and organisations. • The human element plays a central role in the system as it designs, develops, constructs, operates, maintains and manages each and every part of the system. • Maritime transport of dangerous goods is interlinked with a wide range of parties (e.g. individuals, groups and organisations) with converging, but sometimes conflicting, interests in transport 	<ul style="list-style-type: none"> ▪ Dangerous goods related activities including: <ul style="list-style-type: none"> - Cargo handling – loading/discharging - Packing, stowage and segregation - Documentation - Cargo securing • Identify bottlenecks in transport chains of dangerous goods within each country and among countries in the BSR. What is the current state of co-operation and co-ordination among parties in the transport of dangerous goods within each country and among countries in the BSR? Including the following parties: <ul style="list-style-type: none"> ▪ Governmental responsible and competent authorities or agencies ▪ Carriers/transport service providers ▪ Shippers/consignees/ consigners ▪ Logistics services providers ▪ Customs services • What is the degree of reliability, 	<ul style="list-style-type: none"> • Harmonize or streamline dangerous goods related procedures and activities across organisations, countries and throughout the entire BSR. • Provide financial and technical assistance and expertise to close gaps in practices and technological developments in the BSR, if necessary. • Ensure that dangerous goods training programs are: <ul style="list-style-type: none"> ▪ In compliance with relevant international and industry regulations. ▪ Harmonized across industries and countries in the BSR. • Disseminate the best practices in dangerous goods training in the BSR. • Enhance awareness and safety culture and environment protection in transport of dangerous goods in the BSR. • Provide financial and technical assistance and expertise to enhance and harmonize dangerous goods

Nr.	Concluding remarks	Research areas and questions	Recommendations
	<p>facilitation, safety and health, the marine environment and property protection and other issues.</p> <ul style="list-style-type: none"> • The safety and the marine environment protection of the transport of dangerous goods rely very much on the knowledge, experience, training and awareness of all parties concerned. 	<p>efficiency and effectiveness in domestic and international transport of dangerous goods in the BSR?</p> <ul style="list-style-type: none"> • Identify and study the best transport practices and technologies or solutions available in the BSR and the world. • Identify gaps or discrepancies in transport practices and technological developments in the BSR. • Study the current state of dangerous goods knowledge and training, including: <ul style="list-style-type: none"> ▪ The level of dangerous goods knowledge and expertise. ▪ The level of dangerous goods training. ▪ Dangerous goods training programmes including these questions: <ul style="list-style-type: none"> - Are dangerous goods training programmes in compliance with relevant requirements? - Are they harmonized across countries of the BSR? 	<p>training programmes in the BSR, if necessary.</p>

Nr.	Concluding remarks	Research areas and questions	Recommendations
		<ul style="list-style-type: none"> - Is there any gap or discrepancy? • Identify and study the best practices in dangerous goods training in the BSR and the world. 	
3	<i>Statistical data on dangerous goods vessel and port traffic</i>		
	<ul style="list-style-type: none"> • Large and increasing amounts of different types of PDG and bulk dangerous cargoes are carried by water. • It is estimated that over 300 millions tons of different types of dangerous goods are transported in the BSR. • Statistical data on dangerous goods/ cargo vessel and port traffic is an essential element of exposure data that is needed for assessing and managing dangerous goods risks. • Statistical data on dangerous goods vessels and port traffics is limited in the BSR, in particular dangerous goods traffic to/from Russia. 	<ul style="list-style-type: none"> • Study the current state of systems and practices in collection, compilation, analysis and dissemination of dangerous good traffic data in the BSR. • Identify and study the best practices, tools and techniques for collection, compilation, analysis and dissemination of dangerous good traffic or shipments data in the BSR and other countries. • Study the possibility of creating a common framework for collection and dissemination of dangerous goods vessel and port traffic data on a regular basis in the BSR. • The international and regional legal systems concerning notification systems 	<ul style="list-style-type: none"> • Disseminate the best practices, tools and techniques for collection, compilation, analysis and dissemination of dangerous goods traffic or shipment data. • Some of the best practices, tools and techniques for collection of dangerous goods traffic data can be acquired from the USA, Sweden and other European countries. • If all parties concerned agree, take appropriate measures to ensure that statistical data on dangerous goods vessels and port traffic in the BSR are collected accurately and on a regular basis.

Nr.	Concluding remarks	Research areas and questions	Recommendations
	<ul style="list-style-type: none"> The present estimations of dangerous good traffic in the region have a low degree of confidence. 	<p>for ships carrying dangerous goods or marine pollutants that already exist.</p>	<ul style="list-style-type: none"> Ensure that data are available to all parties concerned. Statistical data on in/out bound vessel traffic in the BSR can be collected in the Öresund strait, which is the strait between Sweden and Denmark, and Kiel (Germany). Some categories of traffic data include: types and numbers of ships; types and amounts (ton and ton-km/miles) of dangerous goods/cargoes; types, amounts or numbers of containments; and traffic directions in the BSR.
4	<i>The regulatory system governing transport of dangerous goods</i>		
	<ul style="list-style-type: none"> The regulatory system is an essential constituent element of the transport system of dangerous goods. Because of risks and threats posed to humans, the marine environment and properties by hazardous 	<ul style="list-style-type: none"> Review and study the current state-of-the-art regulatory systems in the BSR in terms of contents, development, implementation and enforcement. The content of the regulatory system: <ul style="list-style-type: none"> What regulations concerning transport of dangerous goods and other relevant 	<ul style="list-style-type: none"> In every risk/safety study as well as on a regular basis, it is important to review and study the current state, best practices and issues concerning the regulatory systems. Develop, adopt and amend national regulations in accordance with

Nr.	Concluding remarks	Research areas and questions	Recommendations
	<p>properties of dangerous goods, international and domestic maritime transport of dangerous goods, as well as other transport modes, supply chain and related activities, is highly regulated by a complex regulatory system.</p> <ul style="list-style-type: none"> • The regulatory system affects significantly all other elements of the transport system of dangerous goods and related activities in many different ways. • Un-harmonized or incompatible regulatory systems and systems-related issues negatively affect the reliability, effectiveness and efficiency of the transport system of dangerous goods. 	<p>regulations (including acts, ordinances, regulations, recommendations, guidelines, notices etc) are in place in each respective country in the BSR?</p> <ul style="list-style-type: none"> • Adoption, development, amendment, and harmonisation of regulations, including these questions: <ul style="list-style-type: none"> ▪ Are the national regulatory systems in the BSR adopted, developed, implemented, or amended in accordance with the relevant international and regional regulations? ▪ Are they harmonized with the relevant international and regional regulations? ▪ If harmonized, to what degree are they harmonized? ▪ Do governments and responsible/competent authorities in the BSR maintain up-to-dated regulatory systems? • Implementation and enforcement of regulations, including these questions: 	<p>international and regional regulations.</p> <ul style="list-style-type: none"> • Maintain the regulatory system up-to-date in line with the relevant international and regional regulations and technological developments. • Harmonize national regulations with the relevant international and regional regulations. This is the best way to harmonize national regulatory systems across countries in the BSR. • Implement and enforce uniform regulations across countries, industries and sectors in the BSR.

Nr.	Concluding remarks	Research areas and questions	Recommendations
		<ul style="list-style-type: none"> ▪ Are regulations implemented and enforced uniformly in the BSR? ▪ Is there any discrepancy in implementation and enforcement of regulations among countries in the BSR? If yes, to what degree? 	
5	<i>Dangerous goods inspection programmes</i>		
	<ul style="list-style-type: none"> • The main purpose of dangerous goods inspection programmes is to observe and enforce compliance with relevant regulations concerning the transport of dangerous goods. • Regulations, in turn, are designed with the purpose to protect human safety and health, the environment and properties from risks associated with transport of dangerous goods. • Dangerous goods inspection programmes are in place in several countries in the BSR, such as Germany, Finland and Sweden, and 	<ul style="list-style-type: none"> • Study the current state of dangerous goods inspection programmes in the BSR, including these questions: <ul style="list-style-type: none"> ▪ Are dangerous goods inspection programmes in place in all countries of the BSR? ▪ If yes, are they harmonized or compatible? Is there any discrepancy? ▪ How are results of inspections compiled, analysed, disseminated and followed up? ▪ What analysis methods or techniques are employed to analyse results/ figures? 	<ul style="list-style-type: none"> • In accordance with relevant regulations, ensure that dangerous goods inspection programmes are in place in all countries of the BSR, if not already in place. • Harmonize and implement uniform dangerous goods inspection programmes across all countries of the BSR. • Coordinate inspections among countries – avoid unnecessary double inspections. • Share/disseminate the best practices, concerning issues and results of inspections.

Nr.	Concluding remarks	Research areas and questions	Recommendations
	<p>other parts of the world, such as in the USA and Japan.</p> <ul style="list-style-type: none"> • However, inspections cost money, time and other resources. 	<ul style="list-style-type: none"> ▪ Is there any risk-based approach? • Identify and study the best practices and issues concerning dangerous goods inspections in the countries of the BSR and other parts of the world. • Study costs and benefits associated with dangerous goods inspection programmes, including these questions: <ul style="list-style-type: none"> ▪ How much do inspections cost tax payers, industries and consumers? ▪ What is the view of industries? Are they a burden for the industries? ▪ What are the benefits? How are they measured? • Do the present costs justify the benefits? 	<ul style="list-style-type: none"> • Provide financial and technical assistance and expertise and know-how to the countries, industries, sectors or authorities in the BSR, if necessary. • Employ the most advanced risk-based analysis approaches or methods, which may result in some of the following benefits: <ul style="list-style-type: none"> ▪ Better analysis of inspection results in general. ▪ Exploring relationships among categories including deficiencies or violations, violators (shipper/ carrier), types of containments, destinations/ origins, and transport modes. ▪ Identifying and quantifying the root causes including the most influencing contributing factors. ▪ Estimating and ranking risks. ▪ Exploring and targeting deficiencies and violators posing highest risks. ▪ Performing cost-benefit analysis.

Nr.	Concluding remarks	Research areas and questions	Recommendations
			<ul style="list-style-type: none"> ▪ Exploring the most effective and efficient risk management strategies and measures. ▪ Designing tools, parameters and criteria for accurately measuring and evaluating risks management strategies and measures. ▪ Enhancing safety and environment protections as well as the reliability, effectiveness and efficiency in the transport of dangerous goods. • Integrate elements of dangerous goods inspection programmes into accident/incident databases and accident reporting and investigation procedures.

ATTACHMENTS

A.1 Packaging definitions

Package types	Definition – IMDG Code 1994
<i>Bags</i>	Bags are flexible packaging made of paper, plastics film, textiles, woven materials or other suitable materials.
<i>Boxes</i>	Boxes are packaging with complete rectangular or polygonal faces, made of metal, wood plywood, reconstituted wood, fibreboard, plastics or other suitable materials.
<i>Crates</i>	Crates are outer packaging with incomplete surfaces.
<i>Composite packaging</i>	Composite packagings are packagings constituting of an outer packaging and an inner receptacle so constructed that the inner receptacle and the outer packaging form an integral packaging. For instance, plastic receptacle with outer steel drum.
<i>Drums</i>	Drums are flat-ended or convex-ended cylindrical packagings made of metal, fibreboard, plastics, plywood or other suitable materials. Wooden barrels and jerricans are not covered by this definition. Jerricans are metal or plastic packagings of rectangular or polygonal cross-sections.
<i>Inner packagings</i>	Inner packagings are packagings for which an outer packaging is required for transport.
<i>Inner receptacles</i>	Inner receptacles are receptacles that require an outer packaging in order to perform their containment function.
<i>Outer packaging</i>	An outer packaging is the outer protection of a composite or combination packaging together with any absorbent materials, cushioning and other components necessary to contain the protect inner receptacle or inner packagings.
<i>Unit</i>	Unit means any of the followings: vehicle; container; tank; intermediate bulk container (IBC); unit load or receptacle, which is loaded or unloaded separately as one piece.

<i>Unit load</i>	Unit load means a number of packages that are either: 1) placed or stacked on and secured by strapping, shrink-wrapping or other suitable means to load on board such as pallet; 2) placed in a protective outer packaging such as a pallet box; 3) permanently secured together in a sling.
<i>Vehicle</i>	Vehicle means any: road freight; or tank vehicle; or railway freight; or tank wagon, permanently attached to an underframe and wheels, or chassis and wheels, which is loaded and unloaded as a unit. It also includes a trailer, semi-trailer or similar mobile unit, except those used solely for the purpose of loading and unloading.
<i>Cargo transport units</i>	Transport units are: 1) a road freight vehicle; 2) a railway freight wagon; 3) a freight container; 4) a road tank vehicle; 5) a railway tank wagon; and 6) a portable tank.
<i>Portable tanks</i>	Portable tank means a tank having a capacity of more than 450 litres whose shell is fitted with items of service equipment and structural equipment necessary for the transport of dangerous liquids whose vapour pressure is not more than 3 bar - absolute at temperature of 50 G C It is a tank that has stabilizing members external to the shell and is not permanently secured on board the ship. Its contents should not be loaded or discharged while the tank remains on board. It should be capable of being loaded and discharged without the need of removal of its structural equipment and capable of being lifted on and off ship when loaded.
<i>Demountable tank</i>	Demountable tank means a tank over a permanently attached tank of a road tank vehicle having a capacity of more than 400 litres, and complying with requirements of type 1 and 2 portable tanks.
<i>Road tank vehicle</i>	Road tank vehicle is vehicle fitted with a tank complying with the relevant requirements for type 1, 2, or 4, intended for the transport of dangerous liquids by both road and sea mode of transport, the tank which is rigidly and permanently attached to the vehicle during all normal operation of loading, discharging transport and is neither filled nor discharged on board and is driven on board on its own wheels.



The UNITED NATIONS system

PRINCIPAL ORGANS OF THE UNITED NATIONS

INTERNATIONAL COURT OF JUSTICE

SECURITY COUNCIL

GENERAL ASSEMBLY

ECONOMIC AND SOCIAL COUNCIL

TRUSTEESHIP COUNCIL

SECRETARIAT

Military Staff Committee
Standing Committee and ad hoc bodies
International Criminal Tribunal for the Former Yugoslavia
International Criminal Tribunal for Rwanda
UN Monitoring, Verification and Inspection Commission (Unmiv)
United Nations Compensation Commission
Peacekeeping Operations and Missions

Main committees
Other subsidiary committees
Standing committees
and ad hoc bodies
Other subsidiary organs

PROGRAMMES AND FUNDS
UNCTAD United Nations Conference on Trade and Development
ITC International Trade Centre (UNCTAD/WTO)
UNICDP United Nations Drug Control Programme
UNEP United Nations Environment Programme
UNHSP United Nations Human Settlements Programme (UN-Habitat)
UNDP United Nations Development Programme
UNRWA** United Nations Relief and Works Agency for Palestine Refugees in the Near East
UNICEF United Nations Children's Fund
WFP World Food Programme
UNRWA** United Nations Relief and Works Agency for Palestine Refugees in the Near East

UNHCR Office of the United Nations High Commissioner for Refugees
UNICEF United Nations Children's Fund
WFP World Food Programme
UNRWA** United Nations Relief and Works Agency for Palestine Refugees in the Near East

OTHER UN ENTITIES
OHCHR Office of the United Nations High Commissioner for Human Rights
UNOPS United Nations Office for Project Services
UNU United Nations University
UNSSC United Nations System Staff College
UNRISD United Nations Research Institute for Social Development
UNRISD United Nations Research Institute for Social Development
UNRISD United Nations Research Institute for Social Development

UNHCR Office of the United Nations High Commissioner for Refugees
UNICEF United Nations Children's Fund
WFP World Food Programme
UNRWA** United Nations Relief and Works Agency for Palestine Refugees in the Near East

RESEARCH AND TRAINING INSTITUTES
INSTRAW International Research and Training Institute for the Advancement of Women
UNICRI United Nations International Crime and Justice Research Institute

UNHCR Office of the United Nations High Commissioner for Refugees
UNICEF United Nations Children's Fund
WFP World Food Programme
UNRWA** United Nations Relief and Works Agency for Palestine Refugees in the Near East

FUNCTIONAL COMMISSIONS
Commission for Social Development
Commission on Human Rights
Commission on Narcotic Drugs
Commission on Crime Prevention and Criminal Justice
Commission on Science and Technology for Development
Commission on Sustainable Development
Commission on the Status of Women
Commission on Population and Development
Statistical Commission
REGIONAL COMMISSIONS
Economic Commission for Africa (ECA)
Economic Commission for Europe (ECE)
Economic Commission for Latin America and the Caribbean (CECLAC)
Economic and Social Commission for Asia and the Pacific (ESCAP)
Economic and Social Commission for Western Asia (ESCWA)
United Nations Forum on Forests
Sessional and Standing Committees
Expert, ad hoc, and related bodies

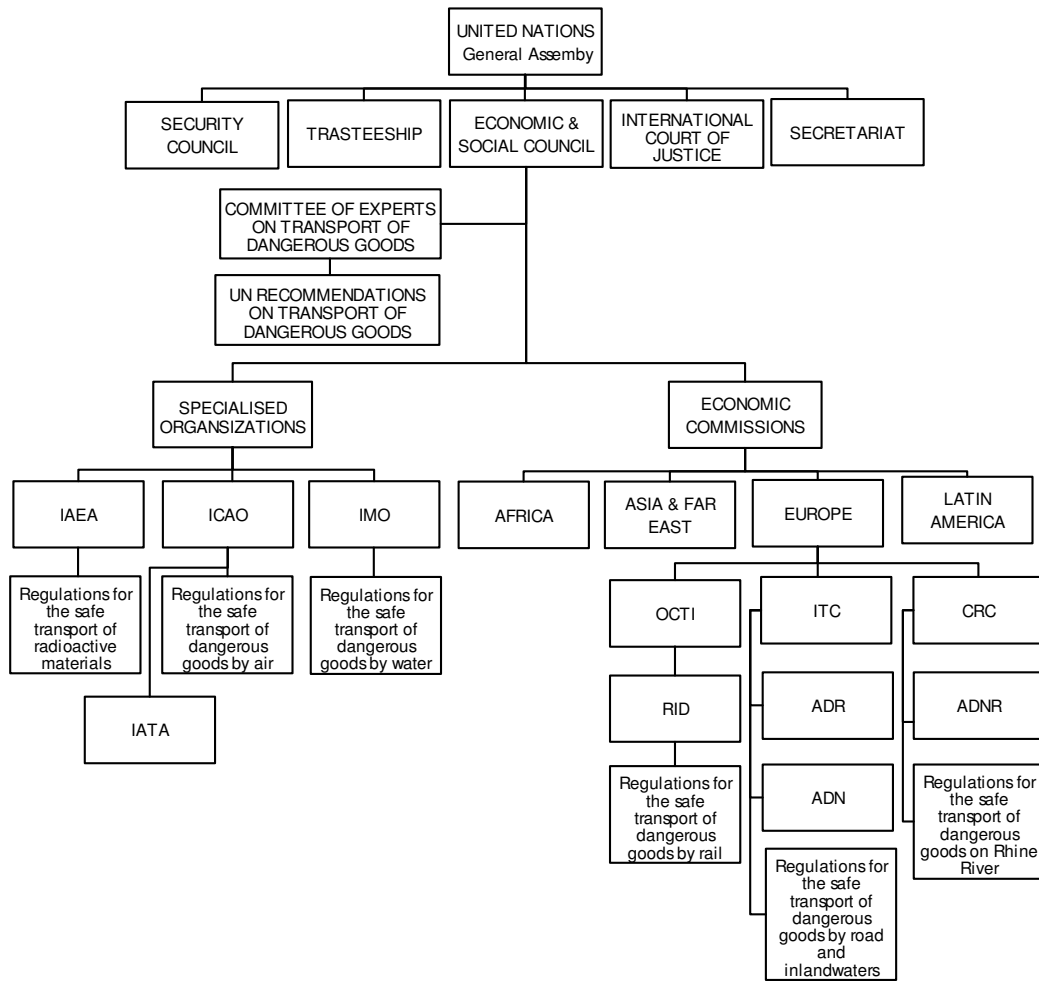
SPECIALIZED AGENCIES*
ILO International Labour Organization
FAO Food and Agriculture Organization of the United Nations
UNESCO United Nations Educational, Scientific and Cultural Organization
WHO World Health Organization
WORLD BANK GROUP
IBRD International Bank for Reconstruction and Development
IDA International Development Association
IFC International Finance Corporation
ICSID International Centre for Settlement of Investment Disputes
IMF International Monetary Fund
ICAO International Civil Aviation Organization
IMO International Maritime Organization
ITU International Telecommunication Union
UPU Universal Postal Union
WMO World Meteorological Organization
WIPO World Intellectual Property Organization
IFAD International Fund for Agricultural Development
UNIDO United Nations Industrial Development Organization

OSG Office of the Secretary-General
ODS Office of Internal Oversight Services
OIA Office of Legal Affairs
DPA Department of Political Affairs
DDA Department for Disarmament Affairs
DPKO Department of Peacekeeping Operations
OCHA Office for the Coordination of Humanitarian Affairs
DESA Department of Economic and Social Affairs
DGACM Department of General Assembly and Conference Management
DPI Department of Public Information
DM Department of Management
OP Office of the Inspector General
UNESCO Office of the United Nations Security Coordinator
OHRLS Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States
ODC Office on Drugs and Crime
UNOG UN Office at Geneva
UNOV UN Office at Vienna
UNON UN Office at Nairobi

*Autonomous organizations working with the United Nations and each other through the coordinating machinery of the Economic and Social Council.
**Report only to the General Assembly.

Source: United Nations 2004

UNITED NATIONS SYSTEM AND REGULATIONS FOR
TRANSPORT OF DANGEROUS GOODS



A.3 List of IMO's Conventions

The main categories of IMO's Conventions are (IMO 2004):

- Maritime safety
- Marine pollution
- Liability and compensation
- Other subjects

Maritime safety

- International Convention for the Safety of Life at Sea (SOLAS), 1974
- International Convention on Load Lines (LL), 1966
- Special Trade Passenger Ships Agreement (STP), 1971
- Protocol on Space Requirements for Special Trade Passenger Ships, 1973
- Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 1972
- International Convention for Safe Containers (CSC), 1972
- Convention on the International Maritime Satellite Organization (INMARSAT), 1976
- The Torremolinos International Convention for the Safety of Fishing Vessels (SFV), 1977
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978
- International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F), 1995
- International Convention on Maritime Search and Rescue (SAR), 1979

Marine pollution

- International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)
- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (INTERVENTION), 1969
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (LDC), 1972
- International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC), 1990
- Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances, 2000 (HNS Protocol)

- International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS), 2001
- International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004

Liability and compensation

- International Convention on Civil Liability for Oil Pollution Damage (CLC), 1969
- International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND), 1971
- Convention relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material (NUCLEAR), 1971
- Athens Convention relating to the Carriage of Passengers and their Luggage by Sea (PAL), 1974
- Convention on Limitation of Liability for Maritime Claims (LLMC), 1976
- International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS), 1996
- International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001

Other subjects

- Convention on Facilitation of International Maritime Traffic (FAL), 1965
- International Convention on Tonnage Measurement of Ships (TONNAGE), 1969
- Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation (SUA), 1988
- International Convention on Salvage (SALVAGE), 1989

A.4 Swedish regulatory system

The following are in some details the most important Swedish regulations (including acts, ordinance, regulations, directives, and directions) concerning transport of dangerous goods, safety, security and environment protection (SFS 2006; SMA 2006; TG 2006; Notisum 2006; SRSA 2006):

Dangerous Goods

- Swedish Transport of Dangerous Goods Act (2006:263).
- Swedish Ordinance (2006:311) on transport of dangerous goods. The ordinance contains regulations related to the law (2006:263) on transport of dangerous goods
- Swedish Rescue Services Agency regulations on the safety adviser for transport of dangerous goods (SRVFS 2006:9). The Swedish Rescue Services Agency prescribes regulations based on 16 § Ordinance (2006:311) on transport of dangerous goods.
- Swedish Rescue Services Agency regulations on transport of dangerous goods on road and terrain (ADR-S) (SRVFS 2006:7). The Swedish Rescue Services Agency prescribes regulations based on 15 and 16 § Ordinance (2006:311) on transport of dangerous goods.
- Swedish Rescue Services Agency regulations on transport of dangerous goods on rail (RID-S) (SRVFS 2006:8). The Swedish Rescue Services Agency prescribes regulations based on 15 and 16 § Ordinance (2006:311) on transport of dangerous goods.
- Swedish Maritime Administration regulations on sea transport of packaged dangerous goods (SJÖFS 2005:15) (IMDG Code). The Swedish Maritime Administration prescribes regulations based on chap. 2, 1 §, and chap. 3, 2 and 4 § Vessels Safety Ordinance (2003:438) and 2, 4, 9, 10, 13 and 22 § Ordinance (1982:923) on transport of dangerous goods.
- Swedish Maritime Administration regulations and general directions on domestic sea transport of packaged dangerous goods in shipping areas D and E (SJÖFS 2004:18).
- Swedish Maritime Administration notification with regulations and general directions on transport of dangerous goods in port (SJÖFS 1991:8). The Swedish Maritime Administration prescribes regulations based on chap. 2, 4§, Vessels Safety Ordinance (1988:594) and 22§ Ordinance (1982:923) on transport of dangerous goods.
- Swedish Maritime Administration Regulations and general directions on compulsory registration, information obligations, and reporting obligations

in certain cases (SJÖFS 2005:19). The Swedish Maritime Administration prescribes regulations based on chap. 3, 11 §, and chap. 7, 2 §, Ordinance (1980:789) on measures against pollution from ships, 22 §, Ordinance (1982:923) on transport of dangerous goods, chap. 2, 1 §, Ordinance on Vessel Traffic (1986:300) and chap. 2, 7 §, Ordinance on Vessels Safety (2003:438).

- Swedish Maritime Administration regulations and general directions on transport of packaged dangerous goods on ro-ro ships in the Baltic Sea. The Swedish Maritime Administration prescribes regulations based on chap. 2, 1§, and chap. 3, 2 and 4§, Ordinance on Vessels Safety (2003:438) and 5, 6, 9, 10, 13, 14 and 22 § Ordinance (1982:923) on transport of dangerous goods

Maritime security

- European Parliament and Council Ordinance (EG) nr 725/2004, 31st mars 2004, on enhancing ship and port facility security.
- Swedish Maritime Security Act (2004:487). The act contains supplementary regulations to the European Parliament and Council Ordinance nr 725/2004, 31st mars 2004, on enhancing ship and port facility security.
- Swedish Ordinance on Maritime Security (2004:283). The ordinance regulates certain conditions related to the European Parliament and Council Ordinance nr 725/2004, 31st mars 2004, on enhancing ship and port facility security.
- Swedish Maritime Administration Regulations on Maritime Security (SJÖFS 2004:13). The Swedish Maritime Administration prescribes regulations based on 3, 4 and 9 § Ordinance (2004:283) on Maritime Security
- Swedish Maritime Administration regulations (SJÖFS 2002:8) on ISM Code, the International Safety Management Code. The ISM Code is implemented through the regulations.

Seveso Legislations concerning major chemical accidents

- Swedish Act (1999:381) on measures to prevent and reduce consequences of serious chemical accidents.
- Swedish Ordinance (1999:382) on measures to prevent and reduce consequences of serious chemical accidents.
- Swedish Rescue Services Agency Regulations (SRVFS 2005:2) on measures to prevent and reduce consequences of serious chemical accidents.
- Regulations (AFS 2005:19) on prevention of serious chemical accidents.

Ship reporting system

- European Council Directive (2002/59/EC) on a supervision and information system for shipping.
- Swedish Maritime Administration Regulations (SJÖFS 2005:19) on compulsory registration, information obligations, and reporting obligations in certain cases. European Council Directive (2002/59/EC) is implemented through the regulations.

A.5 Status of IMO's Conventions/Instruments

Table presents IMO's conventions/instruments as per 31 July 2004.

Convention/ Instrument	Entry into force date	No. of Contracting States	% of the world tonnage
IMO Convention	17-Mar-58	164	98.48
1991 amendments	-	83	82.94
SOLAS 1974	25-May-80	152	98.45
SOLAS Protocol 1978	01-May-81	106	94.83
SOLAS Protocol 1988	03-Feb-00	75	63.57
Stockholm Agreement 1996	01-Apr-97	9	9.65
LL 1966	21-Jul-68	154	98.41
LL Protocol 1988	03-Feb-00	73	63.44
TONNAGE 1969	18-Jul-82	141	98.18
COLREG 1972	15-Jul-77	146	97.44
CSC 1972	06-Sep-77	76	60.36
1993 amendments	-	7	4.39
SFV Protocol 1993	-	10	10.09
STCW 1978	28-Apr-84	147	98.42
STCW-F 1995	-	4	3.33
SAR 1979	22-Jun-85	82	51.59
STP 1971	02-Jan-74	17	22.42
SPACE STP 1973	02-Jun-77	16	21.51
INMARSAT C 1976	16-Jul-79	89	92.37
INMARSAT OA 1976	16-Jul-79	87	91.40
1994 amendments	-	40	29.57
FAL 1965	05-Mar-67	98	64.96
MARPOL 73/78 (Annex I/II)	02-Oct-83	128	97.06
MARPOL 73/78 (Annex III)	01-Jul-92	113	92.93
MARPOL 73/78 (Annex IV)	27-Sep-03	98	54.37
MARPOL 73/78 (Annex V)	31-Dec-88	117	95.21
MARPOL Protocol 1997 (Annex VI)	-	16	54.68
LC 1972	30-Aug-75	81	70.08
1978 amendments	-	20	19.06
LC Protocol 1996	-	20	11.96

Convention/ Instrument	Entry into force date	No. of Contracting States	% of the world tonnage
INTERVENTION 1969	06-May-75	81	71.40
INTERVENTION Protocol 1973	30-Mar-83	47	45.12
CLC 1969	19-Jun-75	45	4.94
CLC Protocol 1976	08-Apr-81	56	58.03
CLC Protocol 1992	30-May-96	98	93.14
FUND Protocol 1976	22-Nov-94	33	47.01
FUND Protocol 1992	30-May-96	88	88.14
FUND Protocol 2000	27-Jun-01	-	-
FUND Protocol 2003	-	6	8.58
NUCLEAR 1971	15-Jul-75	16	19.81
PAL 1974	28-Apr-87	30	35.59
PAL Protocol 1976	30-Apr-89	24	35.29
PAL Protocol 1990	-	4	0.81
PAL Protocol 2002	-	-	-
LLMC 1976	01-Dec-86	47	45.12
LLMC Protocol 1996	13-May-04	14	15.04
SUA 1988	01-Mar-92	110	81.55
SUA Protocol 1988	01-Mar-92	98	77.67
SALVAGE 1989	14-Jul-96	45	34.38
OPRC 1990	13-May-95	77	58.92
HNS Convention 1996	-	6	1.92
OPRC/HNS 2000	-	10	15.39
BUNKERS CONVENTION 2001	-	5	0.47
AFS CONVENTION 2001	-	8	9.36
BWM CONVENTION 2004	-	-	-
<i>Sources: IMO 2004 and Lloyd's Register of Shipping/World Fleet Statistics as at 31 December 2002</i>			

4.6 Checklist for inspections in accordance with the MoU

CHECKLIST FOR INSPECTIONS IN ACCORDANCE WITH THE MoU

2. Date _____ 3. Time _____

1	Place		1.1 Terminal		1.3 Company					
4	Vehi- cle	4.1 Nationality	4.2 Reg.number	5. Trailer/semi- trailer/container	5.1 Nationality	5.2 Reg.number	1.2 Harbour	1.4 System	1.5 Road	
6	Carrier, address									
7	Driver				Driver's assistant					
8	address				address					
8	Consignor				Place of loading					
9	address				Place of discharge					
9	Consignee				address					
10	Total quantity of dangerous goods per transportunit _____ kg									
11	ADR 1.1.3.6 quantity limit exceeded <input type="checkbox"/> 11.1 Yes <input type="checkbox"/> 11.2 No									
12	Transport with <input type="checkbox"/> 12.1 Tank <input type="checkbox"/> 12.2 Bulk <input type="checkbox"/> 12.3 Package <input type="checkbox"/> 12.4 Other									
12	Transport in accordance <input type="checkbox"/> 12.9 ADR <input type="checkbox"/> 12.10 <input type="checkbox"/> 12.11 IMDG Code <input type="checkbox"/> 12.12 ICAO-TI <input type="checkbox"/> 12.13 RID <input type="checkbox"/> 12.14 <input type="checkbox"/> 12.15 MoU <input type="checkbox"/> 12.16 Other									
Transportdocuments	* A) Checked: B) Not in acc. with the rules C) NA * A) * B) * C) Risk-categ. Note									
	13	13.1 DGD <input type="checkbox"/> 13.2 Stowage plan								
	14	Written instructions								
	15	15.1 Bilateral <input type="checkbox"/> 15.2 Multilateral <input type="checkbox"/> 15.3 Nat. auth.								
	16	Cert. of app. for vehicles 16.1 Vehicle								
	17	17.1 Driver's training certificate (ADR 8.2.1, 8.2.2)								
	17	17.2 Other ADR-training								
	18	Cargo approved for transport								
	19	Vehicle approved for the transported cargo								
	20	Provisions related to the mode of transport (bulk, kolli, tank)								
Transport	21	Prohibition of mixed loading								
	22	22.1 Handling 2)								
	22	22.2 Loading/stowage 2)								
	22	22.3 Cargo securing 2)								
	23	23.1 Leakage 2)								
	23	23.2 Damage to package/vehicle 2)								
	24	UN packaging marking/tank marking (ADR 6) 2)								
	25	25.1 Package marking (5.2.1)								
	25	25.2 Package labelling (5.2.2)								
	26	Tank/vehicle placarding (5.3.1)								
Equipment on board	27	Placarding/markings of cargo transport units (5.3.2, 5.3.3, 5.5)								
	28	General purpose safety equip (ADR 8.1.5(a))								
	28	28.1 Scotch								
	28	28.2 Warning equipment								
	28	28.3 Warning vest								
	28	28.4 Handlamp(s)								
	29	Equipment acc. to the goods carried (ADR 8.1.5(b))								
	30	Other equipment specified in the written instruc. (ADR 8.1.5(c))								
	31	Fire-extinguish 31.1 Type A (ADR 8.1.4.1(a)/ 8.1.4.2)								
	31	31.2 Type B (ADR 8.1.4.1(b.c))								
40	Other									
39	The most serious risk category of established infringements									
41	Authority/officer having carried out the inspection (sign)				Clarification of signature					

1) To be filled only if relevant for an infringement
2) Check of visible violation

A.7 Example of Swedish Maritime Administration Database

Source: Swedish Maritime Administration (SMA 1985-2000)

SJÖFARTSVERKET		Rapport från SjöOlycksSystem		
Sjöfartsinspektionen		2000-02-01	08:45	
Utredningsstaben		Rapporten avser ärende nr 2293		
Olycka	Tillbud	Fartygsnamn: Öresund		
Händelse datum: 1994/02/23		Händelse typ: Grundstötning/Grundkänning		
Diaries nr: 9470320		Ärendet lagt adacta 1994/12/31		
Fartygsuppgifter				
Signal:	SLQE	Byggnadsår:	1986	
Nationalitet:	Sverige	Ombyggd:		
Fartygsart:	Ro/ro fartyg	Isklass:	1 B	
Fartområde:	Stor kustfart	Material:	Stål	
Inspektion området:	Malmö Sjöfarts inspektionsområde	Framdrivning	Motor	
Längd:	186,00 m			
Bredd:	23.00 m			
Djupgående:	5.60 m			
Brutto:	16925			
Dödvikt	6300			
Maskinstyrka:	13200 kw			
Dubbel botten:				
Dubbel sida:				
Klassällskap:	Den Norska Veritas			
Senaste inspektion:	1993-10-01	Brister:	Nej	
Senaste inspektion klassen:	1993-10-01	Brister:	Nej	
Händelsen				
Konsekvenser:				
Gradering av olycka:	Mindre allvarig olycka med/utan personskada			
Evakuering:	Nej			
Huvudsaklig orsak:	Farvattnets beskaffenhet, grunt/trång osv.			
Bidragande orsaker:	Andra förhållanden där den mänskliga faktorn inverkat			

Lotspliktigt:	Nej	Isbrytarass:			
Lots ombord:	Nej	Avgångshamn:	Köpenhamn		
Besättning:	8	Destination:	Helsingborg		
Totalt ombord:					
Tid and plats					
Klockslag:	06:00	Latitud:	N554215		
Veckodag:	Tisdag	Longitud:	E123505		
Farvatten:	Hamnområde				
Trafikområde:	Utanför svenskt territorialvatten				
Inspektionsområde:					
Land:	Danmark				
Nationellt geografisk område:	Kattegat och Öresund				
Sjökort nr:	134	utgivet år:	5	utgivningsland	Danmark
Fartygets verksamhet					
Verksamhet ombord:	Normal seglats				
Bryggbemanning:	Befälhavare, styrman och en man (minimum)				
Styrmotod:	Handstyrning med rorsman				
Fartygets verksamhet:	Vid avgång från hamn				
Typ av last ombord:	Annan känd last			Farligt gods:	
Vädret och vind					
Ljus:	Mörkt				
Sikt:	>10km eller >5nm, God sikt				
Nederbörd:	Snöbyar				
Vindriktning:	Varierande				
Sjögång:	1,6-3,3 m/sek, Lätt brist				
Personskador					
Skadade		Omkomna		Försvunna	
Svensk besättning:	0	Svensk besättning:	0	Svensk besättning:	0
Utländsk besättning:	0	Utländsk besättning:	0	Utländsk besättning:	0

Passagerare:	0	Passagerare:	0	Passagerare:	0
Lots/båtman:	0	Lots/båtman:	0	Lots/båtman:	0
Andra ombord:	0	Andra ombord:	0	Andra ombord:	0
Ej ombordvarande:	0	Ej ombordvarande:	0		
Fartygsskador					
Skrovskada:	Ja				
Läckage:	Inget läckage				
Skadans längd:	Ingen skada				
Skadans höjd (bredd):	Ingen skada				
Skadans största intryckning:	Ingen intryckning				
Lokalisering, babord/styrbord:	Inte aktuellt				
Lokalisering, höjd över botten:	Inte aktuellt				
Lokalisering, längs fartyget	Roder				
Utsläpp				mängd i meterton	
Information om brister/fel i utrustning samt använd räddningsutrustning					
Händelsebeskrivning					
Vid rundsvägning i mellanbassängen kändes en skakning i skrovet men inget oegentligt kunde uppräckas vid undersökning. Några dagar senare tyckte man att fartyget styrde dåligt. Konstaterades att större delen av BB roder var borta.					

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This report deals with the maritime transport system of packaged dangerous goods (PDG) and principles of risks of marine accidents/incidents involving dangerous goods. The report is part of the Safe and Reliable Transport Chains of Dangerous Goods in the Baltic Sea Region (DaGoB) project and the author's own research.

The main aims of the DaGoB project include: a) improve co-operations at various levels among parties concerned in transport of dangerous goods in the BSR; b) provide up-to-date information on cargo flows, supply chain efficiency and risks related to transport of dangerous goods; and c) disseminate and transfer the knowledge gained from the project on local, national, regional and international levels.

The author's research work concerns the development of a risk analysis framework for readily application in the maritime transport system of PDG as well as the demonstration or validation of the framework in practice. One of the main parts of the thesis constitutes the "Frame of Reference", which provides relevant concepts, definitions and theoretical models in the essential interrelated research areas, such as: a) the maritime transport system of PDG; b) risks of dangerous goods accidents/incidents; and c) the risk management system. The "Frame of Reference" serves as a theoretical platform for the development of the risk analysis framework. The framework development involves exploration of many relevant concepts and their relationships. This report deals with the first two research areas, namely: a) the maritime transport system of PDG and b) risks associated with it.

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