NAVIGATIONAL SAFETY OF SHUTTLE TANKERS

Henryk Śniegocki

Gdynia Maritime University, Department of Navigation
Aleja Jana Pawła II 3, 81-345 Gdynia, Poland
tel.: +48 58 6201968, fax. +48 58 6606126
e-mail: henryksa@am.gdynia.pl

Abstract

This article deals with a very important problem, i.e. with the safety of shuttle tankers at sea. The author presents systems and mechanisms observed at these types of vessels which have great influence on safety both during loading and discharging operations, as well as at sea. A dynamic positioning system was introduced together with its subsystems and their role in increasing safety. Another issue discussed in this article is the problem of oil pollution during cargo handling operations and sea pollution resulting from accidents of tankers. This article also covers some problems connected with training of crew of these specialized vessels, operating the instruments and equipment installed on them and also with the maritime infrastructure. Some problems connected with navigation observed in some regions of the world were also discussed here.

Transport of oil close to the coast is a branch of oil transportation in full swing. Each even the minor failure results in serious consequences for people, for vessels and for the environment. Constant development of new technologies used on shuttle tankers and constructing new vessels equipped with the most modern technical solutions aims at minimizing the risk of situations threatening people's life, situations dangerous for the vessel and the marine environment.

Keywords: *shuttle tankers, dynamic positioning, safety of navigation, oil transportation*

1. Introduction

Globalization of industry, greater demand for sources of energy has an influence on dynamic development of sea transport. The necessity of transportation of different types of liquid cargos being a great threat both for people and environment requires a great caution for safety both during sea transport as well as during handling operations. The transport of oil products, sea transportation branch, is developing most dynamically. Highly specialized tankers are used to carry this type of cargo. They must comply with very strict regulations both regarding protection of natural environment and those connected with safety of the crew.

2. Types of tankers

There are a lot of different classifications of tankers. One of them is classification with references to the type of cargo. We can distinguish the following types:
- tankers used for carrying oil products
  - oil tankers,
  - LNG – Liquefied Natural Gas,
  - LPG – Liquefied Petroleum Gas,
- chemical carriers,
- other product carriers.

Deadweight (DWT) is another factor taken in classification of these ships:
- 10,000-24,999 DWT: General Purpose Tankers,
- 25,000-44,999 DWT: Medium Range Tanker,
- 45,000-79,999 DWT: Large Range 1(LR1),

- 80,000-159,999 DWT: Large Range 2 (LR2),
- 160,000-319,999 DWT: Very Large Crude Carrier (VLCC),
- 320,000-549,999 DWT: Ultra Large Crude Carrier (VLCC).

Tankers used for crude oil have some restrictions regarding sea areas they sail. Here we can introduce another division as to their dimensions:

- Seawaymax – these are maximum size vessels which can cover the route joining American Great Lakes,
- Panamax – these are tankers of maximum size which can go through the Panama Canal,
- Aframax – average freight rate assessment maxima tankers which offer minimum cost of transport and great cargo handling capacity at the same time,
- Suezmax – these are greatest tankers which can go through the Suez Canal,
- VLCC – great size tankers,
- ULCC – these are the greatest carriers which can be operated only by a dozen or so ports all over the world.

Cargo handling operation at sea is highly risky and may result in damage to ships and at the same time they endanger the sea environment. There was a need for constructing vessels for crude oil transportation from oil rigs or floating tanks which would offer safest transport. More frequent crude oil exploitation from oil deposits located off shore resulted in construction of new tankers, i.e. shuttle tankers.

3. Shuttle tankers

Shuttle tankers are specialized vessels designed for transporting crude oil in coastal sector (mainly from oil rigs or floating tanks to refineries or land terminals). Their DWT ranges from 100,000 DWT or even more but we can also meet vessels which are far greater in size. The majority of shuttle tankers is operated in the North Sea in the Gulf of Mexico and close to South American coasts (mainly the coast of Brazil). They can also be met off South African coasts, in the region of Singapore and Australia and everywhere where crude oil must be transported on short distances.

These vessels carry crude oil mainly but they are also used for transportations of other crude oil products. Shuttle tankers were constructed to minimize the results of oil spillages close to shore, to avoid penalties connected with oil pollution. Their construction increases the safety of cargo handling at open sea and close to the shore.

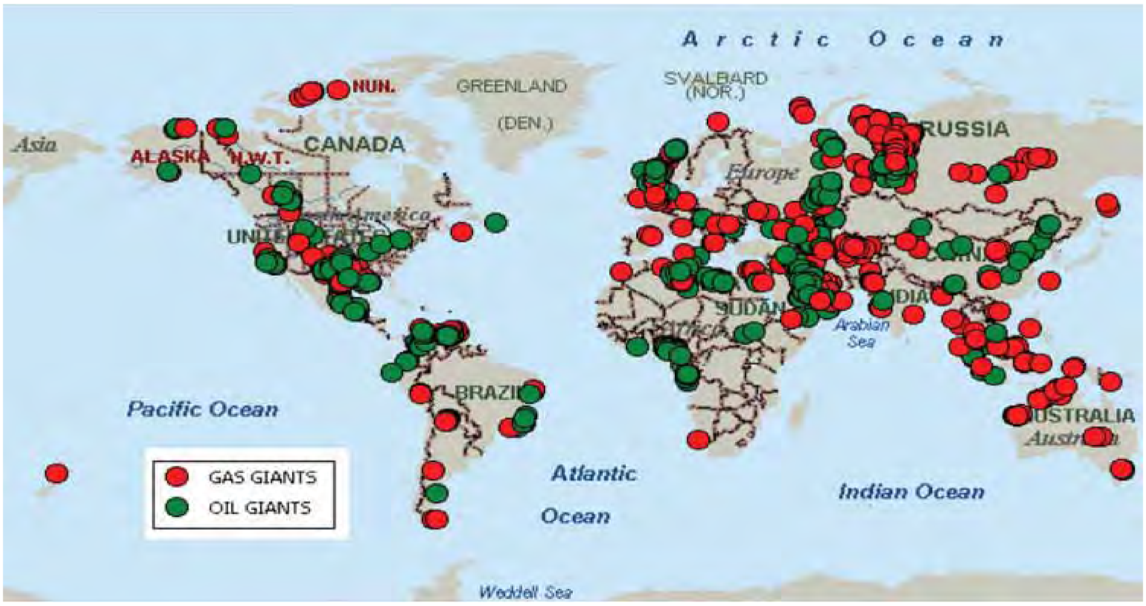

Fig. 1. Big oilfields [13]

Fig. 2. Shuttle tankers [12]

4. How DP system works

Shuttle tankers apart form typical navigational instruments such as radars (S-band or X-band), gyrocompasses, magnetic compasses, GPS, autopilots, echo sounders, GMDSS, ALDIS, ECDIS, are also fitted with Dynamic Positioning Systems (DP). This system assures safe navigation in the region of oil rigs as they make it possible to keep vessel in a given position or in a given region during cargo handling operations. It is also additional device making port maneuvering easier. DP systems used on these vessels are made up of a series of devices enabling very accurate defining of ships position and keeping the vessel in a very accurate position or in a defined safety area.

The main navigational systems used in DP are:

- referential systems of very high accuracy, which make it possible to define the ship position,
- systems defining the ships course,
- systems defining wind direction and speed,
- systems defining VRU.

The referential systems can further be subdivided into absolute and relative systems.

The first group is made up of such devices as GPS, DGPS, GLONASS, and DGLONASS which are used to define position with the help of satellites. The second group includes DARPS, ARTEMIS, Fanbeam, RADius, RadaScan, CyScan, HPR and Taut Wire. These systems define positions in relation to other objects using electromagnetic or radio waves or a laser beam. HPR and Taut Wire should be described briefly. The first one is a hydro acoustic system and makes use of acoustic wave in water. The position of the vessel is defined on the basis of measuring the distance between transponders located on the sea bottom. Taut Wire system is the only one in the above mentioned systems which is mechanical system. It operates using special depressor weight on the sea bottom. The system ‘remembers’ the position of this depressor weight and indicates the movement of the vessel in relation to it.

Such instruments indicating parameters such as course and heading of the vessel or the wind direction and speed play also very important role. Thanks to special sensors installed on DP console we can observe the movement of the vessel ahead, astern and its movement sideways. It is very important to observe the vessels speed constantly.

The above mentioned DP console functions can be used not only during cargo handling operations in open sea but also to help watch officers when the vessel is at anchor and not the entire DP system is used but only parameters form sensors and visualization of vessel’s position show if the vessel is in proper position or not. Apart from so many sophisticated innovations and equipment used there are still accidents which may results in oil pollution.

5. Safety of operation of tankers

Oil pollution resulting from sea collisions has been greatly reduced thanks to special solutions in tanker construction such as building, double bottom hulls.

Figure 3 presents number of oil spillages, average (7-700 t) and major (>700) oil spillages in the years 1970-2008. As we can see the number of spillages is decreasing. Number of major spillages has been greatly reduced, average spillages happen quite often. And this should give rise to actions aiming at further improvement of the safety of tankers.

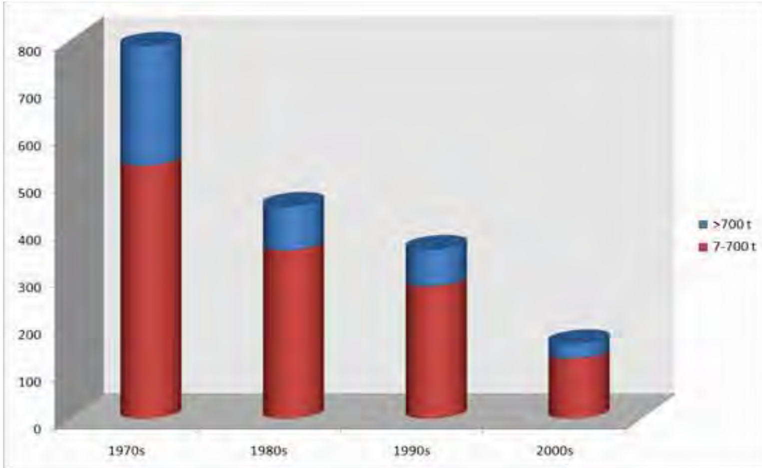

Fig. 3. Number of average (7-700 t) and major (>700) oil spillages in the years 1970-2008 [11]

Figure 4 presents the decrease in oil spillages exceeding 700 t in the years 1970-2008. The development of technology and the introduction of the new solutions resulted in the decrease of spillages from average 25.5 in the years 1970-1979 to 3.4 in the years 2000-2008.

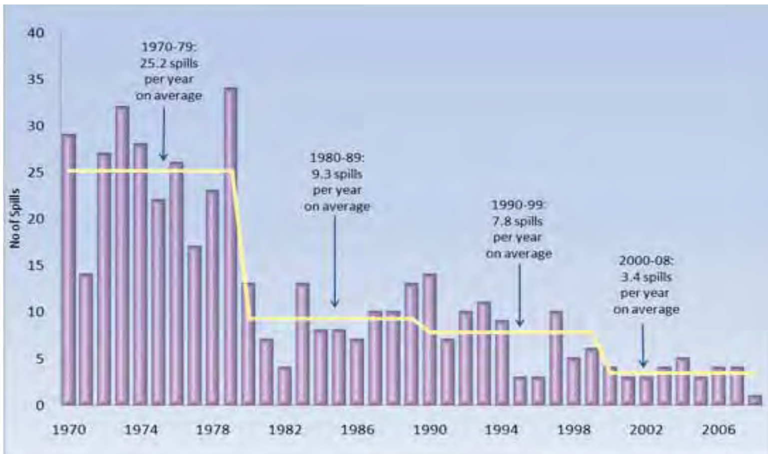

Fig. 4. Number of oil spillages above 700 t in the years 1970-2008 [11]

Figure 5 presents amount of oil spilled in the years 1970-2008. The greatest spillage caused by one vessel was presented here. As it can be seen major individual spillages have been reduced. Nowadays we can observe only a number of minor spillages caused by a great number of vessels. Figure 6 presents spillages lower than 7 t over the years 1974-2008 with reference to their source.

The greatest number of minor spillages can be observed mainly during cargo handling operations. The most frequent cause of this incident is breaking of cargo loading arms, seals or improper connection between ships's manifold and manifold of the coastal refinery or floating production storage unit.

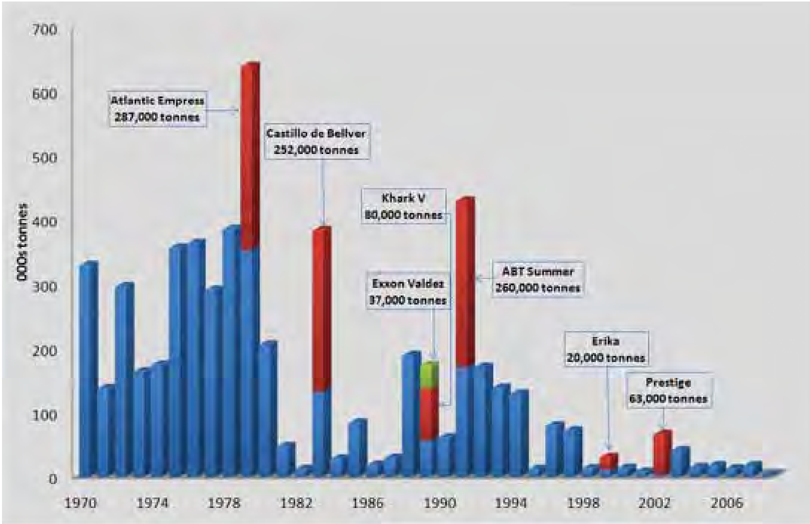

Fig. 5. The amount of oil spilled in the years 1970-2008 [11]

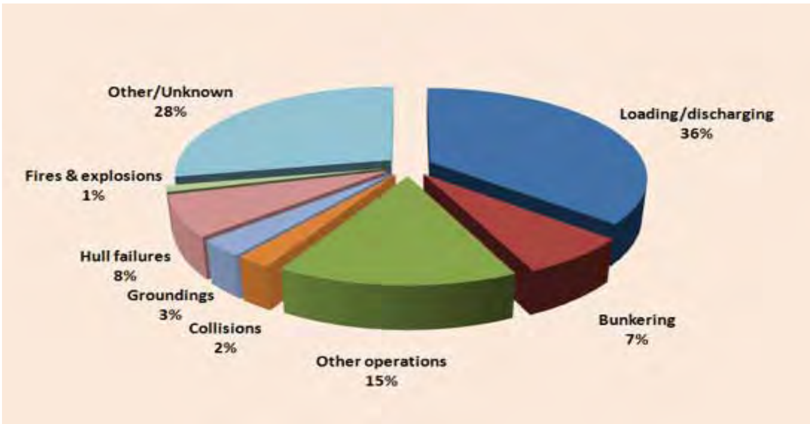

Fig. 6. Reasons for oil spillages lower than 7 t in the years 1974-2008 [11]

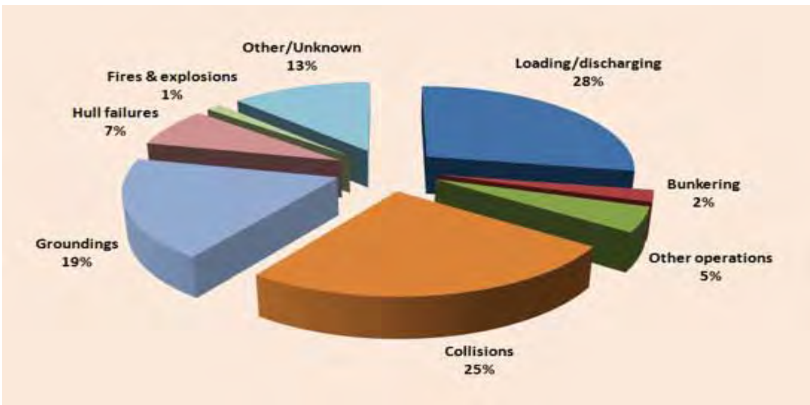

Fig. 7. Reasons for oil spillages ranging 7-700 t in the years 1974-2008 source [11]

As it can be seen cargo loading and discharging is the most frequent reason for average spillages ranging between 7-700 t. Second place is taken by collisions. It is clearly shown what should be done in order to minimize oil pollution of sea environment. Fig. 8 illustrates causes of major oil spillages where the amount of oil released into the sea exceeded 700 t. This pie chart was made taking into account accidents where tankers were involved in the years 1974-2008.

Here the situation is different from the previous cases. The basic reason for major spillages lies not in cargo handling operations or collisions but grounding. It covers 34.2% of all accidents connected

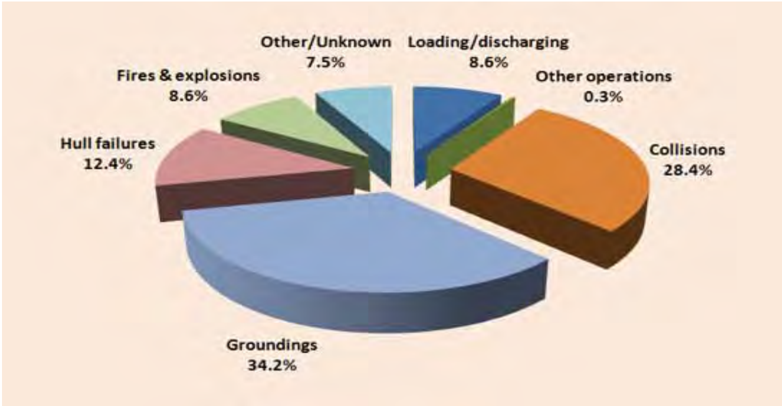

Fig. 8. Reasons for spillages exceeding 700 t in the years 1974 – 2008, source [11]

with major oil spillages exceeding 700 t. Reasons for grounding may be various but most often it results from:

- Human Error; negligence of watch officer was the most frequent reason,
- Problems witch steering gear,
- Main engine failure, where the vessel is not under control and is exposed to wind or current and is pushed aground.

Most frequent reasons for spillages in DP vessels group are collisions of these vessels with floating production storage and offloading units FPSO or FSO type. The main reason for such event is human error. However it sometimes happens that the spillage occurs because of failure of some cargo handling equipment. An example of such pollution is the event which happened on 27 December 2007. During cargo loading operations between a shuttle tanker Navion Britannia and platform Statfjord A loading arm broke which resulted in spillage of 4400 cubic meters of oil into the sea. It turned out that the cause of the breakage was too high pressure in the loading arm. The pressure increased rapidly causing hydraulic hose to break on Navion Britannia which further resulted in closing ship's couple valve too early.

The above example shows that accidents are caused not only by human error but also because of cargo handling installation failures. Human error can be minimized by constant training, upgrading and increasing skills of shuttle tankers' crews.

Figure 9 shows that 54% of all sea accidents are caused by human error. There is another argument for additional trainings and seminars for vessels' crews especially for those employed on shuttle tankers.

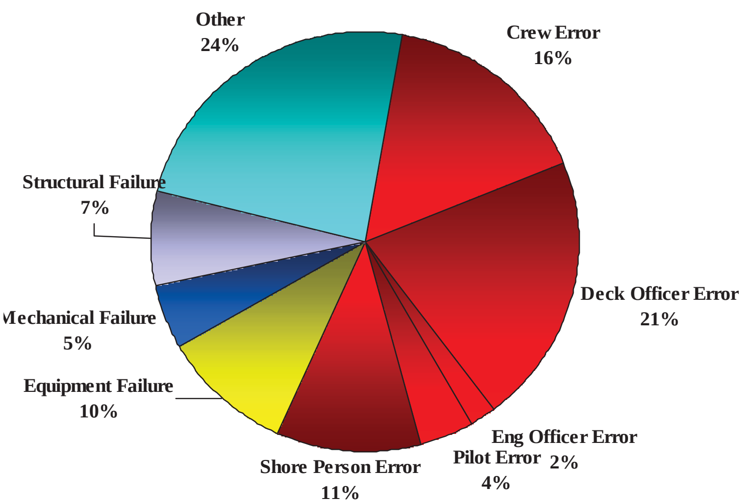

Fig. 9. Reasons for sea accidents [10]

6. Safety of tankers and crew qualifications, ships equipment and marine infrastructure

Nowadays officers employed on shuttle tankers apart from complying with STCW convention requirements must undergo training in DP, referential systems and cargo handling equipment in coastal sector. The aim is to prepare the crews for very dangerous cargo handling operations performed in the open sea and very often in adverse weather conditions. Additionally, officers after completion of these courses should have knowledge regarding referential systems their functions, operating errors and restrictions. Additional training for shuttle tankers is addressed to officers. There is no such requirement of training for crew on operational level, directly involved in handling cargo equipment. It could be suggested that another great step to minimize risk of spillages would be introduction of specialized courses for deck crew (operational level). Such training would increase the level of knowledge regarding handling equipment, monitoring loading and discharging operations, and maintenance of this equipment. It could result in better observation of some construction elements of this equipment thus resulting in quicker detection of malfunctioning of the equipment and in this way avoiding navigational and ecological disasters.

Another step which could be taken is to increase demands connected with the use of DP systems by shuttle tankers. This could influence the safety during maneuvers of approaching platforms or floating storage units and also during cargo handling operations in the open sea. It is a frequent practice that shuttle tankers approach platforms without using DP systems. It can be observed in Campos Basin close to Brazil. It happens because vessels do not have appropriate software needed for a given platform or because such a platform is not fitted witch referential systems e.g. DARPS or reflectors for such systems as RADius. Tougher regulations should be introduced, so as each approach to platforms would make use of DP system. This would help masters a lot to increase the level of safety. Such procedures should be first worked out and then implemented in order to employ the equipment and define qualification requirements of the crews and consequently result in increasing safety of operations.

The DP equipment manufactures try to upgrade their products. In 2006 Kongsberg introduced most modern model of DP K-Pos console. This model replaced SDP console and contains a number of improvement. These improvements aim at reaching more accurate and stable position of the vessel regardless external conditions which may affect vessel.

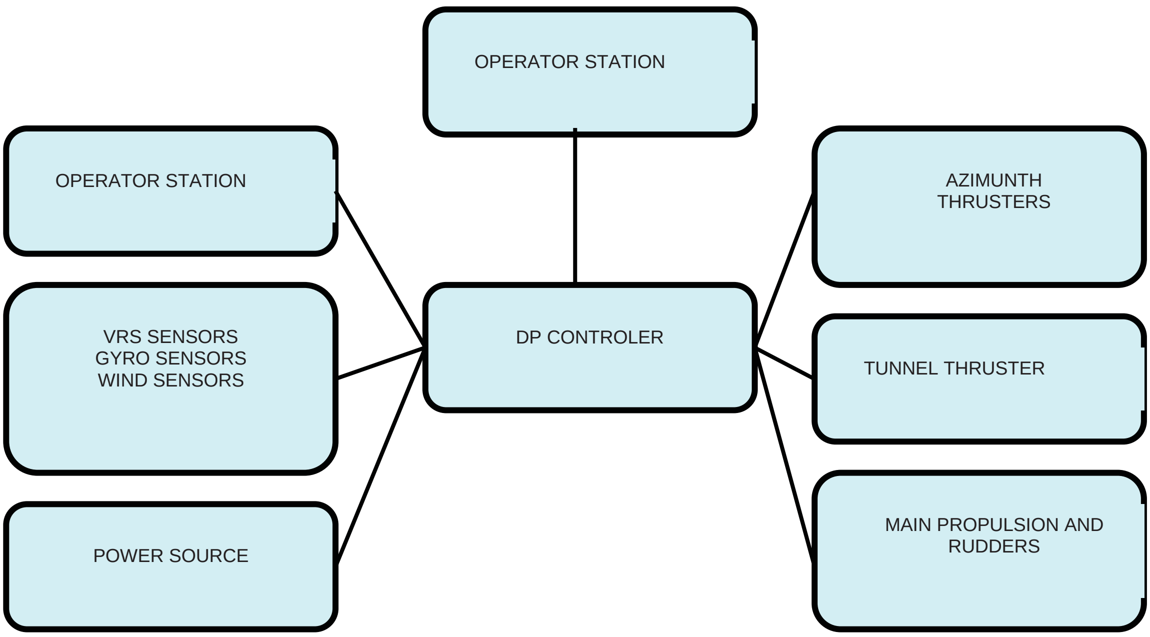

Fig. 10. Simplified scheme of DP system [9]

7. Conclusions

Maritime branch of sea transport, oil transportation in coastal waters is developing all the time. Constant demand for oil on the one hand and the development of exploitation technologies, on the other hand makes it possible to reach deeper and deeper deposits of oil. We learn about discoveries of new sources especially near the coast of South America and this undoubtedly will result in the increase of cargo handling operations on shuttle tankers. Taking into consideration the amount of crude oil exploited from the sea bottom and cost of its transportation, a conclusion may be drawn that there would be demand for increasing shuttle tankers fleet and constant demand for improving their construction and making use of more effective propulsion methods. It is also very important to train the personnel employed on these vessels. Qualification requirements for seafarers should be precisely defined and periodically verified by special authorities. A very important tool in the process of education and training should be cargo handling simulator, dynamic positioning simulator, trainings connected with handling DP system devices and offshore courses. Upgrading courses for crews and better technologies used for vessels' construction would minimize the possibilities of dangerous situations occurrence or disasters connected with oil pollution, as the one observed in the Gulf of Mexico.

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