© Frank Vold, The Norwegian Coastal Administration

«The Maritime Safety Analysis will be an important knowledge base for the Norwegian Coastal Administration’s work on maritime safety in the years to come. It forms the basis for our input to the White Paper, which will be presented by the Government to the Norwegian Parliament in 2016. The White Paper addresses measures for safe maritime transport with the lowest possible risk for loss of life, injuries, acute pollution and asset damage, as well as measures for preventing or limiting environmental damage as a result of acute pollution.»

– The Norwegian Coastal Administration

<table>
<thead>
<tr>
<th>CONTENTS:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction by the Director of Maritime Safety</td>
<td>04</td>
</tr>
<tr>
<td>Stakeholder analysis</td>
<td>06</td>
</tr>
<tr>
<td>Causal analysis</td>
<td>10</td>
</tr>
<tr>
<td>Accident analysis</td>
<td>14</td>
</tr>
<tr>
<td>Accidents involving pleasure crafts</td>
<td>16</td>
</tr>
<tr>
<td>Probability of ship accidents today</td>
<td>18</td>
</tr>
<tr>
<td>Transport of dangerous goods</td>
<td>24</td>
</tr>
<tr>
<td>Forecasts for ship traffic in 2040</td>
<td>26</td>
</tr>
<tr>
<td>Probability of ship accidents in 2040</td>
<td>28</td>
</tr>
<tr>
<td>New maritime safety measures</td>
<td>30</td>
</tr>
<tr>
<td>Expectations for 2040</td>
<td>32</td>
</tr>
</tbody>
</table>
Safe, reliable and efficient maritime transport, and protection of the marine environment, is vital to all activities in Norwegian waters. The Norwegian Coastal Administration works continuously to realise this objective.

The preventive aspect of maritime safety has been strengthened by several measures in recent years. The implementation of ships’ routeing measures outside Norway’s territorial waters, mandatory pilotage in Svalbard, the extended monitoring of maritime traffic, a new pilot exemption certificate scheme, and new marking and improvements of fairways are some examples.

The measures implemented are mainly based on White Paper No. 14 (2004–2005) on Maritime Safety and Oil Pollution Preparedness. The Government has stated that it will submit a new White paper updating this document, and the Norwegian Coastal Administration has prepared an extensive knowledge base for this work, the Maritime Safety Analysis.

The Maritime Safety Analysis provides an extensive foundation for further work on maritime safety, both national and international, and provides background for making decisions influencing the future maritime safety in Norwegian waters.

This report summarises the main findings of the analysis. Hopefully, it may contribute to fruitful discussions on this important topic to guide us towards our vision of making the Norwegian waters the safest and cleanest in the world.
Navigation accidents are often related to human factors

The analysis of the industry’s views on today’s maritime safety shows that there are great challenges related to human and organisational factors.

DNV GL conducted a survey of 33 stakeholders with operational experience or knowledge relating to maritime safety. The majority of the respondents stated that human and organisational factors play a key role and are important underlying causes for navigation accidents, such as collisions and groundings. In particular, the respondents emphasized lack of training and voyage planning in narrow and complex waters as significant causes. The respondents also pointed to the commercial pressure of port calls, low manning and fatigue. External circumstances, such as shifting and harsh weather conditions, are additional influential factors.

Regional differences

The survey shows that there is considerable regional variation as to which maritime safety challenges are most significant.

In the region Troms and Finnmark, harsh weather conditions, fewer search and rescue resources, long distances, darkness in winter and insufficient marking of rocks and shallow areas are frequent responses. In the regions Nordland, Central and West, the challenges are confined harbour conditions, numerous ferries crossing the fairway and ship traffic in fisheries and petroleum activities. In addition, long and confined fairways give the ships limited space to manoeuver. In the region South East, respondents pointed to the pleasure craft traffic between April and October, the surface currents in the Oslofjord area and the ice conditions in Oslofjord in the winter.

In Svalbard, the respondents stated that the nautical charts are not of satisfactory standard and that this has led to groundings. Extreme cold is also a major challenge in these areas, with a danger of icing and increased weight on the superstructure, together with freezing and chill effects on equipment.

It is important to maintain and upgrade navigation aids

The respondents experience Norwegian waters as some of the world’s most challenging for navigators. Modern navigation aids and well-marked fairways are crucial for preventing groundings. Many therefore believe it is important that navigation aids (e.g., lighthouses, lights, fixed and floating marks) are maintained and that they are improved in line with technological innovations.

In the evaluation of the risk reducing effect of Norwegian Coastal Administration’s (NCA’s) current measures, traffic separation schemes (TSS), vessel traffic services (VTS) and pilotage also received high ratings. The combination of TSS and VTS was especially considered to have the best effect against groundings and collisions.

Better control systems are expected

Competence, practice and training are mentioned by many as important maritime safety measures towards 2040. The crew’s competency must be improved in order to match the systems’ complexity. The same applies to changing over to alternative fuels such as gas, batteries and fuel cells. In addition, the respondents expect better data access on board, more automatic controls and warnings from sensors, and bridge systems with a more human-centered design. They also expect improved charts of remote waters, increased use of recommended and mandatory routes and in general more traffic on the sea, as well as larger ships.

“We have come far in the field of ship technology. What we can most improve are the human and organisational factors. We may also be able to further improve navigation technology, such as correct charts and well-marked fairways, and more mandatory traffic separation schemes.”

– Feedback from the survey
FEEDBACK FROM THE INDUSTRY

CURRENT CHALLENGES:

- "Human factors are essential for handling vessels in confined waters."
- "Perceived pressure to conduct port calls and carry out unloading/loading operations within time schedule."
- "Low manning, with the associated danger of fatigue, is an important issue."
- "The greatest challenge facing maritime safety is the combination of fewer crew members and the crew’s lack of experience and competence in navigating Norway’s coastal and confined waters."
- "Navigation errors. In either the planning or execution of the voyage. In the worst case, a lack of planning. The watch officer is busy with administrative tasks other than navigating."
- "The lack of, or insufficient, training and the lack of ability to assess the danger level in situations."
- "For the pleasure craft fleet, it is a big problem that we have very little knowledge into the causes of accidents."

MARITIME SAFETY TOWARDS 2040:

- "There is an expectation that the developments taking place will make hulls more robust and create better ship machinery. Nevertheless, cost will be the deciding factor if the shipping companies can decide. It will therefore be essential that the legislation and requirements follow hand-in-hand with the technological developments and do not lag behind. This may lead to higher risk and lower maritime safety."
- "Schedule traffic in ‘lanes’ so that ships meet/pass each other at fixed, predictable points in a predictable pattern. More areas with TSS – better control of the traffic."
- "Improvements to VTS will be a good, but expensive risk-reducing measure."
- "Giving notice of dangers e.g. inoperative lights, drifting containers and buoys that are not in position, is important for avoiding groundings."
- "Stricter rules for compliance with bridge-watch routines and rest-period regulations."
- "Desirable to improve the experience exchange following accidents. Currently, we have access to good investigation reports of accidents, but there is less information available about accidents that are not investigated."
- "It is important to allow anonymous reporting. Currently, reporting to the Norwegian Maritime Authority will trigger an inspection and may lead to a penalty. This means that many choose not to report incidents, resulting in incomplete statistics."
HUMAN ERROR IS A SYMPTOM, NOT A CAUSE

No single cause of accidents

In the causal analysis, the contributing causes of erroneous actions or misjudgements are mapped by looking at factors that affect performance, positively or negatively. Erroneous actions in shipping are most often the result of complex situations that are intensified by time constraints. The complexity and time available to the crew are further influenced by additional factors affecting the safety performance.

The causal analysis shows that some of the most significant factors affecting the safety performance negatively are:

- Lack of user-friendly procedures
- Insufficient training and experience
- Work task distribution on bridge insufficiently defined
- Equipment not available or insufficiently customized
- External factors, such as wind and strong currents affecting the ship handling

The causal analysis also shows that factors affecting safety performance are influenced by the leadership on the bridge. Available resources are not utilised optimally if the watch officer or pilot does not inform the rest of the bridge crew about the planned voyage. This means that any deviation from the plan is not picked up by the rest of the crew. It has also been shown that there is room for improvement in communication among the bridge crew.

The safety culture may affect many of the underlying and direct causes. Safety culture is the part of the organisational culture that influences person’s attitudes, perceptions, views and conduct on safety. It is important to create a culture where people are open about reporting and learning from incidents.

Understanding the underlying causes is crucial

In order to reduce the number of navigation accidents, the industry must think about maritime safety in a new way. The causal network that was developed in the causal analysis can be used to expand the perspective on what causes accidents and also on where it will be most effective to take actions. The causal network is presented on pages 12 and 13. By looking at the underlying causes of accidents, we can better understand what influences human performance and how organisational processes can be reinforced to support the crew.
CAUSAL ANALYSIS:

The network is a visualisation of causes and causal relations that have led to or may lead to groundings. Each node in the network represents a contributory cause and each arrow represents a causal link that connects two or more causes to each other. The thicker the arrow, the stronger and more frequent are the causal links. The network is based on analyses of accident reports from the Accident Investigation Board Norway (AIBN), the NCA and accident statistics published by the Norwegian Maritime Authority (NMA).

Figure 1: The causal network
SHIP ACCIDENTS IN NORWEGIAN WATERS

Statistics published by the NMA show that more than half of all ship accidents are due to navigation errors.

GROUNDINGS DOMINATE
Around 45% of all ship accidents in Norwegian waters are groundings (over the past 10 years). Around 100 groundings occur each year.

MOST FATALITIES OCCUR IN ACCIDENTS INVOLVING FISHING VESSELS
On average, three people have died each year as a result of groundings or collisions in Norwegian waters over the past 30 years. Apart from the two major accidents in recent times involving Sleipner (16 fatalities) and Rocknes (18 fatalities), most of the deaths occurred due to accidents involving fishing vessels (33% of the total number of fatalities).

CARGO SHIPS DOMINATE THE ACCIDENT STATISTICS
Around 40% of all groundings and collisions during the past 30 years have involved cargo ships, mainly general cargo and bulk carriers.

HUMAN-RELATED CAUSES
Statistics published by the NMA show that the most frequent causes for groundings and collisions have been human-related, such as erroneous action, breach of procedures, etc. In 2014, there were seven accidents caused by the watch officer falling asleep.

FEWER SERIOUS ACCIDENTS, MORE INCIDENTS INVOLVING MINOR DAMAGE
Statistics published by the NMA show that the number of accidents involving serious damage to ships has fallen by approximately 56% since the 2005 White Paper. This is a very positive trend, especially since accidents involving serious damage to ships often include acute pollution, personal injuries and loss of life.

However, we see a clear increase in the number of reported incidents involving minor damage to ships. The number of groundings has increased by around 62% since 2004. The number of registered allisions (striking docks, piers etc.) has more than doubled, while the number of collision accidents has fallen by some 43%. In 2006, more emphasis was placed on registering ship accidents in the NMA’s accident database, and this may be one of the reasons for the increase in registered accidents involving minor damage. Most of the reduction in the number of collision accidents is assumed to be attributed to the introduction of the automatic identification system (AIS).

ACCIDENTS IN NORWAY COMPARED TO SIMILAR IN OTHER COUNTRIES
The biggest challenges to maritime safety vary from country to country. Characteristic for Norway is the fact that the country has a coast that is challenging for navigation and that almost half of all the ship traffic is inside the baseline. An analysis based on extracts of 2013 AIS data and accidents in the exclusive economic zones of selected countries shows that Norway has around 20-30% more navigation accidents per distance sailed than its neighbouring countries Denmark and Sweden. The UK and Australia also have fewer navigation accidents per distance sailed. The NCA should collaborate more closely with these countries in order to improve maritime safety by sharing experiences and learnings.
Deliberate violation of rules is more common among operators of pleasure crafts than commercial ships. The use of intoxicating substances is a particularly significant causal factor.

Accidents involving pleasure crafts have been analysed based on the NMA’s “Report on Safety when using Pleasure Crafts” and accident statistics, accident reports issued by the AIBN and the views of the NCA and the industry.

**32 fatal accidents in 2015**
In total, 411 fatal accidents were registered in connection with the use of pleasure crafts between 2002 and 2015, and a total of 476 people died. The average number of deaths per annum during this period has thus been 34. In 2015, there were 32 fatal accidents involving pleasure crafts and a total of 37 deaths. Compared to commercial shipping, the number of fatal accidents involving pleasure boats has been around four times higher since 2002.*

**Use of intoxicating substances and operating at high speeds**

The statistics published by the NMA show that most of the accidents involve motorised pleasure crafts (resulting in grounding, collision, etc), followed by activities related to fishing. The fatal accidents are usually caused by the boat overturning, followed by people falling overboard and drowning.

Most accidents involving motorised pleasure crafts occur in connection with the use of intoxicating substances. The use of intoxicating substances, such as alcohol, affects the ability to understand and act correctly. The operator has a more relaxed attitude to rules (such as speed restrictions, the mandatory use of lifejackets, etc.). In several cases, high speed was a contributory cause of the accident, often combined with operating in the dark.

**Three regions dominate the accident statistics**
Three regions have experienced a particularly large number of fatal grounding accidents:

- South East (mainly the waters north of Arendal, the areas around Sandefjord, Tønsberg, Oslofjord and Fredrikstad)
- West (mainly the waters south of Bergen)
- Central (mainly the waters around Trondheim).

The geographical distribution of fatal accidents resulting from groundings is much correlated with the population and pleasure craft density, i.e. around the largest cities. Most accidents also take place during the summer months with frequent use of pleasure crafts.

* The fatal accidents in commercial shipping include all types of accidents, including occupational accidents.

**Figure 5: Number of fatal accidents with pleasure crafts compared to commercial ships, since 2002.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Commercial ships</th>
<th>Pleasure crafts</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>2003</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>2004</td>
<td>22</td>
<td>35</td>
</tr>
<tr>
<td>2005</td>
<td>17</td>
<td>44</td>
</tr>
<tr>
<td>2006</td>
<td>24</td>
<td>29</td>
</tr>
<tr>
<td>2007</td>
<td>24</td>
<td>29</td>
</tr>
<tr>
<td>2008</td>
<td>29</td>
<td>26</td>
</tr>
<tr>
<td>2009</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>2010</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>2011</td>
<td>29</td>
<td>24</td>
</tr>
<tr>
<td>2012</td>
<td>29</td>
<td>28</td>
</tr>
<tr>
<td>2013</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>2014</td>
<td>27</td>
<td>29</td>
</tr>
<tr>
<td>2015</td>
<td>26</td>
<td>28</td>
</tr>
</tbody>
</table>

Source: Norwegian Maritime Authority (NMA) accident database.
There are in excess of 100 groundings in Norwegian waters yearly, but only a small percentage of these accidents lead to acute oil spills.

These routing measures were implemented following White Paper number 14 (2004–2005). Together with the implementation of a VTS center in Varde and an improved Emergency Towing Services (ETS), these measures have improved maritime safety. However, it is still the case that the highest environmental risk is related to the transport of crude oil and petroleum products by tankers in transit along the coast, as well as from activities involving shuttle tankers to and from oil installations in the North Sea and tankers involved in short sea shipping.

Probability for accidental crude oil and petroleum products spills

Data from AIS for transported oil in transit along the Norwegian coast shows that tankers comply with the ship’s routing measures off the coast.

These routing measures were implemented following White Paper number 14 (2004–2005). Together with the implementation of a VTS center in Varde and an improved Emergency Towing Services (ETS), these measures have improved maritime safety. However, it is still the case that the highest environmental risk is related to the transport of crude oil and petroleum products by tankers in transit along the coast, as well as from activities involving shuttle tankers to and from oil installations in the North Sea and tankers involved in short sea shipping.

Probability of accidental fuel spills

Calculations carried out by DNV GL show that any oil spills resulting from an accident will be most likely be fuel (bunkers) and that the volume will be less than 200 tonnes.

The analysis also shows that the probability of having a spill accident is highest along the coast of Western Norway and Møre, approximately along the route from Stavanger to Trondheim. This is mainly due to the high traffic volume in fairways in confined waters. The calculations show that around five accidents involving a fuel spill can be expected each year in Norwegian waters.*

* Including spills of a smaller scale, but excluding operational incidents in connection with bunkering, ship-to-ship transfer etc.
The figure shows the estimated annual volume of oil spills in Norwegian waters, divided into grid cells (10x10km), for 2014. The estimated annual oil spill is a product of the probability of an accident and the expected oil spill volume.

The benefit of presenting estimated annual oil spill volumes is that accidents involving crude-oil and oil-product tankers become more visible in the overall risk picture. Such accidents occur so rarely that they are not very visible in a more ordinary presentation that only looks at the probability of accidents or the traffic density. The relative difference between various geographical areas once again shows that there is a higher risk of an acute oil spill in the western part of Norway.

Note that the categories for annual spill volumes in the region Svalbard region in figure 6 are different to those for the other regions. This has been done to better present the geographical spread of risk at Svalbard.

Figure 7: Estimated number of ship accidents each year based on today’s traffic volume, by ship type

Figure 8: Estimated number of ship accidents each year based on today’s traffic volume, by region and accident type

Source: DNV GL navigation risk model.
**RISK OF LOSS OF LIFE**

Passenger, fishing and general cargo vessels dominate the accident statistics for loss of life. These have longer sailed distances than other ship types. Passenger ships have many persons on board compared to cargo ships and fishing vessels. This can result in a higher consequence if an accident occurs.

In Norway, cruise ships have a shorter sailed distance than domestic or international ferries, and this leads to a lower probability of an accident. However, an accident involving a cruise ship may have the highest consequences due to the large number of passengers. In the regions West and Svalbard, cruise ships sail long distances, resulting in a higher probability of accidents. Navigation in the waters around Svalbard represents a particular risk since search and rescue operations in this area are much more difficult as regards response time and available resources.
Throughout history, there have been several examples of nuclear-powered vessels sinking with very high levels of radiation on board without high levels of radiation being measured in the surrounding area or serious environmental consequences detected (e.g., the submarines K-159, K-27 and Komsomolets). Based on these accidents, the likelihood of major spill of radioactive substances is low. However, this is something that must be assessed for each individual scenario and be based on several parameters such as location, water depth, barriers, damage, etc. The long term effects of such accident are also uncertain.

Volatile cargo and fuel
The ship traffic involving volatile cargoes and fuels is dominated by offshore supply ships and gas tankers, which have a 37% and 35% share respectively of the total distance sailed. In addition, Ro-Ro, container and passenger ships (mainly RoPax) have a 9%, 6% and 5% share respectively of the total. Of the ships that use LNG (gas) as fuel, passenger ships account for 71% of the distance sailed, while offshore supply ships are also strongly represented with 15%. Accidents involving volatile and toxic cargoes close to or in densely populated areas may have major consequences for the life and health of the population around the accident site.

The key basis for deciding the geographical coverage of the NCA's five VTS centers is risk analysis of transportation of hazardous cargo, radioactive and volatile cargo and fuel. The VTS coverage area must adapt to changes in the risk picture, in which the geographical differentiation of measures is important.

Dangerous goods is a generic term for cargo that is flammable, radioactive, toxic or noxious. The analysis has mapped the current transport of dangerous goods and the probability of an acute pollution. A general assessment of the environmental consequences of an accident resulting in an acute pollution was also conducted.

LOW PROBABILITY OF ACUTE POLLUTION

Particularly environmentally hazardous cargo
During 2012–2014, 669 voyages with particularly environmentally hazardous cargoes (other than oil) were registered in Norwegian waters. The cargo in these voyages consisted of 49 different products/UN codes in total. The IMO’s criteria for environmental hazardous substances [(the P mark)] forms the basis for this mapping. Most of the products (75%) are IMDG Class 3 (flammable liquids) and IMDG Class 6.1 (toxic substances). The annual frequency of an accident is 0.043, indicating that an accident is predicted to occur every 23 years, without this necessarily resulting in any discharge.

The seriousness of a spill and the decision on what action to take will depend on the size of the spill, as well as where and in which season it takes place. Of the four main categories of particularly environmentally hazardous cargoes (hydrocarbons and natural oils; cyanides, aminos and corrosive substances; halocarbons and metal carbons, and heavy metals), only the latter two will have long-term effects on the environment in the case of a spill. This is due to their low degradability.

Radioactive cargo and fuel
In general, the ship transport of radioactive cargoes to/from Norwegian ports is dominated by offshore supply vessels. Almost half of all voyages with radioactive cargoes depart from offshore installations. Other ship types that carry radioactive cargoes in Norwegian waters are mainly general cargo and Ro-Ro ships.

Since radioactive cargoes are safeguarded by shielding material that is adapted to the radiation level, it is very unlikely that there will be an acute spill of the entire cargo into the sea. Water is also an effective barrier to ionizing radiation. Hence, radiation does not have the same range in water as it does in the air and over land. In the case of an accident involving a ship that transports radioactive deposits from the offshore industry, the environmental consequences are therefore expected to be limited to local effects close to the seabed. This applies even in the case of a very large spill of several tonnes.

As regards transit voyages along the Norwegian coast, AIS data and reports from Varde VTS center show that these are dominated by nuclear-powered icebreakers. During 2012–2014, a total of eight transit voyages by two different Russian nuclear icebreakers were registered. These ships have sailed at a distance well off the coast, and complied with the ships’ routing measures in the Norwegian Economic Zone.

Throughout history, there have been several examples of nuclear-powered vessels sinking with very high levels of radiation on board without high levels of radiation being measured in the surrounding area or serious environmental consequences detected (e.g., the submarines K-159, K-27 and K-278 Komsomolets). Based on these accidents, the likelihood of major spill of radioactive substances is low. However, this is something that must be assessed for each individual scenario and be based on several parameters such as location, water depth, barriers, damage, etc. The long term effects of such accident are also uncertain.

Volatile cargo and fuel
The ship traffic involving volatile cargoes and fuels is dominated by offshore supply ships and gas tankers, which have a 37% and 35% share respectively of the total distance sailed. In addition, Ro-Ro, container and passenger ships (mainly RoPax) have a 9%, 6% and 5% share respectively of the total. Of the ships that use LNG (gas) as fuel, passenger ships account for 71% of the distance sailed, while offshore supply ships are also strongly represented with 15%. Accidents involving volatile and toxic cargoes close to or in densely populated areas may have major consequences for the life and health of the population around the accident site.

The key basis for deciding the geographical coverage of the NCA’s five VTS centers is risk analysis of transportation of hazardous cargo, radioactive and volatile cargo and fuel. The VTS coverage area must adapt to changes in the risk picture, in which the geographical differentiation of measures is important.
INCREASED ACTIVITY EXPECTED

Ship traffic, measured as the distance sailed, is expected to increase by 41% between 2014 and 2040. Increased activity is expected for most ship types, with the exception of offshore and fishing vessels.

Growth in the transport of petroleum products from North West Russia
Towards 2040, growth is expected in the shipment of petroleum products from North West Russia, but there is a high uncertainty regarding the volumes. The main drivers influencing these developments are:
- The expectation of significant oil and gas discoveries in Arctic areas
- The expectation that Europe will still be the main market for crude oil and oil products from North West Russia
- The movement of production from land to sea (e.g. Shvemann field)
- The development of the Yamal, Kinskieye and Okhotsk fields

New transpolar sea route
Ship traffic between Asia and Europe through the Arctic is currently limited but is increasing. The sea ice in the Arctic is expected to decline in the decades to come, especially during the summer. This will make the sea around the Arctic more accessible to ships. Much of this traffic is expected to take the Northern Sea Route. Transpolar sea traffic between Asia and Europe is also expected to increase since the distance over the Arctic is much shorter than through the Suez Canal. New transpolar sea routes between Asia and Europe are likely to be established close to the coast of Svalbard and along the coast of the Norwegian mainland. The growth in the distance sailed is expected to be dominated by container ships and bulk carriers.

Growth in dry-cargo freight and the passenger and cruise segment
Increased activity is expected in the bulk carrier, general cargo, container, Ro-Ro cargo and refrigerated/freezer ship sectors. Most of the increase in flow of goods is foreseen to take place in the region South East. This is because much of Norway’s consumables are imported to the Oslo area first by ships and then forwarded to destinations by truck, railway and feeder vessels.

An increased level of activity is also expected for ferries, high-speed crafts and large passenger ships. These sail on scheduled routes and fulfill important local and regional transport needs – including goods transport. Developments in the tourist industry will drive the level of activity for cruise ships. The drivers in the tourist industry are both global and local. Cruise traffic to Norway has been growing for the last decade.

Reduced activity for fishing and offshore vessels
The fishing fleet is changing constantly. The trend is towards fewer, larger vessels and more efficient fishing operations. These factors are of relatively great importance to the fleet’s expected distance sailed in 2040. However, important developments regarding conditions such as variations in fish stocks, climate changes, the market and political framework are difficult to predict.

Offshore supply vessels (OSVs) are expected to experience reduced activity. This is caused by the expected reduction in activities on the Norwegian continental shelf in the years to come. Offshore service vessels (exploration and drilling activity) are expected to experience the same downward trend as OSVs.

Uncertainty in the forecast
The forecast presented in this report is uncertain, like all forecasts with a long horizon. However, the level of uncertainty varies with the different types of ships and is primarily driven by uncertainty related to the drivers behind the development of the activity.
MORE SHIP TRAFFIC MAY LEAD TO MORE ACCIDENTS

The probability of accidents is closely linked to the volume of ship traffic. An increase in the ship traffic will, on its own, lead to a greater probability of accidents. The forecasts for 2040 showed an expected increase in the traffic volume of 41%, measured by the distance sailed. Based on this, DNV GL has calculated that the annual number of ship accidents in Norwegian waters is expected to increase by 31% by 2040.

Largest percentage increase in the region South East

The estimated increase of 31% will result in approximately 200 ship accidents yearly in 2040 unless new preventive measures are implemented. The largest increase is expected in the regions South East (45%), followed by Svalbard and Central (38% each). These regions are followed by Nordland (32%), West (29%) and Troms and Finnmark (14%).

Today, 4.8 ship accidents involving acute pollution are expected each year in Norwegian waters. By 2040, this figure is expected to be 6.4, which is an increase of approximately 35%. Given that a total of 200 ship accidents are expected in 2040, this means that around 3% of the total number of ship accidents is expected to cause acute pollution.

For 2013, the calculated frequency of ship accidents involving loss of life is 2.1 per year. For 2040, the frequency is expected to be 2.7 per year, an increase of approximately 31%. This means that around 1% of the accidents each year will lead to the loss of human life.

New measures can have a great effect

In order to maintain or reduce the probability of ship accidents between now and 2040, it is necessary to look at new measures that cover both on-board performance, where it is mainly NMA that is the responsible authority, and the fairways and infrastructure that are NCA’s main responsibility.

DNV GL calculated that extending VTS coverage from Fedje to Stadt will reduce the number of accidents for Norwegian waters by about 5.6%. This is a significant number for a single measure such as VTS. However, even if all Norwegian waters are covered by VTS in 2040, it is reasonable to assume that this alone cannot prevent the expected 31% increase in accidents. This is mainly because there is already VTS coverage in many areas. It is therefore necessary to look at the potential effect of e-navigation and other measures focused on human factors and safety culture to address the remaining increase of 25.4%. However, in order to calculate the risk-reducing effect of these measures, they must be put into more concrete terms and geographically specified in greater detail.

The probability of accidents is closely linked to the volume of ship traffic. An increase in the ship traffic will, on its own, lead to a greater probability of accidents. The forecasts for 2040 showed an expected increase in the traffic volume of 41%, measured by the distance sailed. Based on this, DNV GL has calculated that the annual number of ship accidents in Norwegian waters is expected to increase by 31% by 2040.
NEW MARITIME SAFETY MEASURES TOWARDS 2040:

BETTER DECISION SUPPORT FOR THE WATCH OFFICER

The 2005 White Paper was based on the principle that the risk increases more or less proportionately to the growth in the distance sailed, i.e. the traffic volume. In order to ensure that the risk remains at the same level, new measures have been implemented. Towards 2040, ship traffic is also expected to increase, meaning that the measures must be reassessed in order to keep the risk level unchanged.

After analysing the underlying causes of navigation accidents, risk analyses and feedback from the maritime industry, DNV GL has proposed six packages of measures to the NCA.

Proposed packages of new safety measures

1. **Extend the geographical coverage and services provided by the vessel traffic service (VTS)**
   - Expand the areas covered by VTS
   - More use of dynamic risk monitoring of ships
   - Exchange of routing information between ships, pilots and VTS
   - Make information on weather, sea state, traffic etc. more easily available to the navigator

2. **Improve learning processes following navigation accidents**
   - Improve NCA’s internal evaluation of the fairway following a navigation accident
   - Use accident analyses to increase the focus on navigation accidents involving ships using a pilot or pilot exemption certificate (PEC)
   - Use causal networks in accident analyses

3. **Strengthen the interaction between the bridge crew and pilot**
   - Strengthen the interaction between the bridge crew and the pilot (focusing on BRM)
   - Standardise mandatory pilot magnets that must be brought with the pilot when boarding the ship

4. **Improve fairways and navigation aids**
   - Conduct a risk assessment of fairways in order to prioritise areas with the highest risk
   - Increase user involvement in new fairway projects
   - Further develop the cooperation with the Norwegian Meteorological Institute in order to establish real-time information on weather, wave and current conditions
   - Examine speed restrictions in confined waters
   - Replace all incandescent sector lights with LED sector lights
   - Install remote monitoring of all lights on aids to navigation

5. **Navigation support for pleasure craft operators**
   - Initiate activities that contribute to improving attitude and awareness
   - Establish more recommended or secondary fairways for pleasure crafts
   - Establish a mobile application for use in planning voyages
   - Speed restrictions

6. **Improved maritime safety for the waters around Svalbard**
   - Establish recommended fairways
   - Review the set of navigational charts
   - Establish precautionary areas
   - Identify and enforce requirements related to ice and climatic factors
   - Strengthen maritime traffic monitoring around Svalbard
**A HOLISTIC APPROACH TO MARITIME SAFETY**

Greater focus on safety culture
Traditionally, the maritime safety focus has been on technological developments. In future, more emphasis is expected to be placed on the human and organisational factors that influence maritime safety. Organisational learning, conflicting goals, incentives, competence, attitudes to procedures, cooperation and communication are some of the areas that should be focused on in order to improve maritime safety.

More traffic monitoring and development of VTS
More dynamic monitoring of the ship traffic and a wider area of VTS coverage should be part of NCA’s improved support to the navigator. In addition, the exchange of sailing information between the ship, VTS and the pilot may contribute to a better understanding of the situation and errors being more easily revealed.

Bridge solutions with the user in focus
The International Maritime Organization (IMO) e-navigation project is currently working on measures relating to: the improvement and standardisation of bridge solutions, correct amount of information presented in a good way, integration of available nautical information, automated updating of maps and automatic exchange of ship data between ship and land. Towards 2040, NCA will continue to test and implement some local and “light” versions of the above-mentioned measures in Norwegian waters.

Improved analysis of causes to accidents
It is important to learn from accidents in order to implement measures that improve maritime safety. The causes of accidents at sea need to be analysed more extensively. This especially relates to accidents involving pleasure crafts and ships that are required to use a pilot or alternatively a PEC. This will assist NCA to find mitigating measures that work for the actual causes of accidents. At the same time, it is also important to differentiate the measures geographically since the risks vary in different waters.

Electronic fairways
Technological solutions for interactive fairways are expected to be established. This will make available electronic data from sensors in the fairways that fit into existing infrastructures for bridge systems and VTS. Examples of elements in an electronic fairway are: Situation-adapted fairway information and real-time data and forecasts relating to sailing conditions. Such information may be navigation warnings, sailing regulations, sailing guides and real-time information on weather, wave and current conditions.
This publication is a summary report based on eight reports submitted to the NCA in the Maritime Safety Analysis project in 2015.

**Authors:**
Hans Jørgen Johnsrud, DNV GL  
Tore Relling, DNV GL  
Fenna van de Merwe, DNV GL  
Henrik Jønsen, DNV GL  
Sarah Lassèlle, DNV GL  
Håvard Abusdal, DNV GL  

**GIS modelling:**
Karl John Pedersen, DNV GL  
Gjermund Grøven, DNV GL  

**Quality managers:**
Magnus Strandmyr Eide, DNV GL  
Peter Nyegaard Hoffmann, DNV GL  

**Graphic design:**
Birthe Gravdal, Coor Media  
Nina Visnes, 07 Media  

**Contact persons:**
Trond Langemyr, NCA (Email: Trond.Langemyr@kystverket.no)  
Øystein Goksøyr, DNV GL (Email: Øystein.Goksøyr@dnvgl.com)
About the Norwegian Coastal Administration:
The Norwegian Coastal Administration (NCA) is an agency of the Norwegian Ministry of Transport and Communications responsible for services related to maritime safety, maritime infrastructure, transport planning and efficiency, and emergency response to acute pollution. The main objective of the NCA is to ensure safe and efficient navigation in the fairways along the coast and into ports, as well as national preparedness for acute pollution.

About DNV GL:
Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 15,000 professionals are dedicated to helping our customers make the world safer, smarter and green.