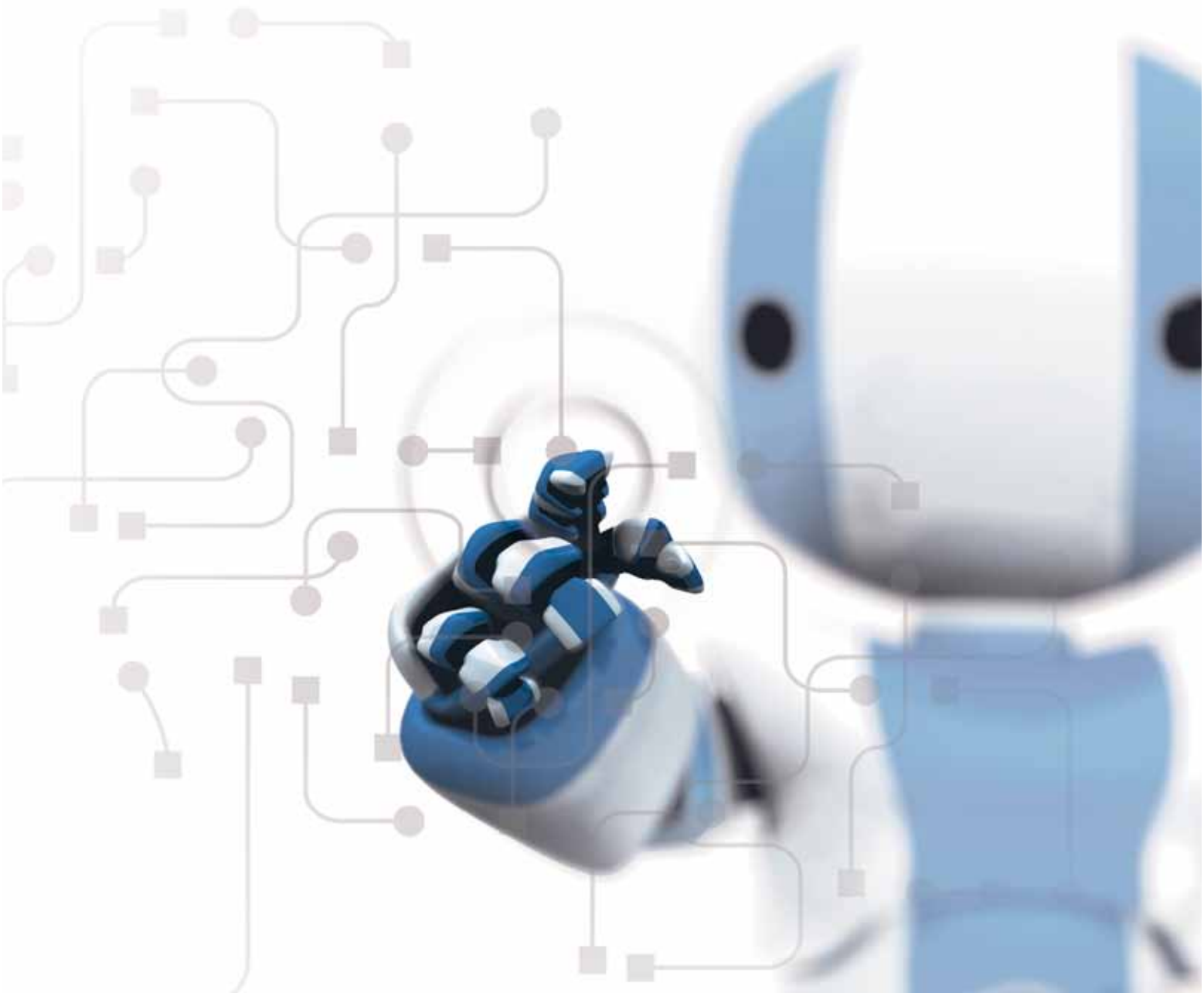

Research Review

Creativity to meet global challenges

Edition 2009

MANAGING RISK

Opportunities from a changing world?

Working towards our vision "global impact for a safe and sustainable future" implies that we must have a view on how the world is developing, and how best to respond to these trends. Identifying suitable materials for renewable energy production, suggesting measures to reduce emissions from ships, enabling safe operations in Arctic waters, reducing risks created by biological agents, and ensuring the quality of embedded software in technical systems, are all examples of such responses.

How is the world changing?

A society in motion. The world's population is growing fast, resulting in young populations in developing countries, while populations in the developed world are greying. Urbanisation and migration are increasing. Trading blocks, together with new economies in countries like India, China, and Brazil, will increase in importance.

Borderless business. The growing number of consumers in emerging economies, the shift of economic activities within and between regions, and the greater ease of obtaining information and developing knowledge anywhere, will all have an effect on the marketplace. Global operations, a more flexible workforce, collaborative innovation, networked technology, and new business models are changing the whole notion of an enterprise.

The power of 0 and 1. A variation of Moore's law, predicting the doubling of computing power every 18 months, is expected to hold true for at least the next 5-10 years. Thus, in 2015 the performance of a standard PC may be 32 times higher than it is today. Computer storage, processing, and networking power will continue to drop in price, whilst simultaneously increasing in capacity.

Energy: opportunities and threats. The world is facing two energy-related threats: lack of adequate, secure supplies of energy at an affordable price on the one hand, and the environmental damage caused by consuming too much of it, on the other. The need to curb the growth in fossil-energy demand, to increase geographical and fuel supply diversity, and to mitigate climate-destabilising emissions is more urgent than ever.

A vulnerable earth. The negative effects that 7 billion people impose on the ecosystem are becoming ever more obvious. The results are escalating exploitation of natural resources, resource shortages, and increased environmental pressures, resulting in health impacts and climate changes. Humanity must prepare for the consequences of the ongoing climate changes and work together to slow down or reverse these adverse effects.

Managing director, DNV Research & Innovation

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MANAGING RISK

MARITIME TRANSPORT

The maritime industry has in the last decade experienced a period of high activity and enormous expansion. Strong economic growth and the need for primary resources and energy in several emerging economies, including India and China, have led to a significant increase in demand for seaborne trade.

However, the industry is now in a period of recession, brought about by the general collapse in the world finance systems and its widespread implications for the real economy. Nevertheless, the pressure on the industry to progress towards sustainable development has not abated. In the coming decade, this trend will be reflected by further focus on safe, environmentally-friendly, secure, and efficient maritime transport.

With a world fleet that is likely to grow substantially as the industry recovers from the current slump, this calls for new approaches, innovative technical designs, and changes in the ways in which ships are operated and managed. In the long-term, international traffic will increase generally, and significantly more traffic is expected in Asian waters. New ships will be larger, with increased automation and software dependencies, and with improved environmental, safety, and security performances.

A shift towards risk-based regulations will facilitate increased innovation in ship design and the exploitation of novel solutions. Advanced ship-based and shore-based measures, and decision support tools for reduction of risk, will be introduced. Efficiency and safety in ship operations will be increased by the implementation of e-navigation and improved fleet management, but may also be reduced by lack of qualified personnel. High bunker prices are expected in the long run, along with stricter environmental regulations (e.g. air emissions, ballast water), and this will force the shipping industry to focus on new technical and operational solutions for achieving greater cost- and energy-effectiveness, and better environmental performance.

Improved tools for performance evaluation of new solutions will enhance their introduction into the shipping industry. Technology alone will not solve these challenges; innovative transport concepts will also have to be developed. Without these, congestion and environmental concerns could threaten future economic growth in several regions of the world.

MARITIME TRANSPORT

Innovative ship designs and risk-based approval

The EU project SAFEDOR is due to finish early in 2009. The project's achievements will be reviewed in a Springer book on Risk-Based Ship Design, and a guideline on "Approval of risk-based ship design" will be submitted to the IMO. SAFEDOR has focused on developing a risk-based regulatory framework, a risk-based design framework, design tools, and actual ship design examples.

By using risk-based approaches, ship owners will be able to implement those innovative ships and maritime transport solutions that cannot be approved today because of limitations in the current prescriptive rules and regulations. Shipyards and equipment manufacturers will benefit from the introduction of risk-based approaches by enabling novel and optimised ships and systems incorporating new technology, functionality, and materials.
Yards that are acquainted with risk-based approaches will benefit by being among the first to respond to the demand from ship owners for such novel and innovative ships. Thus, risk-based ship design and approval is a timely response to the maritime industry's need to deliver ever more innovative transport solutions to their customers. Furthermore, risk-based ship design and approval also answer society's demand for increasingly safer transport.

Strategic research objectives that have been achieved include:

1. A risk-based and internationally-accepted regulatory framework.
2. Design of methods and tools which can be used to assess operational, extreme, accidental, and catastrophic scenarios.
3. Production of prototype designs for European safety-critical vessels to validate the proposed methodology and document its practicability.
4. Systematic transfer of knowledge to the wider maritime community.
5. Improvement in training of maritime industry staff at universities in new technological, methodological, and regulatory developments.

In the SAFEDOR project DNV has been one of the main partners with strong contribution in the above tasks. Following the SAFEDOR project, the European maritime industry has identified the implementation of risk-based frameworks as a key priority towards 2020 (WATERBORNE 'Vision 2020'). DNV will utilise these results to develop new classification services.

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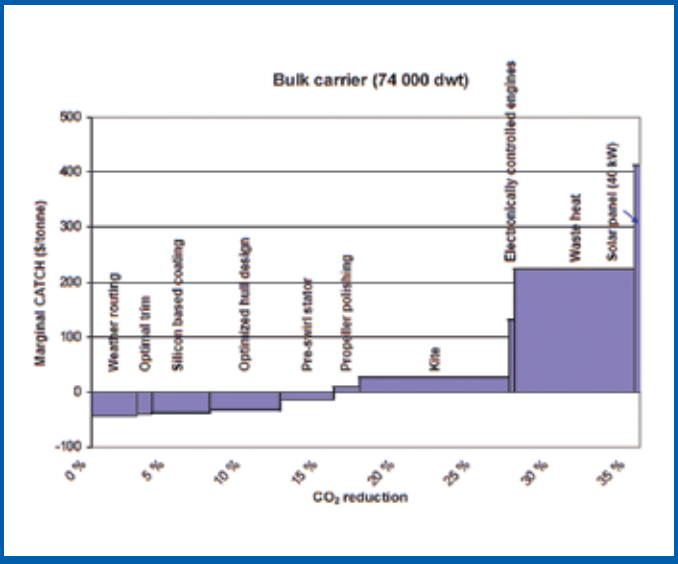

Marginal abatement cost curves for shipping

DNV has assessed the cost-effectiveness of technical and operational measures for reducing CO_2 emissions from shipping through use of a parameter known as CATCH (Cost of Averting a Tonne of CO_2-eq Heating). The result is a list of measures, arranged in order of decreasing cost-effectiveness, which can be drawn as a marginal abatement cost curve.

Reducing GHG emissions from shipping is high on the international agenda. To assist the industry in achieving emission reductions in a cost-effective manner, DNVRI has developed an analytical approach for rational and robust decision support, using the CATCH parameter. The parameter is calculated as the sum of economic costs and benefits divided by the emission reduction volume achieved by an emission reduction measure. The cost of implementing a measure includes both initial costs (e.g. installation cost, design cost) and operational costs (e.g. maintenance, training, lost revenue).

The cost as well as the benefit from the measure (e.g. fuel cost savings, increased revenue), is calculated annually during the expected operational lifetime of a vessel, and discounted to a present value.

The methodology developed by DNVRI has been applied to a number of specific technical and operational measures for reducing CO_2 emissions for a Panamax bulk carrier.

This demonstrated that several measures are cost-effective. If the CATCH criterion is 50$/tonne CO_2, reductions in the order of 25-30% is achievable in a cost-effective manner.

By using the CATCH approach to generate marginal abatement cost curves, DNV can assist ship owners and yards in achieving emission reductions in a cost-effective manner. Ship owners and builders can ensure that all economically feasible measures (negative marginal cost) are implemented, whilst avoiding those measures with high costs and small effects. The approach can also guide regulators in designing rational GHG regulations. For example, it could be used to determine the requirement level of IMO's Energy Efficiency Design Index (EEDI), or to estimate the CO_2 price of a global emission trading scheme given a cap on emissions.

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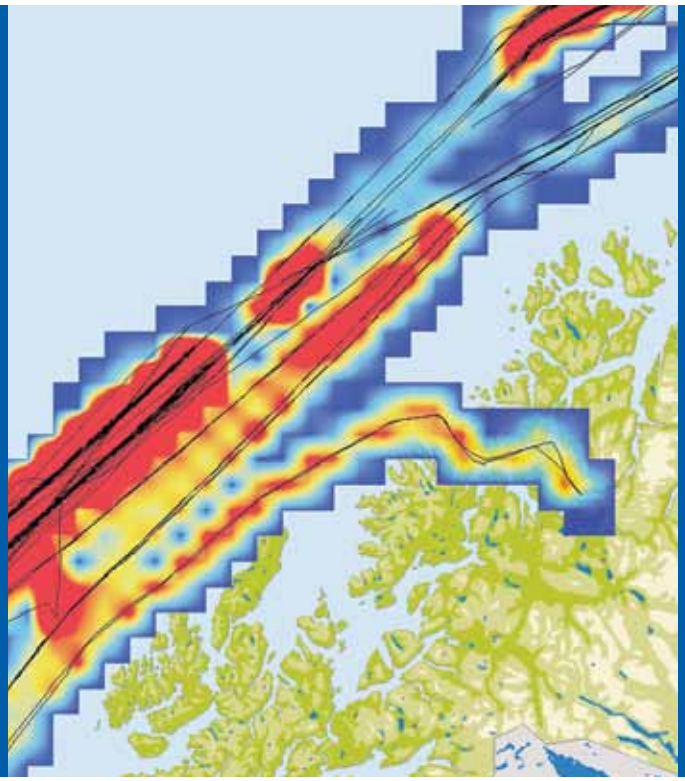
MARITIME TRANSPORT



Next generation navigation risk model

Using AIS, Monte-Carlo simulations, and GIS tools, DNVRI is developing the next generation navigation risk model to reduce the risk of shipping accidents along the coast. The model will facilitate analysis of proposed risk-reducing measures, such as new traffic separation zones or contingency resources.

Recent decades have seen a number of serious shipping accidents that have resulted in the spillage of large volumes of oil into the marine environment. Oil spills are particularly damaging in Arctic and sub-Arctic regions, such as northern Norway, because of high environmental sensitivity. With the opening of the Northern Sea Route, due to a receding ice cap and increased offshore activity in the polar region, ship traffic in general, and crude oil tanker traffic in particular, is projected to increase along the Norwegian coast in the coming decades. These factors together amount to a considerable risk that needs to be addressed in order that serious ecological and economic consequences can be avoided.

In the Norwegian Research Council funded FOB project (improved monitoring and decision support), a new statistical navigation risk model is being developed using novel methodology and information sources, with the aim of improving risk analysis, and subsequently contingency resource and traffic planning. One important aspect of the model is the use of historical AIS (Automatic Identification System) data to achieve unprecedented accuracy in estimating traffic patterns. Another is the use of Monte Carlo simulations, with a deterministic model for drifting ships and historical weather data, to find probable drift tracks at different times of year. Combining this with powerful GIS (geographical information system) functionality, the model is constructed to evaluate the risk-reducing effects of contingency resources, such as tug boats, and to calculate risks based on hypothetical future traffic patterns.

The model is intended to support decision-making in the planning phase, by allowing optimal placement of contingency resources at any given time of year, and by facilitating analysis of proposed risk-reducing measures, such as new traffic separation zones, or analysis of future increases in traffic.

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Future power plant design

New components are emerging for powering ships. These include fuel cells, superconductors, cogeneration, solar panels, kites, sails, fins, and new fuels. Designing and optimising such complex systems require advanced modelling techniques. DNV's goal is to contribute to a more sustainable shipping industry and to ensure that the transition to new methods of power generation is as smooth and safe as possible.

Research worldwide is directed towards developing new power technologies and alternative fuels as successful alternatives to diesel power. This cluster project is being conducted in close cooperation with the research and innovation hub in Piraeus, Greece and will position DNV in forefront of future maritime environmental challenges.

However, to utilise new technologies on ships, the complete system must be orchestrated to ensure that safety and reliability are maintained. At the same time, optimisation of the advanced systems is necessary to minimise fuel consumption and environmental footprint.

In its efforts to make ships with new technologies more attractive to ship owners, DNV has tailored a portfolio of R&D projects that focus on removing technological barriers and demonstrating fitness for purpose. Innovative R&D projects include COSSMOS, which analyses complex machinery power systems consisting of many different, new elements, via advanced modelling and simulation. Several ongoing projects focus on the complete development of fuel cell power plants, including their successful demonstration onboard merchant vessels. DNV has developed classification rules for fuel cell installations on ships, and in the FellowSHIP project, a dynamic model of a fuel cell is being developed. The Pose2idon project is investigating the possibility of using superconductors, thereby showing the diversity of possible components in future power plants for ships. In the future, shipping will use various different ways of generating power, and DNV will be there to qualify the technology and provide decision support for our customers.

DNV is helping the shipping industry become cleaner and more cost effective by focusing on the development of novel machinery systems and alternative fuels and processes

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MARITIME TRANSPORT

Higher waves and more extreme weather conditions will have an impact on maritime safety. (courtesy: BBC)

White Paper on Effects of Climate Change on Marine Structures

Global warming and extreme weather events reported in the last years have attracted significant attention in academia, industry and media but little has been done to study the potential impacts on shipping and the offshore industry. Will marine structures have to withstand larger environmental forces in a changing climate?

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) issued in 2007, a detailed literature review as well as results from R&D projects carried out by DNVRI have been scrutinized in order to disclose past and future trends in storm frequency, intensity and tracks caused by climate change. It turns out that the emphasis in the literature has been mainly on changing temperature, sea level and ice, and less on wind speeds and wave heights, the parameters that mostly effect marine structures. Those studies tend to focus on the average values and less information is available on extremes.

Although climate change is clearly visible in global average temperatures, sea level, precipitation patterns and ice, it has not been possible to draw firm conclusions regarding changes in wind and wave regimes during the second half of the 20th century. There are several indications that storm tracks have shifted polewards in both hemisphere and weaker indications that the intensity of strong storms, including tropical cyclones (often called hurricanes or typhoons) has increased but that the number has decreased. These trends seem to continue in the projections reported by IPCC and others. Changing storm tracks and increase in intensity of the strongest storms will have impact on the wave regime, not only in terms of height of the highest waves but also in terms of crossing seas and nonlinearity of sea states. Changing storm tracks will also lead to regional differences in changes of wind and wave regimes. These are some of the findings reported in a white paper developed by DNVRI.

The topic must be closely followed and DNVRI will continue investigations on these issues in a new EU project EXTREME SEAS which is planned to be initiated in 2009. In the meantime statistical procedures to deal with climate change trends should be improved and more regional studies should be considered, e.g. for the North Atlantic.

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MARITIME TRANSPORT

Optimisation of maritime transport and logistics

Vessel owners face significant uncertainty and complexity in their business decisions. Vessel prices and demand for transport fluctuate hugely, so the purchase of a vessel entails a significant risk. Additionally, the current emphasis on cost and emissions reduction requires a rigorous approach to the complex problems of fleet routing and scheduling.

DNVRI is currently developing two mathematical models to provide advanced decision support to vessel owners and operators. This research is being conducted in close cooperation with the research and innovation hub in Piraeus, Greece.

The first model, known as TRADS (tactical routing, deployment, and speed optimisation), captures the key revenues and operating expenses of a fleet of liner vessels. The model also represents transshipment hubs and associated costs, port delays, regional trade imbalances, and the possibility of rejecting transportation demand selectively. Using a novel algorithm, the model computes a set of routes that minimise fuel consumption and operating expenses, while satisfying as much transport demand as possible. Future research into the TRADS model will permit a finer representation of level of service in the maritime portion of the supply chain.

The second model, known as ROBUST, represents the key managerial decisions made by the fleet owner over a long-term planning horizon. These decisions include purchasing, selling, lay-up, and deployment of vessels to a specific trade. Some managers prefer a conservative strategy that protects them against market volatility, while others prefer an aggressive strategy. Based on an individual manager's expectations of how vessel prices and freight rates will evolve over the years, ROBUST provides a vessel purchasing, deployment, and retirement plan that is best suited to the manager's risk preference.

DNVRI has acquired state of the art modelling and software tools to explore these and other advanced topics in maritime optimisation and logistics.

These models will be further developed and tested during 2009.

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MARITIME TRANSPORT

The Port State Control tool kit

The DNV Maritime Strategy states that: "DNV must be the best performing Class Society on Port State detention and other publically available quality statistics".
Our challenge is to ensure that this is achieved!

Performance in Port State inspections continues to make headlines globally. This, combined with increased transparency and greater availability of data from sources on the internet, means that all parties have considerable interest in improving their performance in this area.

In order to fulfil the critical issues involved in such improvement, DNV Maritime has investigated how it can best work with its clients to achieve an increase in Port State performance. This dialogue, which took place in autumn 2008, is the first phase of a continuous improvement process which aims at enabling DNV Maritime to offer more advanced advice, guidance, and training to its global client base on the topic of Port State control.

Research undertaken with our clients has resulted in the development of the new DNV PSC tool kit. The PSC tool kit provides a selection of tools, designed to assist both Office and Sea Staff in focussing on the preparations necessary prior to Port State inspection. The PSC tool kit includes:

1. Port State Control - Top Detention Items 2008 (Booklet)
2. DNV PSC Wizard - Wizard Software that can be used to create a ship-specific PSC Guide
3. Port State Control Posters - Good and Bad Practice
4. DNV PSC Tool Kit Folder - For storage of all documentation related to PSC Inspections.

The PSC tool kit has been developed in this format so that communication with crew members is improved, and so that ownership of the shipping company can be established, as the PSC tool kit has the ability to upload company logos, and add ship-specific information and pictures. The DNV tool kit will form the foundation for future Port State campaigns by DNV, and is able to store Port State Control Circulars and other updates as we continue to increase awareness of this topic amongst our clients.

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Learning from maritime experience

Since 2005, DNV has recorded all findings from surveys onboard ships worldwide into a structured database that allows detailed analyses of trends and frequencies across the more than 5000 vessels classed in DNV.

This knowledgebase is unique in the maritime industry and has already provided in-depth insights into topics that have previously been difficult to address.

One example, which can serve to illustrate the potential of this database in the years ahead, is problems with rudder damage. Rudder damage is a well-known problem on all ship types, and frequently difficult and untimely repairs are necessary to ensure the safe operation the vessel. By using the information stored in DNV's database, we were able to identify those rudder types which most frequently experienced most damage, and also where the damage usually occurs. We were also able to highlight the importance of high quality, accurate repairs to reduce the possibility of problems recurring.

From the results of this analysis, we were able to provide DNV's surveyors with more relevant tools for repairing areas where these types of damage occur. By improving the focus on inspection areas and methods of repair in these critical areas, surveyors not only can save time during inspection, but also be confident of verifying a more reliable and durable repair.

In addition to empowering our surveyors, we were also able to provide relevant practical advice to our approval centres regarding what to look for during initial rudder approval and what should be avoided.

Our findings on rudders have been used to initiate rule changes, with the aim of avoiding designs which are known to be associated with these commonly-occurring damage types.
Several thousand findings are recorded into the database annually. DNV is committed to utilising this knowledgebase in the years ahead to contribute to the continuous work of improving safety at sea.

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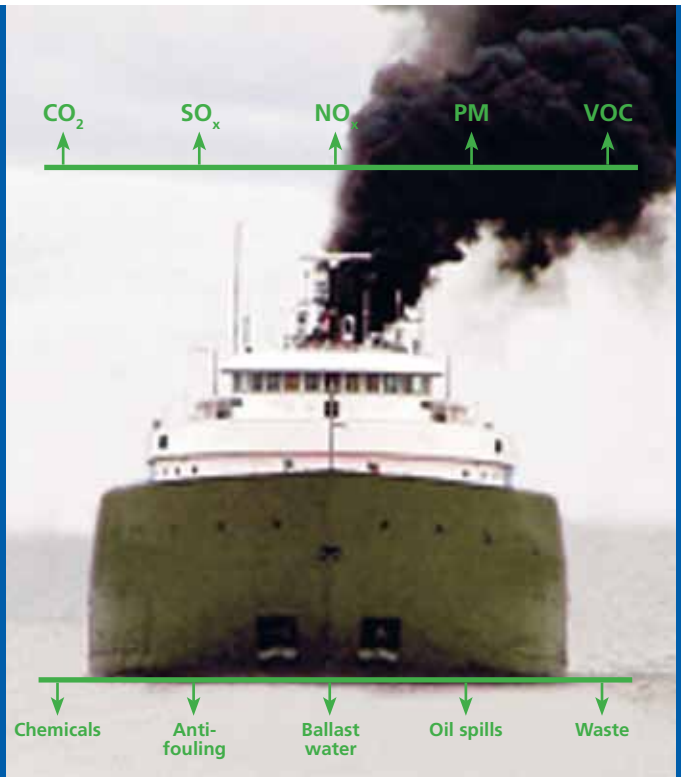
MARITIME TRANSPORT



Reporting tool for environmental performance

Pressure on the shipping industry to achieve low emission operations is increasing. DNV Software, in cooperation with DNV Maritime, has developed a tool for monitoring and reporting the environmental performance from ships in operation, which can be used as basis for fuel efficiency programmes and for evaluating approaches to reduce environmental impacts.

The maritime industry is facing growing public concern, and is the subject of increasing focus, regarding its environmental performance. There is strong international pressure for emissions to air and water to be reduced, and economic and regulatory instruments are also being established at the national level.

The guideline proposed by the IMO for a standardised energy effinciency operational indicator (EEOI) is suitable for comparing CO_2 emissions of vessels across fleets, in relation to the transport work they have performed. The indicator is calculated on the basis of fuel consumed, cargo transported, and distance sailed, which are all reported daily from the vessels, and also upon carbon emission factors.

Computed indicator values can be compared to a fleet, to sister ships, or over specific periods of time. Eventually they can be used as a basis for minimizing emissions from transport. This benchmarking approach can contribute towards driving the shipping industry towards higher energy efficiency and lower emissions.

The software packages, Nauticus Air and Nauticus Environment, offer easy, efficient web-based solutions for ship owners and operators by which they can measure and monitor their environmental performance. The system is configurable to customer needs, hosted in DNV's data-centre, and based on maritime best practices. The emission factors and calculations are verified by DNV expertise.

Nauticus Air/Environment provides a solution for environmental accounting and performance management.

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Effective data capture via services in the clouds

By providing software as a service over the Internet, with virtualisation and dynamic scalability, users can take advantage of these services on any Web-connected device, anytime and anywhere; this is termed "services in the clouds". DNV Software has delivered several solutions hosted on the Internet, of which Nauticus Air/Environment is one example of software as a service.

Software as a service (SaaS) is a model in which an application is used as a service provided to customers on demand, and by using a less costly, on-demand subscription model, the up-front investment is reduced. The licensing thus becomes a variable leasing fee, rather than a larger fixed cost at the time of purchase. SaaS software is accessed remotely via the Web, with centralised functionality and feature updating, and central hosting of the solution by the service provider. Software that will be offered to many users, and with few customisations, are SaaS candidates. Economies of scale are obtained when there is a high volume of users.

The concept of "cloud computing" incorporates technology trends such as SaaS and Platform as a service (PaaS), where the services provided rely on the Internet as backbone for delivering the services.

Nauticus Air/Environment is an example of a SaaS provided by DNV Software. Nauticus Air/Environment provides a solution for environmental accounting and performance management. The idea is to capture data from many sources, but store the data centrally at one place. Users can then analyse and understand trends in their data.

Since the data are stored centrally, a range of possibilities arise related to benchmarking and analysis across industries, customers, and customer assets. By offering the software services in the clouds, the services are available to everyone connected. Once a critical mass of data is achieved, the possibility of capturing a higher volume of users increases.

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OIL AND GAS

Predicting future demand for oil and gas, and forecasting future prices of oil and gas are not the easiest of exercises at this point in time. When well-known experts are asked to estimate the price of oil at the end of 2009, their answers vary significantly in range, and also change depending on when the question is asked.

Therefore, perhaps more useful answers might be obtained from questions such as: Which trends do you believe in? Which scenarios are most likely? And, which underlying data are reasonably robust?

The annual global increase in demand for oil and gas has fallen from 1.9% to 1.1%. If no actions are taken, production is expected to drop between 6 % and 8 % per year, depending on who you ask. In other words, there is a gap of between 7.1 % to 9.1% annually on the demand for oil and available production. With a global production of approximately 80 million barrels per day, this means that between 5 and 7 million barrels of daily production capacity has to be added globally on an annual basis. Initially, this could be provided by increased production and the spare capacity of some Middle Eastern countries. However, in the longer term, the current spare capacity will be insufficient and new investments will need to be made.

In "DNV Technology Outlook 2015" we looked at some long-term trends in oil and gas production. Here we debate whether our predictions are still valid.

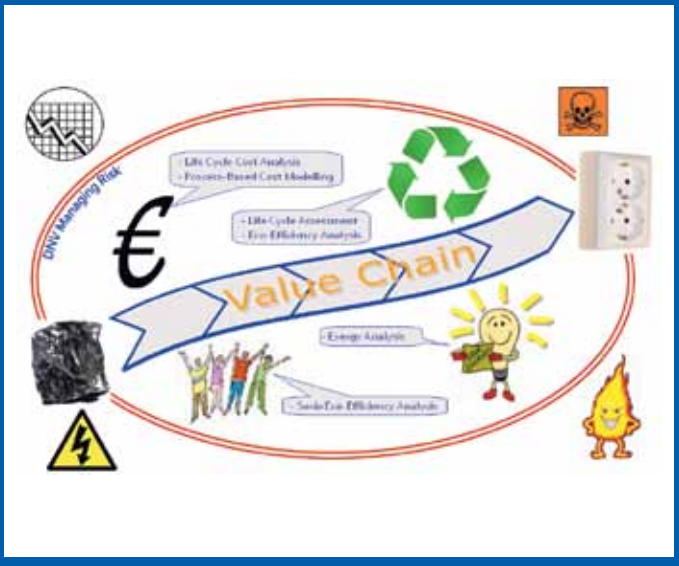
- The economic recession has hit the industry much harder then we anticipated.
- As we predicted, the oil and gas majors control a smaller share of the exploitable reserves.
- As expected, we have seen some resource protectionism, and national energy companies taking tighter control of their resources.
- As we predicted, there is a very strong focus on extending the service life of existing installations.
- New technologies will be needed for drilling in deeper waters, for production of oil and gas in Arctic areas, and for extraction from oil sands, etc. However, due to the current price of oil, some projects may not materialize as quickly as we had predicted.

In conclusion, although we made some mistakes regarding the short-term effect of the financial crisis, we firmly believe that the long-term trends and drivers are still there.

OIL AND GAS

Managing risks in Energy Value Chains

As part of the Energy Value Chains theme, DNVRI has studied the Coal-to-Electricity value chain. This work includes an evaluation of various value chain assessment methods, a state-of-the-art study of the various Coal-to-Electricity value chain elements and its boundary conditions, and mapping of uncertainties and challenges related to the value chain.



The value chain assessment methods studied include technical, economic, environmental, and social aspects, as well as different combinations of these various factors. The value chain used in assessing state-of-the-art and identifying uncertainties and challenges includes the following elements:

- Coal extraction
- Coal preparation
- Coal transport
- Power production

In addition to assessing the value chain elements per se, the coal resources, the market, and the trade routes have also been mapped. The main legal drivers and regulations which influence operations related to the value chain have also been identified.

The risks and challenges identified in this work have been categorised as technical, economic, operational, social, or environmental. Existing services that are delivered by DNV and that can be applied to manage these risks have also been identified.

Being a phase 1 type project, both input from DNV Energy and external expertise has been vital. Two workshops have been arranged to obtain guidance and feedback from DNV Energy offices more closely located to the coal market (Germany and USA), as well as from experts in related fields, such as carbon capture and storage, and value chain modelling. The project team have also visited a coal fuel power plant and met with the management of the power plant operations.

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Process qualification

Investments in projects and developments within the energy sector are normally fairly large, and failures may result in substantial financial consequences. Therefore, the industry tries to avoid unnecessary risks by employing field-proven technologies, and there is traditionally a reluctance to introduce new technologies that do not have a track record.

From the start of the offshore oil and gas period until now, the hydrocarbon resources have been relatively easily accessible. In order to fuel the world energy demand, oil companies have started to explore deeper waters and longer tie-backs, and this requires new technologies. To transport the hydrocarbons from the reservoir to the platform or shore, pre-processing of the well stream is normally needed. In the future, subsea processing will often be an enabler for the development of some fields. In addition to going longer and deeper, oil companies have started to produce from oil fields which, only a few years ago, were seen as technically impossible to exploit. The processing systems required must be reliable and must be able to deliver the product quality for which they are designed. Some of the process technology applied subsea will be adapted from topside technology, but in some cases completely new technology must be developed.

In order to reduce the risks related to unproven technology, DNV has, in cooperation with the oil & gas industry, developed a systematic approach to qualify technologies for first-time industrial use. While this recommended practice, DNV-RP-A203 ”Qualification procedures for new technology”, provides a general approach, focusing on avoiding failure of components, a more detailed procedure is now being developed that describes how to qualify upstream process technologies. We are in need of a systematic approach to ensure that the processes will perform reliably within specified qualitative and quantitative limits. In such an approach, the risks associated with inadequate performance must be identified and quantified by understanding the chemistry and physics of the processes, as well as understanding the interactions with the containment, monitoring, and control systems.

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OIL AND GAS

Qualification of CO_2 Capture Technology

A new guideline for qualification of CO_2 Capture Technology has been developed by DNV in close cooperation with the industry. The method is based on DNV-RP-A203 "Qualification of Technology", and has been tested on two amine-based post-combustion concepts and one oxy-fuel concept.

As the political focus on CO_2 and its role in global warming increases, it is to be expected that major CO_2 emission sources, including large-scale traditional and raw material production units, will be forced to reduce their discharges. One option is to capture and store CO_2 in geological formations; the main challenges for this approach are the development of robust and cost-efficient technologies, and the identification of suitable storage sites.

In order that the robustness and reliability of new technologies for CO_2 capture can be best determined, a new guideline has been developed. The development has been organised as a Joint Industry Project (JIP), with DNV working in partnership with Aker Clean Carbon, Aker Solutions, StatoilHydro, Statkraft, and Gassnova.

The guideline is designed to address how to qualify CO_2 capture technology in general and how to identify which sections of the technology include novel components or systems that need qualification, by using a cost efficient risk-based procedure through the qualification process.

The guideline contains the following main steps:

- Qualification basis: system description, detailed descriptions of the process, and relevant performance criteria
- Technology assessment: breakdown into components and chemical engineering processes
- Failure mode identification and risk ranking: use of HAZOP and FMECA to identify and rank failure modes
- Selection of qualification methods: which methods can be used to demonstrate that relevant criteria are met - testing, analysis, or adjustments to operational procedures
- Data collection: the actual testing, analysis, or process simulation
- Functionality assessment: comparison with the Qualification Basis, answering the question of whether the specified performance criteria were met

The new guideline will be converted to a recommended practice and published before the end of 2009.

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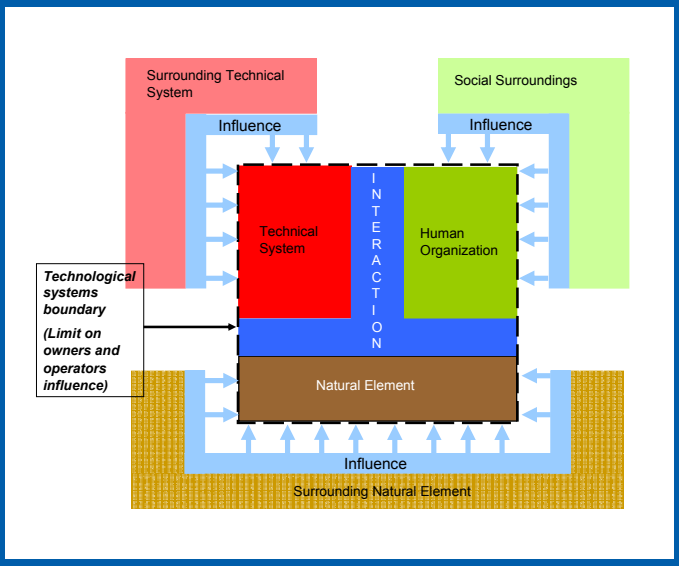

Risk performance indicators

The vision of the RPI-project is to offer a holistic view on operational risk management that will satisfy multiple stakeholder requirements on controlling losses from operations. The system should be a market-leading operational risk management system that provides global application in several industries. The system should allow synergetic transfer of knowledge.

One particular aim of the RPI-project is to develop high competence in forecasting conditions and providing input to management, prior to the development of dangerous conditions. Application of reliable prediction methodologies will be central to the project.

The second aim of the project is for risk to be approached in a holistic way when assessing the risk of unwanted losses due to loss of life, injury to humans, property, and the environment, and business interruptions. A central theme of the RPI-project is to understand the reliability and organisational performance of technical systems and how the interaction between these two factors affects the performance of the total system.

One practical result of the RPI-project is the development of a new DNV risk management service, to be used for managing the risk of unwanted losses during the operational phase. This service shall encompass systemic interactions, covering technical and human organisations, with emphasis on the use of leading indicators.

The RPI-project literature study has revealed a long-term, general shift of focus from risk assessment in the design and construction phases, towards a focus on operational errors and operational risk management. The long-term trend has less focus on individual human errors, and more on human behaviour in a human organisational setting. Despite improvements in pre-operational risk assessment, with more and better-designed safety systems, the expected improvements in safety in technical systems have not occurred. Improved health safety and environment (HSE) management has led to better results in terms of small accidents/injuries, but there is a clear mismatch between good HSE performance and low risk of major accidents; thus improving HSE alone does not necessarily contribute towards a better safety performance. The Baker panel report documented major systemic/organisational weaknesses which resulted in the BP refinery accident in Texas, USA in 2005.

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OIL AND GAS

Positioning in riser systems

While offshore exploration and production is moving to deeper waters, in recent years several new challenges have been posed to the industry. These include high pressures, high temperatures, sour oil, and low seawater temperatures. Riser technologies are developing fast and the offshore industry needs to update riser codes in order to address this new reality.

In the riser field, the recognised codes are API 2RD and DNV OS-F201. In 1992, the American Petroleum Institute (API) Subcommittee 2 formed a task group to draft a production riser recommended practice. The first edition of API RP2RD was published in 1998. The US Minerals Management Service requires that all production risers in the Gulf of Mexico work in accordance with this recommended practice. Since publication of the first edition, the industry has gained considerable experience in the design of riser systems. In 2001, DNV published its riser standard, DNV-OS-F201, based on limit state design, and this paved the way for an alternative to the working stress design format. The benefit of incorporating guidance in key areas, based on lessons learned from past experiences, has motivated the industry to update the existing API RP2RD.

In 2008, a Joint Industry Project (JIP) was established by DNV and MCSaiming in order to update the API 2RD for ISO and API's approval.

MCSaiming and DNV have both played key roles in the development of the new ISO 13628-12. The project is managed by MCSaiming, with DNV as deputy project manager. DNV is also contributing technically on design criteria, fabrication and installation, materials, and qualification of riser components. Based on the ISO API 2nd revision, clients' feedback, and the revision of the pipeline standard (DNV-OS-F101), revision of DNV OS-F201 has been initiated by DNV. Major effort has been directed towards the calibration work of the factors to control the safety level of the design, improvement on the material section, and the link between the requirements for materials and fabrication is optimised.
An important role for DNV is to reflect its experience and knowledge gained from its work in developing recommended practices and standards. This also applies to the new riser revision, which will incorporate the experiences and knowledge gained since the 2001 version.

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New guidelines to ensure pipeline integrity

It is essential that operators keep pipelines operating safely and efficiently. Simultaneously, awareness at both the regulatory and public levels is increasing, leading to stricter regulation and standards for integrity monitoring. Few guidelines exist, and therefore DNV is developing a recommended practice to help operators to document pipeline integrity.

While the need for integrity management is becoming stronger, there are often implementation difficulties. Many pipelines, especially older ones, were not designed to facilitate today's monitoring and inspection regimes. Also, many pipelines are impossible to inspect with an in-line inspection tool, complicating the verification of the pipelines' current condition. Therefore, operators have had to develop their own solutions for pipeline integrity management. Many use the API and ASME codes developed for onshore pipelines, combined with their own, often project-specific, pipeline integrity management systems.

This lack of common practices resulted in DNV leading a joint industry project (JIP) to create guidelines on how to establish, implement, and maintain integrity during the entire service life of a submarine pipeline system. This has resulted in the development of a tool for the industry, for which no such formal guidance currently exists. These guidelines will be presented in the recommended practice, DNV RP-F116. They are based on the requirements in DNV's recognised pipeline standard, DNV OS-F101.

This will be the only complete guidance available that provides a reliable point of reference for both industry and authorities, and will help to raise the standard of submarine pipeline integrity management. Companies can also use their adherence to these guidelines as a component of documenting their compliance with regulations. For authorities, it will provide a useful tool when reviewing their regulatory regime.

The recommended practice will cover three main areas of integrity management:

- The establishment of integrity in the design, manufacturing, and installation phase.
- The transfer of vital information from design to operation to ensure the integrity of the pipeline during operation.
- The maintenance of integrity during the operational phase.

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OIL AND GAS

Figure 1: The Cost Of Loss In The Refining Industry

Achieving Excellence in Process Safety Management

In recent years, the process industry has made tremendous improvements in occupational safety and environmental emissions. However, when we examine major accident events over the same period, a very different picture emerges. In the last three years (2006-2008), the loss from refinery and petrochemical incidents around the world has exceeded $1 billion.

An analysis conducted by DNV reviewed over 400 refinery accidents over a 40-year time span, and showed a trend of rising losses over this period. Figure 1 is derived from this work and shows how the refining industry has performed in terms of its annual losses arising from major accidents. In the last three years alone (2006-2008), the total loss from refinery and petrochemical incidents around the world has exceeded $1 billion.

In 2005, DNV set up a database to track and record accidents and incidents which have been reported in the processing industry. Since its inception, over 1 800 incidents have been recorded, and these can be summarised into categories of incident type and incident consequence, as in Tables below.

Incident Type	Number of incidents
Loss of primary containtment	745
Fire	538
Explosion	369
Off-site environment release	44

Incident Consequence	Number of incidents
Loss of life/injury **	169
Site evacuation	114
Regulatory fines	674
Production downtime	219

** Note that of these 169 incidents, 155 involved loss of life, resulting in the deaths of 298 people. 721 people were injured in these events.

Applying an integrated approach

The management of major accident hazards will not be solved overnight. We must adopt a more integrated approach to their management, which considers not just the consequences of failure, but also the likelihood of failure. Asset integrity management, management systems, inherently safer designs, and organisational factors all need to be improved if the industry is to learn the lessons from the past, and translate them into process safety improvements.

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Fibre in flexible development

Over the past 15 years, there has been a marked acceleration in the development and use of fibre-rope systems for anchoring. The main reason for using fibre-rope systems is to minimise weight onboard floating vessels, and DNV has been active in this development.

This development has covered the inclusion of the fibre-rope non-linear behaviour in design methods, how to perform accurate tests, and how to certify anchoring systems as a whole. Assessment of damage, inspection, and protection against sea-bed particle intrusion has also been included.

Fibre ropes are very light-weight, and some are close to neutral buoyancy. The flexibility of the material in straight tension keeps the floater, which moves with the wind and waves, in position. The fibre rope is used instead of relying on hanging chain weight to achieve the required flexibility.

The rope material is usually made of polyester, as used in clothing textiles. Materials known from applications such as military armour can also be highly suitable for anchoring in waters of 5 000 metres depth, or even more.

The feasibility of anchoring in areas considered impossible only a couple of years ago, will be advanced considerably by the use of fibre-rope systems, thus improving the possibilities for precise, environmentally-friendly positioning. The recent technological developments, driven by the needs of the exploration industry, will also provide significant benefits for offshore renewable energy, such as wind and waves. The harsher the environment, the more energy can be produced from wind and waves, and the more suitable are fibre ropes for this type of anchoring.

DNV Offshore Mooring Standards:

- DNV-OS-E301 covers aspects of mooring analyses.
- DNV-OS-E303 covers fibre rope design and certification.

DNV Recommended Practices:

- DNV-RP-E304 covers damage assessment and inspection criteria.
- DNV-RP-E30X is being developed for testing, and applying results in design.

DNV has extensive experience in the field of fibre ropes for offshore mooring and anchoring, and has a large-scale test facility in Bergen, Norway.

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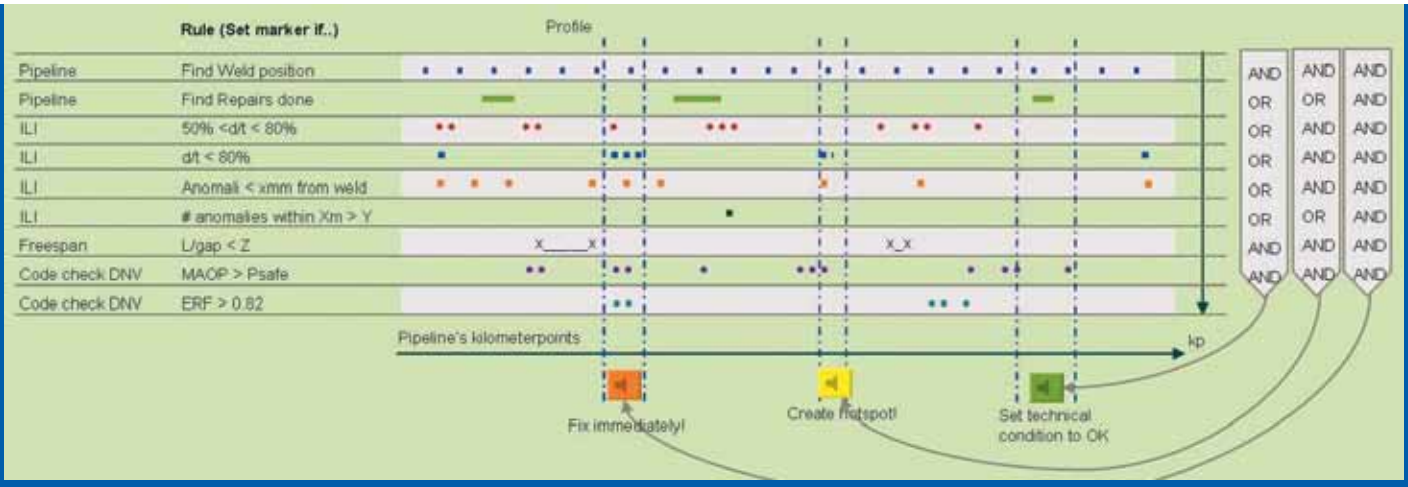
OIL AND GAS



Threat and damage screening using orbit+ Pipeline

By leveraging the Brix RuleEngine, orbit+ Pipeline can deliver customer-specific rule sets without requiring any programming effort. This approach can be used for screening large amounts of data for threats, damages, and failures.

Judging potential damage from the threats to which a pipeline is exposed is an integral part of risk assessment. Huge amounts of data are collected for the pipeline, which may include inspection and monitoring results and/or material data. Industry-specific rule sets for integrity management have been developed by standards bodies, operating companies, and authorities, and applying these rules is essential for conducting risk assessments for the pipelines.

However, developing and maintaining software that caters for the enormous variability, both in the rules themselves and in their usage, is a complex task. For orbit+ Pipeline, one of the most important requirements was that the risk screening rules should be configurable to the needs of individual clients. Another necessity was that pipeline engineering skills, rather than C# programming skills, would be used to determine who could best configure the rules for risk screening. orbit+ Pipeline's Risk Screener meets these requirements for flexibility, but without compromising its stability, by applying a three-step approach to gain flexibility.

To start with, the rules themselves are defined and maintained in Brix RuleEngine. This means that rule definition is kept separate from rule execution. In orbit+ Pipeline there are individual rules for assessing probability and consequences of failure, and for risk, through a risk matrix. Secondly, a configuration area for client-specific settings is provided. Here, each client defines which threats apply to which pipelines, and hence which rules apply to which threats. Lastly, the Risk Screener's user interface allows the users to include, exclude, and tweak rules on the fly. It is possible to screen for probability, consequences, or risk by combining the results in a risk matrix.

DNV can deliver orbit+ Pipeline together with DNV's best practice risk screening rules, and these can be combined with both regulatory and client-specific rules.

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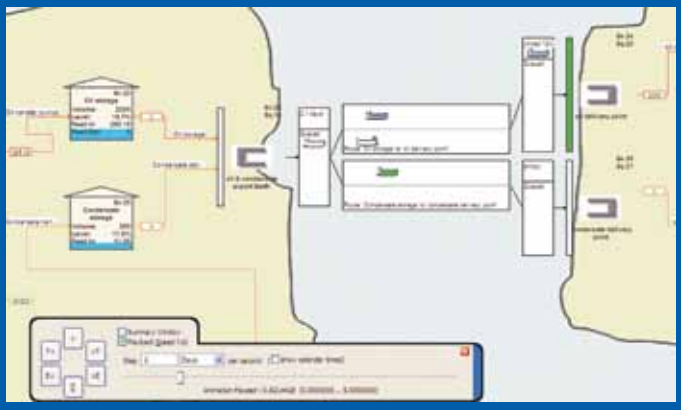

Improving supply chain diagnostics in TARO

DNV Software's MAROS and TARO Performance Forecasting tools are used extensively in the oil and gas industry to assess and improve the performance and reliability of fixed assets. The need to extend this capability beyond production and refining, so that product transport can be included, has resulted in the extension of the simulation algorithms to the supply chain.

Both Maros and Taro use advanced simulation techniques to predict the effectiveness of a system in terms of its reliability, availability, and productivity. They can be used to quantify the lifecycle cost effectiveness of a system, and to optimise a system to improve profitability.

TARO's capabilities have been extended to model supply chain logistics including export storage, berth loading and unloading, and the transport chain through to customer delivery and storage.

This bulk transport logistics enhancement required a novel approach so that the simulation of dynamic entities could be superimposed onto a static infrastructure. The movement of the cargo was merged with the event driven algorithm, and, for the first time, the software was extended beyond its traditional realm of oil and gas flow.

The new capabilities allow the simulated system to be scrutinised in greater detail, with monitoring of factors such as berth prioritisation, transport loading and unloading, queuing, storage trigger levels, customer routes, transport speeds, individual transports, and fleets, and any weaknesses or anomalies identified. Animation of in-transit failures and transport call-up based on storage levels will also be added, and additional work is also planned to improve LNG modelling.

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RENEWABLES

It is quite obvious that renewable energy sources will be a major part of the future energy mix, and that fighting climate change will simply not be possible without utilising energy sources that emit less CO_2 then conventional hydrocarbon-based sources. Although renewable energy presently plays a relatively minor role globally, most international research on climate change emphasises that, to be successful, all the different measures available must be utilised. Thus renewables have been an area of considerable focus for DNV.

In "DNV Technology Outlook 2015", we listed three main areas of importance within renewable energy fields: biofuels for transportation, wind power, and sun, wave, and tidal energy.

Financial backing and the support of policies proposed by authorities are essential for scaling-up, over the next decade, the tiny fraction of the worldwide renewable resources that are economically accessible with deployment-ready technology. This applies to the three areas listed: biofuels for transportation, wind power, and sun, wave, and tidal energy.

Which challenges and opportunities do we predict within this field? Due to the diverse nature of renewable energy, and the widespread distribution of resource availability at different locations, a broad range of solutions are expected to reach the market. The technological options are plentiful; wind power presently accounts for the highest proportion of new capacity installed annually, whilst bioenergy, in all its forms, represents the largest current source of renewable energy. We expect to see a hydrogen highway within the not too distant future. The oceans contain huge amounts of power that could be exploited to generate useful energy, and a breakthrough on floating wind turbines is expected within the next 5 – 10 years.

How has DNV contributed to the renewables revolution? DNV firmly believes that renewable energy will be a significant part of the future energy supply mix. Therefore, in order to serve our customers as best we can within this emerging area, we have invested heavily in R&D activities. On the following pages some of our efforts in 2008 are presented.

These include:
-The effects of bioethanol on pipeline components and networks
-A European approach to hydrogen safety
-Setting the standards for Wave Energy Devices
-Enabling deployment of offshore wind turbine technology

RENEWABLE ENERGY

Pipeline transportation of biofuels

Increased use of biofuels will require the development of an efficient means of transportation from production plants to gasoline stations. DNV is working with industry and governments to ensure safe and reliable pipeline transport and storage of biofuels. In the future, other aspects of biofuel use, such as sustainability and production will be addressed.

Materials compatibility issues are currently the focus of DNV activities in biofuels. Several generations of biofuels are recognized, of which first and second generation bioethanol are of greatest interest in terms of volume and commercialization. For bioethanol, the major materials compatibility issues are stress corrosion cracking (SCC) of steel and the compatibility of elastomeric seals and gaskets. DNV is leading a multi-year effort to address both the short-term and long-term needs of the industry.

The major accomplishments of this programme include:

- The conclusion that SCC of steel does not occur in blends below E-10 and therefore existing infrastructure can trans port these blends safely
- Metallurgical grade and fabrication have minimal effects on SCC
- Hydrated ethanol does not cause SCC
- Some amine and ammonium compounds can mitigate or prevent SCC
- SCC tendency varies between batches of ethanol and over time
- Dissolved oxygen, the major cause of SCC, can be monitored. DNV, in collaboration with sensor vendors, has developed a wireless sensor that can be used for remote monitoring of tanks and pipelines to obtain data for risk assessment.
- Some elastomers, notably Viton and low-swell Buna, suffer significant volume swell upon exposure to gasoline following exposure to ethanol.

These, and other, findings will be incorporated into guideline documents and risk management practices. DNV will continue to work with industry in addressing technical issues related to the transport of advanced biofuels, including cellulosic ethanol, biobutanol, and biodiesel.

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A common European approach to hydrogen safety

The 5 year EC-funded HySafe project is reaching completion. The work accomplished will contribute to the transition to more sustainable development in Europe, by facilitating the safe introduction of hydrogen technologies and applications.

HySafe is a Network of Excellence within EC's 6th Framework Programme. It is one of the first IPHE recognised projects and currently the only one dedicated to safety aspects.

The HySafe network has brought together competencies and experience from various research and industrial fields. Considerable effort has been directed towards hydrogen safety issues, including comprehensive safety studies and the evaluation of innovative mitigation techniques. Synthesis, integration, and harmonisation of these efforts are expected to break new ground in the field of hydrogen safety and contribute towards the increase of public acceptance of hydrogen as an energy carrier.

The consortium consists of 25 partners from 12 countries: Germany (5 partners), France (3), Norway (3), UK (3), Netherlands (2), Spain (2), and Denmark, Greece, Italy, Poland, Sweden, Russia and Canada, each with 1 partner. DNV has participated in several of the activities and has been responsible for the Risk Management Cluster as well as Work Package #5 'Development of a Hydrogen Incident and Accident Database' and Work Package # 12 'Risk Assessment Methodologies'.

The hydrogen incident and accident database (HIAD) is now up and running, and contains more than 250 verified records.

The work completed under 'Risk Assessment Methodologies', has identified and developed best practices, standards, and methodologies for risk management of hydrogen applications, including methodologies suitable for determining safety distances, and input into regulatory issues.

The work undertaken provides input into the requirements for the Hydrogen Highway from Stavanger to Oslo that will become operational during spring 2009. It will also be carried forward in a new international effort.

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RENEWABLE ENERGY

Optimising wind project performance

Some wind energy projects are not living up to their potential due to limited understanding of meteorological conditions, turbine performance difficulties, and reliability problems. DNV assists project developers in making accurate energy production predictions, and helps owners to understand performance shortfalls and their underlying causes. This optimises energy and revenue production.

Although the wind energy industry is maturing, a large number of projects do not meet their energy production expectations. Studies of wind projects in North America have shown that, on average, wind projects are producing about 10% less energy than their best-estimate preconstruction forecasts.

DNV is leading research activities to obtain a better understanding of the causes for these performance shortfalls. For projects in the development stage, we are studying factors such as turbulence and atmospheric stability in order to develop better models of the responses of turbines to meteorological conditions and to have a better understanding of how conditions that are unique to a specific project site might affect energy production. Using the information obtained, we will be able to help developers manage their risks through more accurate expectations of their predicted revenue, while also reducing uncertainty in the revenue estimates.

For projects already in operation, DNV is researching new advanced tools and methods for identifying and quantifying those problems that prevent turbines from producing the maximum energy predicted. These tools will assist owners in detecting subtle problems, which are having minor effects on turbine performance, before they develop into bigger problems with larger effects. By optimising turbine performance, project owners may be able to recover a portion of their revenue shortfalls, and will also be better informed for making cost-benefit assessments regarding project operations. DNV provides project owners with the tools and information to make optimal decisions throughout the entire life of a wind farm, from the initial prospecting stages, through development and construction, and over the entire project life. Our ongoing research will help wind projects by reducing uncertainty and risks, and by maximising energy production.

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A new standard for tidal and wave energy systems

A UK-based team in DNV Energy's Offshore Class department has launched a new Offshore Standard for tidal and wave technology, DNV-OSS-312. This standard was developed in response to the rapid growth in the wave and tidal industries around the world, and to formalize the risk-based certification service that DNV has been providing to a plethora of players.

Wave and tidal energy has the potential to provide a significant proportion of the world's energy requirements in the years ahead, and is already progressing towards becoming a multi-billion dollar industry. Much of the technology that is required to operate in an inherently hostile environment is relatively new, and novel concepts are being proposed almost daily. Thus, there was an increasing need for a consistent approach for how to manage risks for this type of development.

The new DNV-OSS-312 addresses the following processes:

- Certification
- Verification
- Technology Qualification
- Warranty Surveys
- Environmental Condition Assessment
- Hydrodynamic Analyses and Model Testing
- Technical Risk Assessment
- In-Service Inspection Planning
- Reliability Assessment
- Inspection of Equipment and Structures
- Marine Operations
- Manufacturing Surveillance

DNV has already begun working with several wave and tidal development companies, including: Atlantis Resource Corporation (Singapore/Australia), Aquamarine Power (UK), Wave Star Energy (Denmark), and Martifer Energia (Portugal).

By guiding development companies through the DNV framework for certification, their chances of creating a successful project are boosted. The new standard and associated services enable companies that specialize in wave and tidal technologies to identify and mitigate the risks. This, in turn, provides assurance about the new technology for investors.

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FOOD &
BEVERAGE

Consumers and retailers set the agenda: retailers and brand owners are sensitive to shifting consumer demands and will translate these to requirements which are imposed down throughout the value chain.

Traceability and transparency: consumers, authorities, and company risk managers are increasingly demanding information on how food has been produced and handled throughout the value chain.

Globalisation of the food chains continues: further vertical integration of the value chain, combined with increased demands for year-round supplies of fresh, exotic products, will continue to sustain the trend for global food-trading patterns.

Environmental and social consciences increasingly influential: concern about the environment and fair treatment of employees of food producers will continue to grow. Attention will be on fair trade products, local produce, reduction in carbon footprint, and eco-friendly products, as well as use of packaging that is recyclable, re-usable, and/or made of biodegradable materials.

Promoting health and wellness: the market for products with functional health benefits or that appeal to consumers inclined towards "natural" foods will increase. These products might be disease-specific, designed to reduce the risk of illnesses such as diabetes or heart disease, or will address general health issues such as digestive health, immune defences, or weight management.

Suspect security: the vulnerability of food supply chains to deliberate attack or threats will engage the media and the authorities, and additional controls to manage food defence will start to emerge.

Growth in processing level of food: as urbanisation continues in the developing world, the decrease in household size and the increase in the proportion of working mothers, together with more food storage opportunities, will lead to a higher demand for pre-prepared food.

Efficient use of resources: water and arable land are predicted to be limiting factors in providing sufficient food for the world's growing population. These limitations will result in changes in legislation and agricultural production approaches, and the development of new technologies.

FOOD

Sustainability in the food production chain

Consumer demand is driving companies to develop and deliver sustainable products. This requires an understanding of many interrelated factors including natural resources management, economic and welfare issues. DNV is exploring these issues so that we can better help customers develop, meet or verify their sustainability goals or claims.

There are many definitions of sustainability in food production. To effectively manage sustainability it is important to develop specific indicators that can be used across food catagories as well as some that are specific depending on the geography or food category. Global acceptance of such indicators would facilitate benchmarking and allow verification of sustainability claims. One example that is currently being developed is within aquaculture systems where generic indicators could serve to examine common issues related to generic environmental, social and economic factors. Additional specific indicators related to water quality, feed, location, etc will provide additional value, but will likely vary depending on the type of production employed.

Given that food accounts for 17 – 32% of total green house gas emissions in western societies it is unsurprising that there is a focus on food product CO_2 footprints. While consumers and other stakeholders have growing expectations towards reducing food CO_2 footprints, the industry has been struggling with the technical difficulties of accurately measuring and reporting the CO_2 footprints associated with often complex, dynamic and global supply chains. Nevertheless there are opportunities for cost effective abatement within the food industry and our research has been directed towards on how best to identify "hotspots" in the supply chain to allow rapid abatement activies in a cost effective manner.

Of course CO_2 is but one component within food sustainability, and must be considered in context with other factors such as water usage, resource use, and societal issues, as well as in conjunction with food quality and safety, price, and availability.

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Fishing for a sustainable future

The continuous increase in food demand is likely to lead the global community to demand even greater focus on sustainable production and better resource management. Both the fisheries and aquaculture sectors have specific and unique challenges regarding sustainability that need to be better understood and to allow the sectors to adapt and grow responsibly.

The predicted growth in the human population will probably result in the fisheries, and particularly the aquaculture sector, being the focus of increased attention in the future. The future harvest of wild fish depends on how resources are regulated and controlled, whilst vigorous development of the aquaculture industries depends on factors such as water usage and use of locations.

In 2008 we continued to work on a number of projects related to sustainability issues in both the fishery and the aquaculture sector, within the wild catch segment, focus was on enhancing our knowledge about illegal, unregulated, and unreported fishing activities (IUU), and identifying tools to detect and reduce this "trading" activity. The use of structured risk assessment and the implementation of a robust traceability systems are two tools that can be used together to help reduce the risk of IUU fish entering the market.

Within aquaculture a new project was initiated to identify the sustainability challenges and explore how these may be addressed in a practical manner. Initial work has focused on identifying stakeholders including relevant academic and government research environments and industry partners that are willing to work together to test new solutions and approaches in this quickly developing field.

Additional activities has included exploring biological verification technologies that can be used to confirm things such as species or origin and to understand how these technologies may be combined with a traceability system to provide added value. The new generation of DNA based technologies are rapidly increasing in power while associated costs are falling and so should offer exciting possibilities to the fish sector in the years to come.

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FOOD

Traceability; tools and opportunities

Risk management in food value chains by using internal management systems combined with traceability systems for: Access; Reliability; Speed; Quality; Versatility.

The ability to track items as they move through the value chain, and to trace the custody of ingredients, raw materials, and packaging back to source, provides a foundation by which organisations can manage risk in their value chain. Success is measured by speed of information retrieval, and the usefulness and format of the data received. These factors, which are necessary in order to build a well-functioning traceability system, rely heavily on cooperation between chain partners, not only at a physical and transactional level, but also regarding information exchange and timeliness.

Versatile and validated traceability systems provide opportunities for harvesting information that supports a wide range of actions, such as increasing sustainability, building food defence networks, and verifying the legality and safety of raw materials from source. In mature value chains, the added value lies in the opportunity to apply a risk-based approach to identifying hotspots, in order to tailor effective mitigation actions.

The priority level objectives of this ongoing project are to standardise knowledge and to design tools for tailored assessments of traceability systems, including their ability to provide requested information. Such data may originate from diverse sources, e.g. internal quality and management systems, registries, suppliers, and importers.

The challenges for each chain partner are a) to utilize existing management and logistics systems fully, and b) to build chain traceability through trust and willingness to share information beyond the minimum legal requirements. A value chain mapping tool has been developed during this project, and has been used successfully during a risk assessment exploring possible entry points of uncontrolled materials into a global food value chain.

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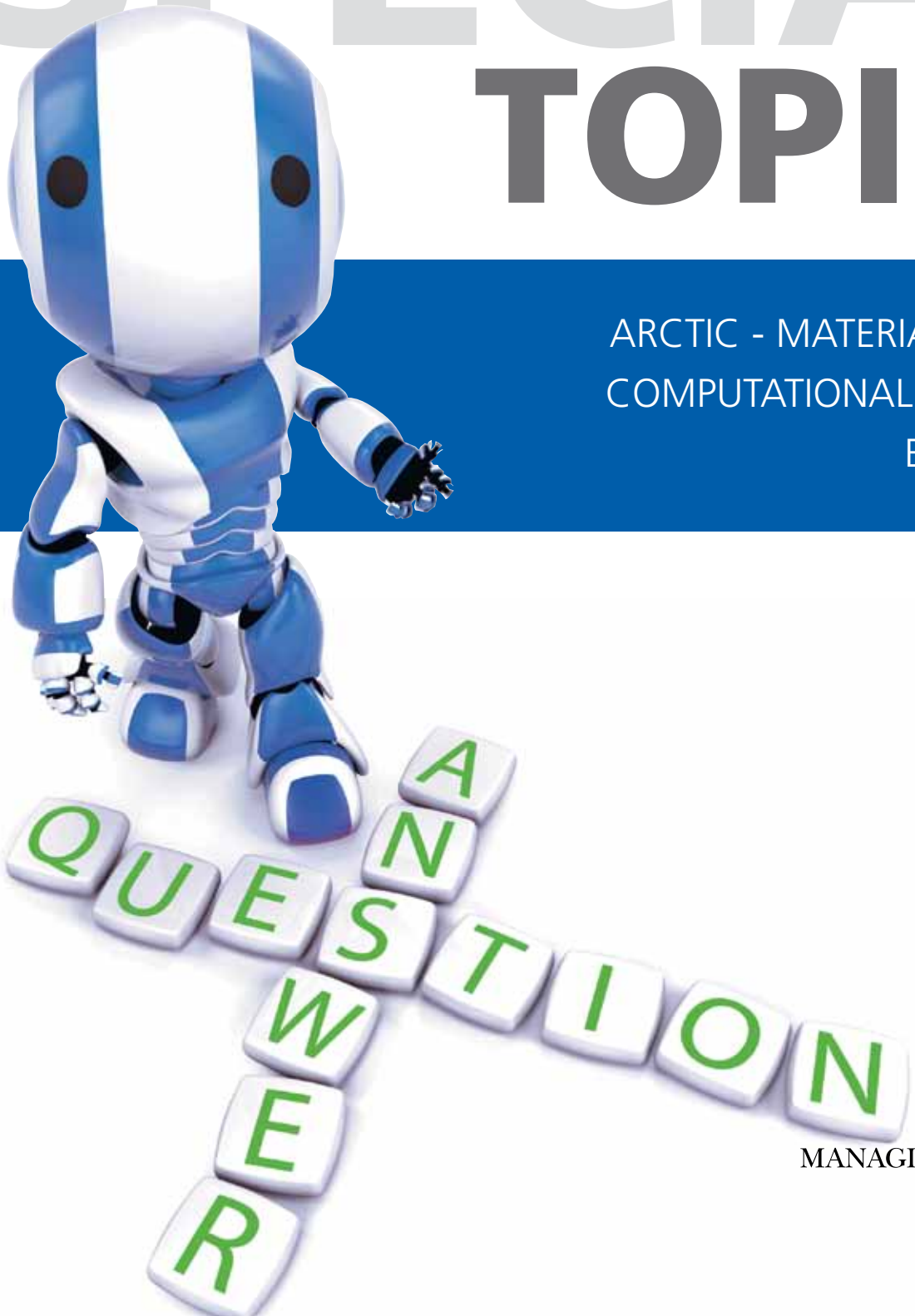
SPECIAL TOPICS

ARCTIC - MATERIALS - BIORISK
COMPUTATIONAL MECHANICS
EXPLORING IT



MANAGING RISK

ARCTIC TECHNOLOGY

A large proportion of the world's oil and gas reserves are to be found in the Arctic, and the effects of climate change are providing new possibilities for sea transport in this region. However, the extreme weather and harsh environmental conditions pose major challenges to the industry. DNVRI is addressing important issues for safely pushing back the Arctic frontier.

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MARICE - Marine Icing

Reduced ice cover, resulting from climate change, could open up the Arctic to oil and gas development, and also a new shipping lane between Europe and Asia. With these possibilities the risk of icing is likely to increase, and the industry is likely to pose questions that the engineering and scientific communities may find difficult to answer.

Icing is defined as the ice that forms from sea spray or precipitation hitting a ship or other structure. It has long been a hazard for vessels, particularly small ones, in cold regions. The consequences of icing include stability and safety problems. Instability is known to occur when large masses of ice accumulate on decks and structures. The safety of personnel is at risk when gangways become slippery, when escape routes become inaccessible, or when ice accumulates above working spaces and may fall on personnel. Additionally, emergency equipment, such as rescue boats, may freeze into place and be difficult to launch.

MARICE is a research project with the overall objective of providing predictive tools for, and mitigation measures against, atmospheric and sea spray icing for activities related to oil and gas fields, including associated ship traffic. Emphasis will be directed towards the ocean areas to the north of Norway and Russia. The tools will be applicable to design, as well as operational planning, and the work will be conducted both as field and laboratory trials, and by developing computer models. This will include improving models for predicting the amount and location of marine icing, collecting field data for calibration and verification, and improving anti-icing and de-icing technologies. The results will be implemented in codes and standards, as well as in a navigational system designed to assist in avoiding icing by strategic rerouting.

The project will be headed by DNVRI. Partners in the project include SINTEF, NTNU, and Jeppesen Shipping. Cooperation with research institutes in the US and Canada, where similar problems occur, has also been established.

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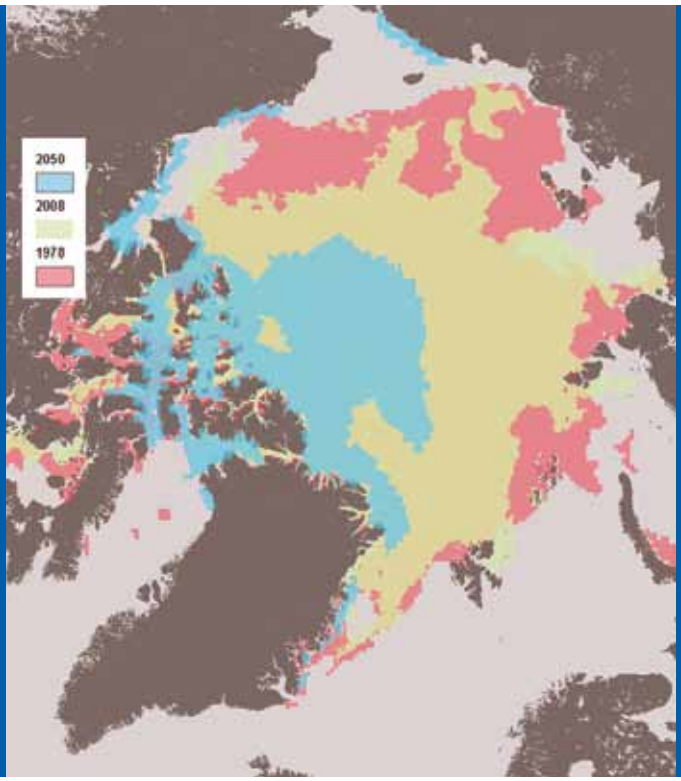

Polarcross

Reduced ice cover in the Arctic, caused by climate change, has encouraged speculation that the Arctic Ocean may open as a shipping lane. This possibility, combined with the expectation that much of the undiscovered oil and gas reserves are located here, has led to rapidly increasing interest in the potential for developments in the Arctic.

The aim of the Polarcross Project is to study how future changes in ice conditions may affect petroleum and shipping activities in the far north. This will be achieved by extracting ice information from one or several climate models used by the Intergovernmental Panel on Climate Change (IPCC). The various forecasts will be used to define ice cover scenarios and to evaluate potential advantages and impacts of, for example, choosing a route across the North Pole instead of a southerly route through the Suez Canal. The potential impacts on future development of oil fields in ice-infested waters can also be evaluated for each scenario. As the models have been run with a range of assumptions regarding the IPCC emission scenarios, it will be possible to consider different possible outcomes of global warming and ask "what if…?" questions relevant to our activities.

A ship simulator for ice-going ships will be developed. Ice transit simulation can be used to estimate transit times, power requirements, fuel consumption, emissions, and transportation efficiency of most vessel types in various ice conditions. The aim is to develop a transit simulator for ship transit in ice that can be used as an internal research tool. There is no such tool available in the marketplace today, which can be readily used by DNV.

POLARCROSS will be conducted in cooperation with national and international institutes. A panel of internationally-recognised experts on ice and climate change was established in 2008 and will continue as advisors to the project. The simulator will be developed in close collaboration with Norwegian and Finnish experts.

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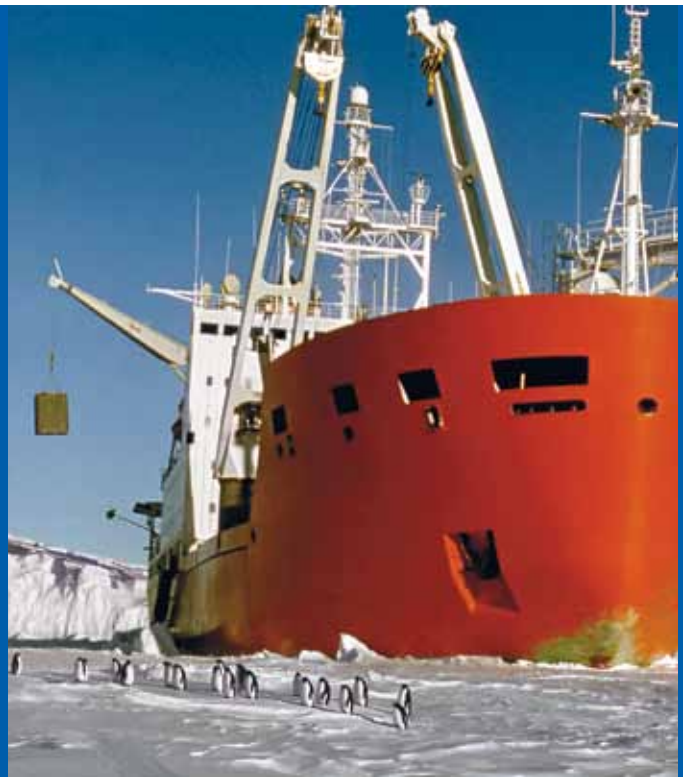
ARCTIC TECHNOLOGY



Ice load monitoring makes Arctic navigation safer

A three-year research project initiated by DNV has led to the development of an ice load monitoring system that provides bridge personnel with real-time information about the actual ice loads on the ship's hull and shows satellite information about ice on the vessel's planned course, which is integrated into electronic navigation maps.

Shipping activity in ice-infested waters is increasing and seasonal variation, combined with the effects of climate change, can provide new business opportunities in Arctic waters. But both the ship and its crew are placed at risk if the actual ice loads exceed those that the ship was designed to withstand.
DNV is developing technological solutions to ensure that Arctic operations are safe and environmentally sound. The Ice Load Monitoring project is an example of how DNV identifies critical risks and then works to find mitigating solutions. The project culminated in 2008 with the development of a comprehensive decision support tool that has been tested over the last two winter seasons onboard the Norwegian coastguard vessel, KV Svalbard.

The system includes fibre optic sensors, which measure shear strain on the vessel's hull, and electromagnetic equipment, which measures the thickness of the ice at the bow. This information is analysed and displayed on the bridge. Additionally, meteorological and satellite data about ice on the route ahead of the vessel is integrated into electronic charts, allowing for optimum route selection. This project is the first in which the actual ice loads are monitored and presented in real-time at the bridge as a component of a decision support system. Extensive processing of the measured data, including calculation of the correlation between loads and other parameters, has provided valuable information and knowledge about the feasibility of such a system. The system is now ready to be installed, both for new buildings and for ships in operation.

The Ice Load Monitoring project was supported by the Norwegian Research Council. Other partners were Teekay, StatoilHydro, Light Structures, The Norwegian Meteorological Institute, C-map/Jeppesen, DNVRI, and the Norwegian Coastguard.

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Unified oil and gas standards in the Barents Sea

In the years ahead oil and gas exploration, production, and transport will increase in the Barents Sea. Authorities and industries, in both Russia and Norway, recognise the unique challenges to be faced here, resulting from very low temperatures, harsh weather, ice, icing, darkness, lack of infrastructure, and the special need for environmental protection.

A Russian-Norwegian cooperative project, Barents 2020, led by DNV and applicable in both Russian and Norwegian waters of the Barents Sea, was therefore launched in early 2008, with the aim to recommend standards for safeguarding people, the environment, and asset values. Phases 1 and 2 of the project were financed by the Norwegian Government through the Barents 2020 program. From the outset, a working assumption has been that operations in the Barents Sea shall be at least as safe as those in the North Sea. Through a thorough process of research, position papers, workshops, conferences, and negotiations the Russian and Norwegian project partners have now agreed to select the following 7 topics for further study in phase 3 of the project during 2009:

1. Prepare the basic list of internationally-recognised standards for use in the Barents Sea.
2. Recommend standards for the design of stationary offshore units against ice loads in the Barents Sea.
3. Recommend standards for risk management of major hazards on offshore drilling, production, and storage units operating in the Barents Sea, including fires, explosions, and blow-outs.
4. Recommend standards for evacuation and rescue of people from ships and offshore units, including standards for rescue equipment under the various conditions of the Barents Sea.
5. Recommend standards for the working environment and safety, related to human performance and decision making (human factors), for operations in the Barents Sea.
6. Recommend standards for safe loading, unloading, and ship transport of oil in the Barents Sea in order to minimise the risk of accidental oil spills.
7. Recommend standards for operational emissions and dis charges to air and water in the Barents Sea.

This work will be presented at a conference in Moscow in December 2009, and the final report submitted to the relevant authorities.

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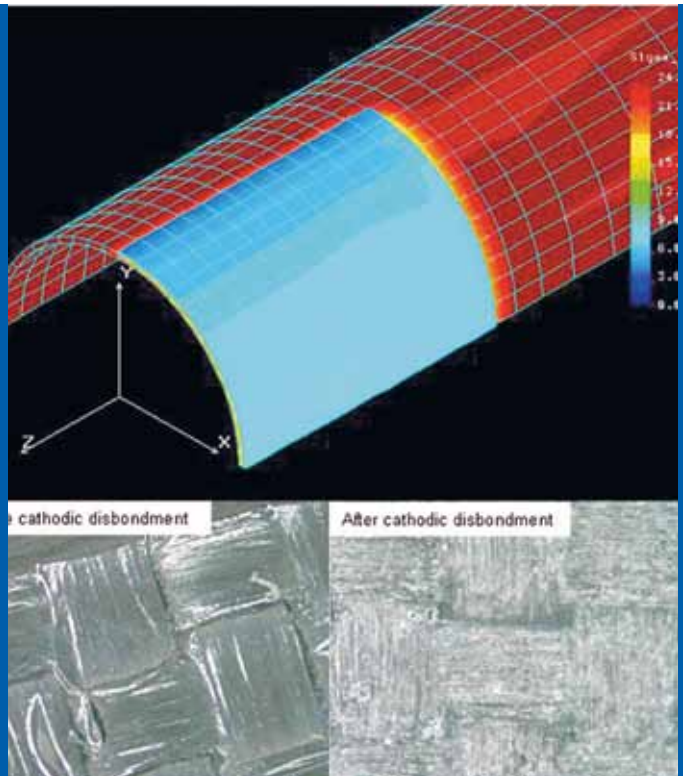
MATERIALS TECHNOLOGY

Materials technology is an integral part of managing risk for equipment, processes and systems in general. Expert knowledge is required to be able to understand the challenges and provide solutions. DNV R&I is exploring the possibilities of using sensor technologies to dynamically monitor and evaluate the risk status. We are also assessing the impact of new multifunctional surface technologies on safety and life cycle cost of maritime installations. Furthermore, DNV R&I is developing tools for assessing the safe use of nanotechnology.



Repair of metallic structures with composites

Composites are used to reinforce metallic structures in marine, infrastructure, and underground environments. The performance of the entire metal-composite system is addressed with regard to corrosion of the substrate, water intrusion at the composite-metal interface, and adhesion loss on the metal surface or within the composite itself.

DNVRI is involved in a research programme to evaluate the use of composite repair patches for pressure vessels, as an alternative to welding. We have shown that a patch repair introduces a discontinuous stress profile in pressure vessels, and although the composite may reinforce a defect in the substrate, stress discontinuities at the interface at the edges of the patch must be accommodated. A patch may be most suitable for using in systems with a reduced pressure rating.

Metallic structures in corrosive environments are protected by cathodic current. In studies of coating disbondment, it has been found that coatings lose adhesion due to the formation of an alkaline environment created by cathodic reduction of dissolved oxygen in water, usually near a defect in the coating layer. As the environment becomes more alkaline, organic polymers in the adhesive layer dissolve. The formation of the alkaline environment is cyclic and self-supporting as the disbondment around the defect spreads. Since fibre-reinforced composites use adhesives and polymers as matrix materials, cathodic disbondment is of concern whenever cathodic protection is applied to structures with composite repairs.

Defects likely to occur with composite materials may be voids in the matrix or following an impact from an external force. Depending on the impact strength, damage tolerance, homogeneity, and composition of the polymer matrix, cathodic disbondment can threaten the integrity of structures reinforced with composite repairs by reducing the integrity of the repair itself. Carbon fibre repairs, in particular, introduce an additional variable because of their high conductivity, and it has been found that cathodic reduction can occur over the entire surface of carbon fibre in contact with the electrolyte.

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The SHARP project

The SHARP project (System Health Assessment Using Remote Platforms) will focus upon wireless sensor technology, embedded sensor networks, and dynamic risk and reliability assessment and modelling. It will address systems that are highly heterogeneous, and spatially or geographically extended, and that change with age or over time.

The market is moving rapidly towards using advanced sensor technology, in combination with wireless systems, for real-time monitoring of a range of different operational parameters (e.g. temperature, strain/stress, fatigue, corrosion, CO_2, water content) of complex systems, including onshore and offshore installations, subsea installations, refineries, ships, nuclear plants, aircraft, buildings (high rises), windmills etc. The key objectives for this drive are a) to obtain more reliable data, which take into account real-time process variations (either stochastic or deterministic natures of events), and b) to reduce the number of people needed to work at particular sites (e.g. remote or hazardous workplaces).

By feeding appropriate information into more advanced Risk Based Inspection prediction models, the time-varying nature of, for example, environmentally-assisted failures could be taken into account. This information allows the status of the various parts of a complex system to be assessed on a continuous basis, which has the potential to result in considerable cost saving, maintenance optimisation, increased efficiency, increased reliability, and, in some cases, life-extension.

There are a range of potential services that DNV could offer to clients who use advanced sensor and wireless technologies. These services include: development of standards and recommended practices, aiding in selection and positioning of sensors, assessment of data gathered by sensor systems located on complex systems (e.g. refineries, pipeline and subsea systems, ships, and windmills), and data processing through appropriate risk assessment models.

The SHARP project started in 2008 and test cases will be identified in industries relevant to DNV, and that combine the use of sensor technology and real-time risk assessment.

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BIORISK

Biorisk Management is the management of risks where the principle hazard is a biological agent. DNVRI is exploring how risk assessment methodologies can be tailored to meet the unique challenges that these hazards pose in the environment of a containment laboratory. We have also been exploring modern concepts of security management and developing specific methodologies to assess biosecurity risks.

Biosecurity

The international Laboratory Biorisk Management Standard (CWA 15793) describes laboratory biosecurity as: "the protection, control and accountability for biological agents and toxins within laboratories, in order to prevent their loss, theft, misuse, diversion of, unauthorized access or intentional unauthorized release".

Concern regarding the threats posed by biological agents is a major driver that is changing the way these agents are handled and stored in biological containment facilities, and impacting on how these facilities are being regulated. Our research activities aim to develop our competence further in this emerging area for DNV, to enable us to supply a world-class service.

DNV has a systematic and holistic approach when assessing biosecurity needs at containment facilities. Laboratory biosecurity should be underpinned by good laboratory biosafety practices. Biosecurity and biosafety should, moreover, be managed under one integrated Biorisk system at the respective facilities. Biosecurity is, however, more than simply an extension of biosafety measures. Rather, optimised biosecurity measures require dedicated tools, efforts, and funds, as well as appropriate competence.

DNV is responding to the increased interest in laboratory biosecurity in several ways, including the development of tailored threat assessment methodologies, exploring how laboratories can improve organisational robustness, and examining why conflicts between biosafety and biosecurity measures can occur and how these may be identified and managed.

A knowledgeable and trusted co-worker with malicious intent is perhaps the most dangerous threat to any organisation and this is equally true for laboratory environments. DNV has been exploring personnel reliability issues and has developed a course designed to build awareness and explore approaches to managing this sensitive and difficult issues.
Effective biosafety and biosecurity management are critical issues with respect to supporting the Biological Weapons Convention. DNV has worked closely with the Norwegian Ministry of Foreign Affairs to help develop approaches based on international standards that can be used to build capacity in developing countries in these critical areas.

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Preparing businesses for pandemics

Experts at the World Health Organisation believe that the world is now closer to another influenza pandemic than it has been at any time since 1968, when the last of the previous century's three pandemics started. DNV has been exploring how businesses can develop business continuity plans that take into account the unique challenges that such a pandemic are likely to bring.

In 412 BC, Hippocrates described the first influenza pandemic, and since then the world has suffered regular pandemics, of which 28 have been described since 1580. The last serious pandemic, caused by Spanish influenza in 1918/1919, resulted in an estimated 40 million deaths and gave the clear message that not only are such pandemics likely to be severe, but also that their effects are likely to impact far beyond the boundaries of the health sector.

From an empirical perspective, the next pandemic is now overdue, and one high-profile candidate virus, H5N1, which might lead to a new pandemic, has been circulating in the avian population since 2003 and has caused over 250 human deaths already. As a response to this imminent threat, many countries have developed national pandemic preparedness plans. However, in much of the private sector awareness and preparedness appear to be less developed. The uncertainty around the exact nature of the next pandemic means that many business continuity management decisions will need to be reviewed, or even taken, during the actual crisis. However, it is also critical that plans are developed before the pandemic starts, when time is available, when stakeholders can be consulted, and while key resources, such as cleaning equipment or protective clothing, are still readily available.

In order to help our customers prepare for a pandemic, we have developed a Pandemic Influenza Business Continuity Assessment tool, based around the structure of the Business Continuity Management System Standard BS25999, and containing specific information extracted from the scientific literature, and from available guidelines and best practices. This tool has been tested in-house and will be used to continue a structured exploration of which measures are appropriate for organisations to implement before the next pandemic starts to spread, in order that their staff and businesses are suitably and adequately protected.

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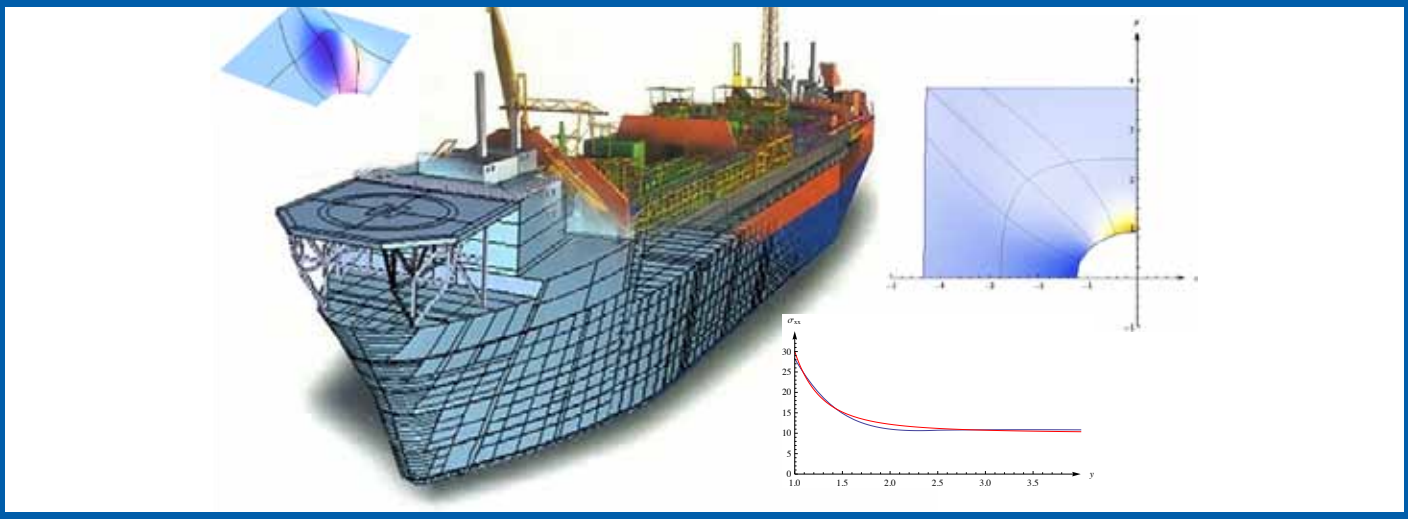
NEXT GENERATION COMPUTATIONAL MECHANICS

DNVRI is increasing its efforts to ensure that DNV remains an international leader within the field of Computational Mechanics (CM) for structural, fluid, and fluid-structure applications. The primary targets are next generation methods and tools.



Isogeometric analysis

DNVRI has joined two projects addressing so-called "Isogeometric Analysis". The projects, Exciting and ICADA, address exact geometric representation of objects being considered, throughout their entire chain of design, simulation, optimisation, and lifecycle management.

Both Exciting, a 3 year project within the EU 7th Framework Programme, and ICADA, a Norwegian Research Council project addressing advanced structural analysis of thin-walled structures in marine applications, are aiming towards a seamless integration of modelling and simulation through the concept of isogeometric analysis. The gap between CAD and simulation tool geometry, in particular the geometry in Finite Element Analysis (FEA), introduces a complex, time-consuming, and error-prone mesh generation process. Simulation methods that simplify the mesh generation process, by eliminating the need to communicate with the CAD geometry, hold great promise for the future. In this respect, the isogeometric analysis concept generalises and enhances the FEA on various issues including exact representation of geometry, simplified mesh generation, and mesh refinement.

The strategic objectives of Exciting are to establish a new class of computational tools in fluid and structural mechanics based on the isogeometric concept, to achieve a seamless integration of CAD and numerical simulations, and to establish a proof of concept through a number of pilot industrial applications.

The ICADA project complements the Exciting project regarding the analysis of thin-walled structures in ship applications. The project targets a more robust and efficient transfer of models between design and analysis, and making adaptive spline finite element methods suitable for practical use in industry.

The method considered in the projects is still in its infancy; only the future will show whether the current and widely-used FEA can be replaced by an even more powerful and efficient technique, such as the isogeometric method.

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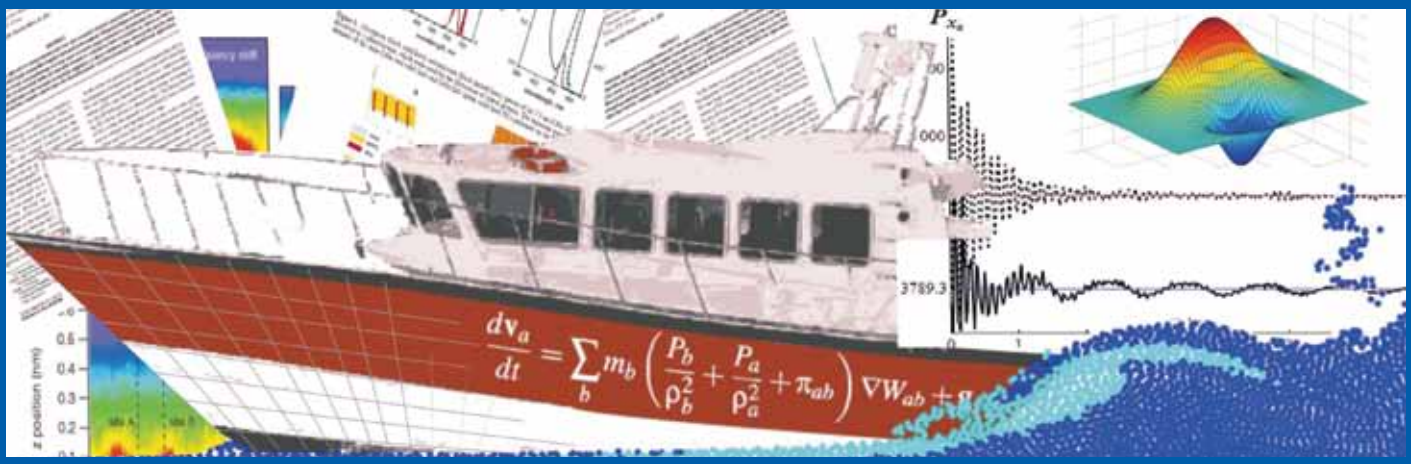

To mesh or not to mesh in DNV?

Many applications in DNV include considering turbulent behaviour of free fluid surfaces, and considerable effort has been directed towards how such problems can be simulated effectively. The limitations of the classical mesh-based methods have been addressed by the development of meshfree and particle methods, and our goal is to assess whether these methods have the potential to be used by DNV as strong mathematical tools.

In the fields of computational fluid dynamics and fluid structure interactions, considerable effort is directed towards effective simulation of important problems involving free fluid surfaces that are subjected to large deformations. This phenomenon is an integral part of many DNV applications including bow slamming, sloshing in LNG tankers, and green water on ship decks.
In the classical numerical methods all the information (velocity, pressure, etc.) are connected to a fixed, or updated, reference mesh. However, when large deformations occur in a problem, it is difficult to apply the mesh-based methods as they suffer from severe distortion of the background mesh. Thus, a large proportion of the overall computational effort, especially in three-dimensional simulations, is expended on secondary technical details, such as mesh generation and refinement.

The meshfree and particle methods have been developed to address the limitations associated with meshing. The original goal was to modify the internal structures of mesh-based methods and build new approximation tools using a set of scattered points (particles) without applying the mesh connectivity between them. Thus, the free interface is represented by a group of particles which can move freely and can be easily tracked.

The meshfree methods are particularly attractive for investigating problems of fluid dynamics with non-linear behaviour, but are still under intensive research and development. There are approximately 100 different schemes which can be classified as meshfree or particle methods, and three main representatives of these have been chosen for investigation within the project "Next Generation Computational Fluid Dynamics and Fluid Structure Interactions". Our goal here is to assess the potential of these methods as strong mathematical tools for industrial simulation of the behaviour of fluids and structure-fluids in highly nonlinear problems.

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EXPLORING IT

The world has glimpsed only the beginning of an IT revolution. Individuals increasingly expect to have information available at the fingertips. Production, manufacturing, and businesses increasingly rely on advanced IT. The complex infrastructures behind this inherently imply risks to society, businesses, and individuals. DNV must develop competence and services on such risks. Simultaneously, huge gains could be made from better use of IT to support DNV's services, automated surveillance being just one example. New services can emerge from trusted roles in digital value chains.

Information security

Borderless accessibility to information also implies borderless crime. Information is at risk, not only because IT systems can fail, but also because they can be attacked. As society and businesses have become ever more dependent on functioning IT systems, the risk of cyber attacks can no longer be neglected.

DNV BA is one of the world's leading actors in certification of ISMS (Information Security Management System) to the ISO 27001 standard, and provides extensive consultancy in the same area. The rationale behind such services is basically that quality and inventory of processes are the most important factors in information security; technical security countermeasures will only work properly when used as components in a complete system that includes these organisational measures.

DNVRI operates a cross-programme security focus area to improve DNV's approach in security risk management, where security is defined as protection from deliberate, human-initiated attacks. Information security is an important part of this work, as information may be a critical asset to an organisation, and information about physical assets also must be secured, along with the assets themselves. The results may considerably enhance DNV's information risk management services, particularly in cases where information security must be considered alongside other security issues, such as physical protection and personnel security. The key words here are "required" and "sufficient". Security must be adequate, but over-securing is costly and also may be intrusive.

A major challenge in information security is to determine the appropriateness and efficiency of the countermeasures implemented. ISO 27001 certification provides some knowledge on these issues, but is limited in range. Further research could investigate maturity level assessment for information security.

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The digital time bomb

Did you know that together we will produce 988 billon gigabytes of digital data in 2010? That is about six times the amount of digital data produced in 2006. Over the next 3 years, we will generate the same amount of data as was produced in all the preceding years put together. Clearly, digital information management is one of the main challenges of the future.

The sheer volume of data generated today demonstrates that we must learn to select what to store and preserve for the future. Data can be ranked as: legal (compliance); must have; nice to have; and not so important information. However, storing the data is useless unless it can be managed, found, read, understood, and relied upon, over time. Today we are able to read the Rosetta stone, but we are unable to read information from the East German Robotron computer (see picture above) from 1990. There is a digital disease with symptoms which may include:

a) File format obsolescence
b) Lack of information traceability over time
c) Loss of important information

At the core of DNV's research in this area is LongRec, a 3-year project led by DNV, and including several Norwegian partners, as well as being linked to the global InterPARES 3 project. This research will strengthen DNV's services in information risk management.

Notable investigations include:

a) A Digital Safe service, with BBS as technology partner, providing secure and managed storage of particular information records, and to be tested with pilot customers in 2009;
b) A service for maturity assessment of an organisation's ability to manage information over time;
c) A system for mapping and maintaining (legal) compliance requirements over time.

This work is also tied to information security and interoperability as described elsewhere in this Research Review. The Digital Safe and compliance management are both examples of DNV as a provider of automated, on-line risk management services, an area that complements and adds to DNV's current, largely manual services.

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EXPLORING IT

Safe and reliable software-intensive systems

Powered by the desire for more efficient work processes, more integration, and increased automation, software and IT systems are becoming increasingly complex. In most industries, systems seldom operate in isolation, but share functionality and information.

There is an increasing trend to integrate formerly separate domains of industrial and enterprise software. As the complexity of systems increases, so too does our dependence on these systems. We require systems that we can trust, systems that are reliable, safe, and secure. In other words, we need systems that always act consistently, and will behave as we expect them to do.
When business processes are tightly integrated, this tends to impact on associated systems. Not only does system malfunction irritate the users, but, more importantly, it may case severe consequences such as loss of hydrocarbon production, or propulsion/steering failure on a ship. Such events might result in enormous economic losses, as well as endangering human lives and causing environmental damage.

DNVRI has been working with software safety, reliability, and security for several years. In 2008, we finalized a Joint Industry Project (JIP) funded by DNV, together with Kongsberg, Valmarine, ABB, Meyer Werft, Aker Yards, Wärtsilä, Bjørge, and the Research Council of Norway. The project investigated challenges related to increasing software-intensive systems with critical functions onboard ships. Also in 2008, we kicked off the GoICT project. The vision of GoICT is to develop recommendations and best practices for engineering and cost-effective development and qualification of software-intensive technologies in the energy sector. The results of the GoICT project will also be useful for the maritime sector.

The overall aims of the project are to reduce the probability of hydrocarbon production flow stop and to decrease the risk of harm to humans caused by software malfunction. GoICT is a 3.5 year JIP financed by Cisco, DNV, FMC, Invenia, IO Centre (NTNU), Kongsberg, Norwegian Defence, OLF, PTIL, SAS Institute, StatoilHydro, and the Research Council of Norway.

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The meaning of 0 and 1

Even when you can find, read, and trust your data, you still need to be able to understand them properly before they are useful. The quest for semantic interoperability arises when data are shared or used in communications between business processes. Frequently there is a lack of clarity to the intended users and their IT-systems about how the shared or exchanged data are to be interpreted.

For an enterprise to be successful in business it must be able to transmit (or share)

- the data (or records) themselves, and
- a description of the meaning of the data that is accurate and clear enough to enable correct use of the data

The term "semantic interoperability" is often used to mean the ability of two or more computer systems to exchange information, and that the meaning of the information exchanged is automatically interpreted by the receiving system with sufficient accuracy to produce useful results, as defined by the end users of both systems. In addressing questions on interoperability and focusing on the meaning-layer of interoperability, we should bear in mind that information is always about things that are objects in the real world, in the widest sense of the words. For example the information can be about concrete objects (such as persons or pumps), or about abstract objects (like a certificate or a particular salary). Semantic interoperability is firstly about being able to refer unambiguously to the objects about which there is information. Secondly, it is about being able to identify those properties that we ascribe to the objects when we represent information.

DNVRI has activities in the Longrec and Semicolon projects which are related to establishing semantic interoperability by use of different semantic technologies and models. Semantic technologies provide tools and methods to build more adaptive and flexible software by exploiting the meaning of the information at hand. Lack of semantic interoperability is an obstacle to cooperation between businesses and/or regulatory bodies, regardless of whether the information use and exchange is electronic or based on other means.

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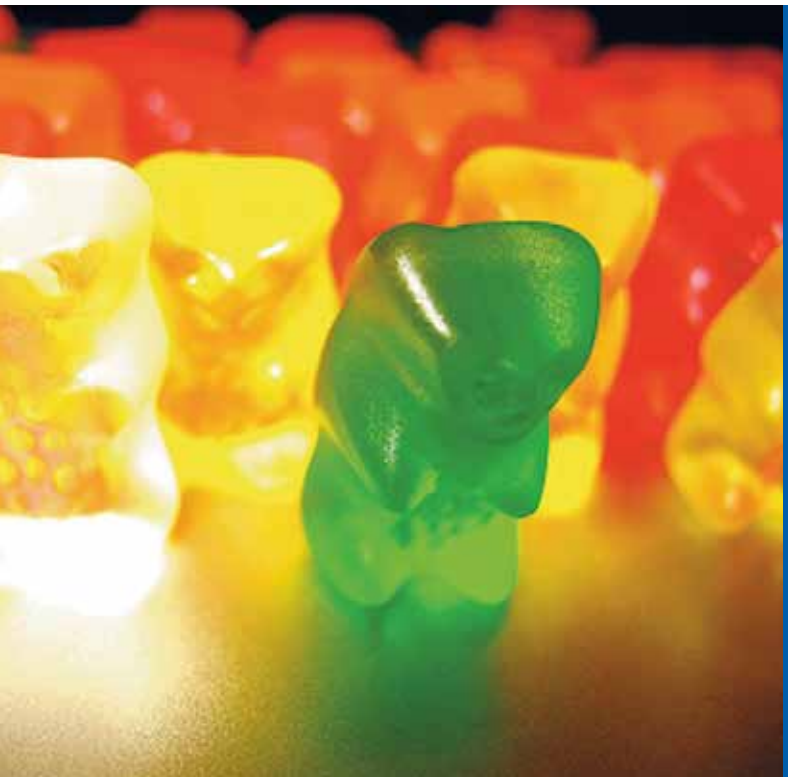
EXPLORING IT



Green IT and sustainable IT services

Evolving laws, regulations, public scrutiny, and the visibility of climate change effects have together driven corporations to add climate change issues onto their agendas. From this perspective, DNVRI and ITGS initiated the Green IT project as a foundation for research and service development to reduce greenhouse gas emissions from ICT production and use.

Climate change is recognised by DNV as a growing challenge which must be addressed. ICT is playing an increasing role in the climate change field as it can contribute directly (e.g. through emissions from ICT infrastructures), indirectly (through the use of ICT to enable green initiatives), and systemically (through impacts related to the social effects of ICT). Many information-intensive organisations have a growing need to understand and address ICT and sustainability in a wider context. Since the decisions of IT executives are usually driven or bounded by business strategies, they will be called upon to contribute to those strategies towards sustainability.

The resulting need for expertise in different domains is creating new opportunities for ICT (consulting) industries. By combining our expertise on climate change, sustainability, risk management, and ICT services, DNV has the potential to capture a large share of this emerging market, by positioning itself as an independent third-party advisor to organisations on planning, verifying, or executing their Green IT initiatives.

Some promising short-term certification and consulting service developments targeting ICT users and ICT industry include:

- Greenhouse gas (GHG) footprint calculation, reporting methods, and tools
- Analysis of ICT GHG footprint
- Sustainable purchasing processes (supplier management)
- Management of exposure to rules and legislation
- GHG supply chain monitoring, accounting, and reporting for the ICT industry

The initial services will be built on four pillars: a footprint calculation tool, a benchmark database, a sustainability readiness model containing a collection of best practices, and sustainable IT training courses for IT executives. With these services, ICT and business executives will be able to educate themselves, evaluate their current status, compare themselves with their peers, define their positions, and identify those practices that they should implement in order to achieve their intended positions.

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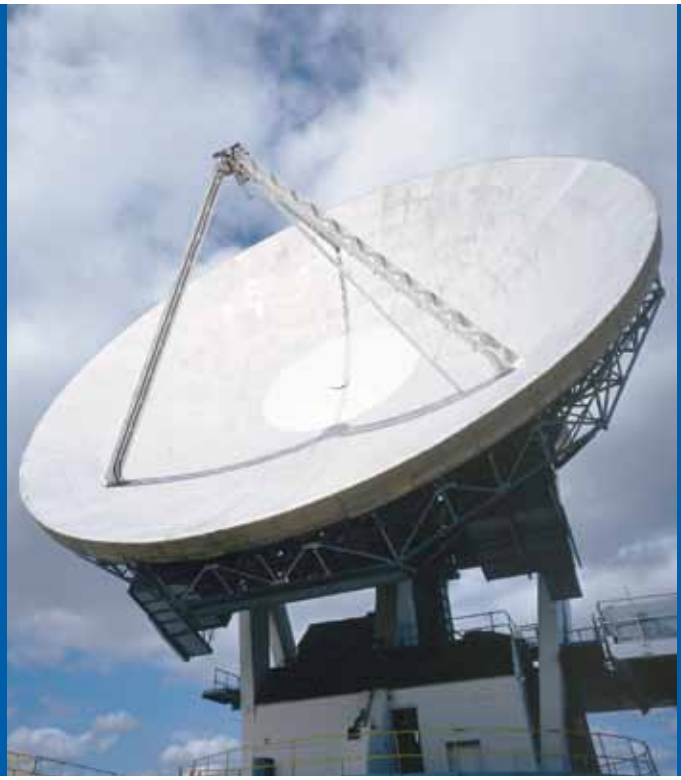
New ways for independent validation of software requirements

In all industries and areas of society, safe and robust operation of technical systems is increasingly dependent on reliable and safe software. Therefore, our abilities to assess, verify, and validate software-based systems is highly important.



Independent Software Verification and Validation (ISVV) is a quality practice intended to improve the quality of a software product through verification and validation by an organisation that is totally independent from the software developer.

The Space section within DNV Business Assurance has, in cooperation with other European companies, defined a unified ISVV process for the European Space Agency (ESA).

Of particular interest is how different types of modelling, e.g. based on the Unified Modelling Language (UML) in combination with software-oriented Failure Modes, Effects and Criticality Analysis (FMECA), can be used for validation of requirements. Validation in this context means to search for missing, incomplete or wrong requirements.

Requirement modelling and/or formalisation are effective ways of revealing unspecified behaviour with respect to possible input scenarios at an early stage of the project. The most common type of problem discovered is "total omission of credible input scenarios" in the requirements specification.

For verification of hard real-time requirements for applications using a multi-tasking operating system, DNV has applied a modelling tool based on Rate Monotonic Analysis (RMA), which can be used to assess whether an application will always perform according to its specified timing budget.

Criticality analysis, in the form of FMECA, combined with different forms of modelling result in the introduction of strong elements of early-stage validation into processes that are normally concerned with manual verification of written specifications. Thus, early introduction of such methods may eliminate or reduce the occurrence of downstream problems and therefore be cost-effective when considering the economy of the total project.

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EXPLORING IT

PROBAN - Probability from models

Proban was developed to answer DNV's need for basic structural reliability calculations. This programme calculates probabilities, crossing rates, distributions, and sensitivities from event and function models.

A function model is a state-of-the-art limit state function, together with the joint statistics for each of its arguments, load, material, etc. An event model is for example a union of failure modes. The user codes the functions and provides them in a DLL.

As the tools of Proban, which are a collection of analytical techniques and simulation methods, are general in nature, they are also of interest beyond Proban's originally intended application.

Therefore, DNV Software has initiated a project for equipping Proban with a new, intuitive, graphical user-interface, using the latest development tools. Top-down modelling of event models and function models have been implemented. All modelling is stored in user-defined libraries for easy application in other projects. The result viewer is able to obtain the result presentation separately from the Proban executable.

The aim of this project is to provide Proban as a component within the Risk Framework, DNV Software's generic framework for risk analysis.

The project also intends to provide the computational core of Proban as a library of methods that can be linked with other programs.

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Proper project control - better business margins

During the recent ship building boom, most ship builders were struggling with delivery capacity. However, the financial crisis has resulted in a new era for most ship builders, and efficient planning, lean production, and choosing the "right" projects will be crucial for healthy business margins.

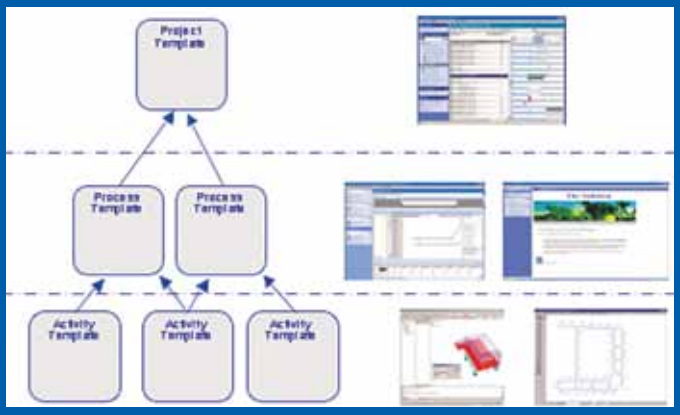

Figure hh: Consistent relationships provide possibilities for proper project control and efficient change management

DNV Software has developed a software system that enables yards to improve quality, reduce overhead costs, and increase engineering productivity by utilising the power of sharing best engineering practices in an efficient way throughout the entire organisation. Process templates and project templates are the cornerstones of the solution. A process template defines a business process with respect to its activities, conditions, application integration, and input/outputs. Process templates contain information about estimated man-hours and the duration for each activity, which is useful for initial planning. Process templates can be added to the system at any time and made available to its users.

A project template defines a project plan for a given project type by specifying the process templates that the project should handle. Different project types can be supported by providing several project templates. After a plan has been created, changes can be made to the plan to suit the specific project.

The solution developed encompasses the following main functions:

- Basic functionality for Project Planning
- Execution of activities in work processes
- Monitoring of progress of activities (deviation reports etc.)
- Management of Drawings, Comments, and Correspondence

A new building project cannot be covered by a single plan. Brix Project Manager enables a set of plans to interact within the main project, such as the main schedule, the production plan, the inspection plan, and the test plan. The system provides several perspectives within the plan, enabling the user to view it according to, for instance, SFI structure, discipline, work-package, or unit. Different users work with different perspectives. A single task can be displayed in one or several perspectives. Plans can be created by using project templates and process templates.

Contact: Elling Rishoff
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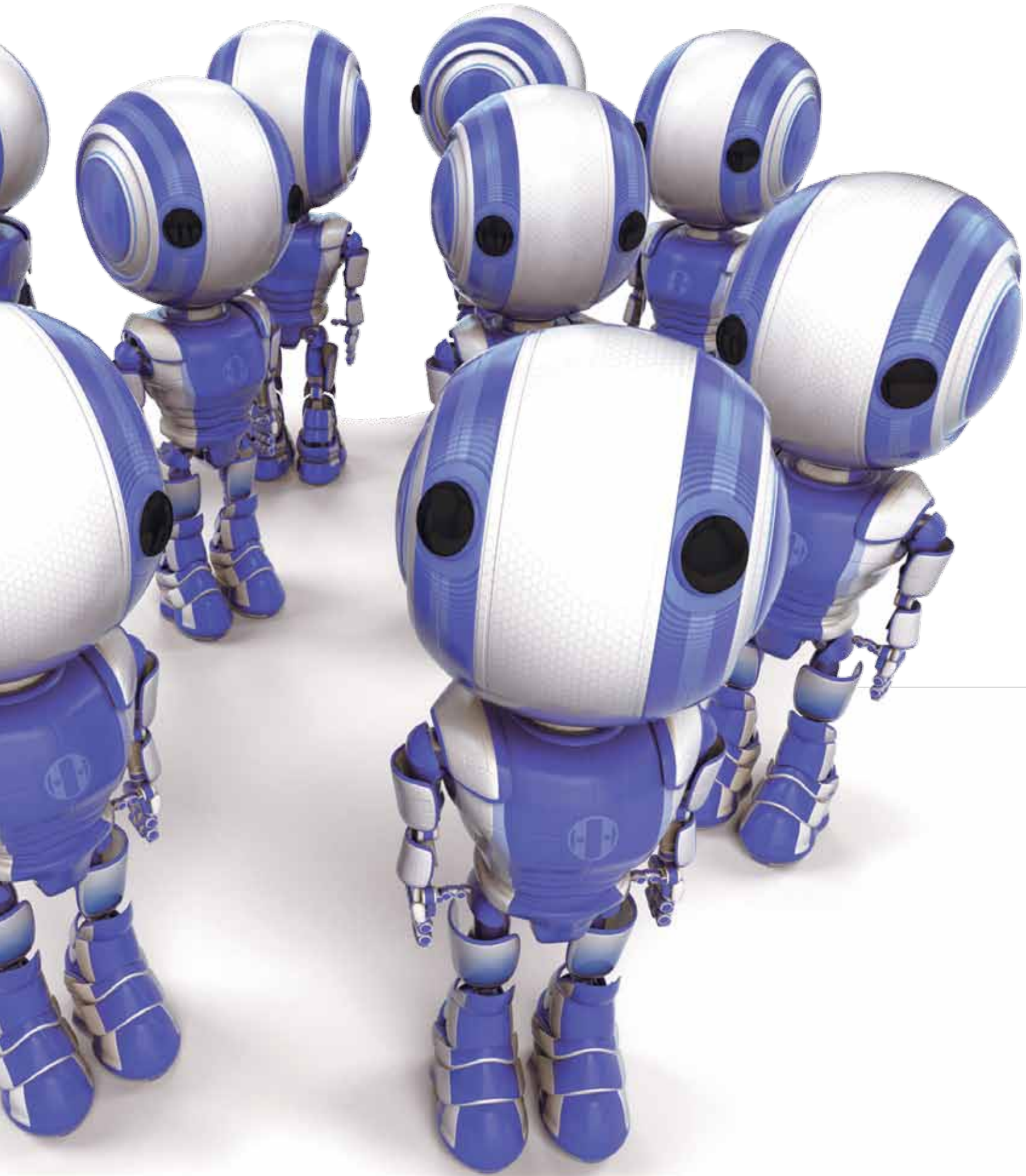
DNV FELLOWS

The main role of the DNV Fellow is to take care of the DNV core technologies. This is done through creation of networks across business areas. Establishment of communication channels and meeting places, identification of state-of-the-art, technology gaps, and the need for new tools and methods are all part of the scope of activities for the Fellows.

MANAGING RISK



Risk Management

Frank Børre Pedersen
Focus here is on describing and assessing the state-of-the-art in risk management. Emphasis is placed on describing the potential for improved and shared use of relevant methods and tools in DNV's technical and business risk management services, including common use of terms.

Managing risk is DNV's job and therefore the concepts of risk and reliability underpin most DNV services in all BAs. The Fellow role includes maintaining and further developing this core competence.

The focus areas for 2009 will be:

- Arranging the 3rd annual Risk seminar in Høvik
- Starting the work on "DNV's Risk Handbook"
  - Identify relevant standards and good practices
  - Overall description of methods
- Identifying "DNV's Risk network"
  - Will produce the Handbook
  - Participate in the Risk Forum 2009
- Internal networking and support

Contact: Frank Børre Pedersen
(frank.borre.pedersen@dnv.com)

Safety and human factors

Gunnar Hauland
Emphasis here is directed towards describing the possibilities for shared use of Human Factors (HF) methods and tools in DNV's service portfolio for analysing and managing safety performance. HF methods address the interaction between human, technological, and organisational factors.

Gunnar Hauland holds a PhD in psychology. He has more than twelve years working experience of performing applied psychological research and HF consultancy work, primarily within transportation and process control industries.

Safety Culture is a key topic in 2009, contributing to the alignment and further development of a common DNV approach to improvements in safety culture. A SharePoint has been established as a meeting place for the different branches of DNV offering such services. Please contact Gunnar Hauland if you would like to participate in this network.

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Computational Mechanics

Olav Rognebakke

Here, focus is on description of methods and trends within computational mechanics (CM) and their applications to loads, fluids, structures, and interaction problems, primarily within the maritime and energy sectors.

CM is an important element in the foundation of DNV Maritime, DNV Energy, DNV Software, and DNVRI. While each BA uses significant resources for developing own competence, services, and profile, the Fellow activities have been directed towards strengthening and sharing of competences and tools of common interest to several BAs.

Focus areas for 2009 will be:

- Computational Mechanics Workshop
  – A meeting ground for interested and competent DNV employees from different BAs and countries
  – Obtaining contributions towards an update of the White Paper by discussing appropriate content and delegating sections.
- Extending the CM sharepoint or creating a CM Wiki so that information, including papers, competence, experiences, and project ideas, can be more easily shared; maybe even value propositions for new CM-related services
- Mapping and publishing of CM-related competences among CM forum members.

Contact: Olav Rognebakke
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Materials and Sensors

Sean Brossia

The focus is on state-of-the-art and characterisation of important trends in materials technology, with emphasis on materials with particular relevance to DNV services. Attention is particularly directed towards the overall technical, functional, and environmental performance of materials, and on identifying needs for improvements within DNV regarding applications of materials technologies.
DNV currently has more than 250 experts within Materials Technology and Structural Integrity, in addition to large laboratory facilities (5 locations), which together makes DNV one of the most powerful materials groups worldwide.

Some of the key goals for 2009:

- Continue the successful collaboration through the Global Materials Forum. This event endeavours to assist in enhancing collaboration across DNV, such that, when it is beneficial for our projects and clients, we work together as a worldwide team.
- Continue the development and global role out of materials related training.
- Identify cutting edge research topics within materials.

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Energy

Stein Bjørnar Jensen
Focus here is on energy value chains, with emphasis on new technologies and solutions that may improve the efficiency and environmental performance of such systems. Energy storage, energy distribution, and mixing of energy generated from different sources are all components of energy value chains.

By definition, the DNV Fellow shall serve as organiser and key point of contact for core technology and competence networks within DNV. The role of the Energy Fellow is: "understanding and use of energy systems". DNV provides many services to the energy supply and energy intensive industries, but available competence in DNV on total energy systems is scattered and restricted, and our portfolio of "energy services" is also limited. The energy marketplace is changing, even as you read this. The two main agents of change could be appropriately named "security of supply of affordable energy" and "mitigating effects of greenhouse gas emissions". Both industries and authorities are actively involved in finding new solutions to these twin challenges, and there are probably many undiscovered opportunities for DNV across the BAs within this market arena. The Energy Fellow has therefore focussed on establishing a "White Paper for Energy" which can be obtained by contacting DNVRI.

The purpose of this White Paper has been to trigger discussions and provide background for further planning. Should you wish to participate in future discussions on this topic or contribute comments, please contact me directly or DNVRI.

Contact: Stein Bjørnar Jensen
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Environment

Tor Jensen
Safeguarding life, property, and the environment is the major objective of DNV, and therefore addressing environmental issues is of fundamental importance in our work.

The focus of this Fellow will be on improved environmental performance of human activities through utilisation of new technology, measures for reduction of pollution and overall environmental impact, and reducing our use of non-renewable resources.

The new vision of DNV, "Global impact for a safe and sustainable future" is, as Henrik Madsen states, "…..rooted in the belief that in addition to its long-term focus on safety and quality, DNV must prioritise addressing two of the world's most pressing concerns, safeguarding the environment and balancing the needs of business and society".

The main activities of the Fellow in environmental technology will be to enhance and improve collaboration and networking across the various BAs, and to utilise knowledge, methodology, and tools. Later, the production of environmental strategies with corresponding business plans will be encouraged. The production of a White Paper, based upon input from key stakeholders within our broad environmental services and product portfolio, will form the basis for this work.

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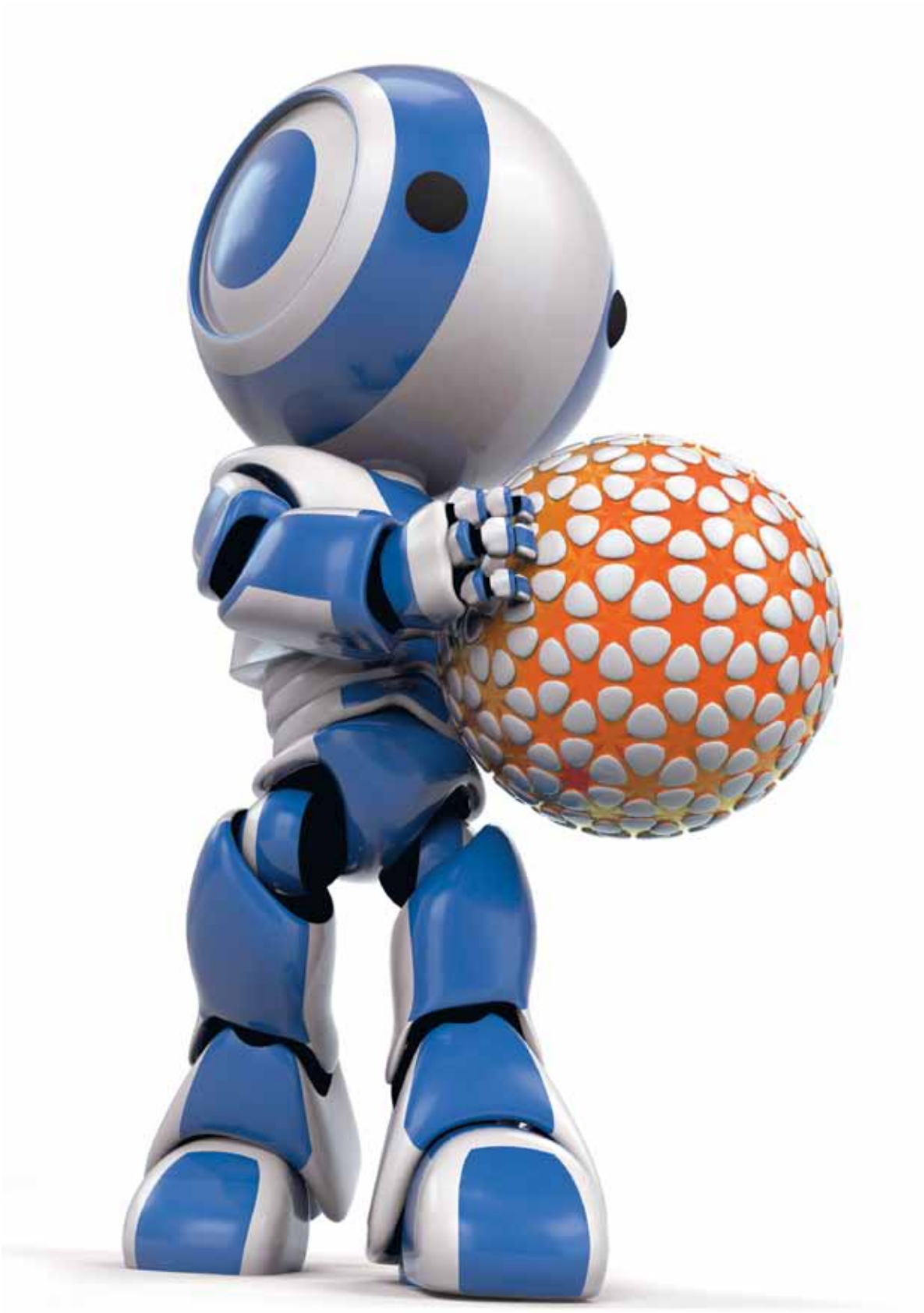

ICT

Arto Järvinen
Focus is on state-of-the art within Information and Communication Technology, ICT, how ICT impacts people, businesses and society at large, and how it can be used to improve our services and internal efficiency and effectiveness. As this is a fast moving area, it is important to spend a relatively large share of the time on tracking new technologies and trends. Also, due to the rapid development and the size of the total ICT area, it is necessary to concentrate on one relatively limited area at the time. The first such area was Free / Libre / Open Source Software on which I reported during 2008 ending with a seminar at Hövik in November.

The focus area for the first part of this year is Groupware (including Social Software). This type of software is mainly intended to improve collaboration and knowledge management across time and space. Good Groupware also has the potential to limit the need for travel and therefore to decrease adverse effects on the planet.

Some activities planned for 2009 are:
- Build a special interest network for Groupware.
- Continue reporting intermediate results through my blog at http://osl184/ICTFellow/default.aspx.
- Find and document existing good practices, both inside and outside of DNV.
- Create a discussion forum (one common type of Groupware) within ITGS and evaluate.
- Organize a seminar on the topic at Hövik.

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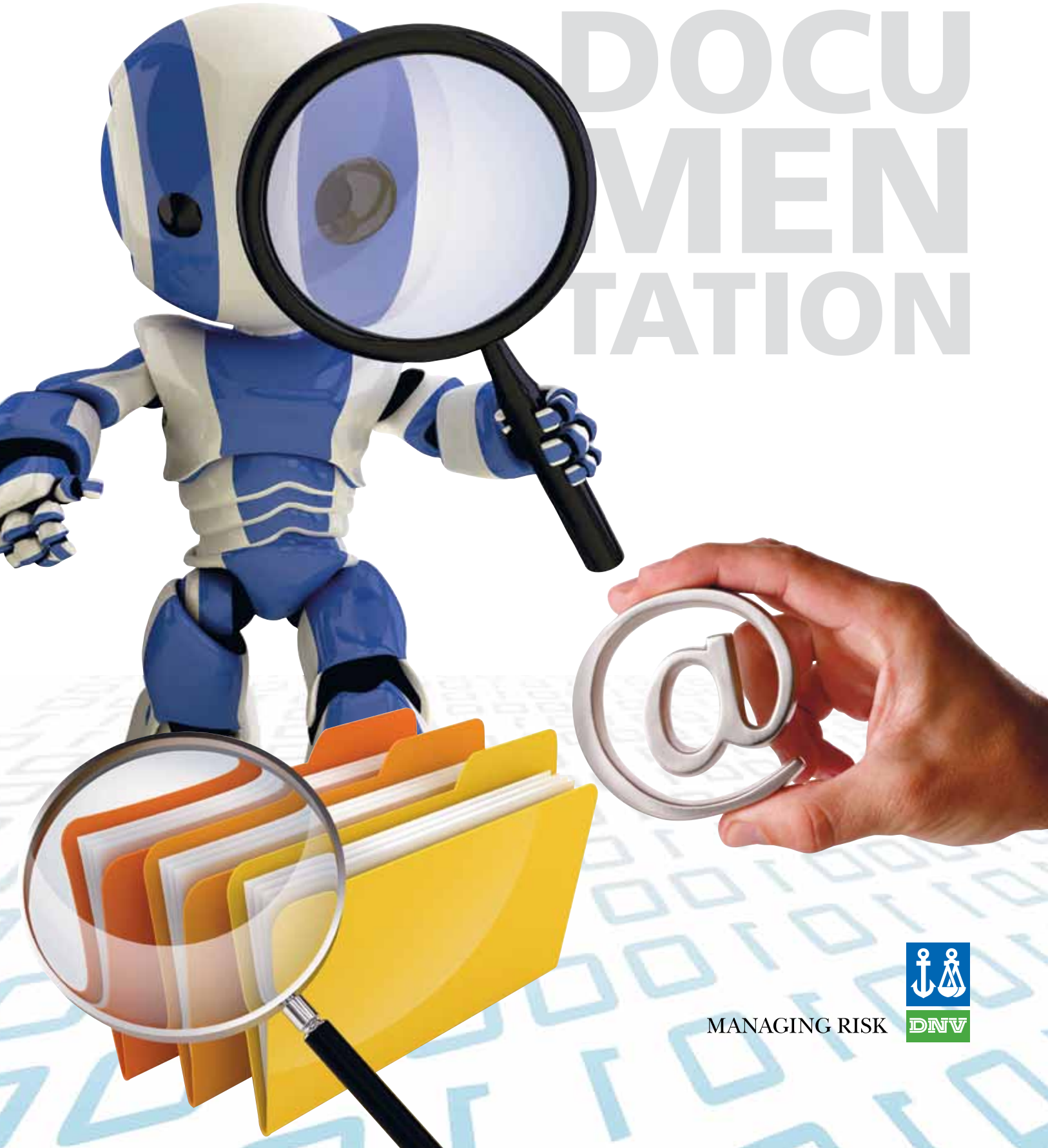
DOCUMENTATION



MANAGING RISK

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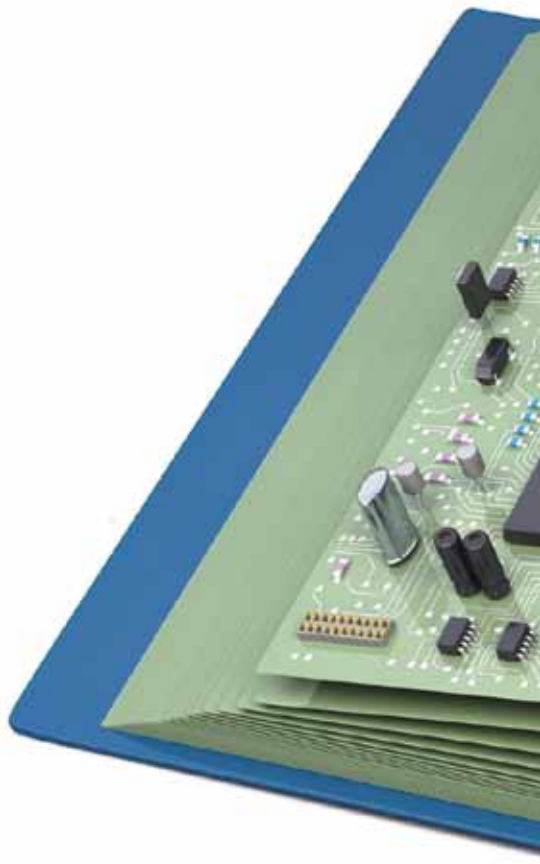

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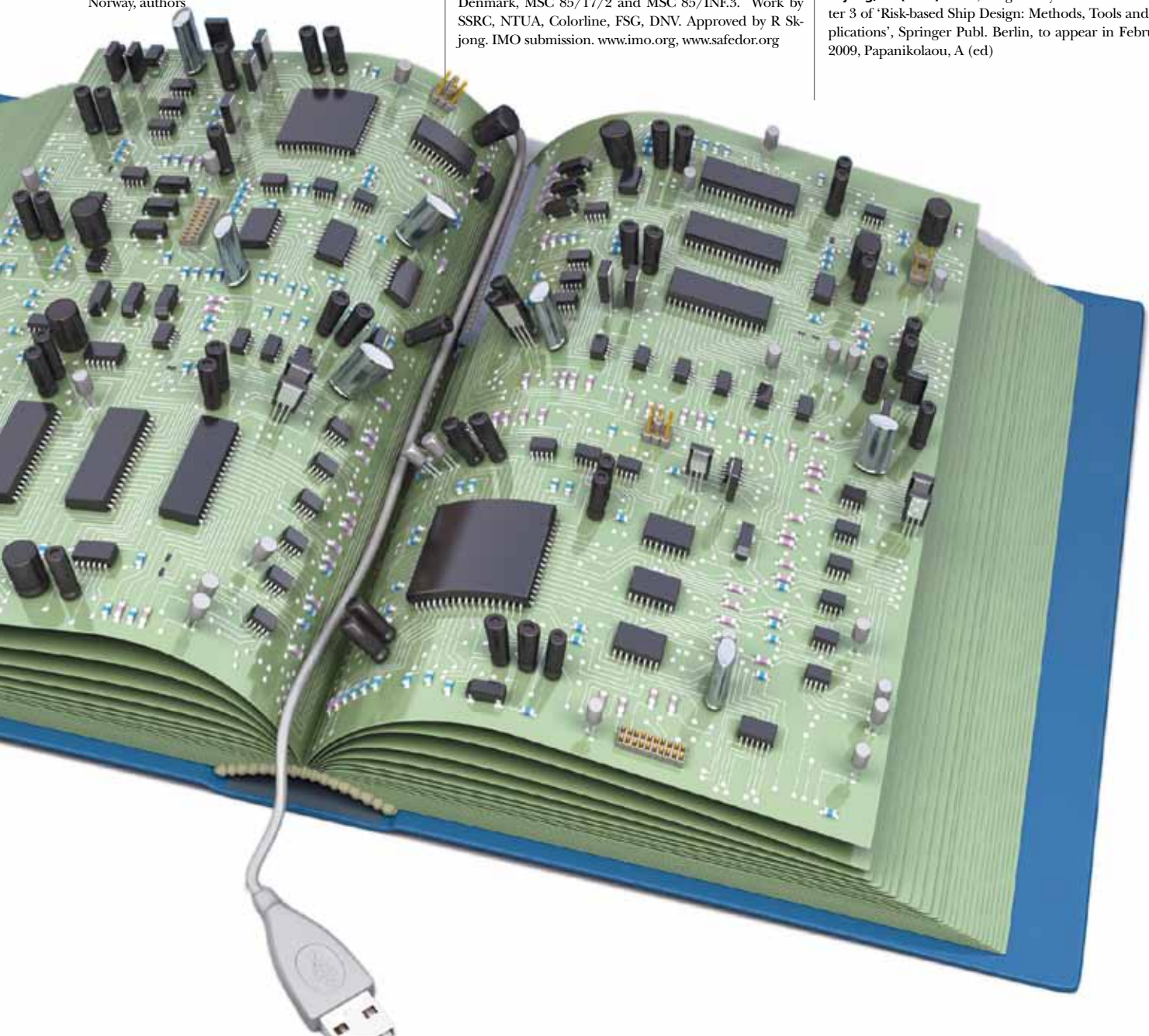

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