



PETROLEUM SAFETY AUTHORITY
NORWAY

The Deepwater Horizon accident

– assessments and recommendations for
the Norwegian petroleum industry

SUMMARY



Summary

A blowout, explosion and fire occurred on the *Deepwater Horizon* (DwH) mobile unit on the Macondo field in the Gulf of Mexico (GoM) on 20 April 2010. Eleven people were killed, a number suffered serious injuries and the unit sank after two days. The uncontrolled oil flow totalled more than four million barrels by the time the blowout was halted 87 days later.

Only eight months earlier, on 21 August 2009, a blowout occurred on the Montara field in the Timor Sea about 250 kilometres off the north-western coast of Australia. This blowout lasted for about 10 weeks and was halted with the aid of a relief well.

The Petroleum Safety Authority Norway (PSA) established an internal multidisciplinary project team in May 2010 to follow up the work being done in the wake of the DwH accident and to develop the best possible basis for the authority's supervision and other measures which could improve health, safety and the environment (HSE) on the Norwegian continental shelf (NCS).

The PSA's report builds on the investigation reports published so far, as well as a number of assessments of the accident by various professional bodies and various national and international processes.

This report falls into two parts:

- Part 1 presents the lessons learnt from the DwH accident which are significant for safety and emergency preparedness related to drilling and well operations on the NCS.
- Part 2 presents the lessons which are significant for preventing major accidents in general, and which are considered relevant for Norway's petroleum industry as a whole.

Investigations of the DwH accident published so far have not identified new underlying causal mechanisms or causes. A number of underlying causes are the same as those identified for the Montara blowout, and also reflect conclusions reached by investigations of serious incidents in the Norwegian petroleum industry.

The DwH accident cannot be confined to considerations which relate only to BP, Transocean and Halliburton, deepwater drilling, blowouts, the GoM and so forth. This incident raises issues which concern a whole industry, national regulation and international processes, and which are relevant for the prevention of major accidents in general. It must lead to improvements in Norway's petroleum activities as well.

This accident has demonstrated the need to assess a number of measures which can contribute to better management of the risk of major accidents, and many relevant measures are pointed out.

Where prevention of major accidents is concerned, the report from the US "National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling" (the presidential commission) assigns accountability to everyone who participates in and influences the petroleum industry. It addresses the accountability of the authorities by pointing to the need to assess regulatory requirements, official regulation/supervision, government organisation, collaboration between government agencies and operating parameters for these agencies so that they can meet all these expectations.

At the same time, it is quite clear that improvements at the government level will be far from enough to prevent major accidents in the petroleum sector, and that **in addition** a very different level of industry involvement is required – both to improve safety and to restore the necessary confidence in the sector.

The consequences of the DwH accident extend far beyond the possibility that drilling operations in the GoM could become 10-15 per cent more expensive. Based on extensive information about and analyses of the accident, the companies, the industry, the authorities and so forth over a long period

(back to the 1970s), the presidential commission has concluded that the errors in managing major accident risk which underlie the DWH accident are representative of what is possible in the rest of the industry and symptomatic of the prevailing safety culture throughout it. The PSA is of the opinion that the DWH accident must be seen as a wake-up call to the Norwegian petroleum sector, that it must lead to a big improvement in managing major accident risk, and that the conclusion that the safety culture needs developing throughout the industry must also be considered relevant for Norway's petroleum activity.

The DWH accident demonstrates the need for improved risk management and processes which lead to more **robust** solutions. These are ones which have built-in safety margins – a degree of slack – and which equip the industry to tackle human and technical error, operational non-conformities, unexpected conditions, the pressure of events and so forth. Robust solutions also contribute to the effective identification and management of hazardous conditions, and to ensuring that sufficient time is available to bring such conditions under control. The need for robust solutions applies to technology, capacity, expertise, organisation and management in every phase.

The Macondo blowout happened in deep water, while the Montara incident occurred in shallow water and with other challenges determined by its location. Norway's petroleum industry is diverse, and factors influencing risk can vary a great deal from area to area. That demonstrates the importance of a risk-based approach to the activity, so that safety and emergency preparedness measures can be adapted to the specific risk factors which apply in each case.

The GoM blowout underlines the need for an integrated approach to well barriers, including the principle of two independent and tested well barriers as well as barrier monitoring. The DWH accident confirms the importance of further development by the companies of performance standards for the various barrier elements. That relates to the level of ambition for these standards when establishing, testing, maintenance and monitoring barriers.

The accident also underlines the importance of temporary plugging and abandonment of wells. About a third of the wells temporarily plugged and abandoned off Norway have well integrity problems of one form or another. The DWH incident confirms that the industry must continue to give high priority to and intensify efforts to improve the integrity of temporarily abandoned wells.

No need has so far been identified for major changes to the requirements set for well barriers in Norwegian regulations. However, a requirement exists for high priority to be given to a thorough updating of the Norsok standards related to methods, technology and work processes for drilling and well operations, well design, the equipment and media used for barrier elements, well control and so forth to ensure that they reflect developments in technology, knowledge and best practice. It is also important that routines are established for regular updating of these standards.

An event like the DWH accident underlines the importance of being prepared for the unexpected and of detecting it when it occurs. Robust and appropriate equipment is one important factor, while the ability to handle safety-critical conditions is another. About 40 minutes elapsed on DWH from the initial indications that a well kick was coming until people reacted. Lack of information via screen diagrams, sensors and instruments, and inadequate use of existing data and equipment have been identified as contributory factors in this context.

Norwegian regulations require that personnel must be capable of handling hazards and accidents, and that provision must be made so that personnel with control and monitoring functions are able to acquire and respond to information efficiently at all times. In light of the DWH accident, it is considered natural that the industry collaborates to further develop, qualify and adopt technology and visual tools which permit real-time monitoring of well barrier condition and the maintenance of well control.

For use in its supervisory activities, the PSA has developed a method for systematic follow-up of barriers. This approach is also intended to help improve processes for systematic follow-up of barriers and well control both among managers and by the individual employee involved in drilling and well operations. The DwH accident confirms the importance of the PSA's continued development and clarification of the conditions for utilising this approach to supervision. It is also considered relevant to continue conveying this approach to industry, since it is also relevant for the companies' own evaluations, audits, training and exercises.

Norway requires well control equipment to be designed and activated in such a way that it takes care of both barrier integrity and well control. Although a failure of the blowout preventer (BOP) was not a direct cause of the DwH accident, it was an important contributory factor to the catastrophic outcome. Investigations and analyses of the BOP were still under way when the PSA's report was being finalised. The PSA has not drawn any conclusions about the standards to which BOPs should be designed and manufactured. However, questions can be posed about BOPs intended for the Norwegian petroleum industry.

The PSA takes the view that the lessons drawn from DwH must not be limited to the well control system which was in use on that unit, but must apply to all types of such systems. The PSA takes it for granted that modern barrier philosophy is applied to the continued development of standards, guidelines and requirements for following up and maintaining BOPs with their control system. A relevant consideration for the PSA will be to assess a clarification of regulatory requirements for blowout prevention, including intervention and seabed BOPs.

Today's requirements stipulate a risk analysis for the control system of a drilling BOP, with specified minimum requirements for its safety integrity level (SIL). As a result of the DwH incident and of the fact that blowouts are not confined to drilling operations, the question is whether such an analysis, with a specified minimum SIL level, should also apply to all types of BOPs, including well-intervention models. In addition, consideration should be given in this context to whether other control and management systems related to well integrity/control exist which should be subject to such requirements.

The DwH accident has demonstrated the need for the industry to develop efficient solutions as quickly as possible for halting and/or diverting the wellstream in the event of a blowout. This requirement also applies to the NCS, and high priority must be given to designing effective resources. A number of company groups and players in several parts of the world are developing arrangements for joint use of resources which can halt and/or divert the wellstream at source in the event of a blowout. Norway's regulations do not stand in the way of such joint resource use. It is important to have efficient plans for sealing wells and halting blowouts should this become necessary. Equipment, resources, procedures, plans, collaboration agreements and so forth must in place wherever a blowout is possible. Moreover, it is important that the resources are tailored to the relevant conditions expected in each case (reservoir conditions, regional factors and so forth). Every technical solution and activity which involves halting and/or diverting the wellstream at source in the event of a blowout with the aid of a system connected in some way or another to the well falls within the concept of petroleum activity, and accordingly comes under the PSA's regulatory authority. It could therefore be relevant for the PSA to assess the need to clarify regulatory requirements for such aspects as applications for consent, emergency preparedness and well control.

When the kick in the Macondo well developed into a blowout, it led to large volumes of gas on the unit. That resulted in two explosion because the fire and gas detection system failed to prevent ignition. The PSA will continue to emphasise that solutions chosen on offshore facilities are designed with as much robustness and inherent safety as possible. DwH and other accidents have shown that this could be crucial for preventing or limiting the scale of a major accident.

A review of applicable regulations, standards and industry practice on fixed installations and units is recommended, together with an assessment of the extent to which these set adequate requirements for ignition source control, positioning and adequate separation of air intakes in power generators,

emergency shutdown of drilling systems, dimensioning fire and explosion loads, and the use of probabilistic methods in relation to a specified minimum level of barrier performance. For its part, the industry should verify that mobile units have defined dimensioning fire and explosion loads, that these can be documented and that these are reflected in the design of physical partitions, review the shutdown philosophy on all mobile units, develop best practice for disconnecting drilling systems in an emergency on fixed installations and mobile units, and verify that the facilities have a system for maintaining an overview of cutouts/overbridgings/inhibitions.

It is considered relevant for the PSA to assess the need to amend prevailing regulations, standards and so forth in such areas as ignition source control, air intakes in power generators, shutdown of drilling systems, dimensioning fire and explosion loads, and so forth. It is also regarded as relevant for the industry to carry out such actions as verifying that facilities are tailored to dimensioning fire and explosion loads, that the shutdown philosophy includes ensuring an appropriate division between manual and automated action by the fire and gas detection system, and that a system exists for maintaining an overview of cutouts/overbridgings/inhibitions. Further development of best practice for emergency disconnection of drilling systems is also considered relevant on both fixed installations and mobile units.

Emergency preparedness in Norway's petroleum industry builds on the principle that it must be possible to pursue operations in an acceptable manner on the basis of both individual and collective assessments of all HSE-related factors which are significant for planning and executing these activities. Key personnel on DwH were not trained in handling an incident on the scale of the blowout, nor did they act in accordance with applicable procedures for notification and response. The way training and exercises at training centres and on facilities are followed up on the NCS today does not reflect to any extent the necessary integration of emergency response organisations and combinations of possible incidents, since the practice is simply to train and exercise on "defined hazards and accidents" which are dimensioning for the activity. Consideration should be given to placing greater emphasis on training and exercises for personnel whose jobs give them key decision-making roles and whose errors could have major consequences.

Weaknesses have been exposed in the lifeboats used on DwH. The PSA has initiated the work required to amend the regulations so that all types of lifeboats are assessed after 1 January 2015 against the safety level corresponding to DNV-OS-E406 and Norsok R-002. In the PSA's opinion, this work will take account of the post-DwH findings on weaknesses in the evacuation equipment.

The sinking of DwH was one in a series of incidents in which semi-submersible units have either sunk or experienced serious float stability problems. The PSA considers it relevant to conduct a detailed assessment of the need to make the regulations more specific in this area and to give greater emphasis to certain subjects in its supervision.

Maintenance deficiencies were a contributory cause of the DwH accident. These related primarily to the BOP (maintenance, testing, faults and so forth), but the unit's general maintenance status is also mentioned to some extent in the various investigation reports. A number of the critical components required to operate the BOP had not been maintained at the intervals recommended by the manufacturer. The control system which operated the BOP on the seabed had been modified, and non-original equipment components with specifications which differed from those of the original parts had been used. No need has been identified so far to amend the requirements for maintenance management in the Norwegian regulations. The DwH accident confirms the importance of maintenance for ensuring that safety-critical equipment can function when required. It thereby also confirms the need to continue giving high priority to processes related to improving maintenance in the Norwegian petroleum industry.

The DwH accident also points to a number of challenges related to operational management functions on facilities and in the support organisation on land. These include challenges related to compliance with procedures and approved practice, risk understanding and assessments in general and in connection with changes to procedures and plans, communication, collaboration and involvement of the workforce. It has also been noted that the companies had good results from managing personal safety but

devoted insufficient attention to major accident risk. The effect of lessons from earlier incidents between facilities, companies, continental shelves and sectors was weak. Over time, it was also seen that a number of decisions favoured considerations of time and money, and disfavoured safety considerations.

The investigation reports refer to substantial challenges posed by the safety culture on DWH, management handling of operational and mandatory changes, and striking the balance between efficiency requirements and safety considerations. The PSA considers it necessary that the government and players in the petroleum industry focus continuously on creating and maintaining a good safety culture in general, and a management culture where safety has a high priority.

The PSA considers it important that the industry continues to give priority to improving the way changes which might threaten the organisation's capacity and expertise are addressed and subject to impact assessments, and to whether risk analysis tools need further development in this context. Moreover, it is considered relevant for the companies to evaluate how operational management functions on the facilities and in the support organisation on land help to prevent major accidents and thereby contribute to important reflections for management and the rest of the organisation.

Apart from lessons which are significant for safety and emergency preparedness related to drilling and well operations on the NCS, experience from the DWH incident is also considered – as mentioned above – to be significant for major accidents in general and is regarded as relevant for all Norwegian petroleum activity.

The DWH accident confirms that major accidents must be regarded as the result of a system error – in other words, a failure over time in a system of interconnected, to some extent mutually interdependent, players and processes.

A system perspective prompts serious questions about why clear and repeated signals concerning the decay of system-critical barrier elements were not picked up by the company's own follow-up, the official regulators or other stakeholders. A perspective of this kind is also important because it prompts a search for measures which can mobilise and make accountable many players both in and around the companies. That also helps to focus attention on such participants as the board and executive management, contractors, equipment suppliers, service providers, licensees, standardisation bodies, industry organisations, unions, insurance companies and so forth. This is a perspective which makes people conscious of the relationship between industry and society, and conveys in a better way that the companies must regard their safety performance and the confidence society has in them as a condition for securing access to business opportunities and as a competitive factor.

Another important message which follows from a system perspective of this kind is that complex systems fail in complex ways. Major accidents cannot be explained by simple models and cannot be prevented by simple solutions. While it is important to simplify reality in order to deal with it in practice, it is **also** important to be able to deal with complexity. This is a fundamental requirement for developing the necessary respect for the uncertainty which underlies most decision, and thereby for being better positioned to choose **robust** solutions.

The fact that a number of the causes of the DWH accident have features in common with earlier major accidents demonstrates a continued need for reflection on the issue of learning from accidents.

A number of improvement initiatives have already been launched after the DWH incident, and great willingness exists in a number of quarters to demonstrate a decisive response. It is **also** important to take time for reflection, not least on the lessons learnt after major accidents.

Relevant questions in this context are:

- why is learning apparently inadequate?
- what does learning involve?

- what can be learnt and what cannot?
- who has something to learn?
- who learns what?
- do we learn what we already know?
- do we learn to improve the same types of problems?
- do we learn to ignore the same types of problems?
- do we learn to fail again?

The DWH accident is not so far considered to have challenged the most overarching principles in the Norwegian regulations, such as the division of responsibility for regulatory compliance and the demand for systematic and risk-based compliance with functional requirements. Nor is the DWH incident considered to have challenged the need for a risk-based regulatory supervision. However, it raises serious questions about the integrity, modernity and efficiency of government regulation, monitoring and influence. That confirms the need for the PSA, on a continuous basis, to continue evaluating and improving the way it seeks to influence safety in the petroleum industry, and the effect of such an influence.

The 2011 report from the presidential commission proposes the creation of an industry-operated self-regulating organisation (on the model of such bodies as the Institute of Nuclear Power Operations - Inpo) which can contribute to the development and implementation of high safety standards as well as providing evaluation of and advice on company operations, management, performance and behaviour. This type of solution functioned well in the nuclear power industry, but is perhaps not entirely suited for the petroleum industry and Norwegian conditions. However, Inpo has a good deal of positive experience which could also be useful for further development of government regulation and the petroleum industry in Norway.

These include:

- the importance of giving weight to risk management and safety rather than regulatory compliance, in order to avoid a tick-box mentality
- the importance of benchmarking safety performance across the players
- the significance of establishing the frameworks needed to involve company managements in assessing safety performance and culture development
- the significance of building up a good reputation over time with regard to professional integrity and purposefulness in order to influence improved risk management
- the significance of **influence** and a recognition that this is exerted through both positive (trust-based processes, dialogue, motivation and rewards) and negative instruments (punishment, exclusion).
- It is also relevant for the PSA to make a more detailed assessment whether some requirements need to be made clearer at the level of regulations, guidelines or interpretations. That could include
- requirements for managing major accident risk, so that differences in such risk management emerge more clearly
- requirements for managing major accident risk which are clearly more consistent with the safety concept, so that they take account of people, the environment and material assets
- requirements for integrated assessment of a number of factors and for handling conflicting goals
- requirements which clarify various areas of responsibility, including
 - the responsibility for systematic compliance borne by each player within their area of responsibility, and what that involves for suppliers of goods and services
 - responsibility of management functions in general and corporate management in particular
 - responsibility for audit functions
 - licensee responsibility
- requirements related to the customer-contractor relationship

- requirements for players to demonstrate that technology, operations, organisation and so forth are tailored to such considerations as regional factors affecting risk, including activities in deep water or in Arctic areas
- requirements for equipment which are intended to avoid circumstances in which a player can deny the authorities or an investigation team access to internal requirements and documents.

The PSA regards the involvement of the companies in standardisation work as a specific way for them to demonstrate their collective responsibility for a high level of safety, and to work actively to incorporate established best practice and to support the national standardisation strategy. The available investigation reports confirm that the companies still need to give high priority to standardisation work, and to allocate the necessary resources in that context. The PSA has plans to conduct a review in 2011 of standards used as recognised norms in the guidelines to the regulations, in order to eliminate possible outdated references and to assess the scope of the references which the authorities can acceptably qualify with their available resources.

A project has been pursued for several years under the auspices of the Research Council of Norway to evaluate existing regulations as well as to reflect broadly on what characterises robust regulation in Norway's petroleum industry and which factors are important for achieving a robust set of regulations. The project has drawn on expertise and experience from a number of quarters, parties and countries. Findings include the importance of a tripartite collaboration between companies, unions and government, how conditions determining the robustness of the regulations develop over time, and unavoidable dilemmas between different considerations.

Priority still needs to be given to R&D activities related to robust regulations in order to continue developing the necessary understanding of what characterises a robust set of regulations, what can be expected of robust regulations and their limitations, and to challenge the robustness of the regulations in the light of advances in knowledge, social developments, changes in the industry, experience from other countries and so forth. In this context, it could be relevant to consider establishing the extent to which the conditions for functional regulations are present in the Norwegian petroleum industry, so that the PSA acquires a good basis for regulatory development and can otherwise adopt the necessary measures.

In this report, the PSA has presented a number of good national and international initiatives for collaboration between government agencies following the DWH accident. These could influence the regulations, standardisation, government supervision, and government duties and resource use in more general terms. In order to be able to respond to so many initiatives in an acceptable manner, it will be important to maintain the existing principles and, for example, to

- ensure that changes to Norwegian regulations and control systems in the wake of the DWH accident are assessed on the basis of their potential impact (positive and negative) on safety and with regard to the context in which they are meant to function
- undertake a risk-based prioritisation of what the PSA chooses to become involved with – in other words, take account of its resource position and experience with the way resource-intensive collaboration between government bodies can be organised in order to dimension and shape its involvement in a good way
- ensure that it benefits from and secures consistency with development activities in which the PSA is already involved, such as the work on management plans and the Barents 2020 project
- retain earlier experience of how important it is to ensure that this type of work is not dominated too strongly by commercial interests, but is rooted in the authorities, industry organisations, unions, key university and R&D teams, and standardisation organisations.

The presidential commission recommends an international governmental collaboration to establish a robust foundation for managing Arctic regions. Both R&D activities and standardisation work are proposed in this context. It is important that the Norwegian safety authorities participate in this work, in part to benefit from and ensure consistency with the development efforts being devoted to the management plans and Barents 2020.

The DwH accident has weakened trust in the industry, which naturally leads to critical questioning about whether the government has adequate and appropriate sanctions, whether the companies suffer sufficiently serious consequences when they fail to operate acceptably, and whether the prospect of sanctions and consequences in the event of an accident are likely to have a preventive effect. However, it is not the case that more regulation, more government supervision, more orders, more punishment and so forth will benefit safety by definition and in all circumstances.

Nor is it the case that regulations and government supervision are the only drivers for company work on safety and for regulatory compliance. It is **also** relevant to assess and take account of the companies' own incentives for preventing major accidents (concern for their own goals and strategies, financial reporting, business continuity, reputation, business opportunities, access to acreage and so forth). It is also relevant to search for government-controlled incentives which can influence/motivate the companies to price the accident risk better, invest more in safety and safety-promoting R&D, and so forth. An economic logic to safety work can be advantageously combined with a more traditional approach to safety, and to a more active involvement by forces which benefit from better safety.

The report from the presidential commissions shows that the level of safety in the petroleum industry must also be seen in relation to national operating parameters which are set for safety considerations and by the safety authorities. It also notes that viewing the development of regulatory duties and allocated resources in an overall context is safety critical.

Due to the developments / activity level in the petroleum industry the PSA has proposed to the Ministry of Labour a need for increased resources.

As mentioned above, the PSA is of the opinion that the need to enhance the safety culture throughout the industry must also be seen as relevant for the Norwegian petroleum sector. Development of a good safety culture calls for broad involvement and commitment by the companies (operators, drilling contractors, licensees and so forth), the unions, the government and so on. A good safety culture is characterised in part by the acceptance of a collective responsibility by the companies for pursuing improvements in safety-critical areas in a concrete way through such activities as a visible and ambitious commitment in the industry organisations (the Norwegian Oil Industry Association (OLF), the Norwegian Shipowners Association (NR) and the like), in standardisation work (Norsok, Barents 2020, Working Together for Safety and so forth), in work on developing the regulations (the Regulatory Forum), and in R&D (Petromaks, Demo2000 and so forth).

An important condition for developing a safety culture and improving frame conditions for managing major accident risk is the development of a management culture which gives weight to safety considerations and where the commitment of the board and the executive management, for instance, to safety issues becomes clearer and more visible within the company, in various industry fora and in the public arena in general. The PSA believes that the issue of better protection for whistleblowers raised by the presidential commission must also be viewed in connection with ambitions related to improving the safety culture in the industry. In the PSA's view, important conditions for a good safety culture include the development of a culture of accountability, where everybody accepts responsibility for safety at their own level, and a culture of openness, which welcomes the raising of safety-related challenges and everyone accepting responsibility for safety.

Given the importance of tripartite collaboration in the Norwegian model, it is considered relevant that the unions also consider their contribution to the improvement processes regarded as necessary for managing major accident risk. It is regarded as relevant in this context to look at the way concern for major accident risk can be balanced with concern for the working environment and welfare.

The DwH accident confirms the need for the PSA and the industry to continue to give high priority to improving the management of major accident risk. A big improvement in this context calls for a broad commitment. A number of relevant measures have been identified, related to risk analysis tools, data,

information on risk in the industry, understanding of the context, expertise, communication in and between companies, safety culture, management, benchmarking of safety performance and so forth. As mentioned above, this is also a matter of mobilising companies, government agencies and a number of other stakeholders.

Conducting a critical review of the information used to manage major accident risk is one of the measures relevant for the companies. This work could include an assessment of

- the relevance, reliability and modernity of the indicators used to follow up risk trends
- inappropriate use of indicators, incentives and reward systems
- the need for better indicators and other information about the business which can be used to secure an **early** warning about a weakening in safety-critical barrier elements.

The PSA is of the opinion that the quality of information applied in managing major accident risk is also a question of what overview the players have of their own business, and thereby a question of the players' own control. The PSA assumes that managing major accident risk cannot be outsourced. In light of the DWH accident, it could be relevant for the companies to review the processes intended to provide the necessary information about the business, assess in part how these processes support a culture of accountability and how various management and audit functions, third-party verifications and so forth contribute in this connection.

The DWH accident thereby confirms the need for the PSA and the industry to continue giving high priority to the work of improving barrier management, and ensuring that this commitment covers all types of barrier elements. The PSA also relates work on improving barrier management with the need to improve the maintenance of safety-critical equipment identified in the Norwegian petroleum industry and the development of the level of risk in this activity. It is accordingly considered relevant that the industry (through the OLF and the NR, for instance) assesses a mobilisation or the establishment of suitable fora to develop better practice for qualifying and maintaining safety-critical equipment and self-assessment of maintenance efficiency in relation to major accident risk. It is natural that a commitment of this kind at industry level addresses the breadth of opportunities and challenges on the NCS, including paying particular attention to the maintenance requirements which follow from a cold climate and aging of facilities as well as the limitations imposed by established organisational boundaries and traditional contractual terms.

Experience from DWH concerning communication between the customer and the suppliers of equipment and services is also important for major accident risk in the Norwegian petroleum industry, where many contractors both contribute to risk and are exposed to it. The PSA will consider defining requirements more precisely in order to clarify different areas of responsibility, including the responsibility for systematic compliance with requirements which rests on each player within their area of responsibility, and what this involves for the supplier of products and services. It could also be relevant for the industry to review established practice related to the type, content and structure of contracts, as well as contractual relations and incentives, in order to assess whether management of major accident risk is taken sufficiently into account.

Implementing an ambitious programme of studies and development related to tools for managing major accident risk could also be assessed. The main purpose could be to develop/identify appropriate decision-support tools in order to manage varying types of risk in various phases, for different conditions and types of decisions, at different levels, for different purposes and so forth. Initiating a process for identifying and prioritising the industry's need for better analysis tools could be considered in order to create ownership of such tool development.

Given recommendations made in the wake of the DWH accident, this work should include risk analysis processes and tools related to

- the well planning phase (well design and drilling plan)

- the need for better handling of changes to the drilling plan during the operational phase.

Consideration must be given to monitoring the development work on risk analysis tools in these areas which is currently under way internationally in the wake of the DwH and Montara accidents, so that the best tools are implemented on the NCS. In this context, the best tools mean decision-support tools which can promote a good understanding of uncertainty in each business, identify relevant safety-critical priority areas, and prompt robust solutions.

As mentioned above, the need has been identified for a greater diversity of risk analysis tools tailored for a number of requirements. It is important that consideration is also given to developing analysis tools which are better able to pick up changes in risk, as well as tools which can address non-technical barrier elements from a number of accident perspectives.

An R&D commitment of this kind assumes that the industry itself takes the lead in initiating, financing and executing such work and seeks, to the greatest possible extent, to include more and preferably different discipline teams at Norwegian universities and research institutes. The government should be included as a key policy contributor, and users at various levels must contribute actively. This proposal should be discussed in greater detail with research institutes and the industry.

The PSA believes that the DwH accident confirms the need for a continued commitment to a substantial improvement in barrier management by the Norwegian petroleum industry, with continued emphasis on work processes for barrier management from a life cycle perspective and a commitment by everyone concerned – including contractors and vessel owners. The DwH accident also confirms that improvements to barrier management should cover all types of barriers and all accident perspectives.

The presidential commission gets across well that the route to improved management of major accident risk in the petroleum industry goes through strong and competent players. Measures which could be relevant include

- government assessment of the financial capacity of the companies as a safety factor in player qualification and licence award processes
- government contributions, including through player qualification and licence award processes, to making company safety performance an important condition for securing access to business opportunities
- industry reviews of processes and criteria for qualifying suppliers of goods and services in light of experience from the DwH incident and earlier major accidents in order to assess whether management of major accident risk is taken sufficiently into account.

The presidential commission's recommendations also confirm how important it is that the PSA continues to give priority to work on the RNNP and safety performance. The PSA is participating in an initiative by the International Regulators' Forum (IRF) aimed at harmonising some accident data internationally. The PSA may also consider whether the proportion of benchmarking in existing RNNP and safety performance work should be increased, and assess measures for ensuring that this work is utilised by more stakeholders.

The route to improving the management of major accident risk in the Norwegian petroleum industry also goes through better administration of accident risk by the authorities. Relevant measures which affect the regulations, supervisory work, and monitoring risk trends and safety performance in the petroleum sector have already been mentioned. The need has also been identified to give continued priority to current work on developing risk analysis tools which are tailored to the government's role and requirements, and which can help ensure that safety aspects are given greater weight in the competition between environmental and value creation considerations, and that major challenges related to regional factors which influence risk are addressed in a better way at an industry level.

That includes a need for the PSA to give priority to

- continued methodological developments for describing accident risk in an area-based, long-term and social perspective
- continued methodological developments for describing the social consequences of major accidents in the petroleum industry
- a review of industry practice with regard to cost-benefit assessments used in practice in connection with risk-reduction decisions, including assessments of prevailing perspectives on the benefit of investing in safety measures and the need to adjust established practice.

The PSA's report also notes that the financial consequences of the DWH accident have exceeded the costs of all previous accidents in the petroleum industry, and incentive structures and an unfortunate balance between safety and financial goals/cost-cutting appear to have been key underlying causes of the accident. This confirms that it will be relevant for the PSA and the industry to assess the measures listed above, and which affect, among other factors

- the understanding of the way different (financial) incentives influence safety management
- the quality of the information base which is intended to express the status of major accident risk and give early warning of dangerous developments
- the perspective on and tools to express the benefit of investing in safety measures and achieving a more accurate pricing of risk
- the safety aspect of decisions taken at company level
- company self-assessments in general, and the involvement of audit functions in particular.

The PSA highlights the fact that it is also important for Norway to secure good operating parameters for safety-related R&D, both in general and in connection with future petroleum operations in the country's far northern waters in particular. To achieve the government's goal of being a world leader in HSE, consideration should be given to identifying the extent to which operating parameters for research in relevant areas are adequate, and whether these parameters make an adequate contribution to overcoming major challenges, achieving the big boosts or accomplishing the major technological leaps. In the PSA's opinion, research which is too fragmented and which lacks predictability and long-term operating parameters could be an obstacle to reaching the goal.

The PSA has also registered that qualifying and implementing apparently good solutions often present a challenge. Consideration should accordingly be given to whether it would be possible, through the operating parameters provided for R&D, to make the route from idea to implementation and application of good solutions in the industry easier and shorter than it is today.

It is considered relevant to propose a review of R&D by the Research Council of Norway to assess in part whether

- concern for preventing major accidents and harm related to the working environment is an important driver for research (in connection with the qualification of technology development through Petromaks and Demo2000, for instance), or whether it has more the character of an "accidental" spin-off from other R&D
- R&D related to major accident risk and the working environment is adequately prioritised and integrated
- the balance between major accident risk and the working environment is appropriate
- the balance between preventive and impact-reducing measures/solutions is appropriate.

Studies could also be conducted into which instruments might promote safety-related R&D in the petroleum industry, and which might help to avoid new technology increasing the accident risk.