Convention on Nuclear Safety

2012 Extraordinary Meeting

The Swedish National Report

11 May 2012, Stockholm

Foreword

During the 5th Review Meeting of the Convention on Nuclear Safety (CNS), the Contracting Parties in attendance agreed to hold an Extraordinary Meeting in August 2012 with the aim to enhance safety through reviewing and sharing lessons learned and actions taken by Contracting Parties in response to events at TEPCO Fukushima Dai-ichi.

It was agreed that a brief and concise National Report should be developed by each Contracting Party to support the Extraordinary Meeting. This report should be submitted three months prior to the meeting to the Secretariat via the Convention-secured website for peer review by other Contracting Parties.

It was also agreed that the Contracting Parties should organize their reports by topics that cross the boundaries of multiple CNS Articles. Each National Report should provide specific information on these topics to address the lessons learned and activities undertaken by each Contracting Party. The National Report should include a description of the activities the Contracting Party has completed and any activities it intends to complete along with scheduled completion dates.

The present report is therefore structured in accordance with the guidance given by the General Committee for CNS. In Chapter 0, a brief description of Swedish nuclear power plants is given with an emphasis on measures that have been taken gradually as a result of new knowledge and experience. The following chapters deal with the six topics, which are: 1) External events, 2) Design issues, 3) Severe accident management and recovery, 4) National organizations, 5) Emergency preparedness and response and post-accident management, and 6) International cooperation. Each chapter concludes with a table illustrating a high-level summary of the items identified. To clarify the relationship between the text and table contained in each chapter, the parts of the text appearing in the table are underlined. Furthermore, the text of some sections/subsections in different chapters is repeated instead of using a reference in order to make the chapters self-explanatory.

The Swedish report has been produced by a working group including representatives from both the Swedish regulatory body and reactor utilities. The regulator has coordinated this work.

Table of Contents

0. Brief description of the Swedish nuclear power plants

There are 10 nuclear power reactors in operation in Sweden; seven Boiling Water Reactors (BWRs) and three Pressurized Water Reactors (PWRs), see Figure 1. All the BWRs were designed by the domestic vendor ASEA-ATOM (later ABB Atom, now Westinghouse Electric Sweden AB) and all the PWRs by Westinghouse (USA).

The three oldest BWRs have external main recirculation loops while the other four units have internal recirculation pumps with no large pipes connected to the reactor pressure vessel below core level. The BWR containments are all of the pressure suppression (PS) type of MARK 2 design and various layouts of the vent pipe configuration and pressure suppression pools.

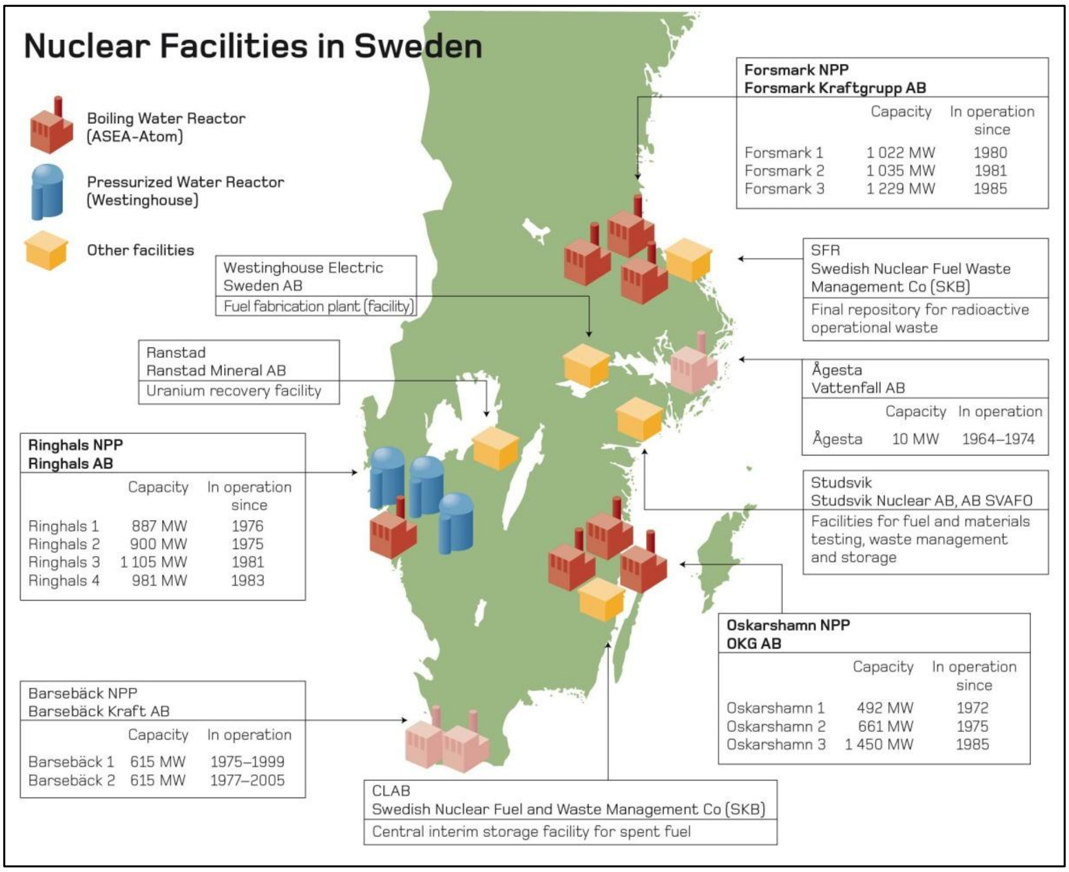

Figure 1 - Swedish nuclear facilities.

Measures to increase the level of safety at Swedish nuclear power facilities have gradually been taken in accordance with new knowledge and experience. New knowledge and experience have emerged from lessons learned from incidents and accidents, from research, from safety analyses and from new reactor designs. International accidents/incidents such as the Three Mile Island (TMI) nuclear accident in 1979 as well as domestic incidents such as the 'strainer event' in Barsebäck 2 in 1992 and the Forsmark 1 event in 2006, have had a major influence on these measures. For example periodic safety reviews started in Sweden in the early 1980s as a result of the TMI nuclear accident and the requirements regarding the reviews have developed over the years and are now quite similar to those recommended in the IAEA Safety Standards. Another example are the Swedish regulations on design and construction of nuclear power reactors which were issued in 2005 and have resulted in extensive back-fitting and modernization programmes for all Swedish nuclear power plants (NPPs). Additionally, insights from the European stress tests have identified further areas of improvement that will be implemented in the upcoming years to strengthen the robustness of Swedish nuclear power reactors.

0.1 Description of severe accident mitigating measures

After the TMI accident in the United States in 1979, a major investigation, decided by the Swedish Government, was launched and conducted by a group of experts and resulted in a number of recommendations concerning:

- strengthening of the regulatory body,
- strengthening of the emergency preparedness and response organizations on the regional level,
- an increased focus on man-technology-organizational (MTO) issues, both at the licensees and at the regulatory body,
- enhanced training of plant operators,
- strengthening of the experience feedback, both at the licensees and at the regulatory body,
- improved severe accident management (SAM), and
- implementation of filtered containment venting system.

Based on these recommendations, the Swedish Government decided that all Swedish nuclear power reactors should be capable of withstanding a core melt accident without any casualties or ground contamination of significance to the population. In the decision it was stated that these requirements can be considered met if a release is limited to a maximum of 0.1 % of the reactor core content of caesium-134 and caesium-137 in a reactor core of 1800 MW thermal power, provided that other nuclides of significance are limited to the same extent as caesium. This resulted in an extensive back-fitting for all Swedish nuclear power reactors including:

- filtered containment venting through an inert multi-venturi scrubber system (MVSS) with a decontamination factor of at least 500,
- unfiltered pressure relief in BWRs in the case of large LOCA and degraded pressure suppression function to protect the containment from early overpressurization,
- independent containment spray,
- all mitigating systems designed to withstand an earthquake[1], and
- a comprehensive set of severe accident management procedures and guidelines.

It was assumed during back-fitting design that the environmental protection requirements can be met if containment integrity is maintained during accident sequences (core melt

[1] The mitigation systems were designed according to US NRC Regulatory Guide 1.60 scaled to peak ground acceleration (PGA) values of 0.15 g horizontal and 0.1 g vertical.

scenarios) and that the releases and leakage from the containment can be controlled and limited.

Several potential threats to containment integrity occur during a core melt process. In brief, these can be categorized into the following groups: pressure loads due to gas and steam generation, temperature loads due to the high temperature of the molten core, impulse loads due to hydrogen combustion and the interaction between the molten core and water, concrete removal due to contact between the corium and concrete as well as high temperatures and aggressive materials.

Two postulated events (special events) were chosen as design basis events for the severe accident mitigating systems:

– Loss of all AC power and steam-driven emergency core cooling systems for 24 hours (BWRs and PWRs). This is the main design basis event covering events where the core is damaged and measures to mitigate external release from the containment are required. It consists of a loss of all core cooling including loss of all ordinary and alternate back-up AC power supply systems. The loss of core cooling will cause core uncover and subsequent core melt. Since containment cooling is also lost, a pressure build-up will occur in the containment. At a certain pressure value, the filtered containment venting system will be activated in order to protect the containment against overpressure.
– Large LOCA in combination with degraded pressure suppression function (for only BWRs). This is the design basis event with respect to early containment overpressurization in the BWRs. The large LOCA causes a rapid pressure build-up in the containment but it does not affect the emergency core cooling or the electricity supply. The maximum amount of radioactive material available for release in this case will thus be equivalent to the content of the primary water during normal operation as specified by the technical specifications.

During these events, no manual actions within the first 8 hours shall be assumed. This means that after 8 hours, prepared manual actions can be credited and the independent containment spray is assumed to be available, which will temporarily reduce the containment pressure and also reduce the filtered release (or delay the initiation).

In the scenario with loss of all AC power in both BWRs and PWRs, reactor pressure vessel melt-through is assumed. In order to fulfil the requirements, cooling of the core debris in the containment must be accomplished and no significant environmental impact should be allowed.

For the postulated event with loss of all AC power in BWRs, the pressure in the containment will not reach the design limit pressure and therefore the actuation of independent containment spray at this time will significantly delay the overpressurization of the containment. At a certain level of pressure, due to compression of non-condensable gases, the filtered containment venting is assumed to be actuated manually, but in the absence of manual actions, the filtered containment venting will be automatically actuated through the bursting of a rupture disc when pressure in the containment exceeds the rupture disc limits.

In the design scenario for PWRs, pressure in the containment will reach the design limit pressure typically after 4-6 hours. Since no manual actions are credited during the first 8 hours, the filtered containment venting will be automatically actuated through the bursting of the rupture discs and will reduce the containment pressure through filtered venting.

After 8 hours the independent containment spray is available which will reduce the containment pressure and also reduce the current containment filtered venting release.

All of the currently operating plants in operation have chosen the MVSS concept to fulfil the requirements of filtered venting, and a conceptual illustration of the overall severe accident mitigation concept for the BWRs and PWRs is presented in Figure 2 and Figure 3, respectively. The major component is the scrubber system comprising a large number of small venturi scrubbers submerged in a pool of water. The water contains chemicals for adequate retention of iodine. A venturi scrubber is a gas cleaning device that relies on the passage of the gas through a fine mist of water droplets. The design of the venturis is based upon the suppliers' broad experience in this area, gained when designing venturis for cleaning polluted gases from various industrial plants.

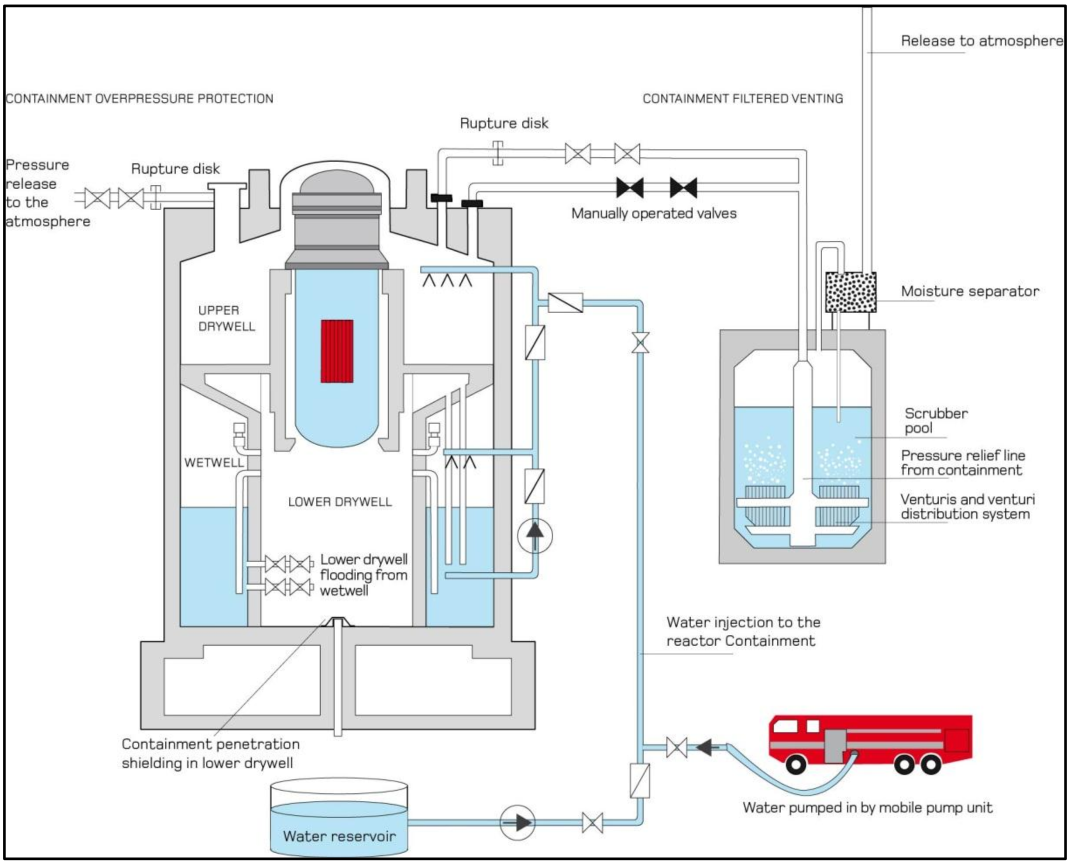

Figure 2 - Schematic view of the severe accident mitigation features installed in Swedish BWRs.

The Multi Venturi Scrubber System (MVSS) can be activated automatically, via a rupture disc, or manually. There are two separate venting lines from the containment for these two modes of operations. The venting line with the rupture disc is always open so that no operator actions are needed to vent this way. The design principle of the system is the same for BWRs and PWRs. The system is made inert to avoid hydrogen combustion.

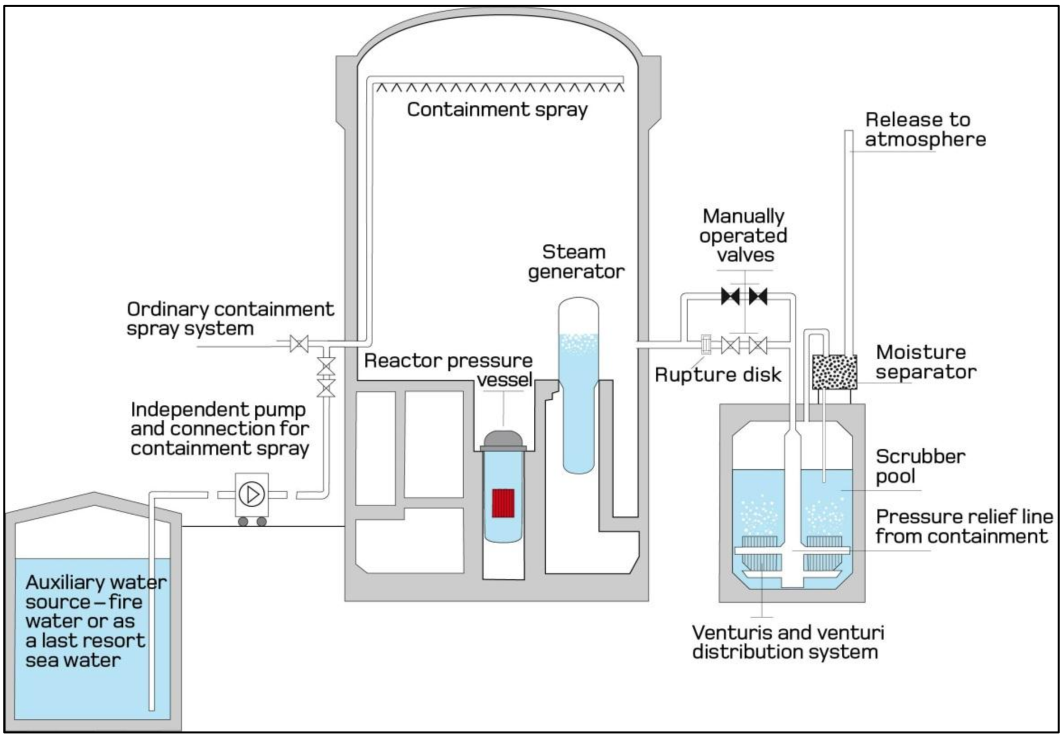

Figure 3 - Schematic view of the severe accident mitigation features installed in Swedish PWRs.

The Swedish strategy for dealing with a core melt in BWRs is to let the core debris fall into a large volume of water in the lower regions of the containment. This is a quite uncommon approach and only a few reactors in the world apply this strategy. Since the strategy is somewhat unique, the international research related to the special phenomena associated with this strategy is fairly limited, even if a wide range of international research has been conducted on phenomena that are also applicable to Swedish plants. An extensive national research programme was set up in the 1980s to highlight all important aspects needing to be addressed and this programme is still progressing. There are uncertainties connected with the Swedish strategy which need to be addressed. Through the Swedish strategy, a major initiating interaction between concrete and core melt will most likely be avoided. However, there are still some open issues identified related to steam explosions which could occur when the core melt interacts with the water and the coolability of the core debris in the containment. The severe accident research is now targeted to confirm that the uncertainties connected to the chosen solution are acceptable. Since the governmental decision in the 1980s, the Swedish utilities and the regulator have collaborated to conduct further research on severe accidents and to monitor international research within the area of severe accidents.

0.2 Description of modernization and safety upgrading of all Swedish nuclear power reactors

Safety improvements of Swedish nuclear power reactors have traditionally been conducted through consecutive plant modifications and specific projects as a result of experience from events and problems identified in the plants. These successive modifications have to a large extent been based on new insights gained through safety analyses and research, but also from newer reactor designs, which have indicated possible safety improvements. This process has to a large extent been driven and confirmed by the periodic safety reviews.

Examples of events that have led to facility modification include the ‘strainer incident’ at Barsebäck in 1992. Experience from this event showed that the emergency core cooling systems in the BWRs with external reactor recirculation pumps did not perform as postulated in the safety analysis reports. The event led to re-evaluations of previous analyses as well as modifications of the affected systems in question at all Swedish reactors. The problem has also been recognised internationally as a major generic safety issue.

Due to the background of these events, the Swedish regulator decided to issue general regulations on the design and construction of nuclear power reactors. These regulations (previously SKIFS 2004:2, currently SSMFS 2008:17) and the general advice on their interpretations entered into force on 1 January 2005 with transitional provisions. When they entered into force, the regulations contained transitional provisions providing the basis for the regulator’s decision concerning reactor-specific modernisation programmes, including a timetable for implementation of these programmes.

The regulations (SSMFS 2008:17) are based on Swedish and international operating experience, recent safety analyses, results from research and development projects and the development of IAEA Safety Standards and industrial standards that were applied in the construction of the facilities. The regulations contain specific requirements for nuclear power reactors on design principles and the implementation of the defence-in-depth concept, robustness against failures as well as other internal and external events for example through additional separation and diversification of components, systems and functions. The regulations also contain requirements on the facilities’ resistance against natural phenomena and other events, such as earthquakes, flooding, extreme winds, extreme temperatures and extreme ice formation. Requirements are also imposed on the main and emergency control rooms, safety classification, event classification and the design and operation of the reactor.

The requirement on diversification which is aimed to protect against the effects of common cause failures (CCF) has meant that additional events (called complex sequences or special events) need to be analysed. The events, together with the events which are the basis for severe accident mitigating systems, form the event class of design extension conditions. The requirement has also meant that the function for reactivity control in the event of ATWS/ATWC (ATWS = Anticipated Transient Without Scram, ATWC = Anticipated Transient Without all Control rods) must be diversified using for example automatic injection of boron.

Since the 10 power reactors operating in Sweden represent seven somewhat unique designs owing to their respective age and vendor, and have different prerequisites for complying with general regulations on design and construction, an impact assessment was conducted for each reactor. These assessments identified whether further analyses and/or back-fitting were needed in relation to each section of the regulations. The measures encompassed by the regulatory decisions for each reactor include:

- improvement of physical and functional separation
- diversification of safety functions
- accident management measures
- robustness to local dynamic effects from pipe breaks
- resistance to external events
- improvement of operational aids

– environmental qualification and surveillance

The most resource intensive measures were associated with improving the physical and functional separation and diversification. At the present time, a significant share of identified measures has been implemented, but some measures remain to be performed. For instance, the major modernization of Oskarshamn 2 is planned to be completed in spring 2013 and important measures remain to be taken on the part of Swedish PWRs until 2015.

In parallel with modernization programmes, power uprates have been conducted at eight of the ten Swedish nuclear power reactors in operation. By the end of the 1980s, nine of the twelve original nuclear power reactors in Sweden had been uprated; this took place between 1982 and1989 with power increases between 6% and 10% from the originally licensed thermal power levels. These power uprates were possible due to better utilization of existing margins, better methods for analyses and improved fuel design, but extensive modifications were not necessary. The current programmes, planned to be implemented during the period 2005-2015 include additional power uprates at seven nuclear power reactors and a minor uprate at one nuclear power reactor. When completed, the ongoing programme, including measures on the conventional side, will add around 1200 MW of electric power to the previous nuclear power production capacity.

In addition to the plant modifications listed above, the licensees need to implement measures to comply with the regulator's new regulations on security and physical protection (SSMFS 2008:12). These measures are not described in this report. For more details, see reference [1].

0.3 Description of ongoing work with the European stress tests

The nuclear accident at the TEPCO Fukushima Dai-ichi nuclear power plant (NPP) in 2011 has initiated extensive evaluations and investigations as well as launched various measures in many countries around the world. The aim is to review and re-evaluate the level of safety at NPPs. For European countries, the Council of the European Union declared that Member States should review safety at nuclear power plants in the European Union by means of a comprehensive assessment of risk and safety ('stress testing'). For Sweden, this work was carried out by the Swedish licensees and reviewed by the Swedish Radiation Safety Authority (SSM) in 2011. The results were published in a national report submitted to the European Commission at the end of December 2011, see ref. [2].

Based on information on the root cause of the nuclear accident at the Fukushima Dai-chi NPP, SSM conducted an initial assessment and determined that no measures were needed of such a nature that the continued operation of the facilities needs to be put into question.

On 22 March 2011, SSM stated in a written communication to the licensees the importance of immediately launching work to identify lessons learned from the situation with the aim of assessing any further radiation safety measures that might be necessary at Swedish nuclear power reactors as well as at the facility for storage of spent nuclear fuel.

On 25 May 2011, SSM ordered the licensees of the nuclear power reactors, as well as the interim storage facility for spent nuclear fuel (CLAB), to conduct renewed analyses of the facilities' resistance against different kinds of natural phenomena. They should also analyse how the facilities would be capable of dealing with a prolonged loss of electrical power, regardless of cause. It was stated in the motivation for the decision that the specific details concerning the scope and performance of these renewed analyses and safety evaluations were stipulated by the specifications for the ‘stress tests’ as agreed between European nuclear safety regulatory authorities and the European Commission.

On 29 December 2011, SSM reported the results of the licensees’ stress tests and the Authority’s assessment. The results were published in a national report which was submitted to the European Commission, see ref. [2]. One of the conclusions was that the work was largely performed in accordance with the specifications resolved within the European Union, see ref. [3].

The results from the stress tests have shown that Swedish nuclear facilities are robust, but have also identified a number of areas of improvement to further strengthen the nuclear facilities’ robustness. The stress tests have shown that the severe accident mitigation systems, including filtered venting of the containment, implemented after the TMI nuclear accident, are of great importance for limiting the off-site impact in the event of a natural disaster that would affect the Swedish nuclear power reactors, and in some specific cases, even prevent core melt during severe accident scenarios. If a situation where pressure builds in the containment of a Swedish NPP similar to the situation that arose in the Fukushima Dai-ichi NPP, the severe accident mitigation systems are expected to in a controlled manner release pressure from the containment to the atmosphere via the filtered venting system. The scrubber function of the filtered venting function will then capture a large proportion of the radioactive substances that may be present in the containment atmosphere during accident conditions. This function was originally only intended to be used in severe accident conditions when core debris would be present in the lower regions of the containments. The stress tests have shown that it might also be possible to use this function over an extended period of time to prevent core melt in scenarios where the core cooling function has failed.

Many of the areas of improvement identified by the licensees and by SSM imply that analyses conducted earlier need to be re-evaluated or supplemented, or that new analyses need to be conducted. This is a prerequisite before one can adopt a standpoint as to whether a measure needs to be implemented. It is important to carefully evaluate identified issues and potential measures and carefully consider all potential situations in order to obtain a robust and optimal solution and achieve an acceptable safety level for all situations. Apart from the need to conduct additional analyses, the need for more tangible action has also been identified, for example installation of equipment and improved emergency response management. However, these measures also require additional analyses in order to provide a basis for the design of the measures.

The areas of improvement identified from the stress tests performed will be managed in different ways depending on their importance from the perspective of safety and the urgency of implementing the measures.

During the spring of 2012, SSM has required all licensees to present action plans for dealing with the deficiencies identified during the European stress tests. The licensees should consider the safety significance of each measure and provide short-term and long-term schedules for each reactor. SSM will review the action plans in terms of safety improvements, scope, level of detail and time schedules, and will request additional details or revision if needed. When the action plans are approved, the Authority will require all the licensees to meet these schedules.

In parallel with the work described above, SSM is currently conducting investigations and preparing reports in accordance with a government assignment. These reports will include evaluations of the issues identified in the stress tests and other lessons learned from the nuclear accident in Fukushima in addition to conclusions drawn. The reports will also contain the regulator's view on any further measures that should be taken at Swedish nuclear facilities and the need for any further requirements imposed on safety improvements. This work will be reported to the government by 31 October 2012.

The above implies that SSM so far has required no physical plant changes at nuclear power reactors in Sweden as a result of the Fukushima Dai-ichi event and to date no significant plant modifications have been made by Swedish licensees as a result of lessons-learned from the Fukushima Dai-ichi event.

0.4 Description of work related to WANO recommendations

The industry organization WANO (World Association of Nuclear Operators) has addressed the Fukushima events in various ways.

A WANO Fukushima commission was formed soon after the events. In August 2011, the commission issued a number of recommendations for a more efficient WANO including increasing the frequency and scope of WANO peer reviews.

Three SOERs (Significant Operating Experience Reports) were issued in 2011 on various aspects of experience from the nuclear accident. These reports are for the internal use of the licensees. The SOERs include recommendations for action by the operators.

The first SOER report (WANO SOER 2011-2) was issued in March 2011. It briefly describes the events and includes recommendations to provide near-term assurance that each station is in a high state of readiness to respond to both design basis and beyond design basis events.

The second SOER report (WANO SOER 2011-3) was issued in August 2011 and contains recommendations to provide assurance that NPPs will increase the sensitivity to spent fuel storage event response and that a high state of readiness is maintained to respond to events that challenge spent fuel pool cooling or coolant inventory control.

The third SOER report (WANO SOER 2011-4) was issued in December 2011 and calls for the development of preplanned contingencies for protection from extended loss of AC power and beyond station blackout (SBO) events similar to those experienced at Fukushima.

These SOERs have been an important part of the industry programmes to learn from experience at Fukushima events. The Swedish nuclear industry's responses to the WANO SOERs are included in the summary tables in chapters 1, 2 & 3.

1. Topic 1: External events

The combined effects of the March 2011 earthquake and tsunami in Japan presented significant challenges to the NPPs. It is important to establish appropriate protection from natural phenomena. Events such as earthquakes, flooding, extreme weather conditions (hurricanes, tornadoes, snow loads, etc.), and external fires should be considered.

Under this topic, Contracting Parties are expected to report on analysis undertaken to re-evaluate the safety of existing or proposed NPPs, taking into consideration the hazards of catastrophic external events. To the extent possible, the Contracting Parties should include information on models and state-of-the-art analyses performed or planned. Significant findings and new preventive measures proposed and/or implemented to protect the NPPs against these hazards should be described. The National Report should also provide information on the treatment of events beyond the current licensing basis of the NPPs.

1.1 Overview of performed analyses/activities within external events

External events were one of the areas assessed in the framework of the European stress tests. In the Swedish national report for stress tests, external events have been described for different types of accidents, starting from design basis where the plants can be brought to safe shutdown without any significant nuclear fuel damage and up to severe accidents involving core meltdown or damage of fuel in the spent fuel pool. It should be noted that the severe accidents involving core melt and melt-through of the reactor pressure vessel were discussed separately as a specific topic and will be discussed further in Chapter 3 of this report.

Results presented in this chapter are mainly based on conclusions drawn in the framework of the stress tests or in the framework of licensee respond to WANO recommendations. This is also the case for the recommendations for further analyses which should be considered as potential measures to increase the robustness of the plants presented in the summary table in Section 1.4. As a result of the stress test assessments, some areas of improvement for the Swedish NPPs have been identified by the licensees while others have been identified by the regulator when reviewing licensee reports. As mentioned in Section 0.3 of this report, the potential improvements identified in the stress test assessments will be managed in different ways depending on their importance from the perspective of safety and the urgency of implementing the measures.

1.2 Activities performed by the operators

1.2.a. Overview of the actions taken or planned by the operators to address external events

Examples of issues addressed by WANO

The first WANO SOER, see Section 0.4, was issued in March 2011. The report briefly describes the events and includes recommendations to provide near-term assurance that each station is in a high state of readiness to respond to both design basis and beyond design basis events. Examples include:

– <u>Verification of capability to mitigate conditions that result from beyond design basis events</u> which includes the following: that equipment designed for severe accident mitigation is available and functional, that procedures for severe accident mitigation strategies are in place and are executable, that qualifications of operators to implement procedures and instructions are verified, etc.

– Verification of capability to mitigate station blackout (SBO) conditions required by station design. This includes ensuring that the capability to mitigate SBO conditions is verified and that required materials are adequate and properly set up.

– Verification of capability to mitigate internal and external flooding events required by station design. This includes ensuring that the capability to mitigate internal and external flooding events required by station design is verified and that required materials and equipment are adequate and properly staged. It also includes performance of walkdowns and inspections of important equipment needed to mitigate fire and flooding events to identify the potential for the loss of equipment function during seismic events relevant for the site. Furthermore, it includes development of mitigating strategies for identified vulnerabilities. As a minimum, one must perform walkdowns and inspection of important equipment (permanent and temporary); also develop mitigating strategies to cope with the loss of such important functions.

The second SOER was issued in August 2011 and contains recommendations to provide assurance that each station will increase the sensitivity to spent fuel storage event response and that a high state of readiness is maintained to respond to events that challenge spent fuel pool cooling or coolant inventory control. The recommendations include:

– Establishment of the time for the Spent Fuel Pool (SFP) maximum bulk temperature to reach 100 degrees Celsius in the event that normal cooling is lost. This information should be readily available in the control room and emergency response facilities.

– Verification of the adequacy of abnormal/emergency operating procedures for responding to a loss of SFP cooling and/or coolant inventory. Verify that the guidance in the abnormal/emergency operating procedures can be implemented during and following severe weather, seismic events, loss of control room, and flooding conditions.

– Verification of an existing programme for regularly checking/testing the functionality of vacuum/siphon breakers associated with SFP cooling or coolant inventory systems.

The third SOER was issued in December 2011 and calls for the development of preplanned contingencies for protection from extended loss of AC power and beyond station blackout (SBO) events similar to those experienced at Fukushima Dai-ichi. The recommendations for example cover:

– Implementation of actions to address loss of AC power events simultaneously at each unit of multi-unit sites. This includes development of methods such as seawater pumps and hoses to maintain safety functions during extended loss of AC power.

– Providing power to essential instrumentation; and fuel and other consumables to power emergency response equipment.

– Securing communications equipment during an extended loss of AC power, etc.

Earthquakes

In Sweden, only the two newest reactors, Oskarshamn 3 and Forsmark 3, were originally designed to withstand earthquakes. The other Swedish reactors became subject to general requirements imposed on resistance against earthquakes when the Swedish Nuclear Power Inspectorate’s regulations concerning the design and construction of nuclear power reactors, SKIFS 2004:2, entered into force in 2005. In order to allow licensees sufficient time to take measures and fulfil the requirements, separate decisions were taken giving the licensees a certain period of time to take the requisite measures to fully comply with the regulations, now designated as SSMFS 2008:17.

Scandinavia is considered to have seismically stable bedrock, so the risk of an earthquake causing damage to buildings has traditionally been considered negligible. Since the early 1990s, the Swedish earthquake probability level of 10^{-5} per year and site is taken into account in the design specifications during plant modifications and new installations. Thus, this is to be regarded as the design basis earthquake (DBE). In addition to hardware modifications, extensive requalification analyses of buildings, systems and components have been performed.

In the design and other analyses, the licensees apply a dimensioning earthquake within a radius of twenty kilometres of a strength corresponding to a strength of approximately 6.0 on the Richter scale and with a probability of once per 100,000 years (10^{-5}). The envelope ground response spectra are valid for a typical Swedish hard rock site. Site-specific investigations have subsequently been performed for the Swedish sites by the licensees. The hardness variation in the rock below the plant has been found to be significantly less than the assumed variation. Hence, site-specific spectra are obtained by multiplying the general Swedish hard rock spectra by 0.85. Swedish earthquake risk is dominated by near-field earthquake events and is characterized by high acceleration responses at high frequencies.

According to the licensees, the Swedish plants are able to achieve a safe shutdown condition in case of a DBE, provided that the deficiencies identified in some plants have been remedied. The most important measure for Forsmark 1 and 2 and Ringhals 1-4 to strengthen their robustness is to remedy the shortcomings identified in SMA-validation (Seismic Margin Assessment). Earlier rough evaluations of the reactor building at Ringhals 1 indicate that the roof of the building can be a weakness and needs to be evaluated further. Another identified deficiency is the control room ceiling at Ringhals 3 and 4. The primary concern is questionable capacity within the support details.

The use of the Swedish earthquake probability level of 10^{-7} per year at site for the evaluation of structures, systems and components needed to prevent radioactive releases to the environment is according to SSM a reasonable choice. Compared to the DBE, the intensity of a 10^{-7} earthquake is approximately four times stronger. The mitigation systems are judged to be able to fulfil their function in the case of the Swedish 10^{-7} – earthquake. The integrity of reactor containments, spent fuel pools and other important buildings are estimated to be preserved in case of the 10^{-7} – earthquake. However, there is a need for refined analyses and further investigations before definite conclusions are possible. To identify measures against threshold effects there is a need for other more extensive analyses such as new calculations regarding the 10^{-7} earthquake for building structures, seismic PSA and SMAverification of Forsmark 3.

Flooding

The source of the flooding considered is high seawater level. No Swedish units are located in close proximity to any body of water other than the sea. Waves are not included in the design basis flooding and are not believed to affect any unit, since no units are located in direct contact with the sea.

The phenomenon of a tsunami is not relevant because Sweden is seismically stable and the surrounding sea is too shallow to generate a significant tsunami. Tsunamis, seiches, tides and other phenomena are considered to be covered by high sea water levels.

The design basis sea water level is +2.02 m above normal sea water level for Oskarshamn NPPs, +2.65 m for Ringhals NPPs and +3.0 m for Forsmark NPPs. The frequency of a rise in the sea water level above the design basis flooding is estimated to be 10^{-5} annually at the Oskarshamn and Ringhals sites. The design basis flooding at the Forsmark site is estimated at 10^{-6} annually. These frequencies are indications that the design bases for flooding are adequate.

All Swedish NPPs can withstand an external sea water level up to 3.0 m above normal sea water level without fuel damage. External flooding above this level has not been analyzed for Forsmark and Oskarshamn NPPs and has therefore been assumed to result in fuel damage. Ringhals has been analyzed further, showing that an external water level of +3.3 m is not expected to cause core damage at any Ringhals unit.

All units are designed to handle flooding due to high ground water level and all units are equipped with drainage systems to remove ground water from the area between the rock and the buildings. As long as the drainage systems are functioning, no flooding due to high ground water level is likely to occur. In case of failure of the drainage function, it is assumed that flooding will take many hours before any severe damage will occur to the plants, which is why manual action is likely to be successfully performed. Only the Oskarshamn units have drainage systems with emergency backup power.

The stress testing has identified many procedural improvements that can strengthen the ability to withstand high water levels. A planned shutdown in the event the sea water reaches certain levels is one identified procedure. <u>A review should be conducted in Forsmark and Ringhals to check for gates and other forms of exterior doors</u> to see how well they withstand external water levels above +3.0 m and then make reinforcements if needed. <u>An evaluation will also be performed of how the water is distributed inside the plants during external flooding</u>.

Spent fuel pools will be affected by flooding at the same water level as the corresponding reactor. The filtered containment venting system is unlikely to be affected by flooding.

Extreme weather conditions

The extreme weather conditions are based on statistics from the past 100 years. An estimation of more improbable extreme weather events is done by the licence holders with the assistance of SMHI (Swedish Meteorological and Hydrological Institute). The design basis events for extreme weather include rain, wind, sea water level, outdoor temperature and lightning.

Extreme air temperatures are considered to be a slow event in which there is time for taking manual measures.

At low air temperature, the concerns for the nuclear power plants are that some essential process measurement piping could run the risk of freezing and thereby indicate inaccurate values to the reactor protection system. In the case of low temperature alarm in the ventilation system, manual measures shall be performed in accordance with the procedure to ensure that freezing of the components concerned are avoided.

In the case of a prolonged high outside air temperature exceeding dimensional values, the ambient temperature may be assumed to exceed the allowable ambient temperatures in the same range as the air temperature that has been exceeded. The engineering judgment is that this can only cause accelerated ageing of the equipment concerned and not instant malfunctioning.

Extreme rainfall and snowfall are considered as slow events where there is time to take manual steps if the ordinary equipment fails to operate as designed.

The main identified risk connected to rainfall is the load of roofs because many roofs are flat or slightly inclined with surrounding ledges. The load can become too heavy if the drainpipes fail to drain the roof. In the assessment of some license holders, proactive actions must be taken within 12 – 24 hours for some buildings in case the drainage pipes are clogged during a heavy rainfall.

Leakage of a roof is not considered to be a significant risk since there is good separation between redundant safety trains.

Administrative measures (instructions/guidelines) to cope with low/high temperature conditions, snow removal and severe rainfall on the part of the roofs identified will be improved.

Another identified risk is if rainwater from the buildings and from the ground leaks into the rock shaft. The drainage pumps in the rock shaft have a good margin in their capacity to prevent flooding of the rock shaft.

In the event of intensive snowfall, the roofs can be overloaded with snow, and if some buildings collapse, there is a risk that the collapsed roofs can destroy safety systems or fuel in the pool for storage of spent fuel. A majority of the buildings are dimensioned to withstand a very intensive snowfall during 1-2 days before the snow must be removed. All the licensees claim that manual measures must be taken in the case of a very intensive snowfall. Operational and maintenance procedures will be reviewed and completed to prohibit unallowable accumulation of water and snow on some identified roofs.

All the licensees have reported that the sites are designed to withstand strong wind. At much stronger winds, there are some shortfalls reported for older plants, such as a risk that beams and parts of the walls can fall down and some roofs may be affected.

For tornado missiles, all the licensees have applied the missiles defined in the NRC Regulatory Guide 1.76. There are some buildings where shortfalls have been reported for the missiles described. Procedures will be completed for the deficiencies found during the stress test; in particular, drawing up a procedure for external impact on the Forsmark 3 unit.

High seawater temperature is considered as a slow event where all licensees have procedures to reduce the reactor power and to shut down the reactor at sea water temperatures around +25°C. After shutdown, no shortfalls for the reactor are expected.

Frazil ice formation in the intake is a fast event. It is caused by low seawater temperatures creating ice crystals that accumulate on equipment below the surface. This is prevented by a recirculation flow in the cooling water canals. The evaluations show that frazil ice formation is not expected because of the recirculation flow.

The plant may be affected thermally, mechanically and electrically if struck by lightning. All licence holders have analysed Boiling Water Reactors in terms of the consequences of a severe lightning strike. The consequences are deemed to be limited. Ringhals 2-4 has previously identified that they need to take measures to deal with events involving lightning as Design Basis Accidents (DBAs).

External fire

All Swedish NPP sites are surrounded with naturally occurring and/or man-made fire-breaks like the shorelines, asphalt roads or sea water cooling channels. The grounds on the sites are covered with asphalt which limits potential fire spreading inside the site fences.

Due to existing firebreaks, and location of the sites, external fires are not assumed to pose any direct threat to the safety of the Swedish NPPs. However, external fire could lead to a loss of off-site power, which will be further discussed in chapter 2 of this report.

1.2.b. Schedules and milestones to complete the operators' planned activities

The evaluation and response to WANO SOER 2011-2 and 2011-3 have mainly been completed, while those for WANO SOER 2011-4 will be finished by the end of April 2012. Efforts to evaluate and initiate measures have begun at the Swedish power plants and there is a desire to collaborate across plant boundaries to identify the best solutions in terms of safety measures. The timetable for starting implementation at the different plants differs.

The Swedish utilities have cooperated and have also had a good dialogue with the regulator regarding stress tests and other aspects originating from the Fukushima events. Urgent actions have already been taken. At the moment, further analyses are ongoing that will provide the basis for final decisions on more long-term measures to be taken.

Many of the areas of improvement already identified imply that analyses conducted earlier need to be re-evaluated or supplemented, or that new analyses need to be conducted. This is a prerequisite before one can adopt a standpoint as to whether a measure needs to be implemented. It is important to carefully evaluate identified issues and potential measures and carefully consider all potential situations in order to obtain a robust and optimal solution and achieve an acceptable safety level for all situations. Apart from the need to conduct additional analyses, the need for more tangible action has also been identified, for example installation of equipment and improved emergency response management. However, these measures also require additional analyses in order to provide a basis for the design of the measures.

The areas of improvement identified from the stress tests performed will be managed in different ways depending on their importance from the perspective of safety and the urgency of implementing the measures.

The Swedish nuclear industry has initiated a joint effort for stress test results harmonization. The goal is to share information, best practices and coordinate further evaluations of stress test findings in the Swedish NPP units. The work is planned to be completed within the year 2012. The preliminary schedule for further work is as follows:

- A first version of a common vision, strategy and targets (called the Industry Position Paper) for the post-Fukushima activities is scheduled to be issued in mid of 2012.
- An early estimation of the time schedule of the needed measures to fulfill the defined targets will be assessed during the second half of 2012.
- Investment decisions will be taken according to the general process for such decision making and decided measures will be incorporated in the plant safety upgrading programmes.

1.2.c. Preliminary or final results of the activities including proposals for further actions

As stated in 1.2.b above, in-depth analyses are still ongoing to identify optimal action plans for activities/plant changes that need to be taken, and to decide on the corresponding time schedules.

1.3 Activities performed by the regulator

1.3.a. Overview of the actions taken or planned by the regulator to address external events

Regulatory action as a result of the accident at the Fukushima Dai-ichi NPP

As a result of the accident at the Fukushima Dai-ichi NPP in 2011, SSM stated in a written communication to the licensees the importance of immediately launching work to identify lessons learned from the situation with the aim of assessing any further radiation safety measures that might be necessary at the Swedish NPPs as well as at the facility for storage of spent nuclear fuel.

In addition to the national actions taken, the Council of the European Union declared that Member States of the European Union should review safety at all NPPs by means of a comprehensive assessment of risk and safety ('stress testing'). On 25 May 2011, SSM ordered licensees of all Swedish NPPs, as well as the licensee for the interim storage facility for spent nuclear fuel (CLAB), to conduct renewed analyses of the facilities' resistance against different kinds of natural phenomena, prolonged loss of electrical power and ultimate heat sink regardless of cause, and also severe accidents, in accordance with the European Commission's 'Stress Tests' specifications. It was stated in the motivation for the decision that the specific details concerning the scope and performance of these renewed analyses and safety evaluations were stipulated by the specifications for the 'stress tests' as agreed between European nuclear safety regulatory authorities and the European Commission.

In the autumn of 2011, SSM reviewed the licensees' stress tests.

On 29 December 2011, SSM presented the results of the licensees' stress tests and the Authority's assessment. The results were published in a national report and submitted to the European Commission.

During the spring of 2012, SSM has required all licensees to present action plans for dealing with the deficiencies identified during the European stress tests. The licensees should consider the safety significance of each measure and provide short-term and long-term schedules for each reactor. SSM will review the action plans and will request additional details or revision if needed. When the action plans are approved, the Authority will require all the licensees to meet these schedules.

In parallel with the European stress tests, SSM is conducting investigations and preparing reports for the Swedish Government. These reports will include evaluations of the issues identified in the stress tests and other lessons learned from the accident in Fukushima. The reports will also contain the regulatory view on any need for supplementary measures to be applied at Swedish nuclear facilities in addition to the measures identified from the stress tests as well as the need for any further requirements or updates to existing regulations.

Swedish regulations related to external events

The Swedish Radiation Safety Authority issued general regulations on the design and construction of nuclear power reactors (regulation SSMFS 2008:17) as described in Section 0.2 of this report. The regulations contain specific requirements on resistance against natural phenomena and other events that may arise outside or inside a facility and which can lead to a radiological accident, including extreme winds, extreme precipitation, extreme ice formation, extreme temperatures, extreme sea waves, extreme seaweed/algae growth or other biological conditions that can affect the cooling water intake, extreme water levels, earthquakes, fire, explosions, flooding, aeroplane crashes and disturbances to or loss of the offsite grid. The regulation states that for each type of natural phenomenon that can lead to a radiological accident, an established action plan shall be available for the situations where the dimensioning values run the risk of being exceeded. When the regulations entered into force, they were accompanied by transitional provisions providing the basis for the regulator's decision concerning reactor-specific modernisation programmes, including a timetable for implementation of these programmes.

Within the assignment given by the Swedish Government, it is stated that SSM should provide the Swedish Government with the Authority's view on any need for supplementary requirements or updates to existing regulations.

Other activities related to the area of external events

Since the mid-1990s, earthquake-induced loads have been applied for Swedish NPPs during plant modifications. In their design and other analyses, the licensees apply a design basis earthquake within a radius of twenty kilometres of a magnitude of approximately 6.0 on the Richter scale and with a probability of once per 100,000 years (10^{-5}). As far as concerns consequence-mitigating systems, a dimensioning earthquake has been applied of a magnitude approximately four times more powerful and having a probability of once per 10 million years (10^{-7}).

The comprehensive work to develop the envelope ground response spectra for Sweden was performed in the late 1980s and early 1990s in a joint venture project with the Swedish authority and the nuclear power industry. The envelope ground response spectra are valid for a typical Swedish hard rock site. The seismicity is defined by the average Fennoscandian seismicity function. The transmission of seismic waves from the source to the surface of the ground is through hard rock having the average properties of Swedish bedrock in respect of its effects on the wave propagation. The 'Swedish earthquake' was presented in ref. [4] as envelope ground motion spectra with a yearly exceedance probability of 10^{-5}, 10^{-6} and 10^{-7}. Site-specific investigations have subsequently been performed for the Swedish sites by the licensees. The hardness variation in the rock below the plants have been found to be significantly less than the assumed variation for a typical Swedish hard rock site. Hence, site-specific spectra at the sites are obtained by multiplying the general Swedish hard rock spectra by 0.85.

The mitigation systems, installed during the 1980s in accordance with a Government decision, were designed according to U.S. NRC Regulatory Guide 1.60 scaled to peak ground acceleration (PGA) values of 0.15 g horizontal and 0.1 g vertical. These are the same response spectra as the original design response spectra for Oskarshamn 3 and Forsmark 3.

In February 2003, a research report entitled *Guidance for Analyses of External Events*, see ref.[5], was published by the Swedish authority under a contract with the Nordic PSA

Group. The goal was to create a common approach to the analysis of external events within the probabilistic safety assessments for the Swedish NPPs.

At the time, the requirements stated that the safety analyses should be based on a systematic identification and evaluation of such events, sequences and other conditions that may lead to a radiological accident. The report *Guidance for Analyses of External Events* was drawn up as a supporting document for the authority's reviews. The report was also expected to give guidance for the performance of the analysis by addressing project planning, identification of external events, screening of events and probabilistic analysis.

The word 'guidance' in the report's title was used in order to indicate a common methodological guidance based on current state of the art concerning the analysis of external events and adapted to conditions relevant for Nordic sites. In addition, the report itself was meant to clarify the scope of the analysis of external events within the probabilistic safety analysis.

1.3.b. Schedules and milestones to complete the regulatory body's planned activities

During the spring of 2012, SSM has required all licensees to present action plans for dealing with the deficiencies identified during the European stress tests. SSM will review the action plans and will request additional details or revision if needed. When the action plans are approved, the Authority will require all licensees to meet these schedules.

The SSM report on lessons learned from the accident at the Fukushima Dai-ichi NPP will be presented to the Swedish Government by the end of October 2012.

The current schedules for completion of the ongoing modernisation and back-fitting of the Swedish NPPs (related to the transitional decisions for the regulations on the design and construction of nuclear power reactors, SSMFS 2008:17) cover 2013 to 2015, when the majority of identified measures will have been implemented, or will already have been implemented in 2013. SSM is currently reviewing performed modernisation and back-fitting at the Swedish NPPs and will continue this review in accordance with the schedule for completion of all planned modernisation and back-fitting for Swedish NPPs.

1.3.c. Conclusions of the regulatory body regarding the outcome of the operators' activities

At this time, and apart from the European stress tests for Swedish NPPs, SSM has not reviewed any additional operator activities addressing experience and lessons learned from the accident at Fukushima Dai-ichi.

SSM's overall conclusion when considering external events in accordance with the European stress tests is that the Swedish NPPs are robust. However, the assessments included in the European stress tests of Swedish NPPs have identified a number of areas of improvement to further strengthen the robustness of the plants. SSM's assessment is that these areas of improvement are of such a nature that the continued operation of the facilities does not need to be questioned. However, it is important that all deficiencies identified and suggested measures are considered and will be managed appropriately depending on their importance from the perspective of safety and the urgency of implementing the measures.

The results from the European stress tests of Swedish NPPs have shown that the severe accident mitigation systems, including filtered venting of the containment, implemented in the Swedish NPPs after the Three Mile Island accident in 1979, are of great importance for limiting the off-site impact in the event of natural disasters that could affect a Swedish NPP. The stress test results indicate that these systems in some specific cases could even potentially prevent core melt in the BWR designs during accident scenarios following natural phenomena or other external events.

For severe accident scenarios where pressure is building up in the containment (similar to the situation that arose in the Fukushima Dai-ichi NPP), the severe accident mitigation systems are expected to release pressure in a controlled manner from the containment to the atmosphere via the filtered venting system. The scrubber function of the filtered venting function is expected to capture a large fraction of the radioactive substances that may be present in the containment atmosphere during accident conditions, before releasing gases and steam into the environment.

The filtered venting function was originally only intended to be used in severe accident conditions when core debris would be present in the lower regions of the containments. However, the stress test results have shown that it might be possible to use these systems for other purposes. For example, the results indicate that it might be possible during situations that could arise due to natural phenomena and other external events to use the filtered venting system to transfer heat from the reactor core to the atmosphere and prevent core melt in scenarios where the ordinary core cooling function has failed and extraordinary procedures are in place.

As far as concerns earthquakes, the stress test assessments indicate that data is somewhat lacking for demonstrating that the functions needed to bring some of the reactors to a safe state will perform as intended during and after an earthquake as stipulated by the dimensioning requirements. Also, these assessments indicate that further analyses are needed to achieve a more accurate estimation of the margin for safe shutdown, as well as analysis to demonstrate the impact of earthquake-induced flooding for some units.

For flooding, the stress test assessments show that all Swedish NPPs can withstand a sea water level of 3.0 meters above the average water level without resulting in core damage. According to licensee assessments, this level corresponds to a probability of 10^{-5}/year (a probability of once per 100,000 years). However, the uncertainty in these assessments is great and further evaluations of plant performance during external flooding are therefore needed. Such evaluation should also include combination effects of waves and high water levels as well as dynamic effects.

As far as concerns extreme weather conditions, the stress test assessments have shown that the Swedish NPPs can withstand impact from several kinds of extreme weather conditions. However, all extreme weather conditions and situations that can arise in the plants due to impact from extreme weather have not been fully evaluated nor considered and therefore further evaluations will be needed to address all issues related to this topic. Such evaluations should furthermore include combinations of extreme weather conditions and combined extreme weather conditions and consequential events.

1.4 Summary table for items related to external events

Table 1 shows a high-level summary of the items reported under 1.2.a, 1.2.b, 1.2.c, 1.3.a, 1.3.b and 1.3.c. The information provided in this table will be used to assist the coordinator in documenting and compiling the measures planned or taken to address the lessons learned from the accident at the Fukushima Dai-ichi NPP.

Table 1: Summary of items related to the topic of external events.

Activity	Activities by the Operators			Activities by the Regulator		
	(Item 1.2.a) Activity - Taken? - Ongoing? - Planned?	(Item 1.2.b) Schedule Or Milestones for Planned Activities	(Item 1.2.c) Results Available - Yes? - No?	(Item 1.3.a) Activity - Taken? - Ongoing? - Planned?	(Item 1.3.b) Schedule Or Milestones for Planned Activities	(Item 1.3.c) Conclusion Available - Yes? - No?
Topic 1 – External events						
Operators						
Verification of capability to mitigate conditions that result from beyond design basis events	Taken	Not applicable	Only minor deficien-cies/gaps have been identified. However, the work has resulted in identified areas for improvement			
Verification that the capability to mitigate station blackout (SBO) conditions required by station design is functional and valid	Taken	Not applicable	-“-			
Verification of capability to mitigate internal and external flooding events required by station design	Taken	Not applicable	-“-			
Assure increased sensitivity to spent fuel storage event response	Taken	Not applicable	-“-			
Implementation of actions to address extended loss of AC power events simultaneously (e.g. seawater pumps and hoses) at each unit of multi-unit sites	Planned	Not decided	No			
Providing power to essential instrumentation and fuel and other consumables during an extended loss of AC power	Planned	Not decided	No			
Securing communications equipment during an extend-ed loss of AC power	Planned	Not decided	No			
The most important measure for some reactors to strengthen their robustness is to remedy the shortcom-ings identified in SMA valida-tion.	Planned	Not decided	No			

Further analysis of structural integrity of roofs of reactor buildings and control rooms of some reactors should be performed.	Planned	Not decided	No			
Further analysis and calculations regarding 10^{-7} earthquakes may be performed to evaluate margins and identify measures against threshold effects for some reactors.	Planned	Not decided	No			
Further analysis of aspects of seismically induced fire for some reactors.	Planned	Not decided	No			
Deeper analysis for some units regarding integrity assessment of the reactor containment, scrubber building and spent fuel pools should be performed for some reactors.	Planned	Not decided	No			
Further investigation of procedure improvements that can increase the capability to withstand flooding above +3m. One aspect of interest is how the water is distributed inside the plants during such an event.	Planned	Not decided	No			
Administrative measures (instructions/guidelines) to cope with low/high temperature conditions should be investigated further.	Planned	Not decided	No			
Review and completion of operational and maintenance procedures to prohibit unallowable accumulation of water and snow on some identified roofs.	Planned	Not decided	No			
Some reactors should investigate their capability to handle events involving lightning as design basis accidents.	Planned	Not decided	No			
Regulator						
A written communication to the licensees about immediately launching work to identify lessons learned from the Fukushima accident.				Taken	Not applicable, completed in spring 2011	No
Ordered licensees to conduct renewed analyses in accordance with the European Commission's 'Stress Tests' specifications.				Taken	Not applicable, completed in May 2011	No
Review the licensees' stress tests.				Taken	Not applicable, completed in Dec 2011	Yes

Presented the results of the licensees' stress tests and the Authority's assessment.				Taken	Not applicable, completed in Dec 2011	Yes
Submit the Swedish national report to the European Commission.				Taken	Not applicable, completed in Jan 2012	Yes
Require licensees to conduct action plans for dealing with the deficiencies identified during the European stress tests.				Taken	Not applicable, completed in April 2012	Yes
Review the action plans and request additional details or revision if needed.				Planned	2012-2013	No
Require all licensees to fulfil action plans				Planned	2013	No
Conducting investigations and preparing reports for the Swedish Government.				Ongoing	Oct 2012 and Jun 2013	No
Provide the Swedish Government with the Authority's view on any need for supplementary requirements or updates to existing regulations.				Planned	Oct 2012 and Jun 2013	No
Issue requirements which include protection against loss of electrical power and loss of ultimate heat sink and require all Swedish licensees to implement modernisation and back-fitting in accordance with transitional decisions.				Taken	2005	No
Review implemented modernisation and back-fitting at Swedish NPPs.				Ongoing	2013-2015	No
Develop the envelope ground response spectra for Sweden.				Taken	Not applicable, completed in 1992	No
Issue requirements on resistance against natural phenomena and other events that arise outside or inside the facility and which can lead to a radiological accident.				Taken	Not applicable, completed in Jan 2005	No
Support a research report on Guidance for External Events Analysis.				Taken	Not applicable, completed in Feb 2003	No

2. Topic 2: Design issues

The Fukushima accident demonstrated that the ability of the NPP's prevention and mitigation systems to respond and operate under extreme scenarios needs to be re-evaluated.

This chapter should focus on actions to prevent severe damage to the reactor and the spent fuel pool, including any last resort means, as well as an evaluation of the time available to prevent severe damage.

For example:

- *Alternating current (AC) electrical power is critically important to the safety of the NPPs. Many of the systems, structures and components (SSCs) used to cool the fuel in the reactor depend on AC power. The loss of cooling, and the loss of all AC power, both on-site and off-site, are highly significant.*
- *The design pressure for containments can be exceeded during prolonged station blackout (SBO) events. The design of the containment structures needs to be re-evaluated to ensure it can mitigate certain beyond-design-basis accident scenarios.*
- *Prolonged SBO events may inhibit the ability to provide water inventory or cooling to the spent fuel pools and could damage instrumentation needed for understanding the condition of the pool and the fuel. The reliability and availability of the spent fuel pool makeup systems may also need to be re-examined.*
- *Methods to prevent or mitigate a loss of ultimate heat sink may also need to be re-examined.*

Contracting Parties are expected to report on the analysis of such design issues. The scenarios mentioned above, among others, need to be evaluated and analysed considering site-specific and design-specific conditions. Evaluation of safety margins should be included if weak points or cliff-edge effects are identified. Proposals for further upgrades should also be mentioned.

2.1 Overview of performed analyses/activities within design issues

Design issues, such as prolonged loss of electrical power and ultimate heat sink regardless of cause, were included in the framework of the European stress tests and in the Swedish national report for the stress tests. These design issues have been highlighted for all NPPs. Different situations and the impact on the NPPs due to loss of electrical power and loss of ultimate heat sink for both the reactor and spent fuel pools have been considered and assessed starting from design basis events where the plants can be brought to safe shutdown without any significant nuclear fuel damage up to severe accidents involving core meltdown or damage to the spent nuclear fuel in the storage pool. It should be noted that the severe accidents involving core melt and melt-through of the reactor pressure vessel were discussed separately as a specific topic and will be discussed further in Chapter 3 of this report.

Results presented in this chapter are mainly based on conclusions drawn in the framework of the stress tests or in the framework of licensee responses to WANO recommendations. This is also the case for the recommendations for further analyses which should be considered as potential measures to increase the robustness of the plants presented in the summary table in Section 2.4 of this report. As a result of the stress test assessments, some areas of improvement for the Swedish NPPs have been identified by the licensees, while others have been identified by the regulator when reviewing licensee reports. As mentioned in Section 0.3 of this report, the potential improvements identified in the stress test assessments will be managed in different ways depending on their importance from the perspective of safety and the urgency of implementing the measures.

2.2 Activities performed by the operators

2.2.a. Overview of the actions taken or planned by the operators to address design issues

Examples of issues addressed by WANO

The first WANO SOER, see Section 0.4, was issued in March 2011. The report briefly describes the events and includes recommendations to provide near-term assurance that each station is in a high state of readiness to respond to both design basis and beyond design basis events. Examples include:

– Verification of capability to mitigate conditions that result from beyond design basis events which includes the following: that equipment designed for severe accident mitigation is available and functional, that procedures for severe accident mitigation strategies are in place and are executable, that qualifications of operators to implement procedures and instructions are verified, etc.

– Verification of capability to mitigate station blackout (SBO) conditions required by station design. This includes ensuring that the capability to mitigate station blackout (SBO) conditions is verified and that required materials are adequate and properly set up.

– Verification of capability to mitigate internal and external flooding events required by station design. This includes ensuring that the capability to mitigate internal and external flooding events required by station design is verified and that required materials and equipment are adequate and properly staged. It also includes performance of walkdowns and inspections of important equipment needed to mitigate fire and flooding events to identify the potential for the loss of equipment function during seismic events relevant for the site. Furthermore, it includes development of mitigating strategies for identified vulnerabilities. As a minimum, one must perform walkdowns and an inspection of important equipment (permanent and temporary); also develop mitigating strategies to cope with the loss of such important functions.

The second SOER was issued in August 2011 and contains recommendations to provide assurance that each station will increase its sensitivity to spent fuel storage event response and that a high state of readiness is maintained to respond to events that challenge spent fuel pool cooling or coolant inventory control. The recommendations include:

– Establishment of the time for the Spent Fuel Pool (SFP) maximum bulk temperature to reach 100 degrees Celsius in the event that normal cooling is lost. This information should be readily available in the control room and emergency response facilities.

– Verification of the adequacy of abnormal/emergency operating procedures for responding to a loss of SFP cooling and/or coolant inventory. Verify that the guidance in the abnormal/emergency operating procedures can be implemented during and following severe weather, seismic events, loss of control room, and flooding conditions.

– Verification of an existing programme for regularly checking/testing the functionality of vacuum/siphon breakers associated with SFP cooling or coolant inventory systems.

The third SOER was issued in December 2011 and calls for the development of preplanned contingencies for protection from extended loss of AC power and beyond station blackout (SBO) events similar to those experienced at Fukushima Dai-ichi. The recommendations for example cover:

- Implementing actions to address loss of AC power events simultaneously at each unit of multi-unit sites. This includes development of methods such as seawater pumps and hoses to maintain safety functions during extended loss of AC power.
- Providing power to essential instrumentation; and fuel and other consumables to power emergency response equipment.
- Securing communications equipment during an extended loss of AC power, etc.

Other issues

In the stress tests, the licensees have identified the following recommendations for further evaluations and reassessments. All recommendations have not been identified by all licensees and are not relevant to all units.

- The ordinary auxiliary power systems are, as far as concerns all Swedish nuclear power plants, dimensioned to manage a seven-day loss of off-site power. However, it has become evident that some facilities would need refilling of lubricant within a few days. Access to and storage of lubricant at the facilities needs to be investigated further and the possible need for increased storage capacity should be evaluated.
- Alternative auxiliary power systems in the form of gas turbines are also available within or close to the facilities. However, these auxiliary power systems have not been safety classified. The licensees' investigations indicate that these alternative auxiliary power systems could be crucial during a sequence of emergency events; also, the need for auxiliary power systems should be investigated further, particularly when considering situations where several reactors are affected simultaneously.
- In the event of a loss of offsite power, failed house load operation in addition to loss of ordinary and alternative auxiliary power, what remains operational then is a battery-backed uninterruptible power supply for instrumentation and maneuvering of components. These batteries are for most units designed for one to two hours of operation, although they are deemed capable of functioning for a longer period of time. An analysis of battery capacity needs to be conducted in order to further improve the level of robustness.
- In the event of a loss of offsite power, failed house load operation in addition to loss of ordinary and alternative auxiliary power, various mobile units can be used, such as diesel-powered pumps and generators. The analysis, nevertheless indicate that the capacity and number of mobile units are insufficient for all kinds of events, particularly if several reactors are affected simultaneously.
- All Swedish nuclear power plants are designed to be brought to a safe state if the salt water intake is blocked and to keep the facility in this state. However, some reactors have not been fully verified as to whether this requirement is fulfilled. An update of design basis events and verifying analyses needs to be conducted.
- Simultaneous blockage of both intake and outlet would involve significantly more difficult situations than the above-mentioned design events and would require crucial action by personnel at the facilities. An analysis of requisite manual measures and available resources needs to be performed. It would also need to consider the personnel's access to the facility on the basis of assumed accident sequences and their impact on the work environment.

- Analyses of beyond design basis accidents also demonstrate the major significance of independent core cooling, where both permanent and alternative systems as well as mobile units strengthen the facilities' safety and robustness. Evaluations of independent core cooling should be conducted and any need for further enhancements should be investigated.
- The analyses also illustrate the importance of available water volumes for the purpose of extending the period of time before serious core damage is unavoidable in connection with severe accidents. A survey of water volumes in various storage tanks and set minimum levels in them needs to be performed. Also, a survey of available water volumes at and in connection with the various sites should be performed and the possible need for reinforcement should be evaluated.
- Manual intervention is required to maintain cooling of spent fuel pools during a situation where both the water intake and outlet are blocked. Further investigations are also required of the need for additional cooling, both by means of permanent installations and mobile units. A key prerequisite in connection with these investigations is that the environment surrounding the ponds allows the personnel access for manual action.

2.2.b. Schedules and milestones for completing the operators' planned activities

The evaluation for and response to WANO SOER 2011-2 and 2011-3 have been completed, while those for WANO SOER 2011-4 will be finished by the end of April 2012. Efforts to evaluate and initiate measures have begun at the Swedish power plants and there is a desire to collaborate across plant boundaries to identify the best solutions in terms of safety measures. The timetable for starting implementation at the different plants differs.

The Swedish utilities have cooperated and have also had a good dialogue with the regulator regarding stress tests and other aspects originating from the Fukushima events. Urgent actions have already been taken. At the moment, further analyses are ongoing that will provide the basis for final decisions on more long-term measures to be taken.

Many of the areas of improvement already identified imply that analyses conducted earlier need to be re-evaluated or supplemented, or that new analyses need to be conducted. This is a prerequisite before one can adopt a standpoint as to whether a measure needs to be implemented. It is important to carefully evaluate identified issues and potential measures and to carefully consider all potential situations in order to obtain a robust and optimal solution and achieve an acceptable safety level for all situations. Apart from the need to conduct additional analyses, the need for more tangible action has also been identified, for example installation of equipment and improved emergency response management. However, these measures also require additional analyses in order to provide a basis for the design of the measures.

The areas of improvement identified from the stress tests performed will be managed in different ways depending on their importance from the perspective of safety and the urgency of implementing the measures.

The Swedish nuclear industry has initiated a joint effort to achieve harmonization of the stress test results. The goal is to share information and best practices and to coordinate further evaluations of stress test findings in the Swedish NPP units. The work is planned to be completed 2012. The preliminary schedule for further work is as follows:

– A first version of a common vision, strategy and targets (called the Industry Position Paper) for the post-Fukushima activities is scheduled to be issued in mid of 2012.
– An early estimation of the time schedule of the needed measures to fulfill the defined targets will be assessed during the second half of 2012.
– Investment decisions will be taken according to the general process for such decision making and decided measures will be incorporated in the plant safety upgrading programmes.

2.2.c. Preliminary or final results of the activities including proposals for further actions

As stated in 2.2.b above, in-depth analyses are still ongoing to identify optimal action plans for activities/plant changes that need to be made and to decide on the corresponding time schedules.

2.3 Activities performed by the regulator

2.3.a. Overview of the actions taken or planned by the regulator to address design issues

Regulatory action as a result of the accident at the Fukushima Dai-ichi NPP

As a result of the accident at the Fukushima Dai-ichi NPP in 2011, SSM stated in a written communication to the licensees the importance of immediately launching work to identify lessons learned from the situation with the aim of assessing any further radiation safety measures that might be necessary at the Swedish NPPs as well as at the facility for storage of spent nuclear fuel.

In addition to the national actions taken, the Council of the European Union declared that Member States of the European Union should review safety at all NPPs by means of a comprehensive assessment of risk and safety ('stress testing'). On 25 May 2011, SSM ordered licensees of all Swedish NPPs, as well as the licensee for the interim storage facility for spent nuclear fuel (CLAB), to conduct renewed analyses of the facilities' resistance against different kinds of natural phenomena, prolonged loss of electrical power and ultimate heat sink regardless of cause, and also severe accidents, in accordance with the European Commission's 'Stress Tests' specifications. It was stated in the motivation for the decision that the specific details concerning the scope and performance of these renewed analyses and safety evaluations were stipulated by the specifications for the 'stress tests' as agreed between European nuclear safety regulatory authorities and the European Commission.

In the autumn of 2011, SSM reviewed the licensees' stress tests.

On 29 December 2011, SSM presented the results of the licensees' stress tests and the Authority's assessment. The results were published in a national report and submitted to the European Commission.

During the spring of 2012, SSM has required all licensees to present action plans for dealing with the deficiencies identified during the European stress tests. The licensees should consider the safety significance of each measure and provide short-term and long-term schedules for each reactor. SSM will review the action plans and will request additional details or revision if needed. When the action plans are approved, the Authority will require all the licensees to meet these schedules.

In parallel with the European stress tests, SSM is conducting investigations and preparing reports for the Swedish Government. These reports will include evaluations of the issues identified in the stress tests and other lessons learned from the accident in Fukushima. The reports will also contain the regulatory view on any need for supplementary measures to be applied at Swedish nuclear facilities in addition to the measures identified from the stress tests as well as the need for any further requirements or updates to existing regulations.

Swedish regulations related to design issues

The Swedish Radiation Safety Authority issued general regulations on the design and construction of nuclear power reactors (regulation SSMFS 2008:17) as described in Section 0.2 of this report. The regulations contain specific requirements on resistance against natural phenomena and other events that may arise outside or inside a facility and which can lead to a radiological accident, including extreme winds, extreme precipitation, extreme ice formation, extreme temperatures, extreme sea waves, extreme seaweed/algae growth or other biological conditions that can affect the cooling water intake, extreme water levels, earthquakes, fire, explosions, flooding, aeroplane crashes and disturbances to or loss of the offsite grid. The regulation states that for each type of natural phenomenon that can lead to a radiological accident, an established action plan shall be available for the situations where the dimensioning values run the risk of being exceeded. When the regulations entered into force, they were accompanied by transitional provisions providing the basis for the regulator’s decision concerning reactor-specific modernisation programmes, including a timetable for implementation of these programmes.

Within the assignment given by the Swedish Government, it is stated that SSM should provide the Swedish Government with the Authority’s view on any need for supplementary requirements or updates to existing regulations.

Other activities related to design issues

Loss of off-site power always leads to a dynamic response, with the risk of creating transients in the electric power system. In 2006, an unexpectedly high transient caused a loss of an electric power system important to safety at Forsmark unit 1. Similarly, a high transient in the main generator of Olkiluoto unit 1 was experienced in 2008 and which damaged safety-related equipment. A common denominator of these events was represented by the deficiencies in design and design verification of the electric power system. In 2008, Forsmark unit 2 also experienced an off-site power transient which due to design deficiencies, caused unexpected behaviour in safety-related equipment. SSM required all the Swedish NPPs to use the result from the analysis of these events to improve the safety of the on-site power systems in the plants.

Additionally, as a result of the Forsmark event, an international working group within the framework of the OECD Nuclear Energy Agency (NEA) was formed in January 2008, with the mission to examine defence-in-depth of electrical systems and grid interaction with NPPs (DIDELSYS). SSM was the main driving force behind the creation of the DIDELSYS mission. Also, Sweden has chaired the task group and related meetings since the formation of the task group. In 2009 NEA issued a task group report, see ref.[6], and at the end of 2011 a final technical Opinion Paper was delivered to the NEA for publication.

SSM has also contributed to the ongoing review of IAEA Safety Guide NS-G-1.8 on electrical power systems and is currently preparing to address the relevant IEEE Standards Review Committees (via NPEC) on the DIDELSYS findings. Also, in 2010, SSM contributed to the European Clearing house's report on the events of Olkiluoto-1 and Forsmark 2, see ref. [7].

In the area of loss of ultimate heat sink, the function and integrity of the suppression pools are of great importance for preventing significant fuel damage during accident conditions for a BWR. They are also important for maintaining the containment integrity and for limiting large early radioactive releases to the environment during severe accident conditions. Being a passive safety system, the pressure suppression function is paramount to the containment behaviour, and ultimately for plant safety. In 2005, a Nordic research network for thermal hydraulic issues, called NORTHNET, was established. The network is supported by the Swedish authority. One of the three research areas within the network focuses on condensation and mixing in the suppression pools. The first project started in 2007. Since then, other projects have followed and are still ongoing.

During the development of the general regulations on the design and construction of nuclear power reactors (regulation SSMFS 2008:17) as described in Section 0.2 of this report, Swedish BWRs' strong dependency on electrical power was identified. At the time, a complete strategy for handling this issue had not been developed and it was decided that this issue would be further evaluated by the Swedish authority before implemented in the regulation. In regards to this issue, a study by SSM was performed and published in 2009. The study proposed a fully independent core cooling system in the Swedish reactors. The issue was then discussed with licensees and a consensus was reached with regard to the overall objectives and performance of the system. Based on the study and further considerations, SSM prepared preliminary and general design requirements for the system. One related issue which required additional considerations was the physical protection of the system. This question is to some extent complicated by the fact that some of the NPPs have ongoing modernisation projects which could affect the requirements for a fully independent core cooling system. However, SSM was about to issue requirements for the system for all Swedish NPPs when the nuclear accident at Fukushima Dai-ichi occurred. As a result of the accident, the issue was postponed in spring 2011. The intention was to enable re-evaluation of the conceptual approach and to accommodate experience and issues identified in the European stress tests.

2.3.b. Schedules and milestones for completing the regulatory body's planned activities

During spring 2012, SSM has required all licensees to present action plans for dealing with the deficiencies identified during the European stress tests. The licensees should consider the safety significance of each measure and provide short-term and long-term schedules for each reactor. SSM will review the action plans and will request additional details or revision if needed. When action plans are completed, the Authority will require all licensees to fulfil these schedules.

SSM's report on lessons learned from the nuclear accident at Fukushima Dai-ichi will be presented to the Swedish Government at the end of October 2012.

The current schedules for completion of the ongoing modernisation and back-fitting of the Swedish NPPs (related to the transitional decisions for the regulations on the design and construction of nuclear power reactors, SSMFS 2008:17) are for the period 2013-2015, where the majority of identified measures have already been implemented or will be implemented in 2013. SSM is currently reviewing performed modernisation and back-fitting at the Swedish NPPs and will continue this review in accordance to the schedule for completion of all planned modernisation and back-fitting for Swedish NPPs.

SSM is currently preparing to address the relevant IEEE Standards Review Committees (via NPEC) on the DIDELSYS findings and will complete this task in 2012.

The strong electrical power dependency in most Swedish BWRs was highlighted in the stress test assessments. Development of a strategy for handling this issue will be included in the post-European stress test process, which is described above.

2.3.c. Conclusions of the regulatory body regarding the outcome of the operators' activities

At this time, and apart from the European stress tests for Swedish NPPs, SSM has not reviewed any additional operator activities addressing experience and lessons learned from the nuclear accident at Fukushima Dai-ichi.

SSM's overall conclusion when considering design issues in accordance with the European stress tests is that the Swedish NPPs are robust. However, the assessments included in the European stress tests of Swedish NPPs have identified a number of areas of improvement to further strengthen the robustness of the plants. SSM's assessment is that these areas of improvement are of such a nature that the continued operation of the facilities does not need to be questioned. However, it is important that all deficiencies identified and suggested measures are considered and will be managed appropriately depending on their importance from the perspective of safety and the urgency of implementing the measures.

The results from the European stress tests of Swedish NPPs have shown that the severe accident mitigation systems, including filtered venting of the containment, implemented in the Swedish NPPs after the accident at Three Mile Island in 1979, are of great importance for limiting the off-site impact in the case of natural disasters that could affect a Swedish NPP. The stress test results indicate that these systems in some specific cases could even potentially prevent core melt during accident scenarios that could arise due to design issues such as prolonged loss of electrical power and ultimate heat sink.

For severe accident scenarios where pressure builds up in the containment (similar to the situation that arose in the Fukushima Dai-ichi NPP), the severe accident mitigation systems are expected to, in a controlled manner, release pressure from the containment to the atmosphere via the filtered venting system. The scrubber function of the filtered venting function is expected to capture a large fraction of the radioactive substances that may be present in the containment atmosphere during accident conditions, before gases and steam are released into the environment.

The filtered venting function was originally only intended to be used in severe accident conditions when core debris would be present in the lower regions of the containments. However, the stress test results have shown that it might be possible to use these systems for other purposes. For example, the results indicate that during situations following prolonged loss of electrical power and ultimate heat sink, it might be possible to use the filtered venting system to transfer heat from the reactor core to the atmosphere and prevent core melt in scenarios where the ordinary core cooling function has failed and extraordinary procedures are in place.

Regarding loss of electrical power, the ordinary auxiliary power supply systems are, for all Swedish NPPs, designed to manage a seven-day loss of off-site power. However, it has become evident that some facilities would need refilling of lubricant within a few days. Access to and storage of lubricant oil at the facilities needs to be investigated further and the possible need for increased storage capacity should be evaluated.

Alternate auxiliary power supply systems in the form of gas turbines are also available within or close to the facilities. However, these alternate auxiliary power supply systems have not been safety classified. The licensees' investigations indicate that these alternate auxiliary power supply systems could be crucial during a sequence of emergency events; also, the need for auxiliary power supply systems should be evaluated further, particularly when considering situations where several reactors are affected simultaneously.

In the event of a loss of off-site power and failed house load operation in addition to loss of ordinary and alternate auxiliary power, what power source that remains available in these situations is a battery backed-up power supply system for instrumentation and manoeuvring of components. These battery capacities are in many cases only dimensioned for one to two hours of operation according to the safety analysis report, although they are estimated to be capable of functioning for a longer period of time. An investigation of battery capacity needs to be conducted in order to further improve the level of robustness. Also, various mobile units could in these cases be used, such as diesel-powered pumps and generators. The analyses nevertheless indicate that the capacity and number of mobile units are insufficient, particularly if several reactors are affected simultaneously. Implementation of additional mobile units at sites should be evaluated further.

The ultimate heat sink for all Swedish NPPs is seawater. As regards loss of ultimate heat sink, all Swedish NPPs will be brought to a safe state, and are designed to be able to remain in a safe state, if the sea-water intake is blocked. However, as far as concerns Ringhals 3 and 4, it has not been fully verified whether this requirement is fulfilled. An update of design basis events and verifying analyses needs to be conducted.

Simultaneous blockage of both intake and outlet would lead to significantly more difficult situations than the above-mentioned design basis events and would require crucial action by personnel. Further evaluations of requisite manual actions and available resources need to be performed. These evaluations also need to consider personnel access to the facility on the basis of assumed accident sequences as well as the impact from the assumed accident sequences on the work environment.

The stress test assessments of beyond design basis accidents demonstrate the major significance of independent core cooling, where both permanent and alternative systems as well as mobile units strengthen the facilities' safety and robustness. Evaluations of independent core cooling should be performed and any need for further enhancements should be investigated.

The stress test assessments also illustrate the importance of available water volumes for system cooling purposes for extending the period of time before serious core damage is unavoidable in scenarios where the ultimate heat sink is lost. A survey of available water volumes in existing storage tanks and re-evaluations of set minimum levels for each storage tank need to be performed. Also, an investigation of the availability of alternate water volumes (reservoirs, storages, etc.) at each site should be performed and the possible need for reinforcement should be evaluated.

Manual intervention is required to maintain sufficient cooling of spent fuel pools during a situation where both the seawater intake and outlet are blocked or in a situation where total station blackout occurs. Further investigations of the need for additional cooling capabilities, both by means of permanent installations and mobile units, should be performed. A key prerequisite is to consider personnel access to the facility on the basis of assumed accident sequences as well as the impact from the assumed accident sequences on the work environment.

2.4 Summary table for items related to design issues

Table 2 shows a high-level summary of the items reported under 2.2.a, 2.2.b, 2.2.c, 2.3.a, 2.3.b and 2.3.c. The information provided in this table will be used to assist the coordinator in documenting and compiling the measures planned or taken to address the lessons learned from the accident at the Fukushima Dai-ichi NPP.

Table 2: Summary of items related to design issues.

Activity	**Activities by the Operators**			**Activities by the Regulator**		
	(Item 2.2.a) **Activity** **- Taken?** **- Ongoing?** **- Planned?**	**(Item 2.2.b)** **Schedule Or Milestones for Planned Activities**	**(Item 2.2.c)** **Results Available** **- Yes?** **- No?**	**(Item 2.3.a)** **Activity** **- Taken?** **- Ongoing?** **- Planned?**	**(Item 2.3.b)** **Schedule Or Milestones for Planned Activities**	**(Item 2.3.c)** **Conclusion Available** **- Yes?** **- No?**
Topic 2 – Design issues						
Operators						
Verification of capability to mitigate conditions that result from beyond design basis events	Taken	Not applicable	Only minor deficiencies/gaps have been identified. However, the work has resulted in identified areas for improvement			
Verification that the capability to mitigate station blackout (SBO) conditions required by station design is functional and valid	-"-	-"-	-"-			
Verification of capability to mitigate internal and external flooding events required by station design	-"-	-"-	-"-			
Ensure increased sensitivity to spent fuel storage event response	-"-	-"-	-"-			
Implementation of actions to address extended loss of AC power events simultaneously (e.g. seawater pumps and hoses) at each unit of multi-unit sites	Planned	Not decided	No			

Providing power to essential instrumentation and fuel and other consumables during an extended loss of AC power	Planned	-"-	No			
Securing communications equipment during an extended loss of AC power	Planned	-"-	No			
Some facilities would need refilling of lubricant within a few days. Access to and storage of lubricant at the facilities needs to be investigated further and the possible need for increased storage capacity should be evaluated.	Planned	-"-	No			
Some auxiliary power systems have not been safety classified. The licensees' investigations indicate that these alternative auxiliary power systems could be crucial during a sequence of emergency events; also, the need for auxiliary power systems should be investigated further, particularly when considering situations where several reactors are affected simultaneously.	Planned	-"-	No			
An analysis of battery capacity needs to be conducted in order to further improve the level of robustness.	Planned	-"-	No			
The capacity and number of mobile units are insufficient for all kinds of events, particularly if several reactors are affected simultaneously.	Planned	-"-	No			

Some reactors have not been fully verified as to whether the intake blockage requirement is fulfilled. An update of design basis events and verifying analyses needs to be conducted.	Planned	-"-	No			
An analysis of manual measures in the event of simultaneous blockage of both intake and outlet and available resources needs to be performed.	Planned	-"-	No			
Analyses of beyond design basis accidents also demonstrating the major significance of independent core cooling should be investigated.	Planned	-"-	No			
A survey of water volumes in various storage tanks and set minimum levels in them needs to be performed. Also, a survey of available water volumes at and in connection with the various sites should be performed and the possible need for reinforcement should be evaluated.	Planned	-"-	No			
Manual intervention is required to maintain cooling of fuel ponds during a situation where both the water intake and outlet are blocked. Further investigations are also required of the need for additional cooling, both by means of permanent installations and mobile units.	Planned	-"-	No			
Regulator						
A written communication to the licensees about immediately launching work to identify lessons learned from the Fukushima accident.				Taken	Not applicable, completed in spring 2011	No
Ordered licensees to conduct renewed analyses in accordance with the European Commission's "Stress Tests" specifications.				Taken	Not applicable, completed in May 2011	No
Review the licensees' stress tests.				Taken	Not applicable, completed in Dec. 2011	Yes
Presented the results of the licensees' stress tests and the Authority's assessment.				Taken	Not applicable, completed in Dec. 2011	Yes

Submit the Swedish national report to the European Commission.				Taken	Not applicable, completed in Jan. 2012	Yes
Require licensees to conduct action plans for dealing with the deficiencies identified during the European stress tests.				Taken	Not applicable, completed in April 2012	Yes
Review the action plans and will request additional details or revision if needed.				Planned	2012-2013	No
Require all licensees to fulfil action plans.				Planned	2013	No
Conducting investigations and preparing reports for the Swedish Government.				Ongoing	Oct 2012 and Jun 2013	No
Provide the Swedish Government with the Authority's view on any need for supplementary requirements or updates to existing regulations				Planned	Oct 2012 and Jun 2013	No
Issue requirements which include protection against loss of electrical power and loss of ultimate heat sink and require all Swedish licensees to implement modernisation and back-fitting in accordance with transitional decisions.				Taken	2005	No
Review implemented modernisation and back-fitting at Swedish NPPs.				Ongoing	2013-2015	No
Require all the Swedish NPPs to use the result from the analysis of occurred electrical events to improve the safety of the on-site power systems in the plants.				Taken	Not applicable, completed in 2007	No
Actively participate in an international working group within the framework of the OECD Nuclear Energy Agency (NEA) that was formed in January 2008, with the mission to examine defence in depth of electrical systems and grid interaction with NPPs (DIDELSYS).				Taken	Not applicable, completed in 2011	No
Contribute to the ongoing review of the IAEA Safety Guide NS-G-1.8 on electrical power systems				Taken	Not applicable, completed in 2011	No
Address the relevant DIDELSYS findings to the IEEE Standards Review Committees (via NPEC).				Ongoing	2012	No

Contribute to the European Clearing house's report on the event of Olkiluoto-1 and Forsmark 2.				Taken	Not applicable, completed in 2010	No
Support the Nordic research network for thermal hydraulics, called 'NORTHNET', with their research related to condensation and mixing in suppression pools.				Ongoing	Not applicable, will be ongoing as long as there are unresolved issues.	No
Issue requirements for a fully independent core cooling system in the Swedish reactors.				Planned	2012-2013	No

3. Topic 3: Severe accident management and recovery (On-site)

This chapter should focus on mitigation actions to be taken if severe reactor or spent fuel pool damage occurs, in order to prevent large radioactive releases.

Effective implementation of severe accident management and on-site recovery actions is a complex undertaking and needs to be carefully planned. It requires substantial personnel resources, development of severe accident scenarios, development and validation of procedures, equipment availability, and extensive training. The Fukushima accident demonstrated that severe accident sequences can be substantially more complex during catastrophic external events due to the unavailability of vital equipment and radioactive releases, multiple units operating at the site, extended loss of power, disruption of communication, and extensive site damage, among other things.

Contracting Parties are expected to report on the results of their reviews of severe accident management and on site recovery actions.

3.1 Overview of performed analyses/activities within severe accident management

Severe accident management was an area that was emphasized in the framework of the stress tests. In the Swedish national report on the stress tests, the severe accident management and emergency response organization was described for different types of accidents, starting from design basis, where the plants can be brought to safe shutdown without any significant nuclear fuel damage, and up to severe accidents involving core meltdown or damage to the spent nuclear fuel in the storage pool. It needs to be mentioned that the severe accidents involving core melt and melt-through of the reactor pressure vessel are design basis accidents for the consequence mitigating systems where the system for filtered containment venting is the main component. The containment filtered venting systems, including relevant instrumentation, are designed for passive operation during at least 24 hours.

The results presented in this chapter are mainly based on conclusions drawn in the framework of the stress tests or in the framework of licensee responses to WANO recommendations. This is also the case for the recommendations for further analyses which should be considered as potential measures for increasing the robustness of the plants presented in the summary table in Section 3.4. As a result of the stress test assessments, some areas of improvement for the Swedish NPPs have been identified by the licensees, while others have been identified by the regulator when reviewing licensee reports. As mentioned in Section 0.3 of this report, the potential improvements identified in the stress test assessments will be managed in different ways depending on their importance from the perspective of safety and the urgency of implementing the measures.

3.2 Activities performed by the operators

3.2.a. Overview of the actions taken or planned by the operators to address severe accident management

Examples of issues addressed by WANO

The first WANO SOER, see Section 0.4, was issued in March 2011. The report briefly describes the events and includes recommendations to provide near-term assurance that each station is in a high state of readiness to respond to both design basis and beyond design basis events. Examples include:

– Verification of capability to mitigate conditions that result from beyond design basis events which includes the following: that equipment designed for severe accident mitigation is available and functional, that procedures for severe accident mitigation strategies are in place and are executable, that qualifications of operators to implement procedures and instructions are verified, etc.

– Verification of capability to mitigate station blackout (SBO) conditions required by station design. This includes ensuring that the capability to mitigate station blackout (SBO) conditions is verified and that required materials are adequate and properly set up.

– Verification of capability to mitigate internal and external flooding events required by station design. This includes ensuring that the capability to mitigate internal and external flooding events required by station design is verified and that required materials and equipment are adequate and properly staged. It also includes performance of walkdowns and inspections of important equipment needed to mitigate fire and flooding events to identify the potential for the loss of equipment function during seismic events relevant for the site. Furthermore, it includes development of mitigating strategies for identified vulnerabilities. As a minimum, one must perform walkdowns and inspection of important equipment (permanent and temporary); also develop mitigating strategies to cope with the loss of such important functions.

The second SOER was issued in August 2011 and contains recommendations to provide assurance that each station will increase its sensitivity to spent fuel storage event response and that a high state of readiness is maintained to respond to events that challenge spent fuel pool cooling or coolant inventory control. The recommendations include:

– Establishment of the time for the Spent Fuel Pool (SFP) maximum bulk temperature to reach 100 degrees Celsius in the event that normal cooling is lost. This information should be readily available in the control room and emergency response facilities.

– Verification of the adequacy of abnormal/emergency operating procedures for responding to a loss of SFP cooling and/or coolant inventory. Verify that the guidance in the abnormal/emergency operating procedures can be implemented during and following severe weather, seismic events, loss of control room, and flooding conditions.

– Verification of an existing programme for regularly checking/testing the functionality of vacuum/siphon breakers associated with SFP cooling or coolant inventory systems.

The third SOER was issued in December 2011 and calls for the development of preplanned contingencies for protection from extended loss of AC power and beyond station blackout (SBO) events similar to those experienced at Fukushima Dai-ichi. The recommendations cover for example:

– Implementation of actions to address loss of AC power events simultaneously at each unit of multi-unit sites. This includes development of methods such as seawater pumps and hoses to maintain safety functions during extended loss of AC power.

– Providing power to essential instrumentation; and fuel and other consumables to power emergency response equipment.

– Securing communications equipment during an extended loss of AC power, etc.

Other issues

The severe accident management and emergency response organization has been analysed in the Safety Analysis Reports for various types of accidents; from Design Basis Accidents to Severe Accidents. Severe Accidents involving core melt and melt-through of the reactor pressure vessel represent the design basis for the consequence mitigating systems where the system for containment filtered venting is the main component. The containment filtered venting systems, including relevant instrumentation, are designed for passive operation during at least 24 hours. Managing a Severe Accident by cooling the corium is however required to be managed in the long term perspective (years).

During the stress test work, the licensees identified the following recommendations for further evaluations and reassessments. All recommendations have not been identified by all licensees and are not relevant to all units.

– The endurance of the severe accident management system in all aspects. The question of how to enhance the existing accident management system to achieve a robust system capable of handling Fukushima-like conditions must be investigated further.

– Capability to handle more than one affected unit. A thoroughly developed plan for managing several, simultaneously affected units should be drawn up, including mobile equipment for supplying water and power as well as staffing and procedures.

– Capability to cool the spent fuel pool. The following improvements should be considered: permanent filling pipes from a protected location to the spent fuel pools in units that do not have them yet. Robust/simple level measurement in the fuel pools that can be read from a radiation-protected location. Analyses of the conditions with a boiling fuel pool with respect to high temperature, radiation, pathways for water and steam, and procedures.

– Introduce/enhance alternative power back-up sources and system for injecting water into the reactor vessel to handle Station Black-Out (SBO). Independent core cooling system and mobile diesel back-up units should be investigated further.

– Enhance management of hydrogen in the containment and reactor building. The possibility of accumulating hydrogen in the reactor building should be analysed and possible countermeasures implemented. Decision support for handling hydrogen in a lengthy sequence, both in the reactor building and containment, should be improved.

– Managing re-criticality. A need has been identified for updating the strategies for handling re-criticality, both for detection and countermeasures. Recent information should be used.

– Measuring radiation levels. A proposal has been made to introduce more dose rate monitors in the reactor building to support accident management.

– Managing loss of containment integrity. Strategies for handling cases of lost containment integrity should be developed.

– Off-site located emergency control centre. Evaluation of the proposed advantages and disadvantages of replacing the existing substitute command centre with a suitable facility outside the plant area so that both command centres will not be located within the site where they could both be affected by the same bad conditions.

3.2.b. Schedules and milestones for completing the operators' planned activities

The evaluation and response to WANO SOER 2011-2 and 2011-3 have been completed, while those for WANO SOER 2011-4 will be finished by the end of April 2012. Efforts to evaluate and initiate measures have begun at the Swedish power plants and there is a desire to collaborate between plants to identify the best solutions in terms of safety measures. The timetable for starting implementation at the different plants differs.

The Swedish utilities have cooperated and have also had a good dialogue with the regulator regarding stress tests and other aspects originating from the Fukushima events. Urgent actions have already been taken. At the moment, further analyses are ongoing that will provide the basis for final decisions on more long-term measures to be taken.

Many of the areas of improvement already identified imply that analyses conducted earlier need to be re-evaluated or supplemented, or that new analyses need to be conducted. This is a prerequisite before one can adopt a standpoint as to whether a measure needs to be implemented. It is important to carefully evaluate identified issues and potential measures and carefully consider all potential situations in order to obtain a robust and optimal solution and achieve an acceptable safety level for all situations. Apart from the need to conduct additional analyses, the need for more tangible action has also been identified, for example installation of equipment and improved emergency response management. However, these measures also require additional analyses in order to provide a basis for the design of the measures.

The areas of improvement identified from the stress tests performed will be managed in different ways depending on their importance from the perspective of safety and the urgency of implementing the measures.

The Swedish nuclear industry has initiated a joint effort to achieve harmonization of the stress test results. The goal is to share information, best practices and coordinate further evaluations of stress test findings on the part of the Swedish NPP units. The work is planned to be completed in 2012. The preliminary schedule for further work is as follows:

– A first version of a common vision, strategy and targets (called the Industry Position Paper) for the post-Fukushima activities is scheduled to be issued in mid of 2012.

– An early estimation of the time schedule of the needed measures to fulfill the defined targets will be assessed during the second half of 2012.

– Investment decisions will be taken according to the general process for such decision making and decided measures will be incorporated in the plant safety upgrading programmes.

3.2.c. Preliminary or final results of the activities including proposals for further actions

As stated in 3.2.b above, in-depth analyses are still ongoing to identify optimal action plans for activities/plant changes that need to be made, and to decide on the corresponding time schedules.

3.3 Activities performed by the regulator

3.3.a. Overview of the actions taken or planned by the regulator to address severe accident management

Regulatory action as a result of the accident at the Fukushima Dai-ichi NPP

As a result of the accident at the Fukushima Dai-ichi NPP in 2011, SSM stated in a written communication to the licensees the importance of immediately launching work to identify lessons learned from the situation with the aim of assessing any further radiation safety measures that might be necessary at the Swedish NPPs as well as at the facility for storage of spent nuclear fuel.

In addition to the national actions taken, the Council of the European Union declared that Member States of the European Union should review safety at all NPPs by means of a comprehensive assessment of risk and safety ('stress testing'). On 25 May 2011, SSM ordered licensees of all Swedish NPPs, as well as the licensee for the interim storage facility for spent nuclear fuel (CLAB), to conduct renewed analyses of the facilities' resistance against different kinds of natural phenomena, prolonged loss of electrical power and ultimate heat sink regardless of cause, and also severe accidents, in accordance with the European Commission's 'Stress Tests' specifications. It was stated in the motivation for the decision that the specific details concerning the scope and performance of these renewed analyses and safety evaluations were stipulated by the specifications for the 'stress tests' as agreed between European nuclear safety regulatory authorities and the European Commission.

In the autumn of 2011, SSM reviewed the licensees' stress tests.

On 29 December 2011, SSM presented the results of the licensees' stress tests and the Authority's assessment. The results were published in a national report and submitted to the European Commission.

In addition to measures identified by the licensees during the assessment of severe accident management, the regulatory body has identified the following items which also have to be considered by the licensees as potential measures for increasing the robustness of the nuclear power plants:

– Guidelines for the emergency response organization for handling an accident over the long term.
– Handling of containment chemistry over the long term (one year or more).
– The function of the containment filtered venting system over the long term (more than 24 hours).
– The performance of the common system for filtered containment venting at the Oskarshamn 1 and Oskarshamn 2 units.
– The analyses of possible destruction of infrastructure as well as destruction on-site and of safety systems and barriers must be carried out while taking into account that not all accident scenarios have been clearly identified in the stress tests.

During the spring of 2012, SSM has required all licensees to present action plans for dealing with the deficiencies identified during the European stress tests. The licensees should consider the safety significance of each measure and provide short-term and long-term schedules for each reactor. SSM will review the action plans and will request additional details or revision if needed. When the action plans are approved, the Authority will require all the licensees to meet these schedules.

In parallel with the European stress tests, SSM is conducting investigations and preparing reports for the Swedish Government. These reports will include evaluations of the issues identified in the stress tests and other lessons learned from the accident in Fukushima. The reports will also contain the regulatory view on any need for supplementary measures to be applied at Swedish nuclear facilities in addition to the measures identified from the stress tests as well as the need for any further requirements or updates to existing regulations.

Swedish regulations related to severe accident management

The Swedish Radiation Safety Authority issued general regulations on the design and construction of nuclear power reactors (regulation SSMFS 2008:17) as described in Section 0.2 of this report. In addition to severe accident mitigating measures implemented in the 1980s, these regulations contain specific requirements on highly improbable events which are not expected. If the event nevertheless should occur, it can result in major core damage. These events are the basis of the nuclear power reactor's mitigating systems for severe accidents. When the regulations entered into force, they were accompanied by transitional provisions providing the basis for the regulator's decision concerning reactor-specific modernisation programmes, including a timetable for implementation of these programmes. Some of the requirements deal with the reactor containment which should be designed taking into account phenomena and loads that can occur in connection with events in the event class highly improbable events. The general advice for example recommends that a safety evaluation should be performed of events and phenomena that may be of importance for containment integrity in highly improbable events. Examples of such events and phenomena, which can result in the need to take measures, include high pressure melt-through of the reactor pressure vessel, steam explosion, re-criticality, hydrogen fire and containment underpressure.

Within the assignment given by the Swedish Government, it is stated that SSM should provide the Swedish Government with the Authority's view on any need for supplementary requirements or updates to existing regulations.

Other activities related to severe accident management

One of the requirements following implementation of severe accident mitigating measures was to continuously follow and evaluate international research and development and draw conclusions on which additional measures could be implemented to improve safety as a consequence of the raised level of knowledge. To fulfil the requirement above, the research and development within the area of severe accidents has been conducted mainly through a joint project between the Swedish authority and the nuclear industry, which is still ongoing. The focus of the project is on risk-dominating severe accident phenomena in Swedish reactors.

3.3.b. Schedules and milestones for completing the regulatory body's planned activities

During the spring of 2012, SSM has required all licensees to present action plans for dealing with the deficiencies identified during the European stress tests. The licensees should consider the safety significance of each measure and provide short-term and long-term schedules for each reactor. SSM will review the action plans and will request additional details or revision if needed. When the action plans are approved, the Authority will require all licensees to meet these schedules.

SSM's report on lessons learned from the nuclear accident at the Fukushima Dai-ichi NPP will be presented to the Swedish Government at the end of October 2012.

In addition to the above, the current schedules for completion of the ongoing modernisation and back-fitting of the Swedish NPPs (related to the transitional decisions for the regulations on the design and construction of nuclear power reactors, SSMFS 2008:17) are for the period 2013-2015. The majority of the identified measures have already been implemented or will be implemented in 2013.

3.3.c. Conclusions of the regulatory body regarding the outcome of the operators activities

At this time, and apart from the European stress tests for Swedish NPPs, SSM has not reviewed any additional operator activities addressing experience and lessons learned from the nuclear accident at Fukushima Dai-ichi.

SSM's overall conclusion when considering severe accident management in accordance with the European stress tests is that the conclusions drawn by the licensees were relevant and reasonable. This was also the case concerning recommendations for further evaluations and/or specific measures. Furthermore, the assessments included in the European stress tests of Swedish NPPs have identified a number of areas of improvement for further strengthening the plants' robustness. SSM's assessment is that these areas of improvement are of such a nature that the continued operation of the facilities does not need to be questioned. However, it is important that all deficiencies identified and suggested measures are considered and will be managed appropriately depending on their importance from the perspective of safety and the urgency of implementing the measures.

The stress tests show the strength of the consequence-mitigating systems, where the accident filters (filtered venting) constitute key systems. In an accident situation where the reactor core has melted through the reactor pressure vessel and residual heat removal has failed, pressure in the containment rises. In this type of situation, the accident filter enables the release of pressure from the containment to the environment. This filter captures the vast majority of the radioactive substances in the gas so ground contamination can thus be largely avoided. The stress tests have demonstrated a need for updated analyses of filter function in terms of accident situations with pressure relief needed in prolonged accident scenarios because these filters are dimensioned for events that are not as prolonged as was the case in Fukushima.

The batteries for instrumentation and manoeuvring are dimensioned so that they are capable of managing the initial accident sequences and subsequent recharging in an easily accessible way. A survey of battery capacity and charging possibilities needs to be performed in order to strengthen the functions of accident systems.

All existing systems for supplying water to the reactor pressure vessel are dependent on offsite power, or ordinary or alternative auxiliary power systems. In the event of a total loss of power, there is no way to supply water to the reactor pressure vessel. As far as concerns pressurised water reactors, the reactor core can be cooled via the steam generators, using the auxiliary feed water system for as long as the batteries allow or for as long as the water from available water sources lasts. An independent core cooling system and alternative mobile auxiliary power systems can substantially raise the level of robustness and will therefore be considered.

In Sweden, work has long been underway to develop the facilities so that they are capable of dealing with the risk of hydrogen gas explosions. The stress tests nevertheless indicate that the risk of hydrogen gas leakage to reactor buildings in BWRs has not been dealt with sufficiently by today's accident response organizations. The risk of hydrogen gas accumulation in reactor buildings needs to be investigated further, as well as the need for additional instrumentation to assist operators. Improvement is also needed in terms of handling hydrogen gas in a long-term perspective, both in reactor buildings and in the containment.

Emergency response management focuses on sequences where the consequence-mitigating systems, with the independent containment spray system and the accident filters, protect the containment's integrity. Lost containment integrity with a relatively large discharge of radioactive substances is not included. Strategies in the emergency response management need to be investigated further and improved.

3.4 Summary table for items related to severe accident management

Table 3 shows a high-level summary of the items reported under 3.2.a, 3.2.b, 3.2.c, 3.3.a, 3.3.b and 3.3.c. The information provided in this table will be used to assist the coordinator in documenting and compiling the measures planned or taken to address the lessons learned from the accident at the Fukushima Dai-ichi NPP.

Table 3: Summary of items related to severe accident management.

Activity	Activities by the Operators			Activities by the Regulator		
	(Item 4.2.a) **Activity** **- Taken?** **- Ongoing?** **- Planned?**	**(Item 4.2.b)** **Schedule Or Milestones for Planned Activities**	**(Item 4.2.c)** **Results Available** **- Yes?** **- No?**	**(Item 4.3.a)** **Activity** **- Taken?** **- Ongoing?** **- Planned?**	**(Item 4.3.b)** **Schedule Or Milestones for Planned Activities**	**(Item 4.3.c)** **Conclusion Available** **- Yes?** **- No?**
Topic 3 – Severe Accident Management						
Operators						
Verification of capability to mitigate conditions that result from beyond design basis events	Taken	Not applicable	Only minor deficiencies/gaps have been identified. However, the work has resulted in identified areas for improvement			
Verification that the capability to mitigate station blackout (SBO) conditions required by station design is functional and valid	-"-	-"-	-"-			
Verification of capability to mitigate internal and external flooding events required by station design	-"-	-"-	-"-			
Ensure increased sensitivity to spent fuel storage event response	-"-	-"-	-"-			

Implementation of actions to address extended loss of AC power events simultaneously (e.g. seawater pumps and hoses) at each unit of multi-unit sites	Planned	Not decided	No				
Providing power to essential instrumentation and fuel and other consumables during an extended loss of AC power	Planned	-“-	No				
Securing communications equipment during an extended loss of AC power	Planned	-“-	No				
The endurance of the severe accident management system in all aspects.	Planned	-“-	No				
Capability to handle more than one affected unit.	Planned	-“-	No				
Capability to cool the spent fuel.	Planned	-“-	No				
Induce/enhance alternative power back-up sources and system to inject water to the reactor vessel to handle Station Black-Out.	Planned	-“-	No				
Enhance management of hydrogen in the containment and reactor building.	Planned	-“-	No				
Managing re-criticality, both for detection and countermeasures.	Planned	-“-	No				
Introduction of more dose rate monitors in the reactor building to support accident management should be considered.	Planned	-“-	No				
Managing loss of containment integrity.	Planned	-“-	No				
Off-site located emergency control centre.	Planned	-“-	No				
Regulator							
A written communication to the licensees about immediately launching work to identify lessons learned from the Fukushima accident.				Taken	Not applicable, completed in spring 2011	No	
Ordered licensees to conduct renewed analyses in accordance with the European Commission’s "Stress Tests" specifications.				Taken	Not applicable, completed in May 2011	No	
Review the licensee’s stress tests.				Taken	Not applicable, completed in Dec. 2011	Yes	

Presented the results of the licensees' stress tests and the Authority's assessment.				Taken	Not applicable, completed in Dec. 2011	Yes
Submit the Swedish national report to the European Commission.				Taken	Not applicable, completed in Jan. 2012	Yes
Item identified as a result of the European stress tests needing further and deeper evaluation: Guidelines for emergency response organization for handling an accident over the long term.				Taken	Not applicable, completed in Jan. 2012	Yes
Item identified as a result of the European stress tests needing further and deeper evaluation: Handling of containment chemistry over the long term (one year or more).				Taken	Not applicable, completed in Jan. 2012	Yes
Item identified as a result of the European stress tests needing further and deeper evaluation: The function of the containment filtered venting system over the long term (more than 24 hours).				Taken	Not applicable, completed in Jan. 2012	Yes
Item identified as a result of the European stress tests needing further and deeper evaluation: The performance of the common system for filtered containment venting at the Oskarshamn 1 and Oskarshamn 2 units.				Taken	Not applicable, completed in Jan. 2012	Yes
Item identified as a result of the European stress tests needing further and deeper evaluation: The analyses of possible destruction of infrastructure as well as destruction on-site and of safety systems and barriers must be carried out while taking into account that not all accident scenarios have been clearly identified in stress tests.				Taken	Not applicable, completed in 2012	No
Require licensees to conduct action plans for dealing with the deficiencies identified during the European stress tests.				Taken	Not applicable, completed in April 2012	Yes
Review the action plans and will request additional details or revision if needed.				Planned	2012-2013	No
Require all licensees to fulfil action plans.				Planned	2013	No
Conducting investigations and preparing reports for the Swedish Government.				Ongoing	Oct 2012 and Jun 2013	No

Provide the Swedish Government with the Authority's view on any need for supplementary requirements or updates to existing regulations				Planned	Oct 2012 and Jun 2013	No
Issue requirements on highly improbable events which are defined as events that cannot be expected to occur and require all Swedish licensees to implement modernisation and back-fitting in accordance with transitional decisions.				Taken	Not applicable, completed in Jan. 2012	Yes
Review implemented modernisation and back-fitting at Swedish NPPs.				Taken	Not applicable, completed in Jan. 2012	Yes
Support the severe accident research on risk dominating phenomena in Swedish BWRs.				Ongoing	2012-2014	No

4. Topic 4: National organizations

The primary responsibility for nuclear safety rests with the licensee. However, the government, the regulator, technical support organizations, vendors, service providers and other stakeholders also play an important role in achieving and maintaining a high level of safety. Well-defined roles and responsibilities, and transparent and open communications, are essential to ensure an effective decision-making process during crisis situations.

Contracting Parties are expected to report on the results of their review of the organizations involved in maintaining and enhancing nuclear safety, and on the strength of these organizations.

In addition to Topic 5, Chapter 5 in this report, this chapter focuses on the defined roles and responsibilities within national organizations during a nuclear accident.

Roles and responsibilities within Swedish national organizations during a nuclear accident

Appointed central or regional (county) authorities are responsible for managing nearly all accidents and crisis situations involving nuclear technology with potential off-site consequences. However, if a national crisis with the potential of affecting many citizens with (coupled) large, cross-sector or cross-regional negative economic, environmental or other detrimental societal effects occurs, it will require decisions and actions by the government.

The County Administrative Board in the affected county (region) is responsible for planning and leading the regional emergency preparedness work. It decides on measures to be taken to protect the public, issues warnings and provides information to the public and is responsible for decontamination following radioactive fall-out/releases. The responsibility for directing rescue services also lies within the County Administrative Board in the affected county unless the government decides otherwise.

The Crisis Management Coordination Secretariat within Sweden's central government offices is responsible for policy intelligence and situation reporting, crisis management, crisis communications and analysis and is a central contact point at the government offices. The Secretariat gathers information, assesses a situation and recommends government actions. The Prime Minister's Office, with the support of the Crisis Management Coordination Secretariat, must ensure that the necessary cooperation within the central government offices and with the relevant authorities is rapidly established. To facilitate cooperation between all authorities concerned, a crisis management advisory body has been formed within the central government offices. The State Secretary of the Prime Minister chairs the advisory body, which is composed of the National Police Commissioner, the Supreme Commander and the Director Generals of the state utility Svenska Kraftnät (Swedish National Grid), the Swedish Civil Contingencies Agency, the National Board of Health and Welfare and the Swedish Radiation Safety Authority. The advisory body also has as members a county governor, representing the county administrative boards, and representatives from the Ministries of the authorities concerned. The State Secretary can also co-opt additional members.

The Swedish Civil Contingencies Agency (MSB) has the responsibility in preparedness work to support the coordination of preparedness measures taken by local, regional and national authorities. MSB also provides methods and communication networks for the competent authorities during extraordinary events. MSB has the overall responsibility for the Swedish national digital communication system (RAKEL) that connects national emergency services and others in the fields of civil protection, public safety and security, emergency medical services and healthcare during emergency situations, and is currently used by municipalities, counties, national agencies and even commercial entities. MSB will also support the Swedish Government Offices by providing documentation and information in the event of serious crises or disasters and provide methods for crisis communication and the coordination of official information to the public.

The Swedish Radiation Safety Authority (SSM) has the responsibility to coordinate the necessary emergency preparedness measures for preventing, identifying and detecting nuclear and radiological events that can lead to damage to human health or the environment. In the event of an accident involving nuclear technology in Sweden, or outside of Sweden with consequences for Sweden, SSM is the appointed National Competent Authority (NCA) and is responsible for providing advice and recommendations concerning protective measures regarding radiation protection, radiation measurements, cleanup and decontamination following a release of radioactive substances, for maintaining and leading a national organization for expert support, and for providing advice and recommendations to the public and the public authorities assigned with managing the impact of the event. SSM is also responsible for keeping the government informed about the situation, developments, expected developments, available resources and taken as well as planned measures, and, following a request by the Crisis Management Coordination Secretariat at the Prime Minister’s Office, or by the Swedish Civil Contingencies Agency (MSB), providing the information needed in order to paint an overall picture of the situation.

In an international context, and in regards to the Community arrangement on early exchange of information, it is SSM’s responsibility to promptly inform the European Commission and neighbouring countries that might be affected in accordance with the IAEA's Conventions on assistance and early warning and the European Commission’s Convention on early warning. Furthermore, SSM is also responsible for continuously providing information on the measures that Sweden intends to take due to an emergency situation.

The Swedish Meteorological and Hydrological Institute (SMHI) assists SSM by providing weather forecasts, weather data and some dispersion calculations in the event of a radiological or nuclear emergency.

In the event of an emergency at a Swedish nuclear power plant or other nuclear facility, the licensee is responsible for immediately contacting the national alarm centre (SOS Alarm), which will in turn alert the authorities and organizations responsible for handling the situation, see Figure 4. In the event of a radiological or nuclear emergency abroad (with a possible request for assistance), the alarm will go to the Swedish Meteorological and Hydrological Institute (SMHI), which is the national contact point (National Warning Point, NWP).

The next step in the alarm process is contacting the officers on duty at SSM and MSB. SSM initiates the following step in the alarm process through automated contact with other officers on duty at designated central and regional authorities and government ministry offices. Central and regional authorities with roles and responsibilities in the acute phase of a nuclear accident or event are required by an ordinance and a government decision to have an officer on duty (SFS 2006:942, Ordinance on Emergency Preparedness and Heightened State of Alert). Government ministry offices are not covered by this Ordinance. Additionally, the ministries in charge of authorities having responsibilities relevant for crisis management maintain their own officer on duty.

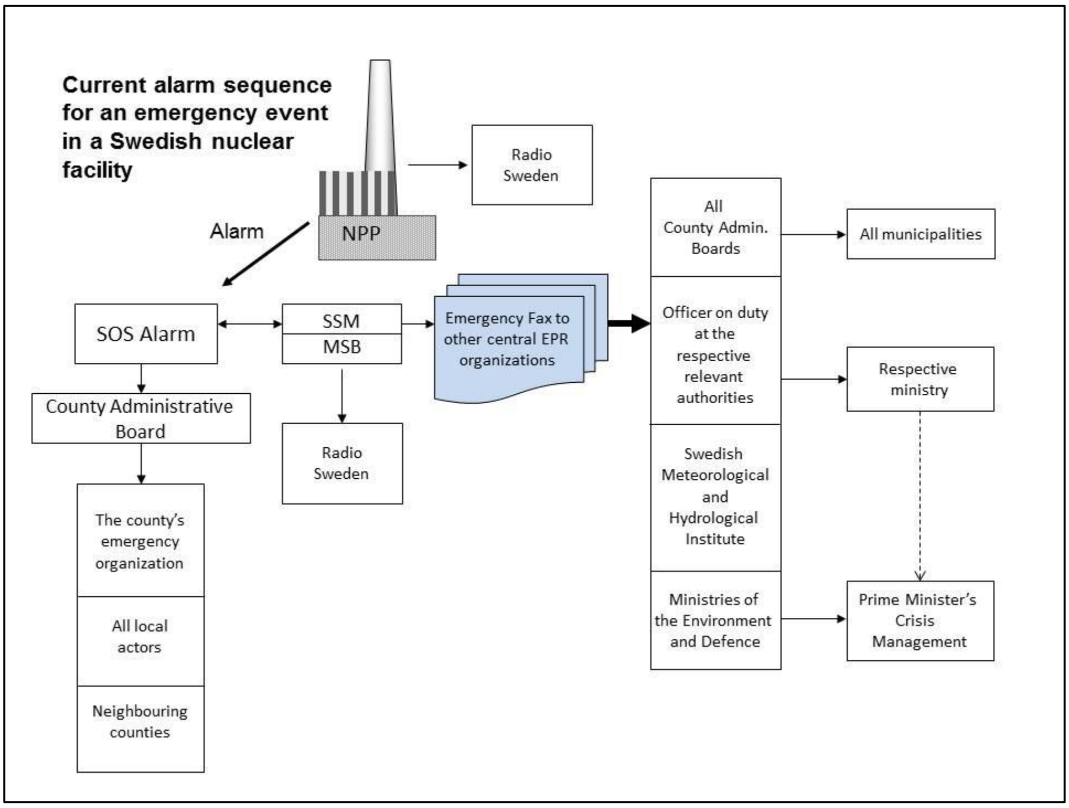

Figure 4 – Current alarm sequence for an emergency event at a Swedish nuclear facility.

A number of authorities, organizations and laboratories will cooperate or operate as supporting functions to the national organizations listed above in the event of a nuclear or radiological emergency. Participating authorities that have cooperating roles for crisis management for instance include the National Food Administration, which is responsible for taking decisions on action levels for the content of radioactivity in foodstuffs, and the Board of Agriculture, which is responsible for taking decisions on action levels regarding agricultural practices and products. Other authorities that have responsibilities during crises and that cooperate with or receive advice and recommendations from SSM include the County Administrative Boards, the Swedish Civil Contingencies Agency, the Swedish Board of Health and Welfare, Swedish Customs, the Swedish Meteorological and Hydrological Institute, Swedish National Police Board, Swedish Coast Guard and the local rescue leader, police and medical personnel.

Authorities, organizations and laboratories that comprise the national expert response organization and, among other duties, participate in radiological monitoring and measurements following nuclear and radiological emergencies are shown in Figure 5 with a summary of the contracted responsibilities covering fixed laboratory measurements, field and airborne mobile measurements and weather and plume dispersion prognoses. In addition to the tasks shown in Figure 5, the laboratories are also contracted for providing expert advice.

In addition to the tasks shown in Figure 5, the Geological Survey of Sweden and the county police force are (for instance) contracted for the use of aircraft and helicopters for airborne measurements of radiation and the Swedish Defence Research Agency (FOI) will be capable of providing expertise, technical assistance and personnel to the Swedish Radiation Safety Authority's crisis organization. Also, a number of additional laboratories around Sweden, as shown in Figure 5, are prepared to make supplementary radiological measurements and analyses and providing expert advice.

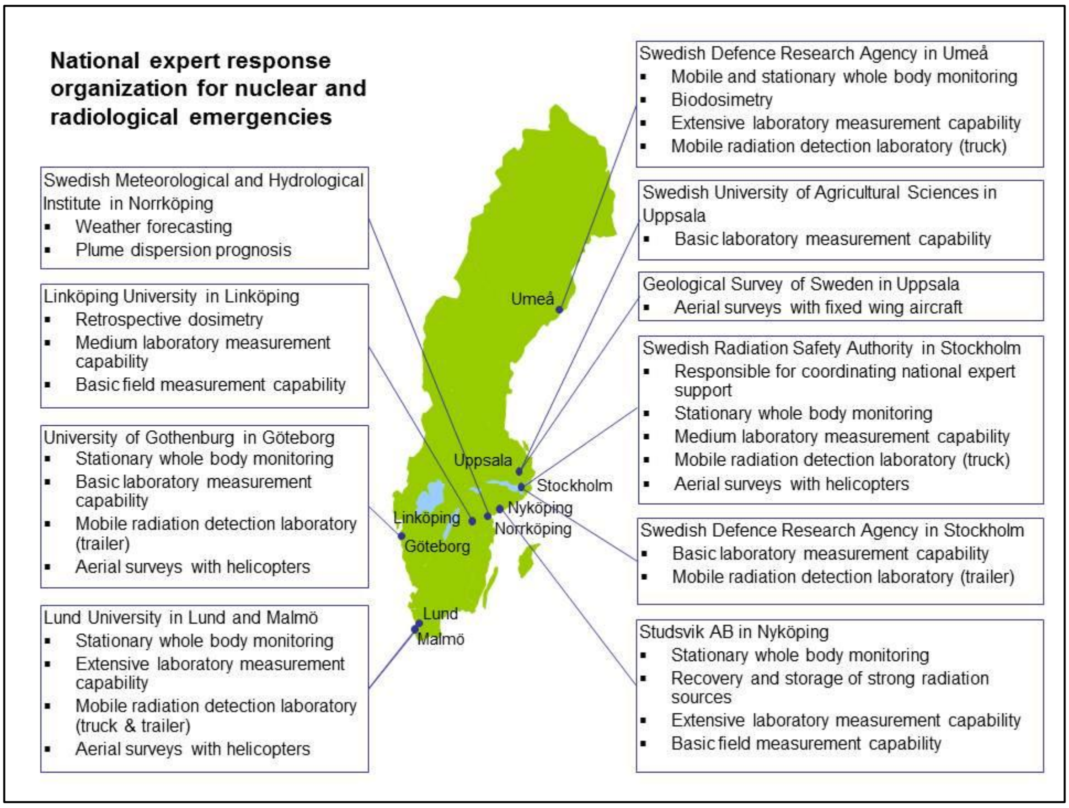

Figure 5 – National expert response organization for nuclear and radiological emergencies.

The Nuclear Medical Expert Group (N-MEG), appointed by the Swedish National Board of Health, has an on-call operation and will be available for giving advice, even in connection with minor incidents. In the event of a major accident, the group is summoned to the national emergency centre located at the Swedish Radiation Safety Authority and is provided with information on radiation levels, meteorological conditions, etc. Using the information available, N-MEG performs a medical risk assessment and delivers the information and suggestions for measures primarily directed to the medical doctor in charge at the county administrative board's rescue work management group. N-MEG advises and informs the treating medical doctors and the medical care centres in the county. Also, the major national hospitals, such as Karolinska Hospital in Stockholm, will in emergency situations be able to provide more advanced treatment and care. Additionally, cooperation and sharing of resources will take place between European hospitals in the event of major accidents.

Also, a number of voluntary organizations such as the Armed Forces, e.g. the Women's Voluntary Defence Service, the Women's Motor Transport Corps and the Women's Auxiliary Veterinary Corps, are prepared to provide assistance in the event of a radiological emergency. One area of assistance that these voluntary organizations are extensively trained and organized for is the rapid collection of agricultural field samples for transport to the national laboratory network for measurement. This will allow for early decision-making on agricultural countermeasures.

Overview of other national organizations involved in achieving and maintaining a high level of nuclear safety

Swedish nuclear power plant operators jointly own the following support organizations:

- The Nuclear Safety and Training (KSU) organization provides operational training, including simulator training, on a contractual basis for all the Swedish nuclear power plants. KSU also analyses international operational experience and provides the results to Swedish operators. In addition, KSU publishes regular reports about operational experience from Sweden and provides other energy- and nuclear-related information to politicians and decision-makers.
- The Swedish Qualification Centre (SQC) is a company for independent qualification of NDT systems (Non-Destructive Testing) to be used by NDT companies at Swedish nuclear power plants.
- ERFATOM is an organization formed through cooperation between operators of Swedish and Finnish BWRs and Westinghouse Electric Sweden AB (formerly ABB Atom) to carry out experience feedback analysis of events at Swedish and Finnish BWRs.
- The Swedish Nuclear Fuel and Waste Management Company (SKB) works with spent nuclear fuel and radioactive waste. SKB owns and operates the facility for intermediate storage of spent fuel (CLAB) in Oskarshamn and the facility for final storage of low- and medium-level waste (SFR) in Forsmark. SKB is also responsible for the R&D work in connection with the technical concept and location of the final repository for spent fuel, including the Äspö Hard Rock Laboratory.

The supply of services in the nuclear field has been concentrated to a few companies in recent years. The main Swedish vendor, ASEA-ATOM, later ABB Atom, is now a part of the Westinghouse Corporation owned by Toshiba under the name 'Westinghouse Electric Sweden AB'. Other active vendors on the Swedish market are Areva, Westinghouse USA, General Electric, Siemens and Alstom Power.

Under Swedish law, a licence holder needs a permit from the government or the Swedish Radiation Safety Authority to contract out a major part of a nuclear activity. For minor parts, it is sufficient under certain conditions to notify the Swedish Radiation Safety Authority that a contract has been awarded. The Swedish Radiation Safety Authority requires the licensees to make the necessary checks of a contractor's quality and competence and to take full responsibility for the work done by the contractor. There is, however, no formal licensing of contractors for normal commercial services, except for NDT companies where accreditation by SWEDAC is required, nor for companies handling asbestos.

Over the past few years, Swedish nuclear power plant licensees have noticed that fewer companies bid on qualified technical projects and services. This reflects the concentration of vendors and service companies on the market and also the increasing demand as a result of the extensive upgrading of the Swedish reactors and the nuclear construction project in Finland.

Studsvik Nuclear AB is an important contractor for materials testing and nuclear fuel investigations. The materials testing reactors are closed, but the company cooperates with staff of the Halden reactor in Norway and maintains the hot cell laboratory. Studsvik Nuclear AB also provides decommissioning and waste treatment services.

Academic education in nuclear technology in Sweden is mainly concentrated to the Royal Institute of Technology in Stockholm (KTH), Chalmers University of Technology in Gothenburg (Chalmers) and Uppsala University (UU).

Sweden has taken a systematic approach to maintain basic academic resources for higher level nuclear education and research. This is partly due to an agreement concluded between the Swedish nuclear industry and the Swedish Radiation Safety Authority to support the Swedish Centre of Nuclear Technology economically over a period of several years. The present agreement covers the period 2008-2013. Efforts are underway to expand the scope of support by including more members in the Centre. The Centre supports professor and lecturer posts and post-graduate education in the nuclear field at the three universities mentioned above.

4.1 Overview of performed analyses/activities by national organizations

In the following sections, all recent activities that can be related to emergency preparedness and crisis management and that are associated with reviews of the national organizations involved in maintaining and enhancing nuclear safety will be described, whether or not these activities are directly driven by the lessons learned from the nuclear accident at the Fukushima Dai-ichi NPP.

The Swedish national organizations are regularly reviewed in the form of exercises and evaluations. Most recently, in the spring of 2011, a country-wide exercise focusing on a nuclear power plant accident was held in Sweden, followed by extensive evaluations. This exercise cannot be recognized as having been planned as a result of the lessons learned from the nuclear accident at the Fukushima Dai-ichi NPP, since it was initiated in February 2011. However, it was carried out in three stages, ending in April 2011. One of the main goals was to evaluate the roles and responsibilities within the national organizations during emergency and crisis situations, and lessons learned from handling the Fukushima Dai-ichi nuclear accident were included in the later stages of the exercise, especially the final seminar held in April 2011.

4.2 Activities performed by the operators or other national organizations involved in achieving and maintaining a high level of nuclear safety

4.2.a. Overview of the actions taken or planned by the operators to address national organizations

The County Administrative Boards in the counties with nuclear power plant conduct, at intervals of a few years, a major exercise within the Nuclear Emergency Preparedness in Sweden. <u>A country-wide exercise focusing on a nuclear power plant accident</u>, SAMÖ/KKÖ 2011, was conducted in Sweden between February and April 2011. The goal of the exercise was to evaluate whether the organizations participating in the exercise had the capability to, both separately and in cooperation, handle the consequences of an accident from both a strategic and an operative perspective with the aim of maintaining and restoring functions important to society. Many organizations, including both national and international organizations/authorities/licensees, observed or participated in the exercise. The Swedish Civil Contingencies Agency (MSB) was in charge of the exercise and, as the affected party, the Oskarshamn NPP's emergency organization had an important role. The national emergency preparedness exercise that was implemented from the point of view of an accident at OKG showed that OKG's organization and activity functioned well. All actions performed by other participants were led by the County Administrative Board and lay outside OKG's jurisdiction. The cooperation was well established and well trained. SAMÖ-KKÖ confirmed that the cooperation was efficient. In summary, the evaluation of the exercise showed that the overall goal of the exercise was met. Improvements can however be made to make the handling more efficient.

4.2.b. Schedules and milestones for completing the operators' planned activities

The first period of the exercise was the acute phase, 36 hours with extensive critical incidents at OKG simulating events in real time, including alerting other parts of society. Evacuation of personnel at OKG was performed. OKG's entire emergency preparedness organization participated.

The needs identified by OKG included evaluating whether the alternative command centre should be placed outside the OKG site in order to avoid access difficulties. Other identified needs concerned evaluation of additional technical equipment as RAKEL units, possible satellite telephones and other equipment for internal needs.

4.2.c. Preliminary or final results of the activities including proposals for further actions

SAMÖ/KKÖ was performed about one month before the Fukushima accident and the scenario in the exercise was by coincidence very similar to the event in Fukushima, simulating a core melt penetrating the reactor pressure vessel followed by radiological releases to the surroundings. The results from SAMÖ/KKÖ basically demonstrate the same needs as shown later in connection with the stress tests.

4.3 Activities performed by the government or authorities

Emergency preparedness and crisis management on a national level involve a number of national organizations and authorities as well as the Government. Therefore, this subsection will not only cover regulatory activities, but will also include activities performed by the Swedish Government and all Swedish authorities.

4.3.a. Overview of the actions taken or planned by the government or authorities to address national organizations

A country-wide exercise focusing on a nuclear power plant accident, SAMÖ/KKÖ 2011, was conducted in Sweden between February and April 2011. Many organizations, including both national and international organizations/authorities/licensees, observed or participated in the exercise. The Swedish Civil Contingencies Agency (MSB) was in charge of the whole exercise. The aim of SAMÖ-KKÖ 2011 was to test the State's capacity for dealing with the consequences of a nuclear accident. The exercise involved all levels of society for the management of both the short-term and long-term consequences. The exercise has been evaluated and the results and conclusions will be assessed further.

During the nuclear accident at the Fukushima Dai-ichi NPP, many national organizations were activated and the Swedish Radiation Safety Authority had its crisis organization activated around the clock during the period 11-31 March 2011 in the Emergency Response Centre located in the premises of the Authority. Several other authorities and organizations were also affected by the situation in Japan, for example the Swedish Civil Contingencies Agency (MSB), the National Board of Health and Welfare, Swedish Customs, the Swedish National Food Agency, the Ministry for Foreign Affairs (UD), the Ministry of the Environment and the Swedish Defence Research Agency (FOI). The activities throughout this period led to a number of lessons learned regarding the performance of the national organizations. One example is the experience from the cooperation between the Swedish Radiation Safety Authority and the Swedish Defence Research Agency (FOI) during the accident. During the accident, the Swedish Defence Research Agency (FOI) was contracted by the Swedish Radiation Safety Authority to assist the emergency organization and to perform analyses and supplementary radiation monitoring. This interaction has been evaluated further and the need for clarification regarding the role of the Swedish Defence Research Agency (FOI) during a radiological or nuclear emergency is currently being discussed.

Handling a nuclear power accident in a country far from Sweden, but nevertheless having implications for Sweden and Swedes living in Japan, has led to a number of lessons learned regarding the performance of the national organizations during the accident and which are still being evaluated; see also Chapter 5 for further information.

The nuclear accident at the Fukushima Dai-ichi NPP highlighted the importance of international cooperation and the capability of a country to coordinate assistance from international authorities and organizations during emergency situations. The Swedish government appointed a Committee of Inquiry to examine the possibilities for Sweden to receive international support during emergency and crisis situations, including nuclear accidents. The experiences from the Fukushima Dai-ichi NPP accident were incorporated in the committee's inquiry. The results of the inquiry were delivered to the Government on 27 April 2012.

The responsibilities for security and safeguards at a national level of authority are shared between the Swedish Radiation Safety Authority, the Swedish Defence Research Agency (FOI) and the Swedish Agency for Non-Proliferation and Export Controls (ISP). On 7 June 2011, the Ministry of the Environment appointed a former deputy director-general to examine the responsibilities for security and safeguards at a national level of authority and to provide recommendations for potential future organizational changes related to the authorities' roles and responsibilities.

4.3.b. Schedules and milestones for completing actions taken or planned by government or authorities

The performance of the national organizations during the country-wide exercise focusing on a nuclear power plant accident, SAMÖ/KKÖ 2011, and during the first month of the accident at the Fukushima Dai-ichi NPP has been evaluated. The results from these evaluations will be assessed further and at this time the schedules for completion of these activities have not yet been set.

4.3.c. Conclusions from the actions taken or planned by the government or authorities regarding the outcome of the operators' activities

The results from the evaluation of the country-wide exercise focusing on a nuclear power plant accident, SAMÖ/KKÖ 2011, demonstrated that Swedish society's overall capacity for dealing with the consequences of a nuclear power emergency was adequate. However, a number of measures for further improvement were identified and will be assessed further.

During the nuclear accident at the Fukushima Dai-ichi NPP, many national organizations were activated and the Swedish Radiation Safety Authority had its crisis organization activated around the clock during the period 11-31 March 2011 in the Emergency Response Centre located in the premises of the Authority. Activities within the national organizations throughout this period have been evaluated and the results will be assessed further.

During the first month of the accident at the Fukushima Dai-ichi NPP, the Swedish Defence Research Agency (FOI) was contracted by the Swedish Radiation Safety Authority to assist the emergency organization and to perform analyses and supplementary radiation monitoring. This interaction has been evaluated further and the need for clarification regarding the role of the Swedish Defence Research Agency (FOI) during a radiological or nuclear emergency is currently being discussed.

The examination of responsibilities for security and safeguards at a national authority level was completed in December 2011. The conclusion has been documented in an official memorandum available at the Ministry of the Environment.

4.4 Summary table for items related to national organizations

Table 4 shows a high-level summary of the items reported under 4.2.a, 4.2.b, 4.2.c, 4.3.a, 4.3.b and 4.3.c. The information provided in this table will be used to assist the coordinator in documenting and compiling the measures planned or taken to address the lessons learned from the accident at the Fukushima Dai-ichi NPP.

Table 4: Summary of items related to national organizations.

Activity	**Activities by the Operators***			**Activities by the Regulator/Government/Authority***		
	(Item 4.2.a) **Activity** **- Taken?** **- Ongoing?** **- Planned?**	**(Item 4.2.b)** **Schedule Or Milestones for Planned Activities**	**(Item 4.2.c)** **Results Available** **- Yes?** **- No?**	**(Item 4.3.a)** **Activity** **- Taken?** **- Ongoing?** **- Planned?**	**(Item 4.3.b)** **Schedule Or Milestones for Planned Activities**	**(Item 4.3.c)** **Conclusion Available** **- Yes?** **- No?**
Topic 4 – National organizations						
Government/authority						
Country-wide exercise focusing on a nuclear power plant accident	Taken	April 2011	Yes	Taken	April 2011	Yes
Evaluations of the country-wide exercise focusing on a nuclear power plant accident	Taken	Oct 2011	Yes	Taken	Oct 2011	Yes
Processing the result from the evaluations of the country-wide exercise focusing on a nuclear power plant accident				On-going		No
Evaluations of performances of the national organizations throughout the first month of the accident at the Fukushima Dai-ichi NPP.				Taken	March 2011	Yes
Processing the result from the evaluations of the performances of the national organizations throughout the first month of the accident at the Fukushima Dai-ichi NPP.				Ongoing		No

Evaluation of the Swedish Defence Research Agency's (FOI) role during a radiological or nuclear emergency				Ongoing		No
Examine the possibilities for Sweden to receive international support during emergency and crisis situations				Taken	April 2012	No
Examination of responsibilities for security and safeguards at a national authority level				Taken	Dec 2011	Yes

* The Operator or Regulator may include other government agencies or entities, stake-holders, if applicable.

5. Topic 5: Emergency preparedness and response and post-accident management (Off-site)

Off-site emergency preparedness and response are essential to prevent or reduce the health effects of a release of radioactive materials. Particularly, in case of accident scenarios beyond design base, large uncertainties and a high number of affected individuals need to be adequately addressed. A number of factors, including the severe damage of infrastructure at the site and its surroundings, the effect on multiple units simultaneously, interruptions to internal and external communication, challenges to the command and control framework, and non-quantified radiation releases, are particularly challenging during the emergency phase.

The accident has further shown the importance of preparing for post-accidental management in advance, including radiological evaluation, defined criteria and efficient mechanisms for decision-making, control and management of contaminated goods, resettlement, communication and information, remediation activities, indemnifications, etc.

Contracting Parties are expected to summarize the results of their review of this topic.

5.1 Overview of performed analyses/activities within emergency preparedness and response

The following section describes recent activities in Sweden focusing on the review and analysis of the off-site emergency preparedness and response capabilities as a result of the accident at the Fukushima Dai-ichi NPP. The Swedish stress tests have resulted in a new focus on different aspects of an emergency response in extreme conditions that shall be addressed during emergency preparedness work. These aspects are presented below.

The Swedish approach to handling the response to the Fukushima Dai-ichi NPP accident is also presented, including a description of the Swedish approach, which resulted in a decision to recommend iodine prophylaxis to Swedish citizens in Japan living or residing within a distance of 250 km from the Fukushima Dai-ichi NPP site.

The Swedish regulator, SSM, has also reviewed and evaluated its own emergency preparedness and response programme, including its links with organizations at the national level (chapter 4). The progress made thus far is due to initiatives taken by the Authority, including the results of the evaluation of the national SAMÖ/KKÖ exercise that took place between February and April 2011, an evaluation of the accident management at the Fukushima Dai-ichi NPP and the results of a recent IAEA IRRS review.

5.2 Activities performed by the operators

5.2.a. Overview of the actions taken or planned by the operators to address emergency preparedness

The severe accident procedures are intended to cover a maximum of 24 hours. Major events would mean that the on-site emergency preparedness organization would require outside assistance to rescue personnel and to extinguish fires in the plant (for about a week). A prerequisite for them to operate is that they can get to and from the site. In the event of a severe accident, the licensee’s emergency preparedness organization contacts the emergency group at Vattenfall and E.On, respectively. The emergency groups have joint exercises with the companies’ emergency preparedness organizations. The groups maintain competence regarding the unit's design and function, radiation protection/radiology and reactor safety. However, it is important to note that the licensee is responsible for all actions undertaken to mitigate the consequences of an event. The evaluation covers evacuation of remaining personnel, inward transportation of personnel, food, fuel, raw water, nitrogen, boric acid, etc. to the site.

In the off-site emergency preparedness organization, the emergency supervisor at the County Administrative Board controls public emergency operations according to the Civil Protection Act (2003:778). Internal communications are required to create a joint status report and forward it to the external emergency preparedness functions. In order to communicate internally and externally, there are a number of systems such as: Meridian PBX with fixed connections and DECT, fixed telephones via external connections, mobile telephones via GSM, operations phone (via 400 kV network), telephones via military lines (FTN) and pagers.

In their work with the stress tests, the licensees have identified the following recommendations for further evaluations and reassessments. All recommendations have not been identified by all licensees and are not relevant to all units:

- Clarify the responsibility for off-site decontamination stations for personnel during shift turnovers and how equipment is to be replaced. Plan for a location off-site where staff can be equipped, dosimetry can be performed, safety equipment may be distributed, etc.
- Investigate the course of action during a long-term need for personnel and all kinds of needed material, food and protective equipment.
- An investigation has been suggested to ascertain advantages and disadvantages when replacing the present substitute Command Centre with a suitable office outside the site so that both Command Centres are not situated within the site where they would possibly both become affected by the same bad conditions.
- It should be investigated whether some of the functions included in the staffing of the emergency preparedness organization are sufficient to sustain shifts around the clock.
- At present, calling in personnel is dependent on a functioning GSM/Telenet/telecommunications network. An improvement in this area should be investigated.
- Identify alternative evacuation routes. It might be preferable to wait with abandonment. If there are no roads, the rescue leaders must investigate the possibility of cross-country, sea or air transportation. This scenario should be highlighted and preparations possibly made.
- For some sites, connecting auxiliary power to the Command Centre is important. In the event that diesel engines and gas turbines are not available, the Command Centre is then restricted to using available battery power.

5.2.b. Schedules and milestones for completing the operators' planned activities

The Swedish nuclear industry has initiated a joint effort for harmonization of stress test results. The goal is to share information and best practices and to coordinate further evaluations of stress test findings on the part of Swedish NPP units. The work is planned to be completed in 2012. The preliminary schedule for further work is as follows:

- A first version of a common vision, strategy and targets (called the Industry Position Paper) for the post-Fukushima activities is scheduled to be issued in mid of 2012.
- An early estimation of the time schedule of the needed measures to fulfill the defined targets will be assessed during the second half of 2012.
- Investment decisions will be taken according to the general process for such decision making and decided measures will be incorporated in the plant safety upgrading programmes.

5.2.c. Preliminary or final results of the activities including proposals for further actions

In-depth analyses are still ongoing to identify optimal action plans for activities/plant changes that need to be made, and to decide on the corresponding time schedules.

5.3 Activities performed by the regulator

The Swedish Radiation Safety Authority (SSM) has the collective responsibility in Sweden for radiation protection and nuclear safety and is placed under the Ministry of the Environment. SSM is a regulatory, supervisory and licensing authority with an expert role in radiation protection, nuclear safety and emergency preparedness and response. Expert advice from SSM is delivered to the authority responsible for deciding on and implementing protective measures. In the case of the Fukushima Dai-ichi nuclear power accident, the Ministry for Foreign Affairs was the counterpart, receiving advice from SSM and making decisions regarding protective measures for the Swedish citizens in Japan. If an accident at a nuclear facility occurs in Sweden, the local County Administrative Board in the county where the nuclear installation is located is in charge of protecting people and the environment. For more details on how the national organization for crisis management during an accident at a nuclear facility operates, see Topic 4 and to some extent Topic 6.

5.3.a. Overview of the actions taken or planned by the regulator to address emergency preparedness

Work is in progress in Sweden to address the questions that have arisen and the lessons learned during the management of an accident at a nuclear facility far away from but nevertheless having implications for Sweden. The work is aimed at two aspects that have arisen from the accident at Fukushima Dai-ichi. The first aspect is improving the crisis management of Swedish citizens located in another country affected by an accident at a nuclear facility in that country. The second aspect is improving the crisis management of an accident of similar severity at a nuclear facility if it occurred in Sweden. One tool in this process is represented by the European stress tests for nuclear power plants and SSM's conclusions that have been documented in the report on the Swedish stress tests, see ref. [2]. Another tool will be assessing the efficiency of the Swedish national emergency preparedness and response system for severe accidents. Questions that have arisen and have been addressed or are planned to be assessed are discussed in this report.

Actions taken in Sweden focused on Swedish citizens in Japan during the accident at Fukushima Dai-ichi

The crisis organization at SSM was activated around the clock between 11 and 31 March 2011. Radiological and nuclear technical analyses were fully active with continuous efforts focused on characterizing the situation in Japan using the sources of information that were available. Official and public OK information sources were used as well as informal contacts. The situation is still being studied and monitored. One of the international studies that Sweden is participating in that is aimed at characterizing the effects of the Fukushima Dai-ichi accident is the UNSCEAR study.

The efforts of the crisis organization largely focused on the need to advise and inform the Government, mainly through the Ministry for Foreign Affairs, which has the responsibility for Swedish citizens abroad and the crisis organization was also focused on satisfying the general public's need for information and meeting the major interest from the mass media. Information for the Government, the general public and the media was produced continuously and experts from SSM provided daily information in different types of media fora. Social networks such as Facebook and Twitter were used by SSM to enhance the availability of the information to the general public.

To ensure the public that no harmful levels of radiation were reaching Sweden, monitoring was performed in Sweden of air, fallout, foodstuffs and goods from Japan. Travellers returning home from Japan were offered medical advice, and travel recommendations and advice for citizens wanting to travel to Japan were produced.

Iodine tablets were distributed with instructions on intake, plus information on other recommendations regarding travel and living in Japan to Swedish citizens in the country. Sweden recommended its citizens residing within 250 km from the Fukushima Dai-ichi site to administer iodine tablets according to the distributed instructions. Because of this unique decision, a brief description is provided below of SSM's criteria for and logic behind the recommendations given regarding iodine tablets during the nuclear accident at the Fukushima Dai-ichi nuclear facility.

Actions taken in Sweden: SSM's criteria for the recommendations given regarding iodine prophylaxis during the accident at the Fukushima Dai-ichi power plant

Sweden was unique in its decision to recommend to its citizens in Japan within a 250 km radius from Fukushima Dai-ichi that they take iodine tablets as a precautionary measure. The following summarizes the conditions, uncertainties, analyses and rationale relevant for this decision.

Conditions and uncertainties. The conditions at the Fukushima Dai-ichi reactors and the spent fuel ponds were unstable during the days following 11 March 2011. The weather patterns indicated that Tokyo or other land-based areas could be targets for air masses from the Fukushima Dai-ichi reactors. The information received in Sweden from the authorities and utilities in Japan, the IAEA and other international bodies was uncertain, incomplete or arrived late. Given these uncertainties, the question that SSM considered was ***how well can the situation be characterized and the consequences determined, and will there be enough time to act if iodine tablets are needed?*** Sweden decided that the situation would not be able to be well characterized because of the lack of clear information and therefore the consequences would not be able to be determined. Sweden therefore determined that there would not be enough time to act if iodine prophylaxis would be need.

Normal practice in Sweden. During the planning phase in Sweden, iodine tablets and information are distributed to all households in the inner emergency zone (12–15 km from the plants). Iodine prophylaxis is recommended in the inner emergency zone if a general emergency is declared at a Swedish nuclear power plant. In addition, local and central depositories of iodine tablets are also maintained for further distribution if the conditions warrant it. During response, iodine prophylaxis is recommended automatically to residents in the inner emergency zone, who previously had iodine tablets distributed to their households in the event a general emergency is declared. Also, in cases other than a general emergency, or for areas outside the 12–15 km zone during a general emergency, consideration would be given to recommending administering and intake of iodine tablets if doses could be limited to a level of a few mSv. In Japan, a general emergency was declared at the Fukushima Dai-ichi reactors. The question that SSM considered was **shall Swedish citizens in a foreign country receive the same recommendations for protective measures that are normal practice inside of Sweden?** The answer was yes.

Analyses and rationale. Sweden followed the recommendations given by the Japanese Government until 16 March 2011. At this time, the Swedish crisis organization was conducting source term analyses as well as dispersion and dose analyses using the information available on inventories, measurement data and the weather. The first analyses used an iodine source of 0.1% - 1% of one reactor inventory of iodine. This gave a prognosis that justified iodine prophylaxis extending to 30 km (from the reactors). As the situation worsened, analyses used 10% of one reactor inventory of iodine. This justified iodine prophylaxis out to 80 km. At this point in time, there was considerable uncertainty regarding the status and the possible development of status at the larger, common spent fuel pond. The pond was heating up and its temperature was above the design temperature. Although it was not a major source of iodine, if it became too unstable the conditions in general at the plant and the other reactors could have worsened because of, among other things, an evacuation of workers and therefore a lack of manpower for dealing with the whole situation. The analyses were then performed using a source term of 10% of three reactors' inventory of iodine, the same as 30% of one reactor, which gave a prognosis that justified iodine prophylaxis out to 250 km.

Thus, SSM's worst case predictions showed that iodine prophylaxis could be justified out to a radius of 250 km from the Fukushima Dai-ichi nuclear power plant. Given the answers to the questions above, the next question was: ***can a reasonable worst case prediction be produced and which response to the worst case prediction is justified?*** Given the fact that a general emergency was declared at the Fukushima Dai-ichi power plant, that iodine tablets are relatively safe and that the philosophy of radiation protection is to optimize below the reference level (which for this case is 100 mGy), Sweden decided that the predictions produced were realistic and responded by recommending iodine prophylaxis. As a result of this decision, iodine tablets with information on intake were distributed to Swedish citizens in Japan on Saturday and Sunday, March 19 - 20.

The way forward: harmonization, coordination and information exchange. Routines for information exchange with regards to planned countermeasures should be introduced and complied with, e.g. through the IAEA's ENAC (USIE) or the EU's ECURIE or through regional agreements. No new channels for information exchange are necessary; however, routines for proper, predetermined usage of existing channels are needed and should be agreed upon by member states. International agreements on protective measures and coordination of strategies for protection are difficult to achieve. Countries will always exercise their own right to choose how to protect their own citizens. There are both possibilities and difficulties regarding the harmonization of protective actions; there are differences in philosophy and approach. Through continued cooperation between countries, however, optimized coordination can be achieved. At the very least, a functioning information exchange between member states should be achievable.

Actions taken to improving the crisis management of an accident of similar severity as the Fukushima Dai-ichi accident at a nuclear facility in Sweden

Two events occurred simultaneously in Sweden that have been analysed and evaluated, leading to suggestions for improvements in SSM's emergency preparedness and response. The first event was a country-wide exercise focusing on a nuclear power plant accident, SAMÖ/KKÖ 2011, which was conducted in Sweden between February and April 2011 (see also Topic 4) after over a year of planning. Many external organizations, including both national and international organizations and authorities, participated in the exercise. The Swedish Civil Contingencies Agency (MSB) and the County Administration Board in Kalmar had the overall responsibility for the national exercise. The aim of SAMÖ-KKÖ 2011 was to test Swedens capacity for dealing with the consequences of a nuclear power emergency. The exercise involved all levels of society and included the management of both the short-term and long-term consequences. The second event was the Fukushima Dai-ichi NPP accident which began on March 11. Although the handling of the accident in Japan affected SSM's participation in the middle phase of the exercise, experiences from the accident in Japan were included in the last part of the Swedish exercise in April, including a seminar on the long-term effects of the accident.

As a result of the accident in Japan and the subsequent activation of SSM's crisis organization continuously over three weeks, several measures for improving the organization have been identified. These have been compiled along with measures resulting from the evaluation of the SAMÖ/KKÖ exercise, and a number of them have been implemented in a first phase of prioritized improvements. Some examples of measures already taken are: clearer routines for incident documentation, improved routines and checklists for the different functions in the crisis organization, supplementary training for staff and improvements in procedures for operational communication, shift planning, work schedules and information management for the regular SSM organization during the time that the crisis organization is activated.

Another important measure is the updating and formalization of pre-defined criteria on countermeasures and the implementation of measurable operational intervention levels and routines for application of intervention levels. These measures are nearly completed, partly in coordination with the other Nordic countries through ongoing work on the modernization of the Nordic Flag Book specifying protective measures in early and intermediate phases of a nuclear or radiological emergency.

In addition to these measures, a more overarching action has been identified as necessary for improving the possibilities for the SSM crisis organization to fulfil its responsibilities during a nuclear accident or event. SSM's regulations specify that the operator of nuclear facilities shall deliver a source term early during an event to SSM. SSM is also responsible for independently assessing the source term to be used in SSM's analysis of the radiological consequences. However, the plant parameters that would provide the basis for the thorough assessment of the situation and the prediction of the accident progression and radionuclide release are not available online in the Emergency Response Centre located at SSM. SSM and the nuclear facilities are currently working towards establishing a system for electronic transmission of plant data from the Swedish nuclear power plants to SSM's Emergency Response Centre.

Actions taken regarding updating regulations SSMFS (2008:15) concerning Emergency Preparedness at Certain Nuclear Facilities

Experiences gained from SSM's supervision of emergency preparedness at certain nuclear facilities as well as experience gained from the Fukushima Dai-ichi nuclear accident have led to a revision of the Swedish regulation SSMFS 2008:15, *The Swedish Radiation Safety Authority's Regulations concerning Emergency Preparedness at Certain Nuclear Facilities.* Specifically with regards to experiences gained from the Fukushima Dai-ichi nuclear accident, clearer and more stringent demands are made regarding radiation protection of personnel and the communications infrastructure at a power plant. The regulation makes specific demands on having a detailed plan for obtaining protective equipment in a drawn out or long-term event, on having a communications system that is not a public system and an increased demand on having an alternative command and control centre not located near the power plant and having alternative communications possibilities.

Actions taken earlier in Sweden to ensure robust command, control and communications: the regulator's Emergency Response Centre

SSM's Emergency Response Centre is well equipped for its function and was well equipped even before the Fukushima event. The facility is designed to ensure an effective and sustainable management of the Authority's emergency operations, both in peacetime and during times of alert. The facility is protected both physically, through strong fortification, and also by an EMP (electromagnetic pulse) shield. The facility can be operated by autonomous systems of power and communications, is fed by an independent power supply and can operate even during extended losses in the external power supply.

In addition to the Emergency Response Centre, the Authority maintains a mobile Radiological Emergency and Assessment Centre (REAC) that can enable the emergency activities, communications and analyses to be performed anywhere off-site. REAC provides redundancy in SSM's crisis management capabilities.

The Emergency Response Centre has fixed, mobile, encrypted and satellite telephony. SSM has installed fax gateways in its premises and at the backup location described below for efficient sending, receipt and rerouting of fax communication.

The emergency response functions at SSM have access to multiple radio communication systems. All emergency field units at SSM are also equipped with RAKEL mobile radio system (TETRA, Terrestrial Trunked Radio) terminals. By linking in the terrestrial part of the RAKEL network into SSM's PABX, the Authority's RAKEL terminals may also be used as traditional mobile phones. RAKEL is also available in the Emergency Response Centre, both in terms of air coverage and in the form of a dispatcher station physically connected to the terrestrial RAKEL network through dedicated lines within the Armed Forces' infrastructure.

SSM is connected to the Internet via a redundant high-capacity link. Furthermore, SSM is redundantly connected to the nationwide county administration network LstNet, which enables digital information exchange with the counties should Internet connectivity be interrupted. SSM is also linked to the closed Armed Forces Network.

To enable the distributed management of complex emergency events, SSM has invested in a high-performing infrastructure for video telecommunication. A number of VTC systems for field use are readily available for deployment. SSM has also provided VTC equipment to critical counterparts such as the Met Office and the Emergency Response Centres in counties with nuclear power plants. Systems connected to the SSM VTC infrastructure are able to communicate over both public and closed telecommunication networks as well as over public and closed IP networks. Core VTC infrastructural components are installed both at the Emergency Response Centre and at the backup location described below.

SSM maintains an unmanned backup location in the form of a server hall in hot standby, geographically well-separated from the Authority's main location, and capable of taking over support of emergency functions should SSM's main premises be compromised. In such an event, mission-critical parts of the emergency response can be relocated to a safe location and operations maintained with the help of this resource. The site may also be used to route communication to and from the Emergency Response Centre if parts of the transmission pathways from Stockholm fail.

Actions identified in Sweden at the national level

In addition to the specific measures identified for improving the efficiency of SSM's crisis organization and the improvements in SSM's regulation for emergency preparedness at nuclear installations (SSMFS 2008:15), several overarching questions for the Swedish national emergency preparedness and response have been identified. These questions have been clarified, gained impetus and become more clearly defined through a fact-finding mission in Japan undertaken by Swedish regulators in December 2012. The purpose of this mission was to achieve a better understanding of how to more efficiently handle the emergency response and compare the Japanese experiences and Swedish systems. These areas are listed below.

The need for information. The pressure on Japan from other countries and international organizations to provide information on the event and to continuously publish everything from measurement protocols to decisions in English has been considerable. How could Sweden manage this and how should it be organized so that foreign actors, who do not understand the Swedish system, receive a correct picture of the situation?

Endurance. The acute phase of the catastrophe in Japan lasted for several months. The intermediate and long-term stages will continue for a long time. How could Sweden, a relatively small country, handle a drawn out course of events?

Measurement capacity. The need for measurements for mapping fallout, monitoring and control of contaminated persons, foodstuffs and provisions, export control, etc., is great, even with a 'small' discharge. With a large discharge, the experience from Japan shows that the need would be enormous. Which measurement capacity should Sweden have and how is Sweden to receive help from other countries?

International assistance/cooperation. Japan, the world's third largest economy with 128 million citizens, 55 reactors in operation before the accident and conducting extensive research and development within nuclear power technology and radiation protection, has received help from several countries to handle the accident. It is clear that Sweden alone would not be able to handle a large accident at a Swedish nuclear power plant.

Allocation of responsibilities. An accident in a nuclear reactor leading to a large discharge of radioactive material is a national catastrophe. Is today's division of responsibilities optimal or how should the responsibility for handling this type of event be allocated between local, regional and national actors in Sweden? How should collaboration be organized between local, regional and national actors and the nuclear installation during an accident at a Swedish nuclear power plant?

Ambition level. An overarching issue is the organizational form of the Swedish emergency preparedness and response system: is it organized so that it is efficient and optimized with the resources at hand to be capable of managing a serious accident at a nuclear power plant in Sweden? Also, at what level of severity of an accident shall preparedness for response be withheld and maintained? How safe is safe enough?

5.3.b. Schedules and milestones for completing the regulatory body's planned activities

The performance of the regulatory body's actions during the country-wide exercise focusing on a nuclear power plant accident, SAMÖ/KKÖ 2011, and the handling of the accident at the Fukushima Dai-ichi NPP have been evaluated. From these evaluations, a number of actions to increase the effectiveness of SSM's emergency response organization have already been implemented. Examples of the measures taken are described in 5.3.a.

The revision of the Swedish regulation SSMFS 2008:15, *The Swedish Radiation Safety Authority's Regulations concerning Emergency Preparedness at Certain Nuclear Facilities* is in its final review stage and will be implemented on 1 January 2013.

SSM and the nuclear facilities are currently working towards establishing a system for electronic transmission of plant data from the Swedish nuclear power plants to SSM's Emergency Response Centre. Phase 1 of this project is scheduled for completion in December of 2012. Also, updating and formalization of pre-defined criteria on countermeasures and the implementation of measurable operational intervention levels and routines for application of intervention levels are underway and will be finalized no later than in 2013.

Several overarching questions for the national system for emergency preparedness and response that have been identified by SSM are under consideration.

5.3.c. Conclusions of the regulatory body regarding the outcome of the operators' activities

SSM's overall assessment of the emergency response organizations at the nuclear facilities is that all licensees have given a good description of strategies, instructions and equipment. The stress tests have also demonstrated limitations in the emergency preparedness organizations. Investigations need to be conducted to ascertain what is needed so that a facility's emergency preparedness organization is dimensioned to deal with situations in which several facilities are affected simultaneously. SSM's opinion regarding which areas in the operators' emergency preparedness need further and deeper evaluation as a result of the European stress tests for nuclear power plants is summarized as the following items:

- Emergency planning should comprise severe emergency situations involving all units at the site.
- Accessibility and functionality of the ordinary on-site emergency control centre and the alternative emergency control centre should be secured with regard to location, protection, robust communications systems and power supply.
- Personnel safety issues have to be re-assessed. High demands should be applied due to rapidly changing high radiation and contaminations levels during execution of accident management measures. Routines for the emergency response organization should be developed further when it comes to protection of personnel in a severe accident environment. Access to protective equipment, dosimetry and management, as well as working procedures, need to be clarified.
- The need for shared resources available at the site should be evaluated since the currently available resources are insufficient if all units at the site are affected (even in the short term).

– Action plans should be set up where the need for external resources, both human and material, should be identified along with the information on where and how they can be obtained as well as the time for their transport to the site.

– Areas critical for accident management in the long term should be identified. These areas can for example include the need for external resources, routines for access to the site and means for managing the larger quantities of radioactive water.

5.4 Summary table for items related to emergency preparedness and response

Table 5 shows a high-level summary of the items reported under 5.2.a, 5.2.b, 5.2.c, 5.3.a, 5.3.b and 5.3.c. The information provided in this table will be used to assist the coordinator in documenting and compiling the measures planned or taken to address the lessons learned from the accident at the Fukushima Dai-ichi NPP.

Table 5: Summary of items related to emergency preparedness.

Activity	Activities by the Operators*			Activities by the Regulator*		
	(Item 5.2.a) Activity - Taken? - Ongoing? - Planned?	(Item 5.2.b) Schedule Or Milestones for Planned Activities	(Item 5.2.c) Results Available - Yes? - No?	(Item 5.3.a) Activity - Taken? - Ongoing? - Planned?	(Item 5.3.b) Schedule Or Milestones for Planned Activities	(Item 5.3.c) Conclusion Available - Yes? - No?
Topic 5 – Emergency preparedness						
Operators						
Clarify the responsibility for decontamination stations outside the site for personnel during shift turnovers and how equipment is to be replaced.	Planned	Not applicable	No			
Investigate the course of action during a long-term need for personnel.	Planned	Not applicable	No			
Identify alternative evacuation routes.	Planned	Not applicable	No			
An investigation is suggested to ascertain advantages and disadvantages in replacing the present substitute Command Centre with a suitable office outside the site	Planned	Not applicable	No			
It should be investigated whether some of the functions included in the emergency preparedness organization staffing are sufficient, to sustain shifts around the clock.	Planned	Not applicable	No			

At present,calling in personnel depends on a functioning GSM/Telenet. An improvement in this area should be investigated.	Planned	Not applicable	No			
Identify alternative evacuation routes.	Planned	Not applicable	No			
For some sites connecting auxiliary power to the Command Centre is important.	Planned	Not applicable	No			
Regulator						
National exercise SAMÖ/KKÖ 2011: seminar on long-term effects				Taken		Yes
Measure to improve the regulator's crisis organization: clearer routines for incident-documentation,				Taken	Not applicable, completed in 2011	Yes
Measure to improve the regulator's crisis organization: improved routines and checklists for the different functions in the crisis organization,				Taken	Not applicable, completed in 2011	Yes
Measure to improve the regulator's crisis organization: complimentary education for staff,				Taken	Not applicable, completed in 2011	Yes
Measure to improve the regulator's crisis organization: improvements in procedures for operational communication,				Taken	Not applicable, completed in 2011	Yes
Measure to improve the regulator's crisis organization: shift planning,				Taken	Not applicable, completed in 2011	Yes
Measure to improve the regulator's crisis organization: work schedules and information management for the ordinary running of SSM's organization during the time that the crisis organization is activated.				Taken	Not applicable, completed in 2011	Yes
Up-dating and formalization of pre-defined criteria on countermeasures and the implementation of measurable operational intervention levels and routines for application of intervention levels				Ongoing	Latest 2013	

SSM and the nuclear facilities are currently working towards establishing a system for electronic transmission of plant data from the Swedish nuclear power plants to SSM's Emergency Response Centre.				Ongoing	Phase 1 complete December 2012.	No
Revision of the Swedish regulation SSMFS 2008:15 , the Swedish Radiation Safety Authority's Regulations concerning Emergency Preparedness at Certain Nuclear Facilities.				Ongoing	January 2013	
General (overarching) questions for the national system for emergency preparedness and response				Planned	Not decided	
Fact-finding mission to Japan in December 2011 regarding countermeasures and mitigating the effects of the accident				Taken		Yes
Pre-defined criteria on countermeasures				Planned	By 2013	
Item identified as a result of the European stress tests needing further and deeper evaluation: Emergency planning should comprise severe emergency situations involving all units at the site				Taken	Not applicable, completed in Jan 2012	Yes
Item identified as a result of the European stress tests needing further and deeper evaluation: The ordinary on-site emergency control centre and the alternative emergency control centre should be secured				Taken	Not applicable, completed in Jan 2012	Yes
Item identified as a result of the European stress tests needing further and deeper evaluation: The personal safety issues have to be re-assessed				Taken	Not applicable, completed in Jan 2012	Yes
Item identified as a result of the European stress tests needing further and deeper evaluation: The need for common at the site available resources should be evaluated				Taken	Not applicable, completed in Jan 2012	Yes
Item identified as a result of the European stress tests needing further and deeper evaluation: Action plans should be set up where the need for external resources, both human and material, should be identified				Taken	Not applicable, completed in Jan 2012	Yes

Item identified as a result of the European stress tests which needing further and deeper evaluation: Areas critical for accident management in long-term should be identified				Taken	Not applicable, completed in Jan 2012	Yes

* The Operator or Regulator may include other government agencies or entities, TSOs or stakeholders, if applicable.

6. Topic 6: International cooperation

An objective of the CNS is ”to achieve and maintain a high level of safety worldwide through the enhancement of national measures and international cooperation...”

The importance of international cooperation was further highlighted during the Fukushima accident and recovery actions. At the Ministerial Conference on Nuclear Safety, “Member States were encouraged to recognize the importance of international cooperation and collaboration in enhancing safety and regulation”. Contracting Parties should include any actions taken or planned to enhance the capability to offer assistance to another Contracting Party, should a severe accident occur.

The Contracting Parties should consider actions to strengthen the global nuclear safety regime, such as expanding the use of IAEA Safety Standards, hosting peer reviews, and enhancing the transparency and effectiveness of communication among operators, regulators and international organizations.

Contracting Parties are expected to report on actions that have been taken, or are planned, to enhance international cooperation, including:

- *Changes in status with respect to the safety conventions;*
- *Mechanisms for communicating with neighbouring countries and the international community;*
- *Cooperation with international organizations;*
- *Cooperation in the frame of international working groups;*
- *Hosting international peer reviews;*
- *Sharing international operating experience; and*
- *Utilization of IAEA Safety Standards.*

6.1 Overview of the topic analysis

Sweden is party to all of the relevant conventions expected for a country operating nuclear power plants, encompassing nuclear safety, emergency preparedness and response, nuclear liability, spent nuclear fuel, radioactive waste and physical protection. Sweden has also formally committed to implementation of the Code of Conduct on the Safety and Security of Radioactive Sources and the Supplementary Guidance on the Import and Export of Radiation Sources.

Sweden has ratified the International Convention on Early Notification and the Convention on Assistance in the Case of a Nuclear Accident. An official national point of contact (the Swedish Meteorological and Hydrological Institute, SMHI) is available every day around the clock. This is also the case for the officer on duty at the Swedish Radiation Safety Authority (SSM).

Sweden participates in numerous bilateral (15) and multilateral (2) international agreements regarding cooperation on matters of nuclear safety and/or radiation protection. The SSM Management System document no. 102, “Policy for International Agreements”, provides internal SSM guidance for concluding international agreements. Additionally, Sweden and SSM are members of the OECD/NEA and actively participate in various working groups and nuclear radiation safety initiatives.

In the area of emergency preparedness, Sweden collaborates (exchange of information) and has concluded early warning agreements with Denmark, Finland, Germany, Norway, Russia and Ukraine in the event of an incident or accident at a Swedish NPP or abroad. There is also an agreement on the authority level (SSM) concluded with Lithuania. Sweden uses the ECURIE information system for information exchange within the European Union and the ENAC/Emercon system for information exchange between the IAEA member states.

The Nordic authorities involved in radiological emergency planning have agreed to exchange data on a routine basis from the automatic gamma monitoring stations in the respective countries. The five Nordic countries of Denmark, Finland, Iceland, Norway and Sweden have compiled a Nordic Manual describing communication and information routines between the countries for an extensive list of scenarios, which have been agreed upon by these five countries.

SSM exchanges information on nuclear safety issues in several ways. As mentioned above, several bilateral agreements (e.g. with CNSC, Canada; NISA, Japan; NNR, South Africa; US DOE, US NRC and US EPA) on issues of emergency preparedness and response, and nuclear, radiation and waste safety are in effect. SSM participates in international meetings and conferences in order to obtain and share information.

The Ministry of the Environment, the Ministry for Foreign Affairs, SSM and other authorities participate in IAEA meetings at all levels. Furthermore, SSM is active in several OECD/NEA activities, in particular the Working Group on Operating Experience (WGOE). Sharing of information also takes place by providing and extracting data from IAEA and NEA databases or event reporting networks, such as the IAEA/NEA Incident Reporting System (IRS), Information System on Occupational Exposure (ISOE), European ALARA Network (EAN), European Medical ALARA Network (EMAN), the Nordic Society for Radiation Protection (NSFS), the International Radiation Protection Association (IRPA) and several others.

SSM takes part in the cooperation of the EU clearinghouse located at the Institute for Energy of the Joint Research Centre in Petten, the Netherlands. The objective of the European Clearinghouse is to promote effective and efficient implementation of operational experience feedback. It is a network of safety authorities and technical support organizations from the EU region and is operated by a centralized office.

SSM has frequently participated in various peer review activities both within the frameworks of the IAEA and WANO. Sweden has during the past five or six years participated through assignment of SSM staff to IAEA *Integrated Regulatory Review Service* (IRRS) missions to Australia, Canada, France, Spain, Russia, the United Arab Emirates, the United States of America, Korea, Slovenia and Switzerland and an OSART mission to Japan. An IRRS was conducted in Sweden during the period 6-17 February 2012.

Sweden is a member of the European Union and the transposition of various EURATOM Directives into Swedish legislation has an indirect link to the consideration of the application of IAEA Standards. Furthermore, when developing SSM's requirements and guides, the IAEA Safety Standards serve as one of the main bases, and there are many examples of the use of IAEA Standards in SSM's regulations and general advice. Sweden and SSM have representatives in all IAEA Safety Standards Committees (CSS, NUSSC, WASSC, RASSC and TRANSSC). Representatives of SSM (formerly SKI and SSI) have to a large extent been involved in the development of IAEA Safety Standards documents.

6.2 Activities performed by the operators

The industry organization WANO has addressed the Fukushima events in various ways. Soon after the event, a WANO Fukushima commission was formed to draw important conclusions on how to make WANO more efficient. In August, the commission issued a number of new wide-ranging commitments to nuclear safety in the form of recommendations which have since then been approved by the Governing Boards:

- Expanding the scope of WANO Peer Reviews, e.g.: Emergency Preparedness; Severe Accident Management; Multiple Unit Impacts; Design Safety Fundamentals.
- Expanding the frequency of WANO Peer Reviews: each station is to be reviewed at least every four years.
- Developing a worldwide and integrated event response strategy: WANO should take an active role in promoting and implementing a worldwide and integrated nuclear industry event response strategy that effectively and efficiently employs the resources of key international nuclear organizations.

6.2.a. Overview of the actions taken or planned by the operators to address international cooperation

All Swedish plants have agreed to host WANO peer reviews with a frequency of at least one review every fourth year for each unit, with a follow-up review in between. The previous target was one review per six years. The scope of these peer reviews has, based on experience from Fukushima, been expanded to include new areas, e.g. Emergency Preparedness, Severe Accident Management, Multiple Unit Impacts and Design Safety Fundamentals.

WANO will also develop a worldwide and integrated event response strategy.

6.2.b. Schedules and milestones for completing the operators' planned activities

WANO is currently developing its processes for peer reviews and other activities. New routines will be introduced gradually over the next few years.

6.2.c. Preliminary or final results of the activities including proposals for further actions

See above.

6.3 Activities performed by the government or regulator

6.3.a. Overview of the actions taken or planned by the government or regulator to address international cooperation

Conventions

Sweden prepared this national report for the Extraordinary CNS Meeting to be held 27-31 August 2012.

The Swedish Parliament has decided on all the necessary legislative changes to prepare for Sweden to accede to the 2004 Protocol to Amend the Paris Convention on Third Party Liability in the Field of Nuclear Energy. It is expected that this step will be harmonized between all EU Member States.

Sweden will formulate a position regarding amendments to the CNS convention to be ready at the Extraordinary CNS meeting to be held 27-31 August 2012.

Mechanisms for communicating with neighbouring countries and the international community

During the early phase of the Fukushima Dai-ichi NPP accident, the information disseminated by Japanese authorities and the IAEA was often delayed. The Internet and the international mass media were the main sources of information. The Swedish embassy in Tokyo, Japan and the personal networks of employees also provided important sources of information. SSM had an opportunity to receive help with translations of press conferences and the like from Japan. This facilitated and made information retrieval more expedient. However, SSM did not use information until it had been confirmed through official sources such as from the Japanese authorities, from the IAEA Incident and Emergency Centre or similar. This is partly why confirmation of the information took a long time.

After a few days, it was apparent that the pressure on the Japanese authorities had become so severe that international communication could not be prioritized. Sweden has a responsibility for its citizens and, furthermore, acknowledging the difficulties for some Swedish citizens to read and understand Japanese, it was felt that additional information should be supplied by the Swedish embassy. SSM issued advice and recommendations to the Swedish Ministry for Foreign Affairs based on the monitoring data available, as well as analyses conducted by SSM's crisis organization. This work was also backed up by analyses conducted by other countries.

After the initial event in Fukushima, the European Clearinghouse focused its efforts on collecting, evaluating and summarizing all the information that was available and then informing the EU countries. This was one of the main brief descriptions available during the event. The clearinghouse published daily updates for the first 16 days when new information was available. In total, 42 updates were issued, the last one on 9 January 2012.

International communication and information dissemination in a crisis situation is an area that should be re-evaluated in the light of the experience feedback from the Fukushima Dai-ichi NPP accident. The Nordic Nuclear Energy Preparedness Group (NEP) will discuss this area at their March 2012 meeting and it is also one of the objectives of the IAEA meeting to be held 17–20 April 2012 with the National Competent Authorities identified under the Early Notification and Assistance Conventions.

Despite the fact that SSM participates and shares information in several ways (networks, international meetings, formal reporting systems, etc.), SSM could evaluate operating and regulatory experience in a more systematic way, including experience in other States, and establish and implement guidance for dissemination of all significant operating experience lessons learned to all relevant authorized parties. This was also one of the recommendations received by Sweden during the IRRS mission in February 2012.

International cooperation

SSM participates actively in many international activities. The latest update of standing groups with SSM participation counted 150 international groups (convention-related, advisory and working groups, committees, etc.). In addition to this, the Swedish Government participates in political fora and has representatives from universities and high schools in research groups, etc. It is clear that many of these groups perform work which is more or less affected or has even emerged explicitly from the Fukushima Dai-ichi NPP accident. For example, many NEA groups have Fukushima-related issues on their meeting agenda, such as technical safety issues, radiation doses, decontamination and waste issues, emergency preparedness and response, outreach activities, etc. A list of all the inquiries, group work and other activities in which Sweden partakes or will partake in this connection would be far too extensive to provide in detail in this report.

As one example of other recent outreach activities, SSM recently issued a survey to certain elements of the international community to assess the licensing challenges associated with regulatory supervision of management systems, operations and safety culture at nuclear power plants.

Hosting international peer reviews

A full-scope IRRS mission to Sweden was performed 6-17 February 2012. The purpose of this IRRS mission was to review the effectiveness of the Swedish framework for safety within the competence of SSM. Special attention was also given to the review of the regulatory implications of the Fukushima Dai-ichi accident within the Swedish framework for safety.

The IRRS review team consisted of 18 senior regulatory experts from 16 IAEA Member States, five IAEA staff members and an IAEA administrative assistant. The IRRS review team carried out the review in the following areas: responsibilities and functions of the government; the global nuclear safety regime; responsibilities and functions of the regulatory body; the management system of the regulatory body; the activities of the regulatory body including the authorization, review and assessment, inspection and enforcement processes; development and content of regulations and guides; emergency preparedness and response; occupational radiation protection; environmental monitoring; control of radioactive discharges and materials for clearance; control of chronic exposure and remediation; waste management; control of medical exposure and transport.

The IRRS mission also included the following policy areas for discussion: supervisory strategies; competence at SSM; and response to the Fukushima Dai-ichi NPP accident. The IRRS review addressed all facilities and activities regulated by SSM including ten nuclear power units, a nuclear fuel fabrication facility, spent fuel and waste management facilities and users of radioactive sources.

The mission resulted in a total of 22 recommendations, 17 suggestions and 15 cases of good practice. The refurbishment programme implemented at Swedish nuclear power plants as a result of periodic safety reviews by SSM was seen as a good practice. Two other such examples of good practices were the training and briefing of specialists/experts to communicate complex regulatory and technical arguments during television and radio broadcasts and that SSM has developed a strong Man-Technology-Organization (MTO) specialist regulatory competence and provided training in this area to a wide range of its inspectors. Examples of areas warranting attention or needed improvements include: the regulatory system and the use of general advice, the inspection programme in many technical areas, internal guidance to the regulatory staff regarding regulatory practices, staffing, competence needs and resources for the regulatory body and national emergency preparedness issues.

Sharing international operating experience

SSM participates in several international information systems and receives data on events and lessons learned from several sources (IAEA databanks and information systems, NEA systems and others). SSM is a member of the EU Clearinghouse located at the Institute for Energy of the Joint Research Centre (JRC) in Petten, the Netherlands. After the initial event of the Fukushima Dai-ichi accident, the EU Clearinghouse focused its efforts on collecting, evaluating and summarizing the available information and informing the EU countries. The EU Clearinghouse constituted one of the best information sources during the event.

Sweden received invaluable information about the experiences from the Fukushima Dai-ichi NPP accident through contact with Japanese authorities, government bodies and engineers via organizations such as INRA (*International Nuclear Regulators Association*), through presentations at the IAEA General Conference 2011 and other international meetings, and through bilateral information exchange between Japan and Sweden.

SSM staff from the Section for Emergency Preparedness and Response travelled to Tokyo and Fukushima prefecture in December 2011. The main objectives of the journey were to find out facts about the accident at Fukushima Dai-ichi and its consequences, to learn from the Japanese experiences in handling the accident and to investigate possible future areas for research collaborations. The group met with representatives of national and local governments involved in handling the consequences of the nuclear accident as well as representatives of the Tokyo Electric Power Company (TEPCO), that owns and operates the Fukushima Dai-ichi NPP. The group also met with the Investigation Committee, led by Professor Hatamura, for the accidents at the Fukushima nuclear power plant.

In March 2012, SSM received a Japanese delegation from the Japan Engineers Federation (JEF), led by Professor Muneo Morokozu from the University of Tokyo. The delegation visited Finland and Sweden and enabled consultations and exchange of information on technical and administrative issues related to nuclear safety, stress tests of nuclear power plants and the lessons learned and experiences from the Fukushima accident.

SSM staff participated in the USNRC's annual *Regulatory Information Conference* (RIC), which was held 13–15 March 2012 in Bethesda, Maryland, USA. Several sessions addressed topics associated with the Fukushima Dai-ichi nuclear accident and lessons learned. Sweden provided information regarding containment venting and filtration as used in Sweden since the mid-1980s.

Utilization of IAEA Standards and WENRA levels

During the IRRS mission to Sweden in February 2012, it was noted that the process for development of SSM's regulations and general advice does not explicitly mention the use of IAEA Standards in this process. This resulted in, as part of one of the IRRS recommendations, a suggestion to better ensure the compliance with relevant IAEA Safety Standards in the process of developing legislation, regulations and general advice. The implementation will be incorporated in the post-IRRS action plan to follow up received recommendations and suggestions.

SSM is aiming for a more strategic process for following up the production and use of IAEA Safety Standards involving more coherent coordination between representatives in the IAEA sub-committees of NUSSC, RASSC, TRANSSC and WASSC and better coordination with the Government Offices.

The WENRA Reactor Harmonization Working Group developed safety reference levels (RLs) for existing nuclear power plants. The methodology and results of the harmonization study were published in January 2006 in the report "Harmonization of Reactor Safety in WENRA Countries". Stakeholders were invited by WENRA to provide comments and, as a result, the RLs were updated in March 2007. The RLs were updated once again in January 2008, mainly to take into account the publication of the IAEA document GS-R-3.

Sweden has implemented most of the RLs but still has work that remains to be done regarding safety in connection with fires and a few other issues. Due to the experience from the Fukushima accident, WENRA will once again revise the RLs. This work will be done rather quickly, and for this reason WENRA will not wait for the IAEA to update the Safety Standards. A gap analysis is planned to be performed in 2012.

WENRA has produced and decided on seven safety objectives for new NPPs. These objectives are rather general and there is probably no need for their modification based on the lessons learned from the Fukushima accident. Instead, lessons learned will be included in the background position papers and/or as a separate chapter in a planned booklet. SSM will use the safety objectives as one kind of input for the investigations to be conducted in accordance with a Government assignment mentioned in chapter 0.3.

6.3.b. Schedules and milestones for completing the government's or regulatory body's planned activities

This national report and a Swedish position on possible amendments to the CNS are to be ready by the extraordinary CNS meeting to be held 27-31 August 2012.

Sweden has signed the 2004 Amendments to the Paris and Brussels Protocol, but the ratification will be done simultaneously by all EU Member States. No such date has been decided.

An action plan for managing recommendations and suggestions from the IRRS mission to Sweden during the period 6-17 February 2012 is being prepared. The recommendations mentioned in this report (*Better use of IAEA Safety Standards, guidance for disseminating operating experience and lessons learned*) should be implemented preliminarily by December 2013.

SSM has decided to improve its coordination of work between the IAEA Safety Standards Committees, i.e. CSS, NUSSC, RASSC, TRANSSC and WASSC. This work has started and will continue throughout the full CSS term of 2012-16.

Assessment and possible improvement of international crisis communication and information dissemination are presently being discussed. As examples, the Nordic NEP meeting in March 2012 and the IAEA meeting with National Competent Authorities in April 2012 have been mentioned. Other work is performed by HERCA and OECD/NEA. Any changes and amendments of the international instruments in this area are not yet decided or planned.

SSM issued a survey to assess the licensing challenges associated with regulatory oversight of management systems, operations and safety culture at nuclear power plants. The result of this survey is to be reported to the Government in October 2012.

Within the Western European Nuclear Regulators' Association, a new review of the published (2006) and updated (2007-2008) reference levels is taking place. A gap analysis has been decided for 2012.

Sweden exemplified the ongoing international information exchange by naming a bilateral event (with Japan) and a national event with international participation (USNRC RIC). Other such activities are highly likely.

6.3.c. Conclusions of the government or regulatory body regarding the outcome of the operators' activities

Learning from the Fukushima Dai-ichi NPP accident will be a process that will continue for several years. Sweden suggests that this event should be a topic at several of the future CNS review meetings and not only for this extraordinary meeting, in order to fully take advantage of the experiences. Sweden is presently active in bilateral and multilateral information exchange on technical, administrative and other issues related to nuclear safety and the Fukushima Dai-ichi nuclear accident. Interest was shown in the filtered containment venting systems installed at Swedish NPPs during the period 1985-89.

During the period 6-17 February 2012, IAEA performed an IRRS (Integrated Regulatory Review Service) mission to Sweden. Over a two-week period, international experts on nuclear safety and radiation protection reviewed Sweden's and SSM's compliance with the IAEA's Safety Standards. The review demonstrated that the Swedish system for nuclear safety and radiation protection is stable and well-developed. However, it also points out areas where the work can be improved. The IRRS recommendations and suggestions are valuable input for the relatively new authority's work and will serve as a platform for ongoing development. Also, some of the identified good practices deserve mentioning, this for instance applied to the work to modernize the nuclear facilities through measures to improve safety, the work with disposal of spent nuclear fuel as well as the approach to openness and transparency. The proceeding self-assessment activity was also appreciated and SSM staff experienced the IRRS activities as very valuable and enlightening. As a country having many nuclear installations and frequently using ionising radiation in several medical and non-medical activities, Sweden will strive to provide assistance in the form of experts contributing to international peer reviews in other countries.

One lesson from the Fukushima Dai-ichi NPP accident is the importance of an international nuclear liability regime for nuclear accidents. The Paris/Brussels Supplementary and Vienna Conventions, with their link to a 1988 Joint Protocol, are the dominating instruments and Sweden is party to the Paris Convention, the Brussels Supplementary Convention and the 1988 Joint Protocol joining these with the Vienna Convention. The 2004 Protocols of amendments to the Paris and Brussels Conventions will add both to the scope covered and to the minimum coverage, totalling the liability insurance or other financial security at the amount of EUR 1,200 million. Sweden has signed the 2004 Protocols but it has been decided that all EU Member States should ratify the 2004 Protocols at the same time.

Sweden has benefited from direct bilateral contact with the people of Japan, technical organizations and the Japanese authorities. Valuable insight in the present decontamination and rehabilitation activities in Japan was given in connection with a visit by representatives of Swedish authorities to Tokyo and the Fukushima prefecture in December 2011. Sweden was also given the opportunity to share some of its knowledge from activities after the Chernobyl accident in 1986. Technical discussions were held during a Japanese visit to SSM in Stockholm in March 2012.

6.4 Summary table for items related to international cooperation

Table 6 shows a high-level summary of the items reported under 6.2.a, 6.2.b, 6.2.c, 6.3.a, 6.3.b and 6.3.c. The information provided in this table will be used to assist the coordinator in documenting and compiling the measures planned or taken to address the lessons learned from the accident at the Fukushima Dai-ichi NPP.

Table 6: Summary of items related to international cooperation.

Activity	Activities by the Operators* (Item 6.2.a) Activity - Taken? - Ongoing? - Planned?	(Item 6.2.b) Schedule Or Milestones for Planned Activities	(Item 6.2.c) Results Available - Yes? - No?	Activities by the Government or Regulator* (Item 6.3.a) Activity - Taken? - Ongoing? - Planned?	(Item 6.3.b) Schedule Or Milestones for Planned Activities	(Item 6.3.c) Conclusion Available - Yes? - No?
Topic 6 – International cooperation						
Operators						
Expanding the scope of WANO Peer Reviews	Ongoing		Not applica-ble			
Expanding the frequency of WANO Peer Reviews	Ongoing		Not applica-ble			
Developing a world-wide integrated event response strategy	Ongoing		Not applica-ble			
Government/Regulator						
Report to Extraordinary CNS meeting in August 2012				Taken	Not applicable	Yes
Accede to the 2004 Protocol to amend the Paris and Brussels Conventions on Third Party Liability in the field of nuclear energy				Ongoing	Parliament decisions taken Concerted accession by EU MS	Yes No
Formulate a Swedish posi-tion regarding amendments to the CNS				Ongoing	Ready before CNS extraor-dinary meeting 27-31 August 2012	No
Assessment and improve-ment of international crisis communication and infor-mation dissemination.				Ongoing	NEP-meeting, March 2012 IAEA-meeting, 17-20 April 2012	Yes
IRRS recommendation to SSM to establish and imple-ment guidance for dissemi-nation of all significant oper-ating experience and lessons learned to all relevant author-ized parties				Planned	Included in post-IRRS action plan To be imple-mented in December 2013	No
International inquiry: assess the licensing challenges associated with regulatory oversight of management systems, operations and safety culture at nuclear power plants				Ongoing	Inquiry sent to selected coun-tries. Report to the Government 31 October 2012	Yes

Host international peer-review (IRRS) in Sweden which took place in February 2012				Taken Ongoing	Self-assessment and IRRS are finished Work with post-IRRS action plan	Yes No
List of SSM staff members available for IRRS and other IAEA review activities				Taken	Not applicable At least annually updated	Yes
Actively participate in information exchange after the Fukushima accident – International organisations				Ongoing	Not applicable	Will continue for many years!
Bilateral information exchange with Japan: visit to Fukushima				Taken	Not applicable December 2011	Yes
SSM's participation in USNRC RIC. Information given on Swedish experience with filtered containment venting systems				Taken	Not applicable March 2012	Yes
Bilateral information exchange with Japan: Receive visitors in Sweden				Taken	Not applicable March 2012	Yes
IRRS-recommendation: Better ensure compliance with relevant IAEA Standards				Ongoing	Included in Post-IRRS plan. To be implemeted in December 2013	No
More strategic coordination and follow-up of the work in the different IAEA Safety Standards Committees				Ongoing	To be implemented during the current CSS term 2012-2016	No
WENRA review of reference levels (RLs)				Planned / Ongoing	Gap-analysis during 2012	No

* The Operator or Regulator may include other government agencies or entities, TSOs or stakeholders, if applicable.

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