Appendixes

A

Statement of Task

An ad hoc committee, operating under the auspices of the Space Studies Board (SSB) of the National Academies, will convene a public workshop that will feature invited presentations and discussion to assess the nation's current and future ability to manage the effects of space weather events and their societal and economic impacts.

Although cost/benefit analyses of terrestrial weather observing systems and mitigation strategies have a long history, similar studies for space weather are lacking. Workshop sessions will include an analysis of the effects of historical space weather events, and will use the record solar storms of October and November 2003 to focus the presentations and provide data to project future vulnerabilities. The inclusion of historic events and intervals will be important to capture the breadth of space weather impacts, which can be different from event to event, and impacts that occur during non-storm times. There will also be sessions on how space weather impacts might change as technologies evolve and new technologies appear.

Topics to be addressed at the workshop include:

- What are the socioeconomic consequences to the nation of severe space weather events?
- What were the specific effects of the October-November 2003 events?
- How likely are events that are more intense than the 2003 events and what might be the consequences of such events?
- Given existing space weather services, what losses were avoided, or could have been avoided, in recent events?
- Are there specific ground- or space-based sensors that might mitigate or avoid the effects of future severe space weather events? In particular: How will assimilation of data from the Advanced Modular Incoherent Scatter Radar (AMISR) and the Frequency-Agile Solar Radiotelescope (FASR) be used? How might the arrays of instruments envisioned for implementation of the Distributed Arrays of Small Instruments (DASI) concept be employed? How would the loss of Advanced Composition Explorer (ACE) data affect forecast capabilities? What steps might better facilitate the transition to operations of the current and planned solar and space physics missions that have application to monitoring and prediction of severe space weather events?

A report of the workshop will be written.

B

Workshop Agenda and Participants

AGENDA

May 22, 2008

8:00 a.m. **Breakfast Meet and Greet**

8:30 a.m. **Introduction**
Daniel Baker, Laboratory for Atmospheric and Space Physics, University of Colorado-Boulder

8:50 a.m. **Panel Session: Space Weather Impacts in Retrospect**
Moderator: Peggy Shea, Air Force Research Laboratory (emeritus) and Senior Researcher, CSPAR
Rapporteur: Kevin Forbes, Catholic University of America
Panel Speakers and Discussion
Speakers: **Peggy Shea**, Air Force Research Laboratory (emeritus) and Senior Researcher, CSPAR
Frank Koza, PJM Interconnection
Leo Eldredge, Federal Aviation Administration
Michael Bodeau, Northrop Grumman Space Technology
Angelyn W. Moore, Jet Propulsion Laboratory

10:30 a.m. **Break**

10:45 a.m. **Panel Session: Collateral Impacts of Space Weather**
Moderator: Louis Leffler, North American Electric Reliability Council (retired)
Rapporteur: Roberta Balstad, Center for International Earth Science Information Network
Panel Speakers and Discussion
Speakers: **Todd M. La Porte, Jr.**, George Mason University
R. James Caverly, Department of Homeland Security

12:00 p.m. **Lunch**

1:00 p.m. **Panel Session: Current Space Weather Services Infrastructure**
Moderator: Joseph Fennell, Aerospace Corporation
Rapporteur: Leonard Strachan, Jr., Smithsonian Astrophysical Observatory
Panel Speakers and Discussion
Speakers: **O. Chris St. Cyr**, NASA
Charles P. Holmes, NASA
William Murtagh, NOAA Space Weather Prediction Center
Herbert Keyser, USAF, Space and Intel Weather Exploration
Michael A. Hapgood, CCLRC Rutherford Appleton Laboratory

2:15 p.m. **Panel Session: User Perspectives on Space Weather Products**
Moderator: Michael Bodeau, Northrop Grumman Space Technology
Rapporteur: Louis Leffler, North American Electric Reliability Council (retired)
Panel Speakers and Discussion
Speakers: **Michael Stills**, United Airlines, Inc.
James McGovern, ISO New England, Inc.
Lee Ott, OmniSTAR, Inc.
David Chenette, Lockheed Martin Advanced Technology Center
Kelly J. Hand, U.S. Air Force

3:30 p.m. **Break**

3:45 p.m. **Panel Session: Satisfying Space Weather User Needs**
Moderator: Joseph B. Reagan, Lockheed Martin Missiles and Space Company, Inc. (retired)
Rapporteur: Thomas A. Stansell, Stansell Consulting
Panel Speakers and Discussion
Speakers: **Thomas J. Bogdan,** NOAA (joining speakers from the previous session)

4:55 p.m. **Session: Summation of Panel Themes**

5:30 p.m. **Adjourn for the Day**

May 23, 2008

8:00 a.m. **Breakfast Meet and Greet**

8:30 a.m. **Session: Extreme Events in Space Weather**
Moderator: William S. Lewis, Southwest Research Institute
Rapporteur: Eugene Cameron, United Airlines, Inc.
Speakers: **James L. Green**, NASA
T. Paul O'Brien, Aerospace Corporation

9:15 a.m. **Panel Session: The Future: Solutions or Vulnerabilities?**
Moderator: Paul M. Kintner, Cornell University
Rapporteur: Genene M. Fisher, American Meteorological Society
Panel Speakers and Discussion
Speakers: **Ronald S. Polidan**, Northrop Grumman
John Kappenman, Metatech Corporation
Christopher J. Hegarty, MITRE Corporation
Thomas McHugh, FAA
Todd M. La Porte, Jr., George Mason University

10:30 a.m. **Break**

10:45 a.m. **Session: The Way Forward**
Moderator: Daniel Baker, Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder
Rapporteur: Arthur A. Small, Pennsylvania State University
Open Discussion with Workshop Attendees

11:30 a.m. **Summation of the Workshop (Rapporteurs and Moderators)**

12:30 p.m. **Workshop Adjourns**

PARTICIPANTS[1]

Kate Agatone, Government Accountability Office
Daniel Baker, Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder
Roberta Balstad, Center for International Earth Science Information Network
Mike Beavin, Office of Space Commerce
Rich Behalu, National Science Foundation
J. Michael Bodeau, Northrop Grumman Space Technology
Thomas J. Bogdan, NOAA
Kevin Briggs, NCS
Eugene Cameron, United Airlines, Inc.
Simon Cantrell, WxAnalyst
R. James Caverly, Department of Homeland Security
David Chenette, Lockheed Martin Advanced Technology Center
Gerald Ditterberner, G.J. Dittberner Science and Technology
Leo Eldredge, Federal Aviation Administration
Don Fairfield, NASA
Joseph F. Fennell, Aerospace Corporation
Genene M. Fisher, American Meteorological Society
Kevin F. Forbes, Catholic University of America
Sandra J. Graham, National Research Council
James L. Green, NASA
John Greenhill, Department of Energy
Kelly J. Hand, U.S. Air Force

[1]Only registrants who signed in upon arrival are listed.

Michael A. Hapgood, CCLRC Rutherford Appleton Laboratory
Christopher J. Hegarty, MITRE Corporation
Charles P. Holmes, NASA
Devrie Intriligator, Carmel Research Center, Inc.
John Kappenman, Metatech Corporation
Herbert Keyser, USAF, Space and Intel Weather Exploration
Paul M. Kintner, Cornell University
Frank Koza, PJM Interconnection
Joseph Kunches, NOAA
Louis Lanzerotti, NJIT
Todd M. La Porte, Jr., George Mason University
Louis G. Leffler, North American Electric Reliability Council (retired)
Irving Leveson, Leveson Consulting
William S. Lewis, Southwest Research Institute
Kara Lovett, Government Accountability Office
James McGovern, ISO New England, Inc.
Thomas McHugh, FAA
Norman Modlin, NPOESS/PEO
Angelyn W. Moore, Jet Propulsion Laboratory
William Murtagh, NOAA Space Weather Prediction Center
T. Paul O'Brien, Aerospace Corporation
Lee Ott, OmniSTAR, Inc.
Vladimir Papitashvili, National Science Foundation
Maria Pirone, AER, Inc.
Simon Plunkett, Naval Research Laboratory
Ronald S. Polidan, Northrop Grumman
Antti Pulkkinen, NASA/Goddard Space Flight Center
Joseph B. Reagan, Lockheed Martin Missiles and Space Company, Inc. (retired)
Jennifer Rumberg, NASA
Roger Seifert, Bonneville Power Administration, Department of Energy
Peggy Shea, Air Force Research Laboratory (emeritus) and CSPAR
Howard Singer, NOAA
Arthur A. Small III, Pennsylvania State University
Don Smart, AFRL
Dennis Socker, Naval Research Laboratory
O. Chris St. Cyr, NASA
Thomas A. Stansell, Stansell Consulting
Leonard Strachan, Jr., Smithsonian Astrophysical Observatory
Michael Stills, United Airlines, Inc.
David Turner, Analytic Services, Inc.
Rodney Weiher, NOAA

C

Abstracts Prepared by Workshop Panelists

IMPACTS OF SPACE WEATHER ON SATELLITE OPERATORS AND THEIR CUSTOMERS

Michael Bodeau, Technical Fellow, Northrop Grumman Corporation

Satellites provide a wealth of services to mankind:

- Satellites (e.g., GOES, POES, DMSP) provide continuous monitoring of terrestrial weather and allow governments to warn citizens of adverse conditions such as hurricanes.
- Hundreds of communication satellites cost-effectively connect remote populations to news, education, and entertainment (e.g., global cell phones).
- Communication satellites also provide one of the most cost-effective means for interconnecting businesses (one-to-many and many-to-one networks) and customers.
- Satellites provide a critical backup to terrestrial cable systems critical to restoring services during catastrophic events (earthquakes, hurricanes) that damage the ground-based systems.
- Precision location made possible by GPS satellites is now becoming a ubiquitous feature embedded in many commercial products (automobile navigations systems, cell phones, dog collars).
- Science satellites study the universe (e.g., Hubble, Chandra, and other astronomy satellites) and our planet (e.g., NASA's Aura and Aqua).

Since the beginning of the space age in the 1960s and the commercialization of space in the 1970s, space weather has posed a constant challenge to designers and operators of satellites, and indirectly to their customers. The impacts of space weather have ranged from momentary interruptions of service to a total loss of capabilities when a satellite fails.

This presentation reviews the impact of one space weather "storm" on a pair of communication satellites to show the dramatic impact to the satellite operator and its customers when space weather interrupts services. Some of the direct costs of the satellite anomalies are reported, while the more far-reaching impacts on society as a whole are discussed.

SPACE SYSTEMS USER PERSPECTIVE ON SPACE WEATHER DATA PRODUCTS

David Chenette, Lockheed Martin Space Systems Company Advanced Technology Center

Lockheed Martin and its customers rely on high-quality space weather data products from the NOAA/NWS Space Weather Prediction Center to help manage the risks of a variety of critical, high-value activities. These include go/no-go criteria in launches, planning of on-orbit operations (including radiation protection), and support of post-anomaly investigations, which are essential to our product improvement process.

Our customers accept launch delays due to poor terrestrial weather, so launch vehicles need not be designed to operate reliably through tornados or hurricanes, for example. Similarly, significant cost efficiencies are realized by not designing launch vehicles for assured performance in unusually hazardous space weather conditions. Managing the risk of the resultant vulnerability requires that launch decisions take into account the space weather conditions expected during the launch and early on-orbit operations. Because the Sun is a significant and impulsive source of high-energy radiation that can disrupt electronics, near-real-time measurements and accurate short-term predictions of solar activity are essential to maintaining the high reliability of launch systems. Predictions of an hour to several hours in advance are required, depending on the mission.

Beyond the initial launch, other on-orbit operations may be susceptible to unusual or extreme space weather conditions. For example, some communications satellites at geosynchronous orbit are more sensitive to the effects of spacecraft charging during orbit maintenance operations than during normal operations. Planning these operations to avoid this susceptibility requires predicting the level of geomagnetic activity from several days to a week in advance. Real-time monitors of geomagnetic activity and predictions for up to a day in advance are required during the actual operations.

Forecasts and knowledge of high-energy solar activity also are critical to radiation safety in manned space operations. The amount of radiation shielding provided by a space suit during extravehicular activity, for example, is significantly less than the maximum shielding that can be provided by a spacecraft. Systems in low Earth orbit are shielded from high-energy solar radiation by Earth and its magnetic field, but for high-inclination orbits, depending on the longitude of the orbit ascending node, Earth's magnetic shielding is not effective, and systems and people can be exposed to radiation at dose rates that are thousands of times higher than average. Also, the shielding effect of Earth's magnetic field does not extend to the Moon; and for flights to Mars humans could be susceptible to solar events on the far side of the Sun, which are not visible from Earth.

Accurate predictions of major solar events are required to protect man and space systems against the radiation risks posed by major solar flare events. Today we can identify active regions that are likely to produce large solar particle events, and we can classify events and predict expected radiation levels after they occur, but we do not have sufficient data and understanding to predict the timing of these events. Improvements are required both in understanding the precursors to major solar events and in the type and resolution of the data necessary to reveal the signatures of those precursors.

Finally, Lockheed Martin depends on comprehensive space weather data products to support post-anomaly investigations. Detailed data are required to describe the space weather conditions at the time and location of any anomaly to assess whether or not the anomaly was related to those conditions. In cases where a causal relationship can be identified, the results are used to improve the design, to modify the implementation of the design, or to modify operations to protect against future occurrences.

Comments on Data and Predictions

The data now provided from the combination of POES and GOES space weather sensors provide excellent real-time monitors of space weather conditions at low Earth orbit and at geosynchronous orbit, and together they can be used to estimate conditions at intermediate altitudes. These data also monitor solar energetic particle radiation intensity near Earth and the extent to which this radiation penetrates into the magnetosphere. They do not support predictions of space weather events, beyond extrapolations that can describe the evolution of a space weather event after it has occurred.

Real predictions depend on measurements of the Sun and the solar wind. The state of the art of these predic-

tions has improved significantly over the past few years, but in many cases it is only slightly better than a prediction based on persistence. Both the level of detail in our understanding of conditions at the Sun and the fidelity of our models for transport from the Sun to Earth contribute to the current deficiencies. The increases in data quality and resolution that are being and will be provided by the GOES Solar X-ray Imagers, the NASA STEREO mission, the Japanese Hinode Solar Optical Telescope, and soon by NASA's Solar Dynamics Observatory promise major improvements in our understanding of conditions at the Sun.

One way to reduce the deficiencies due to the transport models is to measure solar wind conditions upstream of Earth. The ACE spacecraft has provided such measurements, including limited data in real time, and has demonstrated their value. It is essential to "near-real-time" predictions (taking advantage of the tens of minutes of advance warning possible from L1) that these measurements be continued, and augmented with multipoint observations to enable corrections for geometrical effects.

THE 1859 GEOMAGNETIC SUPERSTORM

James L. Green, NASA

The great geomagnetic storm of 1859 is really composed of two closely spaced massive worldwide auroral events. The first event began on August 28 and the second began on September 2. It is the storm on September 2nd that resulted from a white-light flare, observed by Carrington and Hodgson, that occurred on the Sun on September 1. Although still not widely believed at the time, the flare and storm observations showed that the Sun and aurora were connected and that auroras do generate strong ionospheric currents. Since the weather was mostly clear over many of the inhabited areas of Earth, over the several days of the storm an enormous number of people observed the aurora. In addition to published scientific measurements, newspapers, ship logs, and other records of that era provide an untapped wealth of firsthand observations giving time and location along with reports of the auroral forms and colors. At its height, the aurora was described as being a blood or deep crimson red that was so bright that one "could read a newspaper by it."

Several important aspects of this great geomagnetic storm are simply phenomenal. Significant portions of the world's 200,000 km of telegraph lines were adversely affected. Many of them were unusable for 8 hours or more, and there was a small but notable economic impact. At its peak, the Type A red aurora lasted for several hours and was observed to reach extremely low geomagnetic latitudes on August 28-29 (25 degrees) and on September 2-3 (18 degrees). Auroral forms of all types and colors were observed below 50 degrees latitude for about 24 hours on August 28-29 and about 42 hours on September 2-3. Kenneth McCracken at the University of Adelaide discovered among the ice core data from Greenland and Antarctica that the 1859 nitrate anomaly, generated by the storms accompanying solar particle events (SPEs), stands out as the most extreme event during the last 500 years, with an intensity roughly equivalent to the sum of all the major SPEs during the last 40 years. According to Brian Thomas at Washburn University, the 1859 superstorm was strong enough to actually reduce atmospheric ozone by 5 percent for up to 4 years afterward.

From a large database of ground-based observations the extent of the aurora in corrected geomagnetic coordinates can be determined over the duration of the event. Based on modern understanding of how aurora and ionospheric and magnetospheric currents reflect the rearrangement of the magnetosphere in response to changes in the solar wind, the extreme nature of this event can be better understood. It is most likely that these two major auroral storms are from two closely spaced interplanetary coronal mass ejections (ICMEs) reaching Earth very close together in time. The interaction of a fast ICME plowing through a slower ICME has been observed and produces a much stronger shock. This effect may be partially responsible for the extreme nature of the September 2-3 auroral event. If these ICMEs did not interact, it is clear that the August 28-29 event must have cleared a path in the solar wind, thus allowing the September 2nd CME to transit to Earth in 17.5 hours rather then the average ICME transit time of about 80 hours. It is clear that we have not experienced space weather anything like the 1859 superstorm event in the modern spacecraft era, which to date may have been unusually benign from an SPE perspective. We should be fully aware of what the Sun is capable of producing as we increase our reliance on our space mission assets.

SPACE WEATHER, A DOD PERSPECTIVE

Kelly J. Hand, U.S. Air Force Space Command

Successful military operations rely on our ability to effectively integrate weather information into the planning and execution of land, air, and sea operations, but do space weather and its effects matter to military operations? On the terrestrial weather side, practical examples of weather's importance to the effectiveness of military operations are numerous. Successful air operations require knowledge of weather over the target and include plans for weather conditions on ingress and egress routes to and from the target. Land force operations would certainly be at risk without understanding the actual and forecast soil conditions and their impact on land force trafficability. Accurate observations and forecasts of sea-state and littoral conditions are required in order to safely and effectively conduct naval and marine operations. But does space weather matter to the effectiveness of space and terrestrial military operations? The answer is yes.

The military's need for space weather knowledge is linked directly to environmental conditions relevant to impacts on space and terrestrial technological systems and the services those systems are intended to provide. Ultimately, the military value of actual and predicted space weather information is dependent on our ability to apply it effectively. As with terrestrial weather, the benefits are realized when military system operators and users can proactively mitigate or plan for the effects on their specific system or service. In this regard our nation's military relies on our national space weather information infrastructure in general and on the Air Force Weather Agency in particular. The capability of this infrastructure is to monitor, specify, and predict environmental conditions to serve a variety of national needs, including those relevant to military system and mission effects. We call this the space weather piece of space situational awareness (SSA).

For effective space weather SSA it is important to realize that environmental conditions can significantly affect a military system's performance and therefore may impact its ability to bring intended services to the warfighter. For example, satellite systems, spacecraft components and their payloads, communication links for satellite command and control and mission data, and the satellite's respective ground sites can all be affected by the environmental conditions in which they operate. Likewise, terrestrial systems like high-frequency (HF) communications, surveillance, or missile-tracking radars that contribute to missile warning missions can also be affected by the environment. Thus the degree to which the environment impacts these systems and information can be applied to improve performance or protect these systems defines the type of space weather information needed. Fortunately, the natural space environment information the military is concerned about is very similar to information of interest to scientists, NASA operations, and the civil and commercial sectors. This environment of common interest includes the Sun and its energy and mass emissions, interplanetary space and what it contains, and the near-Earth space environment, including the physical parameters that define the magnetosphere, thermosphere, and ionosphere.

To illustrate how the military applies this information, a few military satellite systems are described as practical examples. Figure C.1 is a screen capture of a display of the near-Earth space environment generated by an Air Force Research Laboratory software program. It illustrates the complexity of the natural space environment in the context of low Earth orbit (LEO), medium Earth orbit (MEO), geosynchronous orbit (GEO), and highly elliptical orbit (HEO) satellites. Figure C.1 shows, high above Earth, a cross section of the inner Van Allen belt (~1500-8000 miles altitude—just outside most LEO satellite orbits) and outer radiation belts (MEO intersects the most intense portion at ~12,000 miles altitude).

LEO satellites such as those in the Defense Meteorological Satellites Program (DMSP) operate through the upper atmosphere (at about 600 miles) and are affected by atmospheric drag and sometimes trapped and solar particle radiation. MEO satellites such as the Global Positioning System (GPS) satellites operate in the Van Allen radiation belts at about 12,000 miles altitude and are subject to constant bombardment by the highly energetic electrons that populate this region as well as energetic solar protons and high-energy electrons. Geostationary satellites, like the Defense Satellite Communication System (DSCS) satellites, are at the outside of the radiation belts but operate in a region where charging and discharging can occur on the surface of the spacecraft. Also, GEO satellites experience effects from highly energetic cosmic and solar radiation not as prevalent at LEO altitudes. For these satellite system examples, the users of natural space environmental information include satellite operators and engineers. An example of applications of space weather data includes enabling quicker resolution of

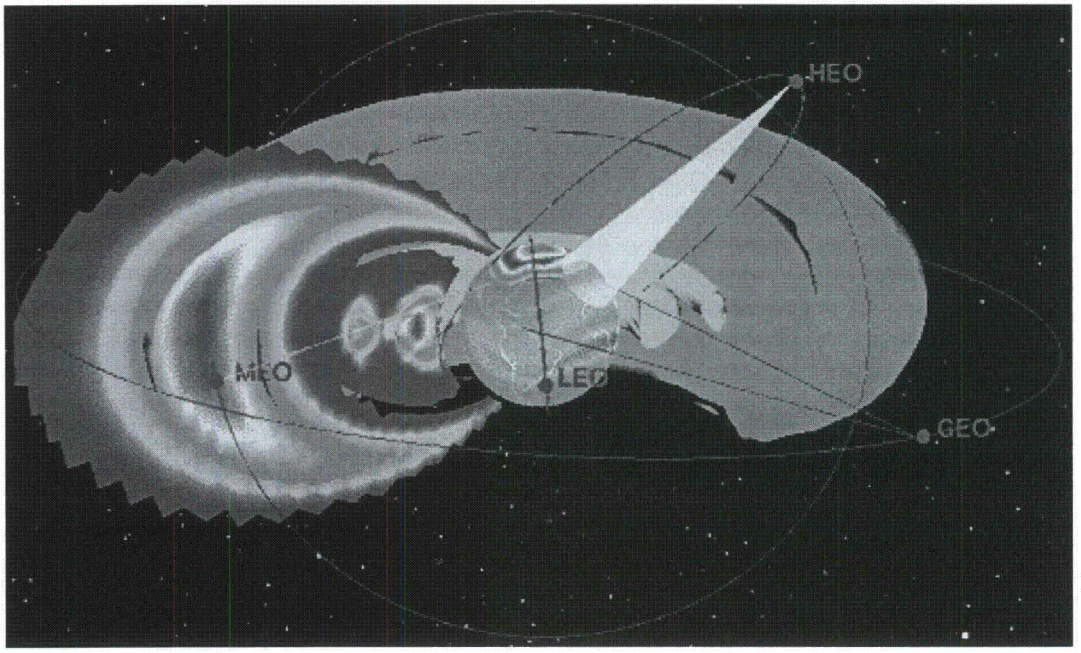


FIGURE C.1 Display of the near-Earth space environment generated by an Air Force Research Laboratory software program.

spacecraft anomaly investigations to get the satellite back into operations and reduce downtime. Also, prediction of when conditions will occur and how bad they will be in the future at the particular satellite can be incorporated into scheduled maintenance procedures.

Finally, all satellites and some ground-based space systems must propagate their radio signals through the ionosphere to reach terrestrial users. Depending on the frequency of the radio signal, the ionosphere can significantly degrade the performance of space system and services, such as communication and GPS services. An example of a terrestrial military system impact concerns high-frequency long-haul communications. An energetic solar x-ray burst can completely black out this type of communication system across the entire Sun-lit Earth. With sufficient space weather awareness, users can plan for and work around these impacts. These few examples highlight the importance of accurate knowledge of the current and predicted state of the natural space environment on military operations.

Conclusion

Space weather has impacts on both terrestrial and space technological systems and services used by the military. Thus the military will continue to depend on our nation's space weather support infrastructure to provide current knowledge and predictions of the natural space environment. In the future as the nation's dependence on space evolves, its reliance on space weather support infrastructure will increase and will benefit from improvements in the state-of-the-science and transition of that science to improved operations.

CURRENT SPACE WEATHER SERVICES INFRASTRUCTURE IN EUROPE

Michael A. Hapgood, CCLRC Rutherford Appleton Laboratory
Chair, ESA Space Weather Working Team

The past 10 years have seen huge progress in developing space weather as a discipline in Europe. In particular there is now a well-established European space weather community comprising scientists and engineers who work together to advance the discipline. However, this bottom-up unity is not yet reflected at higher levels. Space weather services in Europe are set in a complicated, indeed fragmented, landscape that contains a mix of national and European activities.

At a European level space weather activities are supported by a number of actors. The most prominent, of course, is the European Space Agency (ESA). The ESA has done much to stimulate space weather activities. In particular, it has provided seedcorn funding for programmatic studies and for a pilot project on space weather services. These have been very successful and have played a huge part in building the present European space weather community. The pilot project has established a network of 25+ space weather services (SWENET, Space Weather European Network). This network is ideally positioned to be the foundation of an operational European space weather infrastructure. However, to do that, it now needs to find an appropriate long-term home in the broader European landscape. ESA cannot be that home as its task is to carry out research and development—and, having developed new services, it needs to spin them out into an operational body (as it has previously done in building a space meteorology system for Europe—now EUMETSAT). The proposed European program on space situation awareness, which includes space weather as a major element, may provide a path toward that home, especially if, as planned, it builds by federating existing European services.

The other prominent European actor is the European Union (EU). The EU is developing a deeper involvement in space activities; for example, the new EU constitutional treaty, when ratified, will give it a formal legal competence in matters of space policy. This is expected to reinforce its relationship with ESA (their memberships overlap but are not identical), with the EU providing overall policy direction while ESA leads the technical activities that implement those polices. But even without the treaty the EU has been supporting space activities, including some in the space weather domain. EU research funding has supported a variety of activities. Most important is probably the support of human networking under the so-called COST (Cooperation on Space and Technology) actions. There have been several COST actions on trans-ionospheric radio propagation (including space weather effects), and a COST action on space weather has just been completed successfully. A proposal for a new action on space weather is under review. The EU has also funded the development of a coordinated system for digital ionosonde measurements and their dissemination (the DIAS project); a proposal for a follow-up project to combine ionosonde and GPS total electron content measurements is under review as part of a February 2008 call for research infrastructure projects. The EU has also recently funded a major project (SOTERIA) to enable the better science exploitation of space weather data.

The EU-funded COST action on space weather has produced a Space Weather Portal that has the potential to be a gateway to a range of European services. This is likely to be a major focus for future efforts by the European space weather community, especially if the new COST action is approved.

These European projects all provide cross-national support that focuses on front-end services, e.g., generation and dissemination of data products. There has so far been limited European support for space weather monitoring activities that generate the data needed as input to services. (We assume a model where space weather services deliver data products that are of use to end users and those data products are outputs from models of the space weather environment driven by measurements of the environment upstream from the region of interest.) The provision of space weather monitoring is predominantly done by national bodies. A 2001 survey for ESA identified over 100 sensors—most ground-based and focused on measurements of the Sun, ionosphere, and ground-level effects (magnetic field and neutrons). European space-based measurements are limited but include (1) by-products from European space science instruments (e.g., the SWAP solar imager on Proba-2 and the Heliospheric Imager on STEREO), (2) ESA's program to fly space radiation monitors on a wide range of missions, and (3) some limited space weather monitoring on EUMETSAT missions, e.g., the NOAA package on METOP. ESA is seeking to stimulate better coordination of measurements and data handling related to spacecraft effects through a networking

activity that taps into relevant expertise across Europe (Spacecraft Environment and Effects Network of Technical Competence, SEENoTC).

In some cases current national provision puts the monitoring activities at some risk in terms of funding; the national agencies that fund space weather monitoring often have limited understanding of space weather and its European and global context. This is especially true if space weather is funded by agencies that are focused on fundamental science and lack appreciation of modern scientific thinking on complex natural environments. Space weather sits comfortably with environmental disciplines such as atmospheric physics. It sits less well with disciplines that are dominated by a reductionist approach to science. European coordination is an important tool for raising awareness of the importance of individual space weather measurements and allowing national decision makers to understand the global context into which measurements fit.

There are emerging national space weather programmes in several countries—in particular Belgium, France, Germany, and Spain. Denmark and Norway have specialized interests through leadership roles in specific projects—for Denmark the ESA/SWARM mission to study Earth's magnetic field with greater resolution and for Norway the exploitation of Svalbard as a super-observatory for space weather phenomena. Other countries with strong space weather interests include Finland, Italy, Poland, Portugal, Switzerland, Sweden, and the United Kingdom.

Finally we present a SWOT analysis of the European scene. The strengths in respect of space weather services are their value as an application of existing skills in solar-terrestrial and space plasma physics and the ability of developers to engage the wider engineering community. The weaknesses are the fragmented programs discussed above, together with the limited awareness of space weather among decision makers, the poor quality of many existing products, and the risks that arise when space weather is seen as part of astronomy rather than the geosciences. The opportunities are the ability to set a global context in which to make a case for space weather services, and the way that human networking can help to build service context and fix the quality of products. The threats are the risk of piecemeal funding cuts at the national level, possibly exacerbated by competition with other areas. Space weather is also under threat when decision makers think of space as being empty and thus fail to appreciate the effects of the plasmas that pervade outer space.

GLOBAL POSITIONING SYSTEM

Christopher J. Hegarty, The MITRE Corporation

The Global Positioning System (GPS) is a satellite navigation system operated by the United States that includes a constellation of nominally 24 satellites in medium Earth orbit with an approximate altitude of 20,000 km. As illustrated in Figure C.2, new civil and military signals are being introduced. These include the L2 civil (L2C) and military (M code) signals that began with the launch of the first Block IIR-M satellite in 2005. In 2009, the first Block IIF satellite will add a new civil signal, referred to as L5, at 1176.45 MHz. In 2014, the first Block IIIA satellite will add an additional civil signal, L1C, at 1575.42 MHz. Based upon current schedules, the GPS constellation will be fully populated by 2014, 2016, and 2021, respectively, with L2C-, L5-, and L1C-capable satellites.

All of the new civil and military signals include advanced capabilities that are anticipated to result in a significant increase in robustness against space weather effects, specifically ionospheric scintillation and solar radio noise bursts. These capabilities include pilot components for more robust tracking (e.g., a reduction of the minimum signal-to-noise ratio necessary for tracking by ~3-5 dB) and forward error correction of the broadcast navigation data to enable demodulation in lower signal-to-noise conditions.

Two of the new civil signals, L2C and L5, also provide modest increases (1.5 dB and 4.5 dB, respectively) in received signal power relative to C/A code. The addition of L2C and L5 furthermore allows civil GPS receivers to more robustly measure ionospheric delays as compared to the only current civil alternative to employ codeless or semi-codeless techniques to track the encrypted GPS P(Y) code signals on the GPS L2 frequency.

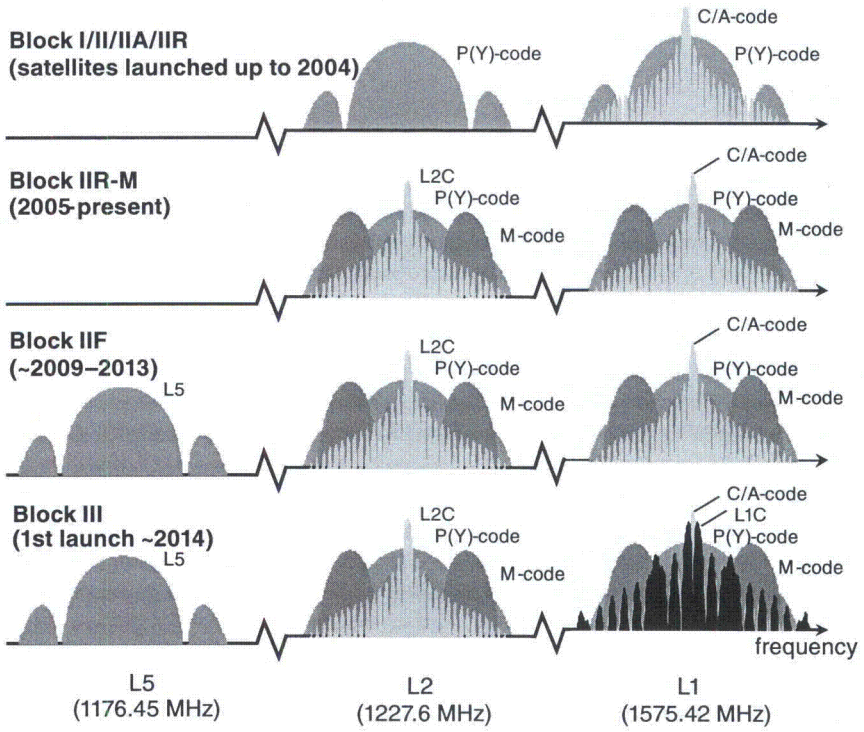


FIGURE C.2 Evolution of GPS signals.

THE VULNERABILITY OF THE U.S. ELECTRIC POWER GRID TO SEVERE SPACE WEATHER EVENTS, AND FUTURE OUTLOOK

John G. Kappenman, Metatech Corporation

Severe space weather events have the potential to pose operational threats to the North American electric power grid; both contemporary experience and analytical work support this general conclusion. A large geomagnetic storm on March 13-14, 1989, triggered a blackout of the Quebec power grid. This same storm also came uncomfortably close to causing similar widespread collapse across northeastern, upper midwestern, and mid-Atlantic regions of the U.S. power grid. More recently, Metatech has carried out investigations under the auspices of the EMP Commission and also for FEMA under Executive Order 13407 to examine the potential impacts on the U.S. electric power grid of severe geomagnetic storm events. These assessments indicate that severe geomagnetic storms pose the risk for long-term outages to major portions of the North American grid. While a severe storm is a low-probability event, it has the potential for long-duration catastrophic impacts to the power grid and its affected users. The impacts could persist for multiple years with a potential for significant societal impacts and with economic costs that could be measurable in the several trillion dollars per year range.

Electric energy supply is the largest segment of energy usage in the U.S. economy, accounting for nearly 40 percent of all energy consumed (in contrast, petroleum accounts for only 22 percent of current U.S. energy consumption). In addition, the operation of many other infrastructures is dependent on a reliable and continuous supply of electricity to maintain their operational continuity. Because of the underlying importance of this service, the electric power grid is a national critical infrastructure. Severe geomagnetic storms may be one of the most important hazards and are certainly the least understood threat that could be posed to the reliable operation of the power networks. As recent detailed examinations have been undertaken concerning the interaction of geomagnetic

storm environments with power grids, the realization has developed that these infrastructures are becoming more vulnerable to disruption from geomagnetic storm interactions for a wide variety of reasons. This trend line suggests that even more severe impacts can occur in the future for recurrences of large storms. These trends of increasing vulnerability also remain unchecked, as no design codes have been adopted to reduce geomagnetically induced current (GIC) flows in the power grid during a storm.

Unlike the more familiar terrestrial weather threats, geomagnetic storms can have a large geographic footprint that can readily encompass major portions of the U.S. electric power grid. This can create in many extra high voltage (EHV) transformers GIC flows that disrupt their normal AC operation. For large storms, widespread and simultaneous disruption can cause correlated multipoint failures and severe voltage regulation problems on the network that can threaten the integrity of the network with the potential for large blackouts. GIC also causes intense internal heating of the exposed EHV transformers, which can lead to permanent damage of these key and difficult to replace assets.

Impulsive geomagnetic field disturbances are an important aspect of the geomagnetic storm environment for electric power grids and other ground-based infrastructures that can be affected by GIC. Significant power grid impacts in present day networks have been observed at relatively low levels of intensity; for example, the Quebec grid blackout during the March 13-14, 1989, storm occurred at a peak intensity of 480 nT/min, and permanent damage to large power transformers has occurred at even lower intensity levels. An analysis of both contemporary and historic storm data and records indicates that dBh/dt impulsive disturbances larger than 2000 nT/min have been observed on at least three occasions since 1972 at latitudes of concern for power grid infrastructures in the United States. In extreme scenarios, available data suggest that disturbance levels as high as 5000 nT/min may have occurred during the great geomagnetic storm of May 1921, an intensity ~10 times larger than the disturbance levels associated with the major impacts observed on North American power grids in March 1989.

Present operational procedures utilized by U.S. power grid operators stem largely from experiences in recent storms, including the March 1989 storm. These procedures are generally designed to boost operational reserves and do not prevent or reduce GIC flows in the network. For large storms (or increasing dB/dt levels) both observations and simulations indicate that as the intensity of the disturbance increases, the relative levels of GICs and related power system impacts will also proportionately increase. Under these scenarios, the scale and speed of problems that could occur on exposed power grids have the potential to impact power system operators unlike anything they have ever experienced. Therefore, as storm environments reach higher intensity levels, it becomes more likely that these events will precipitate widespread blackouts of exposed power grid infrastructures. The possible power system collapse from a 4800 nT/min geomagnetic storm (centered at 50° geomagnetic latitude) is shown in Figure C.3a.

The more difficult aspect of this threat is the determination of permanent damage to power grid assets and how that will impede the restoration process. As previously mentioned, transformer damage is the most likely outcome, although other key assets on the grid are also at risk. In particular, a transformer experiences excessive levels of internal heating brought on by stray flux when GICs cause the transformer's magnetic core to saturate and to spill flux outside the normal core steel magnetic circuit. Previous well-documented cases have noted heating failures that caused melting and burn-through of large-amperage copper windings and leads in these transformers. These multi-ton apparatus generally cannot be repaired in the field, and if damaged in this manner, they need to be replaced with new units, which have manufacture lead times of 12 months or more in the world market. In addition, each transformer design (even from the same manufacturer) can contain numerous subtle design variations. These variations complicate the calculation of how and at what density the stray flux can impinge on internal structures in the transformer. Therefore the ability to assess existing transformer vulnerability or even to design new transformers to be tolerant of saturated operation is not readily achievable. Again, the experience from contemporary space weather events is revealing and potentially paints an ominous outcome for historically large storms that are yet to occur on today's infrastructure. In recent analysis that has been conducted, it is estimated that over 300 large EHV transformers would be exposed to sufficiently high levels of GIC to place these units "at risk" of failure or permanent damage requiring replacement. Figure C.3b provides an estimate of "percent loss" of EHV transformer capacity by state for the same 4800 nT/min threat environment. Such large-scale damage would

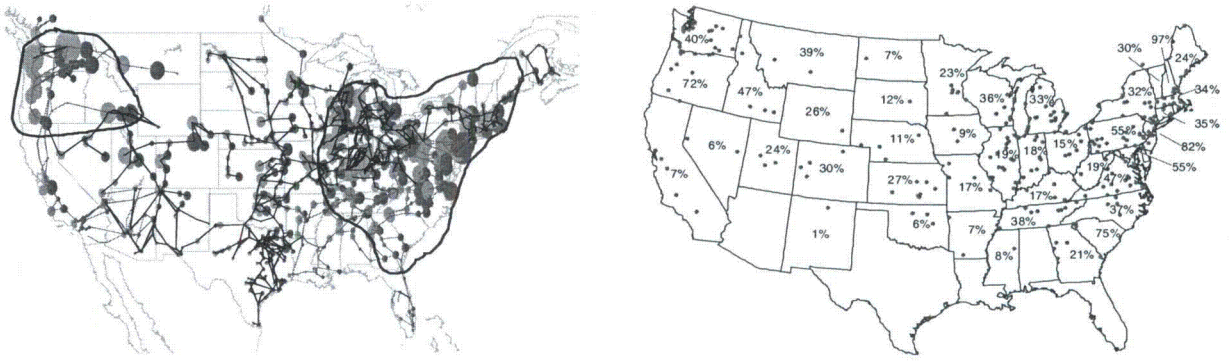


FIGURE C.3 (a; *left*) 4800 nT/min geomagnetic field disturbance at 50° geomagnetic latitude scenario. The regions outlined are susceptible to system collapse due to the effects of the GIC disturbance. The region impacted would be of unprecedented scale and involve populations in excess of 130 million. (b; *right*) A map showing the at-risk EHV transformer capacity by state for this disturbance scenario. Regions with high percentages could experience long-duration outages that could extend multiple years.

likely lead to prolonged restoration time and long-term chronic shortages of electric energy supply capability to the impacted regions.

Given the potentially enormous implications of power system threats due to space weather, it is important to develop effective means to prevent a catastrophic failure. Trends have been in place for several decades that have acted to unknowingly escalate the risks from space weather to this critical infrastructure. Procedures based on K-index-style alerts provide very poor descriptions of the impulsive disturbance environments and lead to uncertainties about the adequacy and efficacy of operational procedures during large storms, because these indices saturate at relatively benign intensity levels. Much good work is being done to develop better means of characterizing and forecasting the threat environments so that power system operator situational awareness of this important threat is better communicated. In terms of the entire grid itself, remedial measures to reduce GIC levels are needed and cost-effective. The installation of supplemental transformer neutral ground resistors to reduce GIC flows is relatively inexpensive, has low engineering trade-offs, and can produce 60-70 percent reductions of GIC levels for storms of all sizes. Additional research work is already under way by the EMP Commission on this task.

AIR FORCE CURRENT SPACE WEATHER INFRASTRUCTURE

Herbert Keyser, USAF, Space and Intel Weather Exploration

The U.S. Air Force (USAF) provides space weather capability for the Department of Defense (DOD) and the nation. Air Force Space Command (AFSPC) is responsible for flying space-based DOD space weather sensors, and Air Force weather procures and operates ground-based space weather sensors and operational space weather models. The Air Force Weather Agency (AFWA), working in conjunction with the National Weather Service's Space Weather Prediction Center (SWPC), collects data, analyzes and forecasts the space weather environment, and provides that information to its customers.

The USAF is focusing on a presidential policy for providing space situational awareness to the nation, to address not only DOD interests, but civil and commercial interests as well. USAF weather and AFSPC are programming to recapitalize current capabilities, develop new capabilities, and mitigate the loss of capability from the National Polar-orbiting Operational Environmental Satellite System (NPOESS) post-Nunn-McCurdy restructuring. With suitable investments, not only by DOD but also by all national partners, we can improve our space weather forecasting capabilities.

The environment is critical in all DOD operations. Specifically, space weather impacts all military operations, whether using communications, Global Positioning System (GPS) services, or flying satellites. When problems occur, the first step is to rule out the environment—and to do this, we need to know the environmental conditions in detail. As the science improves and space weather forecasts become reliable and usable, we can then start planning around expected space weather events, and even configure systems to take advantage of the environment.

Various space weather events cause effects on myriad DOD systems and missions. For instance, an energetic particle event could cause problems with troops communicating in the field, it could expose aircrews to hazardous levels of radiation, or it could interfere with the launching of a satellite. We use various systems to observe and forecast these events, both ground- and space-based; however, we need to be able to do better. This is where modeling comes into play.

Just as in terrestrial weather, we cannot measure the environment everywhere. Currently, AFWA is fielding the first generation of assimilative, physics-based modeling. The Global Assimilation of Ionospheric Measurements (GAIM) model is running at AFWA, with plans to upgrade to a full-physics version in the next couple of years. Models for the magnetosphere, Sun, and solar wind are not as mature; however, AFWA is working to make sure that they can be incorporated, as appropriate.

The DOD network of space weather sensors is in need of a refresh. To this end, the USAF director of weather created a plan to "get well" that focused on our role—ground sensors and modeling. The solar observing sensors and network of ionosondes have been around for a while and are becoming impossible to maintain. USAF weather is taking a phased approach to modernize these systems, with ionosondes being purchased and development work started on the optical solar observing system. We are also increasing our investment to transition current space weather modeling capabilities into operations.

AFSPC is working on replacing capabilities lost on NPOESS as well as helping to sample the rest of the space environment. Because a free-flying satellite would be too expensive, AFSPC is pursuing individual sensors to fly on rides of opportunity from our national and commercial partners. They will also invest in modeling to provide knowledge of effects on their systems. At the same type, we are advocating to NASA and NOAA the development of partnerships to collect information from the rest of the space domain, particularly a solar wind sensor.

As the director of weather says, space weather is a "team sport." No one agency or institution can go it alone. To that end, we already partner with others to get the data we need. First and foremost is the SWPC. Our two forecast centers share virtually all the data, and make combined forecasts every day. Also, the U.S. Geological Survey provides vital magnetometer data to both centers. The USAF also leverages NASA JPL TEC (total electron content) data as well as helping to fund the international tracking of ACE. We have started talks with the National Solar Observatory to get GONG data to AFWA to fill in the gaps in our solar observing and help out while we upgrade our solar optical system.

Of course, to take advantage of the increased data, we need to make corresponding investments in models. USAF weather is increasing its investment in its Space Weather Analysis and Forecasting System (SWAFS) to better use these data, as well as to improve modeling capabilities. AFSPC is making a corresponding investment in effects-based decision aids to take advantage of the improved capability to specify and forecast the environment.

Finally, USAF weather is making sure that we continue to have the needed experts to carry out the space weather mission. We will continue to create advanced academic degree space weather officers, as well as formalize an internal USAF space weather training program.

SPACE WEATHER IMPACTS ON THE ELECTRIC POWER SYSTEM

Frank Koza, PJM Interconnection

Exposure and Vulnerability

The impacts of space weather events on the power system have been well documented. The fact that the major elements of the power system are exposed and particularly vulnerable to space weather can be disconcerting to power system operators. The superposition of extraneous currents onto the normal operational flows on power

system equipment can create conditions that are capable of causing damage in a very short period of time, such that operator action cannot respond in time. Fortunately, most events have relatively benign power system impacts. However, the occasional serious event can have wide-ranging impacts.

March 1989 Event

During March 1989, a solar superstorm created severe impacts on the power system. Most notably, the province of Quebec was blacked out, and there were less severe but serious impacts in other portions of the system. In Quebec on March 13, 1989, a large solar magnetic impulse caused a voltage depression that could not be mitigated by automatic voltage compensation equipment. The failure of the compensation equipment resulted in a voltage collapse in the province in an event that took only 90 seconds to propagate.

Also, during this storm, a large step-up transformer failed at the Salem Nuclear Power Plant, located in southern New Jersey. That failure was the most severe of approximately 200 separate events that were reported during the storm on the North American power system. The other events ranged from generators tripping out of service, to voltage swings at major substations, to other lesser equipment failures.

Assessment of Risk

The operators of the North American power grid constantly review and analyze the potential risks associated with space weather events. Grid operators have access to space weather forecasts, monitor voltages and ground currents in real time, and have mitigating procedures in place. PJM, as an example, has monitoring devices in place at key locations on its system, which are monitored in real time. At the onset of significant ground currents at the monitoring stations, PJM will invoke conservative operations practices that will help mitigate the impacts if the solar event becomes more severe.

What has changed on the power system since 1989? The evolution of open access on the transmission system has fostered the transport of large amounts of energy across the power system in order to maximize the economic benefit of delivering the lowest-cost energy to areas of demand. The magnitude of power transfers has grown, and the risk is that the increased level of transfers, coupled with multiple equipment failures, could aggravate the impacts of a storm event.

The "Perfect Storm"

In trying to conceive of an event that could pose serious implications to the power system, one would think that the peak load case could produce the most severe impacts. However, at peak loads, almost all of the generators are running and there is a lot of spinning mass on the system. Loss of multiple facilities at this time, while problematic, can be handled with emergency procedures and other well-established practices.

The situation that could be more troublesome is a light load case with unusually heavy transfer patterns, as is prevalent in the middle of the night. Loss of multiple facilities at lighter loads and high transfers sets up the potential for voltage collapse with minimal ability for mitigation. (The 1989 Quebec blackout occurred at 2:45 a.m.) It would take the loss of several elements at strategic locations, but if such losses happened at about the same time, a voltage collapse and associated blackout would be possible.

SPACE WEATHER: PUBLIC VULNERABILITIES, INSTITUTIONAL AND PUBLIC POLICY ISSUES

Todd M. La Porte, Jr., George Mason University School of Public Policy

Space weather potentially affects large complex technical systems that are vital for economic and social stability and functioning. Assuring that such systems, principally electric power, communications, and navigation systems, are not damaged or disrupted is a critical problem. Severe space weather events are rare but could

wreak considerable havoc, as has occasionally occurred in previous solar cycles. Such events are known as low-frequency/high-consequence events.

A key issue affecting our ability to prevent disruption to large technical systems is the difficulty of developing the appropriate institutions to deal with the problem on a long-term basis. We know from other emergency and disaster management and planning agencies that institutional development occurs most often under conditions of frequent accidents or errors. When nothing bad appears to happen from one year to another, sustaining preparedness and planning in out-years is extraordinarily challenging. Consequently, space weather is not on the radar screen of many people outside the small technical community and some businesses.

In addition, the systems that would be affected by severe space weather epitomize contemporary society: network systems such as electric power, or navigation and timing systems such as GPS, are increasing (inter)dependent. Operating these systems such that they virtually never fail is critical to economic and social order and human welfare. At the same time, running them is extraordinarily challenging: so-called highly reliable organizations are rare; taken for granted; not well understood; hard to replicate; costly; involve many institutions, technologies, and publics; and require very specific political and administrative conditions. Space weather may threaten failure-free operation of large complex technical systems and organizations.

Developing robust institutions that can respond to extreme space weather events in the absence of a catastrophe, for example a solar superstorm or "solar tsunami," is difficult. There are many discouraging examples: Hurricanes Katrina and Rita, the Christmas tsunami, Three Mile Island, and the shuttle explosions, among others.

But there are some instructive examples as well: e.g., FAA air traffic control and navigation systems, California's earthquake hazard mitigation and management, nuclear power plant safety practices, Dutch storm surge management and engineering institutions, and U.S. nuclear weapons stewardship. All have experienced catastrophic failures in the past, or face clear existential threats in the present. All have institutionalized political constituencies, policy networks, and regulatory structures. All exhibit characteristics of highly reliable organizations as well. Again, understanding the institutional dimension of large technical system operation is critical.

Dependency creep, risk migration, and new technologies are additional potential problems for large technical system operators. As systems become more complex, and as they grow in size, understanding and oversight become more difficult. Subsystems and dependencies may evolve that escape the close scrutiny of organization operators. Dependencies allow risk present in one part of the overall system to "migrate" to others with potentially damaging results. GPS and electric power systems have clearly accelerated dependency creep, and consequent risk migration. New technologies, such as nanoscale components, may not be adequately understood in the context of 11-year solar cycles.

One of the most fundamental concerns for operators of large technical systems is the efficiency-vulnerability trade-off, i.e., how much reserve capacity is available to deal with uncertainty and contingencies. In stable protected environments, systems operate with excess capacity: costs are passed on to users and the society. In competitive market but benign environments, however, systems operate at close to their efficiency frontiers. Slack resources are consumed, buffers shrink, costs fall, and profits rise. But in competitive market and hostile environments, systems become brittle and have trouble operating outside relatively narrow parameters. Vulnerability can be the consequence of increased efficiency. "Security externalities" emerge due to interdependencies, lack of knowledge, lack of slack, lack of trust, and lack of ways to overcome coordination problems. The communities most affected by severe space weather all face this situation.

How might we think about designing for severe space weather events? Space weather is not just a technical matter. It is also importantly a problem of institutions and of society. Solving the recurrent problem of severe space weather entails a number of thorny issues that may ultimately not be resolved without a catastrophic failure to prompt reforms.

USER PERSPECTIVE ON SPACE WEATHER PRODUCTS

James McGovern, ISO New England, Inc.

Impact on Electric Power System

The North American electric power grid acts much like a large antenna, picking up electromagnetic radiation from Earth's geomagnetic field during times of solar storm activity. Only a few amps from geomagnetically induced currents (GICs) in the grounding connections of bulk electric system power stations can wreak havoc on power system operations.

GICs can overload the capability of the electric power system, especially with respect to voltage regulation. They can cause misoperation and malfunction within power relay and protection systems, which can degrade overall system reliability.

Forecast and Real-time Situational Awareness

When a significant amount of solar storm activity occurs, in order for an electric power system to be able to withstand the impact of GIC flows and the resulting harmonics, a system operator must have available timely information that can allow for efficient system re-dispatch and posturing of generation and transmission resources. Without accurate forecast and real-time situational awareness of such solar events, power system failures are likely to occur.

Case in point: On March 13, 1989, at 0245 hr, with Montreal temperatures at minus 15 degrees Celsius, GICs saturated Quebec bulk power system transformers, resulting in a system-wide collapse.

It was over an hour before the system operators realized that the cause of the electrical system failure was a geomagnetic storm of K9 intensity, which resulted in a significant amount of GICs.

Develop Modeling Tools

Additionally, data on solar storms and coronal massive ejection (CME) events made available early on to the operator could allow for a more timely and effective response to their impacts. Also, in the future it may be necessary to develop models of the North American bulk power grid overlaid on a model of the crustal and upper mantle to determine ground resistivity to GICs.

When a frontal or side branch CME event occurs, a forecast of intensity is derived and ultimately provided to the system operator. Often, the estimated time for the ejected matter to reach Earth's surface is not known, due to a lack of understanding of the speed at which the ejected matter is traveling toward Earth.

An understanding of the directional polarity of the ejection is also a critical indicator, as the polarity is a key factor influencing how the event will interact with Earth's geomagnetic field and create GICs. However, often such information is also not available.

In summary, detailed information on space weather forecast data incorporated into a model that correlates the data with the characteristics of the North American bulk power grid is critical to ensure that the system operator has adequate time to posture the system. Regional system operators will also require initial and continuing training to understand their assigned roles and responsibilities in protecting the power system during solar events using these new tools.

SPACE WEATHER: AVIATION VULNERABILITIES AND SOLUTIONS

Thomas McHugh, Department of Transportation FAA

Background

The Federal Aviation Administration (FAA) is in the process of transitioning the National Airspace System (NAS) to utilize space-based navigation as the primary means of navigation. This transition is part of an overall modernization of the NAS to implement integrated Communications Navigation and Surveillance (CNS). Augmented GPS and un-augmented GPS will provide the space-based navigation function. The transition to integrated CNS utilizing space-based navigation will take a long time, and equipage will still be minimal by the next solar peak.

Un-augmented GPS has been in use by aviation for many years. Un-augmented GPS utilizes Receiver Autonomous Integrity Monitoring (RAIM) to provide integrity. Currently RAIM only supports non-precision modes of navigation.

The Wide Area Augmentation System (WAAS) is the FAA's Space Based Augmentation System (SBAS). Other SBASs are under development or already in service. WAAS augments GPS for both non-precision and precision flight operations and covers the entire NAS as well as most of Canada and Mexico. Japan's MSAS was commissioned for non-precision operations in September 2007. MSAS is the acronym for MTSAT Satellite Augmentation System. The European Geostationary Navigation Overlay Service (EGNOS) SBAS is in the final stages of being certified. The Indian GPS Aided GEO Augmented Navigation (GAGAN) SBAS completed initial proof of concept testing in July of 2007 and entered full-scale development testing.

In addition to SBAS systems, Ground Based Augmentation Systems (GBASs) are under development. The first GBAS was recently commissioned in Europe. GBASs are eventually expected to support Category 3 (CAT-3) instrument approaches. Currently SBASs are not believed to be capable of supporting CAT-3 approaches unless the aircraft assumes more of the safety burden.

Space Weather, the Ionosphere, and GPS

The ionosphere delays the GPS signal proportional to the path length, the total electron count (TEC) density along the path, and the frequency of the GPS signals. The density of TEC varies with height, time of day, latitude, and point in the 11.5-year solar cycle, and with solar weather. At midlatitudes TEC density is reasonably well behaved except during strong solar weather events. At equatorial latitudes small quickly moving holes of low TEC and significant levels of scintillation can be observed even under benign solar weather.

GPS is designed to use the difference in delay between the L1 frequency signals and the L2 frequency signals to compute the ionosphere delay at either of the frequencies.

Currently all civil aviation GPS receivers use only the L1 C/A signal. Un-augmented single-frequency GPS receivers use the Klobuchar model (Jack Klobuchar, Boston College) to estimate the ionosphere delay. That model uses a set of polynomial coefficients to describe a lumped vertical (zenith) ionosphere delay on a surface at a fixed altitude above the surface of Earth. Those coefficients are estimated well in advance and broadcast as part of the GPS navigation message. This type of model is sometimes called a thin shell model. SBAS systems broadcast a set of ionosphere grid points to define a patch of a thin shell based on real-time measurement data. WAAS updates the information every 5 minutes. For a GBAS, the ionosphere delay is common between nearby aircraft and the ground system so that the lumped differential correction broadcast by the GBAS includes the ionosphere delay correction.

The Klobuchar model has limited accuracy and is not real time. During solar maximum, the accuracy decreases as the nominal magnitude of the delays increases. Since the Klobuchar model is not real time, it does not react to solar storms, and the error increases further during those events.

The SBAS thin shell model reacts in real time. However, the SBAS thin shell model becomes invalid during severe disturbances in the ionosphere. For example, two different receivers using the same pierce point from two very different look angles could experience significantly different ionosphere delays but would calculate the same

correction. When WAAS detects this type of condition it increases the uncertainty on the ionosphere corrections. This increased uncertainty disables precision navigation.

When the ionosphere is heavily disturbed by solar storm activity there will often be significant scintillation. During very severe events the scintillation could be enough to cause loss of reception on multiple GPS satellites simultaneously. If the scintillation were to be bad enough, it is conceivable that GPS positioning service could be temporarily interrupted.

During at least two events in the last several years, solar flares have emitted radiation in the GPS frequency bands and caused degradation in the received signal-to-noise levels. For WAAS the degradation was about 6 to 10 dB and did not cause significant problems. It is conceivable that a much stronger event could cause enough jamming to cause all GPS reception to be lost for the duration of the portion of the flare emitting radiation at that frequency.

Solution

The first part of the solution is the addition of the L5 civil GPS signals starting with the GPS Block IIF satellites. The first of 12 IIF satellites will be launched in mid-2009. Civilian use of L5 will mitigate the problems with the Klobuchar and SBAS thin shell models. L5 is a protected frequency and has about 400-MHz frequency diversity from L1. The L5 signal design is better than the L1 C/A signal design. The frequency diversity and signal characteristics of L5 will help mitigate unintentional interference.

The second part of the solution is backup navigation systems independent of GPS. Even without considering space weather, backup navigation systems will be needed to mitigate the threat from intentional interference.

The FAA currently plans on maintaining a subset of the existing inventory of ground-based navigation aids for the foreseeable future. This subset of ground-based navigation aids is referred to as the "basic" or "backbone" network. I do not foresee the FAA decommissioning critical navigation aids until the user fleet has installed the necessary satellite navigation equipment. Equipage changes do not happen quickly to that fleet.

Existing ground-based navigation aids do not provide as much capability as GPS and do not fully support the needs of ADS-B and NextGen. Both of those programs have performed backup studies with no clear winner. A mix of eLORAN, DME-DME RNAV, and inertial navigation are the front runners as the backup for the requirements not met by the backbone network. There are also proponents for multilateration. Multilateration is a concept of using the difference in time of arrival of the aircraft's transponder replies at multiple ADS-B locations to compute the position and trajectory of the aircraft.

National Infrastructure

As much as it is becoming more dependent on the national infrastructure component known as GPS, the FAA is already dependent on the national infrastructure for telecommunications and power. If an extremely massive solar weather event disrupts power and telecommunications over a large area, then the FAA will most likely be affected.

The FAA extensively uses terrestrial communications and satellite-based communications. The contracts for those services require high reliability and diversity, but if both the primary and the backup suppliers were affected simultaneously over a wide area, then there would be impacts on the NAS.

All critical FAA systems are required to have backup power. This essential power is usually provided by a hybrid of battery and motor generator uninterruptible power supplies. Short power outages would not severely impact the NAS. However, there are procedures that constrict the functions some facilities are permitted to perform while operating on backup power. If the power outages were widespread and of a long duration, then the NAS would eventually be impacted.

Disclaimer

Opinions expressed in this paper are the technical opinion of the author and are not an official statement of FAA policy.

THE INTERNATIONAL GNSS SERVICE AND SPACE WEATHER

Angelyn W. Moore, Jet Propulsion Laboratory, California Institute of Technology

The International GNSS Service (IGS; formerly the International GPS Service) is a voluntary federation of more than 200 worldwide agencies that pool resources and permanent GNSS station data to generate precise GNSS products.[1] Participants include mapping agencies, space agencies, research agencies, universities, and so on. Currently the IGS supports two GNSS: GPS and the Russian GLONASS. Over 350 permanent, geodetic GNSS stations operated by more than 100 worldwide agencies constitute the IGS network. These civilian, dual-frequency stations contribute data to multiple data centers at a minimum on a daily basis at a 30-second sampling rate; subsets contribute hourly and four times hourly, and an IGS real-time pilot project is getting under way. The IGS maintains a vendor-neutral stance and only specifies functional requirements; the network is therefore very heterogeneous in instrumentation. The IGS dataset is analyzed independently by multiple analysis centers to form the suite of IGS products, including precise orbits, clocks, station positions, and atmospheric products at a range of latencies. All IGS data and products are openly available and are used routinely by Earth scientists and related applications around the globe. Investigators leverage the collective effort of the IGS's network, archive, and analysis infrastructure when they use IGS products with their own GPS and related data.

The material presented in this talk will sample the IGS's response to the October 2003 ionospheric storms from several perspectives. A representative station suffered intermittent loss of tracking on some or all channels during periods of this storm. The effect of such a loss of data will vary according to how many stations in the area are available and whether all of them are affected, and on the application under consideration. The IGS Ultrarapid orbits are a key IGS product that in 2003 were generated twice daily. Through the final week of 2003, some degradation of the Ultrarapid accuracy can be discerned: not all IGS analysis centers were able to contribute orbit products, and accuracies slipped a few centimeters. Nevertheless, the combined IGS Ultrarapid product achieved <10-cm accuracy for most satellites throughout the week. This would generally not have much of an impact on some types of geodetic processing, such as long-term monitoring of plate motion. However, high-rate and real-time GPS analysis is rapidly improving in detecting seismic surface waves and co-seismic displacement.[2,3,4] Brief or partial loss of tracking due to space weather during a critical event could certainly degrade applications with societal and economic impacts, such as tsunami warning systems.[5] The IGS historical dataset is an openly available archive that can be used to evaluate sensitivity to past space weather events; however, care must be taken when using historical data to allow for the improvement over time of the quality of equipment in the network and the density of the network.

The IGS has an active Ionospheric Working Group with four centers routinely analyzing the IGS dataset to produce ionospheric total electron content (TEC) maps: Center for Orbit Determination (CODE), Berne, Switzerland; European Space Operations Center (ESOC), Darmstadt, Germany; Jet Propulsion Laboratory (JPL); and Universitat Politecnica de Catalunya (UPC). The chair is at the University of Warmia and Mazury in Poland.

---

[1]Dow, J.M., R.E. Neilan, and G. Gendt, The International GPS Service (IGS): Celebrating the 10th anniversary and looking to the next decade, *Adv. Space Res.* 36(3):320-326, 2005, doi:10.1016/j.asr.2005.05.125.

[2]Larson, K.M., P. Boudin, and J. Gomberg, Using 1-Hz GPS data to measure deformations caused by the Denali fault earthquake, *Science* 300:1421, 2003, doi:10.1126/science.1084531.

[3]Choi, K., A. Bilich, K. Larson, and P. Axelrad, Modified sidereal filtering: Implications for high-rate GPS positioning, *Geophys. Res. Lett.* 31: L22608, 2004, doi:10.1029/2004GL021621.

[4]Bock, Y., L. Prawirodirdjo, and T. Melborne, Detection of arbitrarily large dynamic ground motion with a dense high-rate GPS network, *Geophys. Res. Lett.* 31:L06604, 2004, doi:10.1029/2003GL019150.

[5]Blewitt, G., C. Kreemer, W.C. Hammond, H.-P. Plag, S. Stein, and E. Okal, Rapid determination of earthquake magnitude using GPS for tsunami warning systems, *Geophys. Res. Lett.* 33:L11309, 2006, doi:10.1029/2006GL026145.

TABLE C.1 The Suite of IGS Ionospheric Products

	Accuracy	Latency	Updates	Sample Interval
Final Ionospheric TEC Grid	2-8 TECU	~11 days	Weekly	2 hours; 5 deg(lon) by 2.5 deg(lat)
Rapid Ionospheric TEC Grid	2-9 TECU	<24 hours	Daily	2 hours; 5 deg(lon) by 2.5 deg(lat)

The Ionospheric Working Group notified the IGS community of extremely high TEC values in the 2003 event, and the combined IGS product reflects the magnitude of the storm. Like the raw dual-frequency data from the IGS network, the IGS ionospheric products (Table C.1) are openly available and archived indefinitely, and can be valuable tools for researching past space weather events.

CURRENT SPACE WEATHER SERVICES INFRASTRUCTURE

William Murtagh, NOAA Space Weather Prediction Center

NOAA's Space Weather Prediction Center (SWPC) monitors, measures, and specifies the space environment and provides timely and accurate operational space weather forecasts, warnings, alerts, and data to end users in the United States and around the world. The program develops space weather observational requirements for NOAA's sensors, ingests and processes NOAA's (and others') data, and transitions research into operations to improve services.

The SWPC staffs a 24-hour/day Operations Center, through which both in situ and remotely sensed data and imagery flow. SWPC forecasters analyze solar images to assess the current state of the solar-geophysical environment (from the Sun to Earth and points in between). Space weather forecasters also analyze the 27-day recurrent pattern of solar activity. Based on a thorough analysis of current conditions, comparing these conditions to past situations, and using a limited suite of space weather models, forecasters are able to predict space weather on times scales of hours to weeks.

NOAA radiation storm and solar flare radio blackout alerts and forecasts are dependent primarily on GOES data. All SWPC space weather alert messages for geomagnetic phenomena are based on real-time data from the Boulder-NOAA magnetometer, which can be taken as a proxy for other midlatitude locations. Most alert products correspond with the NOAA Space Weather Scales thresholds.

During severe storm periods, these products are distributed both by Web access over the Internet and by direct contact with high-priority customers. These data types are also key for the U.S. weather enterprise, and they support the private and commercial sector in the development of products and services using space weather-related information. The USAF provides critical operational data from the Solar Optical Observing Network (SOON) and the Radio Solar Telescope Network (RSTN).

NASA provides key science data from its research satellites (SOHO, ACE, and STEREO) and plans to provide science data from future approved missions. Data from these research satellites are now deeply ingrained in SWPC forecasting processes. The United States Geological Survey (USGS) provides key ground-based data. SWPC also receives data from many countries and their space agencies throughout the world.

These diverse data streams are analyzed continuously, and that information is applied to both predictions and specifications of various aspects of the space environment. These include the behavior of the geomagnetic field, the character of the ionosphere, and the strength of the near-Earth radiation environment.

SWPC currently relies on a limited suite of empirical and physics-based models. SWPC is committed to bring the new generation of numerical space weather prediction models into the forecast office. To accomplish this, SWPC will leverage the prediction and specification models developed by partner agencies (NASA, NSF, and DOD) and transition them to operations. Data-driven and data-assimilative, physics-based models will provide more accurate, longer-lead-time predictions of severe space weather storms on regional and local scales.

SWPC provides a comprehensive database and Web display of space weather products. SWPC also has a product subscription service that allows customers to register to receive products via e-mail. This allows customers

to manage their own records and product selections, while providing SWPC with specific customer and product-usage information. Over 6500 unique customers subscribe to SWPC's product subscription service. Many data files and products are also available on an anonymous FTP server. Selected products are also distributed on the NOAA/NWS Dedicated Broadcast Systems.

The SWPC customer base is large and growing. More than 50 million files are transferred from the SWPC Web page each month. Over 500,000 files are created monthly with near-real-time data for 176 different products serving more than 400,000 unique customers every month in over 120 countries.

Accurate and timely space weather information is vital in mitigating the potential impact of these storms on our technological infrastructure. Geomagnetic storms can cause widespread electrical blackouts, which could result in significant loss of life, as well as a potential GDP loss in the billions of dollars. Polar flights rerouted due to space weather can cost the airline over $100,000 per flight. If airborne survey data, or marine seismic data, are useless or poor because of solar activity, the financial impacts are significant, with costs in the $50,000 to $1 million range. Primary users of SWPC data include the following:

- *Electric power grid operators* use geomagnetic storm detection and warning systems to maximize power grid stability and to mitigate power grid component damage and large-scale blackouts.
- *Spacecraft launch operators* use radiation products to avoid electronic problems on navigation systems and thus prevent launch vehicles from going off course and being destroyed or misplaced.
- *Spacecraft operations and design* rely on space weather products to ensure spacecraft survival in the face of electronic problems. Space weather effects on satellites vary, but effects range from simple upsets to total mission failure.
- *Manned spaceflight* activities are altered to avoid or mitigate effects of radiation storms that impact crews and technological systems.
- *Navigation systems* users need space weather data as a critical input to ensure the integrity and safe use of electronic (i.e., GPS, Loran) navigational systems.
- *Aviation* uses crucial information on space weather impacts, such as communication outages, potentially harmful radiation, and navigation errors to adjust routes and altitudes.
- *Communications operators* anticipate and react to space weather over a wide range of communications frequencies used by emergency management officials, search and rescue systems, and many others.
- *Surveying and drilling operations* rely on accurate and timely space weather data for safe and efficient high-resolution land surveying and sea drilling.

A growing number of customers are realizing social and economic benefits from applications of SWPC products and services. Expect this trend to continue as we become increasingly dependent on space-based systems and other technologies vulnerable to hazardous space weather.

SPACE WEATHER EXTREMES

T. Paul O'Brien, Aerospace Corporation

In general, systems are and will continue to be designed to operate through extremes of the space environment over their designed life. This assumes an accurate climatology, which is not always available. My expertise is in the area of hazards to the health and operation of satellites, so I will use that as the backdrop for a story about extremes of the space environment. For hazards to spacecraft, the principal concerns are surface charging, internal charging, single-event effects, and total dose. Where possible, I will try to highlight general principles that can be applied broadly.

The reader is advised of an important distinction: "space weather" is the description of a short-term phenomenon: a new forecast might lead to a change of operations. "Space climatology" is a long-term statistical description: a new climatology model might lead to a change of system design.

TABLE C.2 The Present State of Space Environment Hazard Climatology of Extremes

Hazard	Responsible Particles	Climatology	Extreme Value Analysis?
Internal charging	100s keV to MeV electrons	Fennell et al. (2000), O'Brien et al. (2007), NASA-HDBK-4002a	Yes, finite upper limit expected
Surface charging	10s keV electrons	MIL-STD-1809, NASA-TP-2361	No
Single-event effects	MeV protons, ions	October 1989 event, Xapsos PSYCHIC model	Yes, finite upper limit expected (debated)
Total dose over mission	eV to keV electrons, protons, oxygen keV to MeV electrons, protons MeV to GeV protons, heavy ions (cosmic rays)	Partial: Thomsen et al. (2007), JPL91 and Xapsos models, AE-8 and AP-8	Partial: only for solar particles, similar to SEE

Planning for Extremes

Engineers typically design to operate through the extremes. It is highly atypical to intentionally design a system to have a likely susceptibility to extremes of the space environment. Trying to operationally forecast specific instances of extremes of the space environment may be of limited value: either we do not know the threshold beyond which to expect a negative impact on any specific technological system, or we do know because it's happened before and therefore is not unusual or very extreme. There are exceptions: e.g., human extravehicular activity and large-scale infrastructure based on GPS.

A solar radio burst on December 6, 2006, resulted in ~25 dB loss in the signal/noise ratio for many GPS receivers (Carrano and Bridgwood, 2008). The radio flux in the GPS L1 and L2 bands likely exceeded 10^6 solar flux units. Based on climatology (Nita et al., 2002), this should occur about once very 30 years, perhaps less often. For most consumer uses, an outage every few decades is reasonable. However, for critical uses, like aircraft navigation, a backup system or an engineering mitigation must be implemented (see also Gary, 2008).

Extremes are often not known well, and sometimes designs fail to meet specifications: mission assurance is a systems engineering approach to ensuring that systems meet specifications; climatology is a scientific approach to ensuring accurate characterization of worst cases.

At present, important aspects of space environment climatology are not explicitly included in NASA, NOAA, and NSF observation objectives. Climatology is obtained as a side-effect of some other priority (e.g., fundamental science, situational awareness), or it is not obtained at all. See Table C.2.

Extreme Value Analysis

Extreme value analysis is a statistical method, primarily developed in the financial and insurance industries. The analysis determines the shape of the "tail" of the statistical distribution of a quantity. It characterizes intensity of the N-year event (e.g., the 100-year flood). Sometimes (especially for geophysical phenomena) it determines a finite upper limit to the intensity or size of the largest possible event. The results allow designers to quantitatively trade design and specifications against risk. Most relevant space environment phenomena appear to have finite upper limits, but quantitative knowledge of those limits is often poor due to a relatively short history of observations.

The extreme value distribution describes the distribution of largest values taken from multiple independent sample sets, where H gives the probability that any sample maximum will be larger than x. H has three parameters: position, μ; scale, σ; and shape, k. Depending on the sign of k, one obtains one of three different families of the extreme value distribution.

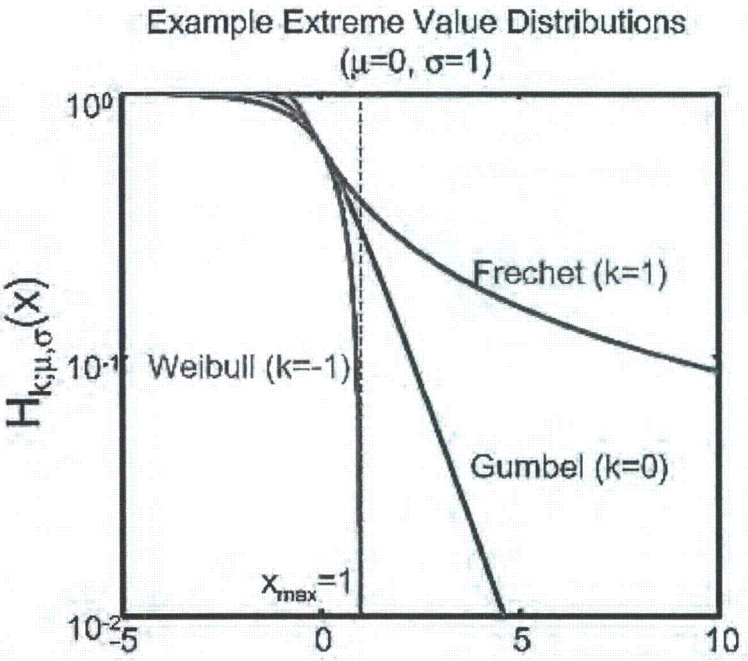


FIGURE C.4 The three families of the extreme value distribution. The Weibull family, $k < 0$, exhibits a finite upper limit and is common in geophysical data. From O'Brien et al. (2007). Copyright 2007 by the American Geophysical Union. Reproduced by permission of the American Geophysical Union.

Figure C.4 illustrates the three families of the extreme value distribution. Using a maximum likelihood method, one can obtain the parameters of H, with the most important being k. O'Brien et al. (2007) applied this method to the electrons that cause internal charging in the outer radiation belt and found a finite upper limit to the fluxes over a large spatial and energy domain. My own analysis (not shown) and that of Tsubouchi and Omura (2007) show that the tail of the distribution of the Dst index of magnetic storm intensity does include the Carrington event (September 1-2, 1859) type intense magnetic storm (Dst < −1600 nT; Tsurutani et al., 2003). Extreme-value analysis thus allows us to bound the largest events expected and to put extremely large events in context.

Concluding Observations

With accurate climatology of extreme events, engineers can make sensible cost-benefit decisions about worst cases: harden design or accept risk. Policy makers must be aware when designs accept risk, just as with earthquakes, hurricanes, and so on. Critical systems must either be hardened or have robust backups.

The following recommended actions might ameliorate the shortcomings of the present state of knowledge of space weather extremes, especially for satellite operations: First, break down cultural and systemic barriers that prevent engineers and scientists from working together to set priorities and develop solutions. Second, promote long-term space environment observation or monitoring as a legitimate scientific objective for NASA; currently, only NSF and NOAA seem to be allowed to do this, while NASA has historically flown the most capable sensors. Given the longer operational life of non-NASA missions, it may be most cost-effective for NASA to exploit more missions of opportunity on operational vehicles.

Acknowledgments

The author acknowledges useful discussion with D. Gary, NJIT, on this topic, and directs the interested reader to his presentation to IES2008 (Gary, 2008). This work was funded by the Aerospace Corporation's Independent Research and Development Program. Available as Aerospace Tech. Report ATR-2008(8073)-1.

References

Carrano, C.S., and C.T. Bridgwood. 2008. Impacts of the December 2006 Solar radio bursts on GPS operations. *5th Symposium on Space Weather.* New Orleans, La., January 20-24, 2008. American Meteorological Society, Washington, D.C.

Fennell, J.F., H.C. Koons, M.W. Chen, and J.B. Blake. 2000. Internal charging: A preliminary environmental specification for satellites. *IEEE Trans. Plasma Sci.* 28(6):2029-2036.

Gary, D. 2008. Cause and extent of the extreme radio flux density reached by the solar flare of 2006 December 06. 12th International Ionospheric Effects Symposium, Alexandria, Va., May 13-15, 2008.

Nita, G.M., D.E. Gary, L.J. Lanzerotti, and D.J. Thomson. 2002. The peak flux distribution of solar radio bursts. *Ap. J.* 570:423-438.

O'Brien, T.P., J.F. Fennell, J.L. Roeder, and G.D. Reeves. 2007. Extreme electron fluxes in the outer zone. *Space Weather* 5:S01001, doi:10.1029/2006SW000240.

Thomsen, M.F., M.H. Denton, B. Lavraud, and M. Bodeau. 2007. Statistics of plasma fluxes at geosynchronous orbit over more than a full solar cycle. *Space Weather* 5:S03004, doi:10.1029/2006SW000257.

Tsubouchi, K., and Y. Omura. 2007. Long-term occurrence probabilities of intense geomagnetic storm events. *Space Weather* 5:S12003, doi:10.1029/2007SW000329.

Tsurutani, B.T., W.D. Gonzalez, G.S. Lakhina, and S. Alex. 2003. The extreme magnetic storm of 1-2 September 1859. *J. Geophys. Res.* 108(A7):1268, doi:10.1029/2002JA009504.

Xapsos, M.A., C. Stauffer, T. Jordan, J.L. Barth, and R.A. Mewaldt. 2007. Model for cumulative solar heavy ion energy and linear energy transfer spectra. *IEEE Trans. Nucl. Sci.* 54(6):1985-1989.

MEETING THE CHALLENGES OF NATURE— THE IMPACT OF SPACE WEATHER ON POSITIONING SERVICES SOLAR CYCLE PROGRESSION AND THE MATURING OF GPS

Lee Ott, OmniSTAR, Inc.

Background of OmniSTAR Groups

OmniSTAR companies were formed by Fugro NV in 1996 to provide differential GPS signals to the offshore oil and gas industry and to the agriculture and geographic information system (GIS) industries. There are three operating companies responsible for the entire world. OmniSTAR, Inc., is responsible for North and South America. OmniSTAR BV is responsible for Europe, Africa, and the Middle East, while OmniSTAR Pty is responsible for Australia and Asia. The three OmniSTAR groups maintain and operate over 130 reference sites around the world. Their task is to retrieve real-time data from reference sites and to create data that are injected into over 14 L-band satellite beams. Due to the criticality of user-base operations, elaborate mechanisms are in place to ensure quality control for the inbound data and in the formation of the broadcast streams to provide integrity to users. All areas of the world are covered by more than one satellite beam, and all uplinks to the satellites can be controlled from each of the OmniSTAR network control centers (NCCs). Each satellite beam contains information for four different types of services. These services are called the VBS, HP, Glonass, and Iono.

Service Descriptions

The VBS service provides GPS single-frequency corrections to users that have single-frequency receivers. The process in the user receiver calculates L1 range corrections using a weighted average of near-reference-station corrections. The process creates range corrections for a virtual base station that is effectively at the user position. This process uses the Klobuchar Iono model to calculate ionosphere delays. The problem with the VBS process is that when the ionosphere delays are disrupted due to space weather phenomena, the accuracy of the VBS solution is degraded. To alleviate this problem the reference stations around the world were upgraded to

dual-frequency receivers, and measurements of the local ionosphere delays are calculated. These delays are then sent to the NCCs and broadcast over the satellite beams, which is our Iono service. VBS users can augment or replace the ionosphere delays calculated by the Klobuchar model with actual delay calculations from nearby stations. Further, a user with a dual-frequency receiver can actually use ionosphere-free measurements to calculate a position. However, on average the ionosphere-free solution has more high-frequency noise due to the codeless tracking of the L2 GPS signal.

The Glonass service is simply a differential Glonass similar to the VBS process. Clients that have a combined GPS-Glonass receiver use this.

The HP (high precision) service consists of two different modes and combinations of both. The first service provides ionosphere-free code and carrier information from its reference sites. The process in the user receiver navigates using the phase measurements only. Code measurements are used at startup to estimate the initial phase offsets and position. The second service does not use reference station information, but rather only precise orbit and clock corrections. It is a phase-based process as well. This service is referred to as XP. Another mode where users can use the reference station corrections along with orbit and clock corrections is called HP/XP.

Space Weather Effects on OmniSTAR Services

When ionosphere disturbances occur, the single-frequency users suffer the worst. Theoretically, the use of Iono service will alleviate some of these issues, but isolated ionosphere disturbances cannot be corrected effectively unless a reference site is extremely close to the user.

Since the HP/XP service uses ionosphere-free corrections, the results will not be affected nearly as much as the single-frequency user set. However, with severe-enough ionosphere disturbances and codeless L2 tracking, receivers may not be able to maintain lock on the GPS satellites. Also, because of limited bandwidth on the broadcast satellites, corrections may be updated too slowly due to the fast changes in corrections at reference sites.

If receivers cannot maintain lock on a sufficient number of satellites, then the accuracy of the solution is degraded due to rising position dilution of precision (PDOP).

Many of our clients rely on positioning to maintain their operations. They use multiple broadcast beams and multiple solutions to maintain reliability and quality control. However, a sudden loss of navigation that can affect all systems can occur as a result of severe ionosphere disturbances. If usage losses cannot be predicted in advance, then it can become extremely costly to our clients:

- *Example 1.* Oil drilling from a semi-submersible that has to disconnect quickly can easily cost the operator a million dollars.
- *Example 2.* Dive boat operations can risk the lives of the divers if the mother ship is driven off position.
- *Example 3.* The cost to an agriculture user is the possible destruction of crops if the guidance system veers off. Multiplied by the number of agriculture users this could have a significant impact.

What Is Needed by the User Community

Better alerts and predictions are needed of areas where ionosphere disturbances will occur. Most of the OmniSTAR user base cannot interpret the information that is currently disseminated. Their only interest is in when their navigation system is going to work.

OmniSTAR does send out bulletins to its users via e-mails and postings on our websites when we know that conditions are such that accuracy might be affected due to PDOP holes and possible ionosphere disturbances. However, more often than not our ionosphere predictions do not come to pass for most of our users due to the localized nature of the disturbances. Thus, our alerts oftentimes are ignored, because we have cried wolf too often.

A SPACE MISSION PROVIDER'S PERSPECTIVE ON SPACE WEATHER

Ronald S. Polidan, Civil Systems Division, Northrop Grumman Space Technology

As a space mission provider, we recognize two distinct aspects of space weather phenomena: measurement and impact. We are interested in helping the science community develop and build future space weather mission concepts, and we recognize the impacts of space weather as our primary environmental factor in designing missions to survive long and well in space and deliver all the mission objectives.

Northrop Grumman has a long history of building missions with space weather payloads, from the earliest Pioneer and Orbiting Geophysical Observatory missions up to the modern-day NPOESS. Since our spacecraft and instrument technology continuously evolves we must stay abreast of how this new technology will survive in the harsh environment of space. We are also very aware of the variability of space weather phenomena and the research that has shown that, prior to our short 50 years in space, space weather events occurred that were much larger and would have been more damaging than anything experienced since 1957. In 2001 the Rumsfeld Commission warned us of the possibility of a "space Pearl Harbor"—an attack on our space assets by an adversary that would leave us vulnerable. We feel there is also a real and serious threat to our space assets from major space weather events. We would also like to avoid a "space Katrina"—a natural space weather storm that severely impacts, disables, or destroys our space assets.

A new factor to be considered when developing future space weather measurement missions is the availability of lower-cost launches. Almost everyone is aware of the efforts to develop much lower cost launch vehicles such as the Falcon family that is being developed by SpaceX. But there are other approaches for low-cost access to space that are less well known. The Lunar CRater Observation and Sensing Satellite (LCROSS), currently being built by Northrop Grumman Space Technology for NASA Ames, is expected to launch in 2009 as a secondary payload with the Lunar Reconnaissance Orbiter (LRO). The LCROSS mission objective is to guide the upper stage of the launch vehicle to an impact in a permanently shadowed lunar crater and analyze the ejecta for the presence of water. While this is a very exciting mission, I would like to focus on how LCROSS is getting into space. The LCROSS mission is not tiny; it has a wet mass of over 800 kg and has significant on-board propulsion. We are looking at LCROSS-based space weather mission concepts that utilize this secondary payload approach for access to space. We feel that this can offer much lower launch costs and provide a vehicle with enough propulsion to get you where you would like to be to perform your space weather measurements.

Switching now to the impacts, rather than measurement, of space weather phenomena on space missions, I would like to discuss two aspects: the possible impacts of superstorms and what new technologies may be on the horizon that could mitigate some of the effects. Fortunately, the possible impacts of a superstorm on our current space assets have already been analyzed by Odenwald, Green, and Taylor (*Advances in Space Research* 38:280-297, 2006). This excellent paper addresses what might happen to our space assets if a superstorm similar to the 1859 Carrington-Hodgson event were to occur today. They suggest that the impacts would be widespread and severe, especially for geosynchronous and medium Earth orbit (GEO and MEO) missions.

To mitigate some of the effects of such superstorms we can look to new electronics technologies that are more tolerant of space radiation. Radiation-hardened-by-design approaches may yield affordable space electronics that could help us "weather" such storms. There are a variety of potential technologies in the marketplace for us to draw from to build our future missions. Currently almost all of these technologies are in early stages of development and need both a sustained technology development and rigorous testing in an appropriate space environment before they are ready for incorporation into a mission. But the promise is high. One small example is the DuraBit™ non-volatile memory being developed by TransEL: it offers the possibility of an upset rate of 1 upset per device every 10^8 years in "worst-case" geosynchronous solar storm conditions, and 1 every 10^{12} years for quiet solar conditions. This wide range of new technology needs to be aggressively evaluated by space mission providers to assess the true value to space missions.

New approaches and new technology are on the horizon that could make our next 50 years in space more affordable, better, and more secure than the first 50 years. We have a better understanding of space weather and its effects, but much more information is still needed. We are in the earliest stages of lower-cost access to space that could greatly benefit space weather measurement. New electronics technology, currently in development,

offers the possibility of mitigating all but the severest effects of space weather storms. We believe that a solid and integrated partnership between industry and the space weather community in developing the missions for the next 50 years of space can lead to more affordable and survivable missions and reduce the impacts of a "space Katrina" on our space assets.

SPACE WEATHER IMPACTS IN RETROSPECT

M.A. Shea, Air Force Research Laboratory (emeritus) and
CSPAR Senior Researcher, University of Alabama, Huntsville

The effect of solar-initiated disturbances on Earth's environment has been known for more than a century. Even before the first visual observation of a solar flare, disruptions in telegraph communications were associated with geomagnetic disturbances. During World War II radar observations were disrupted during solar radio bursts, a fact that was classified until the end of the war. It wasn't until 1946, however, that the emission of energetic particles from the Sun was recognized.

The International Geophysical Year (1957-1958), which coincided with the advent of the Space Age, provided an unprecedented increase in our knowledge of the geophysical and spatial environment. The desire to exploit our spatial environment propelled the engineering community to produce increasingly smaller electronics without, at first, any concrete knowledge of the harshness of the space environment. While solar activity was very high during the 19th solar cycle (1954-1965), this magnitude of activity did not prevail over the next two solar cycles. With the exception of the events in August 1972, solar activity was relatively quiet until 1988. The events over the past two decades together with the major technological advances in the industrial community have resulted in some rather unexpected surprises for scientists, engineers, and even the general public.

This presentation will summarize the chain of events from major solar activity to conditions in Earth's environment that can lead to disruptions in what is now considered to be routine activities. Effects such as communication disruptions, electronic circuitry upsets, and increased radiation dose will be discussed. Specific examples of space weather impacts will be presented. Finally a review of historical solar proton events will be mentioned as cautionary advice that technological planners should consider the possibility of these extremely large events in the design of their operating systems.

NASA'S CURRENT SPACE WEATHER SERVICES INFRASTRUCTURE

O. Chris St. Cyr, NASA Goddard Space Flight Center, and
Charles P. Holmes, NASA Headquarters

Two NASA directorates participate in the national space weather infrastructure: the Science Mission Directorate (SMD) includes the Heliophysics Division, and the Space Operations Missions Directorate (SOMD) sponsors the Space Radiation Analysis Group (SRAG), whose concern is radiation exposure for human explorers in space.

The focus of the programs of the Heliophysics Division is to "understand the Sun and its effects on Earth and the solar system." In particular the programs seek to understand the following:

- How and why does the Sun vary?
- How do Earth and planetary systems respond?
- What are the impacts on humanity?

In pursuit of these questions, the Heliophysics Division has laid out these research objectives:

1. Understand the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium.

2. Understand how human society, technological systems, and the habitability of planets are affected by solar variability and planetary magnetic fields.

3. Develop the capability to predict the extreme and dynamic conditions in space in order to maximize the safety and productivity of human and robotic explorers.

The division executes a series of programs designed to achieve these research objectives. The programs include the flight missions, suborbital flights, and an active research program employing the data gathered from these flight activities as well as pursuing investigations and technologies needed for future missions.

The Heliophysics Division's flight strategy is to deploy modest-sized space missions, frequently, to form a small fleet of solar, heliospheric, and geospace spacecraft that function in tandem to understand the coupled Sun-Earth system. Operating this group of spacecraft as a single observatory (the Heliophysics Great Observatory, or HPGO) allows measurements across distributed spatial scales to be linked with a variety of models and provide capabilities for improving techniques for forecasting space weather. The HPGO has 17 missions currently operating, with 2 scheduled for launch and 4 more under development.

Current members of the HPGO include ACE and STEREO, which have the added feature of real-time data beacons that broadcast current space environment data for use by the space environment reporting and prediction centers at NOAA, USAF, and others. Also near-real-time data from SOHO provide valuable information on current solar activity and warnings of solar energetic particles. The SDO mission's high-resolution solar imagery will be made available in near-real time to the space environment community. Plans are in the works to consider data beacons on the future mission RBSP (2012) and possibly MMS (2014).

The Heliophysics Division solicits through NASA Research Announcements up to nine annual competitions for investigations directed at achieving the division's research objectives. Many of the investigations involve improving models, theory, or physical interpretations fundamental to space weather topics.

The Heliophysics program incorporates a data environment that retains and broadly distributes data gathered from the science instruments of the HPGO. Heliophysics sponsors NASA's participation in the Community Coordinated Modeling Center (CCMC), a multiagency partnership to enable, support, and perform the research and development for next-generation space science and space weather models. The CCMC is a primary vehicle for demonstrating that community research models are suitable for consideration for space weather production uses.

Radiation protection is essential for humans to live and work safely in space. The goal of NASA's Radiation Health Program is to achieve human exploration and development of space without exceeding acceptable risk from exposure to ionizing radiation. Legal, moral, and practical considerations require that NASA limit postflight risks incurred by humans living and working in space to "acceptable" levels.

The Space Radiation Analysis Group (SRAG) at the Johnson Space Center is responsible for ensuring that the radiation exposure received by astronauts remains below established safety limits. To fulfill this responsibility, the group provides:

- Radiological support during missions.
- Preflight and extravehicular activity (EVA) crew exposure projections.
- Evaluation of radiological safety with respect to exposure to isotopes and radiation-producing equipment carried on the spacecraft.
- Comprehensive crew exposure modeling capability.
- Radiation instruments to characterize and quantify the radiation environment inside and outside the human-bearing spacecraft.

The SRAG is NASA's only real-time space environment operations activity. It is a principal customer of NOAA/SWPC. NASA's Office of the Chief Engineer is conducting a comprehensive study toward understanding agency requirements and capabilities needed to support the future human exploration program.

POLAR OPERATIONS AND SPACE WEATHER

Michael Stills, International Operations Flight Dispatch, United Airlines

When planning polar operations, United Airlines relies on the NOAA Space Weather Prediction Center's website to provide the latest space weather data.

SATCOM capability is lost at approximately 82 degrees north latitude as a result of satellite positioning. United has found that solar activity can impede HF capability, and therefore United monitors absorption data in the polar region. Degraded HF in the polar region can limit an aircraft's ability to communicate with air traffic control and the company. This situation will be accounted for in the planning process and avoided. United is also aware of proton flux levels that may be a reason for concern during solar events.

The Space Weather Prediction Center in Boulder has created on its website the tab "Space Weather for Aviation Service Providers," which focuses on the information pertinent to airline operations. In conjunction with alerts based on the NOAA space weather scales, the aviation tab provides a quick snapshot of current space weather.

Airline operations require a considerable amount of preplanning, and terrestrial weather forecasts are an integral part of this process. For polar flights any and all space weather trends or forecasts are taken into account and may include avoidance of the region if the severity of the event dictates per internal policy.

Space weather events do not regularly impact airline operations. There have only been several occurrences since 1999 that have caused United flights to deviate from optimum routes. Though infrequent, these events have been costly and significantly impact some of the long-haul flights. The duration of the events is also of importance.

When space weather events cause operational restrictions, the results have caused delays and fuel stops for flights normally capable of nonstop operations. Current policies protect for solar events, but having information in advance and increasing lead time for planning would be advantageous for the industry. United realizes that much of the data currently available is not specifically geared for aviation.

D

Biographies of Committee Members and Staff

DANIEL N. BAKER, *Chair,* is director of the Laboratory for Atmospheric and Space Physics at the University of Colorado at Boulder and is a professor of astrophysical and planetary sciences and a professor of physics there. His primary research interest is the study of plasma physical and energetic particle phenomena in planetary magnetospheres and in Earth's vicinity. He conducts research in space instrument design, space physics data analysis, and magnetospheric modeling. Dr. Baker has published over 700 papers in the refereed literature and has edited six books on topics in space physics. He is a fellow of the American Geophysical Union, the International Academy of Astronautics, and the American Association for the Advancement of Science (AAAS). He currently is an investigator on several NASA space missions, including the MESSENGER mission to Mercury, the Magnetospheric Multi-Scale (MMS) mission, the Radiation Belt Storm Probes (RBSP) mission, and the Canadian ORBITALS mission. He has won numerous awards for his research efforts and for his management activities, including recognition by the Institute for Scientific Information as being "highly cited" in space research. Dr. Baker was chosen as a 2007 winner of the University of Colorado's Robert L. Stearns Award for outstanding research, service, and teaching. He currently serves on several national and international scientific committees and on advisory panels of the U.S. Air Force and other federal agencies. He was a member of the Panel on Atmosphere-Ionosphere-Magnetosphere of the National Research Council's (NRC's) 2003 solar and space physics decadal survey and he was a member of the 2006 decadal review of the U.S. National Space Weather Program.

ROBERTA BALSTAD is a senior research scientist at Columbia University and a senior fellow with the Center for International Earth Science Information Network (CIESIN) at Columbia University. Dr. Balstad has published extensively on science policy, information technology and scientific research, remote sensing applications and policy, and the role of the social sciences in understanding global environmental change. Before joining Columbia University, Dr. Balstad was the director of the Division of Social and Economic Sciences at the National Science Foundation, the founder and first executive director of the Consortium of Social Science Associations (COSSA), and president of CIESIN. She is chair of the NRC U.S. National Committee for CODATA, a member of the Committee on a Survey of the Scientific Use of the Radio Spectrum, and a member of the U.S. National Committee for the International Institute for Applied Systems Analysis. Dr. Balstad was chair of the NRC Steering Committee on Space Applications and Commercialization.

J. MICHAEL BODEAU has 28 years of experience in the satellite industry and is currently a technical fellow at Northrop Grumman Space Technology. During his career, he has supported the system engineering and detailed design of commercial telecommunication satellites, meteorological satellites, NASA great observatories, and government satellites. His expertise covers the various impacts space weather has on satellite performance and in-orbit anomaly resolution. He has briefed NASA, the U.S. Air Force, NOAA, and other agencies, as well as commercial satellite operators and insurers, on space weather impacts and mitigation. Mr. Bodeau has made multiple presentations to the space weather community on the needs of satellite designers, led a satellite industry splinter group at the October 2002 NASA-sponsored Radiation Belt Model Workshop, and has worked with the space science community to generate new plasma climatology models for GEO satellite design based on 15 years of accumulated in-orbit environment data.

EUGENE CAMERON is manager of Global Support Flight Dispatch for United Airlines and is responsible for coordinating policies and procedures for United Airlines' International Flight Dispatch Operations. Mr. Cameron has been instrumental in the development of cross-polar operations between North America and Asia. He has been associated with the flight dispatch operations of United during his entire career and is active on several International Air Transport Association (IATA) working groups, along with various international air traffic working groups, in the development of new international routes and procedures. Mr. Cameron was the first airline representative to work with the Space Environment Center in 1999 and 2000 to coordinate information exchanges concerning space weather effects on commercial flights in the polar region.

JOSEPH F. FENNELL holds the position of distinguished scientist in the Space Science Application Laboratory at the Aerospace Corporation. Dr. Fennell's recent research has included studies of magnetic storm and radiation belt processes, high-altitude plasma sheet, ring current composition studies, and magnetospheric boundary regions. Dr. Fennell has been involved in the development, fabrication, testing, and flight of many different particle instruments, ranging from auroral and magnetospheric plasma instruments to medium- and high-energy electron and ion sensors. His most recent instrumentation efforts have involved the energetic particle and energetic ion composition measurements on the CRRES, POLAR, and Cluster satellites. Dr. Fennell was a member of the NRC Committee on Solar-Terrestrial Research, and he served on the Panel on Solar Wind-Magnetospheric Interactions of the Committee on Solar and Space Physics: A Community Assessment and Strategy for the Future. He is a member of the NRC Committee on Solar and Space Physics.

GENENE M. FISHER is a senior policy fellow at the Policy Program of the American Meteorological Society (AMS) and a visiting assistant professor of physics at North Carolina State University. Her policy research interests include space weather and atmospheric policy, federal funding of science research, and the interaction between the federal government, scientific community, and private sector. Dr. Fisher's work focuses on policy research and analyses to improve how decisions are made by space weather scientists, end users, and policy makers regarding the impact of space weather on present and future technologies.

KEVIN F. FORBES is an associate professor of economics and chair of the Business and Economics Department at the Catholic University of America, where he teaches courses in microeconomics, industrial organization, and econometrics. He is an active participant in Stanford University's Energy Modeling Forum in which energy experts from government, industry, universities, and other research organizations meet to study important energy and environmental issues of common interest. With the support of the National Science Foundation, he has also written and lectured on the effects of geomagnetic storms on the electricity market. He has recently coauthored a study that examines space weather effects on electricity market outcomes in 12 power grids.

PAUL M. KINTNER is a professor of electrical and computer engineering at Cornell University. Dr. Kintner's research focuses on investigating the interaction of radio signals, both natural and man-made, with Earth's ionosphere or magnetosphere. Dr. Kintner's studies include the propagation of electromagnetic signals (such as VLF signals initiated by lightning or navigational stations), the amplification of both natural and man-made signals

in space, the acceleration of ionospheric plasma by waves to form the radiation belts, and the effect of the space environment on the propagation of radio signals, specifically GPS signals. Dr. Kintner is an experimentalist who acquires electric field and magnetic field measurements from sounding rockets and satellites as well as ground-based measurements using arrays of GPS receivers. He has served on the Arecibo Scientific Advisory Committee, and he chaired the Geospace Mission Definition Team, NASA's Management Operations Working Group, and the Living With a Star-Science Architecture committee. He is a former chair of the NASA Sun-Earth Connections Advisory Subcommittee. He was a member of the NRC Committee on Solar and Space Physics.

LOUIS G. LEFFLER retired in June 2006 after a 47-year career in the electric power industry. He was a manager of critical infrastructure protection with the North American Electric Reliability Council (NERC), where he helped electric utilities develop policy and practices to ensure protection of the nation's electric infrastructure against such hazards as geomagnetic disturbances created by space weather. He also helped develop tools to assist power system operators and reliability coordinators to help ensure bulk electric system reliability. Prior to joining NERC, he worked for the Public Service Electric and Gas Company of New Jersey, and his assignments included working with fossil power production, power station engineering (fossil and nuclear), and power system operations. He was chief engineer of a 1300-MW power station and general manager of system operations. As project manager for the General Agreement on Parallel Paths, he assisted in shaping policy and practices intended to ensure reliable and equitable use of the interconnected transmission systems of the eastern United States and Canada. Mr. Leffler was involved in studying the March 1989 geomagnetic storm, and he was a presenter at the Space Weather Industry Day in Washington, D.C., in May 2006. He is a registered professional engineer and licensed steam plant engineer in New Jersey.

WILLIAM S. LEWIS is principal scientist with the Space Research and Engineering Division of the Southwest Research Institute. Dr. Lewis' primary research interest is in the area of auroral physics. He has co-authored papers on Jupiter's x-ray and far-ultraviolet aurora, Earth's proton aurora, Europa's sputter-produced atmosphere, and the Cassini Ion and Neutral Mass Spectrometer (INMS) investigation. He is currently involved in studies using data obtained with the far-ultraviolet imaging system on the IMAGE spacecraft, with particular emphasis on the proton aurora. Dr. Lewis has been involved in the preparation of several NRC documents. As consultant to the Solar and Space Physics Survey Committee, he worked with the committee and NRC staff on the preparation of the first decadal survey in solar and space physics, *The Sun to the Earth—and Beyond*. He has also worked closely with the NRC Committee on Solar and Space Physics on the *Plasma Physics of the Local Cosmos* report and on a popular booklet based on the decadal survey report. Dr. Lewis is a member of the American Geophysical Union and chaired the Web site committee of the AGU Space Physics and Aeronomy section (1998-2000). He was a member of the NRC Committee on Solar and Space Physics and of the Workshop Organizing Committee on Solar System Radiation Environment and NASA's Vision for Space Exploration.

JOSEPH B. REAGAN is a technology and senior management consultant. He retired in 1996 after a 37-year career at Lockheed Martin Corporation that included serving as vice president and general manager of the Palo Alto Research Laboratories and as a corporate vice president. His primary area of interest is technology development, and he has a broad range of experience in developing technologies in the sensor, software, cryogenics, instrumentation, materials and electro-optical areas. Dr. Reagan spent 25 years of his early career in the study of space radiation and its impact on space systems, the ionosphere, and the atmosphere. He was involved with the first satellite measurements of the aurora borealis in 1960 and led more than 20 space experiments during his career. He was a principal advisor on space radiation effects to Lockheed military and civil space programs. Dr. Reagan is a fellow of the American Institute of Aeronautics and Astronautics and has received numerous awards for his achievements. He was elected to the National Academy of Engineering in 1998 and chaired the Aerospace Engineering section from 2005 to 2007. He also served as vice chair of the NRC Naval Studies Board from 2000 to 2004.

ARTHUR A. SMALL III is an associate professor in the Department of Meteorology at Pennsylvania State University. Dr. Small, an economist, conducts research that focuses on how variations in weather and climate create

economic and financial risks, and on the means to manage these risks effectively. He also applies tools and concepts from quantitative finance to analyze markets for energy products, emissions, and weather derivatives. One of his objectives is to develop models of weather risk that can be integrated with financial models to create tools for derivative pricing, asset valuation, trading, and risk management. Dr. Small's research results have appeared in publications that include the *Journal of Political Economy, Review of Economics and Statistics, Journal of Environmental Economics and Management,* and the BE Press *Topics in Economic Analysis and Policy*. He has served as an editorial reviewer for numerous scholarly publications and currently serves on the editorial council for the *Journal of Environmental Economics and Management.*

THOMAS A. STANSELL heads Stansell Consulting, which he founded in 1999. Previously he was a vice president at Leica Geosystems, where he was involved in technology development and strategic relationships. Mr. Stansell is a pioneer of satellite navigation and has served the satellite navigation community for more than 43 years. Mr. Stansell began his career in 1960 when he joined the Johns Hopkins University Applied Physics Laboratory Navy Navigation Satellite System development program. He led teams that developed the first integrated microcomputer-based satellite navigation receiver and the first microcomputer-based Doppler survey instrument, also called Geoceiver, the primary instrument employed by the Defense Mapping Agency for nearly two decades. In the 1980s he led the transition of Magnavox's commercial satellite navigation and positioning technologies and products from Transit (the first operational satellite positioning system) to the Global Positioning System (GPS). He also led the development of miniature GPS survey receivers, pioneered precise and real-time GPS control of earth-moving machinery, and received patents for multipath mitigation techniques. Mr. Stansell is the recipient of the 1996 Institute of Navigation (ION) Weems Award, the 2000 Institute of Electrical and Electronics Engineers (IEEE) Position and Navigation Symposium (PLANS) Kershner Award, the 2002 GPS Joint Program Office Navstar Award, and the ION Satellite Division's 2004 Johannes Kepler Award. He is a member of the "GPS World" and "Inside GNSS" editorial advisory boards and was elected a fellow of the ION in 1999. Mr. Stansell holds several GPS-related patents, and currently he is serving as the ION western regional vice president.

LEONARD STRACHAN, JR., is an astrophysicist at the Smithsonian Astrophysical Observatory. Dr. Strachan is a co-investigator with the Ultraviolet Coronagraph Spectrometer (UVCS) team on the Solar and Heliospheric Observatory (SOHO) mission. His research involves using space-based ultraviolet spectroscopy to understand the physical properties of the solar corona. These measurements are important for understanding the processes that drive both steady and dynamic solar wind. His previous experience includes participating in the instrument development, science operations, and data analysis for the Spartan 201 Space Shuttle experiment. Dr. Strachan has been a member of the NASA Solar and Heliospheric Management and Operations Working Group and the NASA Sun-Solar System Connection Roadmap Committee. Most recently he served on the NRC Committee on Solar and Space Physics and on the ad hoc Workshop Organizing Committee on Solar System Radiation Environment and NASA's Vision for Space Exploration.

Staff

SANDRA J. GRAHAM has been a senior program officer at the Space Studies Board since 1994. During that time Dr. Graham has directed a large number of major studies, many of them focused on space research in biological and physical sciences and technology. More recent studies include an assessment of servicing options for the Hubble Space Telescope, reviews of the NASA roadmaps for space sciences and the International Space Station, and a review of NASA's Space Communications Program while on loan to the Aeronautics and Space Engineering Board. Before receiving her Ph.D. in inorganic chemistry from Duke University in 1990, she carried out research focused primarily on topics in bioinorganic chemistry, such as the exchange mechanisms and reaction chemistry of biological metal complexes and their analogs. From 1990 to 1994, she held the position of senior scientist at the Bionetics Corporation, where she worked in the science branch of the Microgravity Science and Applications Division at NASA Headquarters.

THERESA M. FISHER is a program associate with SSB. During her 25 years with the Academies, she has held positions in the executive, editorial, and contract offices of the National Academy of Engineering and positions with several NRC boards, including the Energy Engineering Board, the Aeronautics and Space Engineering Board, the Board on Atmospheric Sciences and Climate, and the Marine Board.

CATHERINE A. GRUBER is an assistant editor with SSB. She joined SSB as a senior program assistant in 1995. Ms. Gruber first came to the NRC in 1988 as a senior secretary for the Computer Science and Telecommunications Board and has worked as an outreach assistant for the NAS-Smithsonian Institution's National Science Resources Center. She was a research assistant (chemist) in the National Institute of Mental Health's Laboratory of Cell Biology for 2 years. She has a B.A. in natural science from St. Mary's College of Maryland.

VICTORIA SWISHER joined the Space Studies Board in December 2006 as a research associate. She recently received a B.A. in astronomy from Swarthmore College. She has presented the results of her research at the 2005 and 2006 American Astronomical Society (AAS) meetings and at various Keck Northeast Astronomy Consortium (KNAC) undergraduate research conferences. Her most recent research focused on laboratory astrophysics and involved studying the x-rays of plasma, culminating in a senior thesis entitled "Modeling UV and X-ray Spectra from the Swarthmore Spheromak Experiment."

E

Select Acronyms and Terms

ACE	Advanced Composition Explorer
AFSPC	Air Force Space Command (headquartered at Peterson Air Force Base Colorado)
AFWA	Air Force Weather Agency
CCMC	Community Coordinated Modeling Center (a NASA-supported program)
CME	coronal mass ejection
COST	Cooperation in Science and Technology
CRRES	Combined Release and Radiation Effects Satellite
DOD	Department of Defense
Dst	distributed storage time
ESA	European Space Agency
EU	European Union
FAA	Federal Aviation Administration
GIC	geomagnetically induced current
GOES	Geostationary Operational Environment Satellite
GPS	Global Positioning System
HF	high frequency (3-30 MHz)
JSpOC	Joint Space Operations Center
Kp index	A planetary index of geomagnetic activity that ranges from Kp0 to Kp9 where Kp9 represents the most severe storm
LF/HC	low-frequency/high-consequence
LRO	Lunar Reconnaissance Orbiter (NASA Space Exploration Mission)
LWS	Living With a Star (NASA program)
NSF	National Science Foundation
now-cast	near-term space weather forecast
NSWP	National Space Weather Program
PCA	polar cap absorption
R&D	research and development
RF	radio frequency
SA	situational awareness

SDO	Solar Dynamics Observatory
SEC	Space Environment Center
SEP	solar energetic particle
SOHO	Solar and Heliospheric Observatory
STEREO	Solar-Terrestrial Relations Observatory
SWENET	Space Weather European Network
SWPC	Space Weather Prediction Center (NOAA)
SWWT	Space Weather Working Team
TEC	total electron content
USAF	U.S. Air Force
USGS	U.S. Geological Survey
WAAS	Wide Area Augmentation System

From: Hurd, Sapna
To: Rivera-Lugo, Richard
Cc: Richards, Stuart; Case, Michael
Subject: RE: Spreadsheet
Date: Wednesday, March 23, 2011 10:36:16 AM

Richie, Here are the dates that I have worked in total:

3/11, 3/12, 3/13, 3/15, 3/17, 3/18, 3/19, 3/20, 3/22, 3/23, 3/24, 3/25, 3/26

I am not sure of the upcoming schedule yet. Thanks.

Sapna Hurd
Management Analyst
Division of Engineering
Office of Nuclear Regulatory Research
U.S. NRC
Ph: 301-251-7687
5C04

From: Richards, Stuart
Sent: Tuesday, March 22, 2011 3:15 PM
To: RES_DE; Boyce, Tom (RES); Csontos, Aladar; Gavrilas, Mirela; Hogan, Rosemary; Koshy, Thomas; Sydnor, Russell
Cc: Rivera-Lugo, Richard; Case, Michael
Subject: RE: Spreadsheet

If you are working to support the agency response to the events in Japan, please provide the information requested below by noon tomorrow to Richie Rivera-Lugo.

Thanks
Stu

From: Valentin, Andrea
Sent: Tuesday, March 22, 2011 3:02 PM
To: Case, Michael; Richards, Stuart; Gibson, Kathy; Coe, Doug; Coyne, Kevin; Kardaras, Tom
Cc: Sheron, Brian
Subject: Spreadsheet
Importance: High

Hello All,

I am collecting the names and dates to send to CFO for work being done in support of the Japan response. CFO needs this info since HRMS may not allow the employee to enter time worked unless some changes are made to the system. The memo dated 3/16 said that they need this information ASAP to avoid difficulties processing the appropriate payments.

I plan to submit this interim list by COB tomorrow so CFO can get started on what they need to do. I can always send additional names later. Please remember to send me both names and dates worked (or planned schedule if it has not occurred yet).

4/2010

Thanks,
Andrea

From: Parks, Jazel
To: RES Distribution
Subject: To ease the burden on the Japan FOIA
Date: Wednesday, March 23, 2011 4:45:19 PM

This is (should be) the last mass email for the Japan FOIA today, ☺

For people responding to the FOIA request,

If you are the originator of the email communication, you should be the person responsible for sending the E-Mail for review. People that are the recipients of the E-Mail should not provide me with the same email. This should cut down on duplication.

Hope this helps,

If you have any questions, please feel free to contact me.

Thanks,

Jazel Parks
Research Information Specialist
RES/PMDA/ITIB
(P) 301-251-7690
(F) 301-251-7426
(M/S) C6D20M

4/21

From: Case, Michael
To: Gray, Kathy
Cc: Thorp, John
Subject: RE: ACTION: Confirmation requested for RST Director Schedule - 3/26-4/2/2011
Date: Wednesday, March 23, 2011 7:26:00 AM

Thanks Kathy. I should be OK (although I think I'll need someone to do one day shift on 4/6 because I have an all day steering group meeting. I'll worry about that when we get a bit closer).

From: Gray, Kathy
Sent: Tuesday, March 22, 2011 3:06 PM
To: Case, Michael
Cc: Thorp, John
Subject: RE: ACTION: Confirmation requested for RST Director Schedule - 3/26-4/2/2011

Thanks Mike. FYI – Dave has duty today from 3pm-11pm, so we may not hear back from him til tomorrow or Thursday.

Please note, if you do a complete swap of mids with Dave, you'll have duty March 30-April 2 (mids) and then day duty (7-3pm) starting April 6-9 – are you sure you're up for all those mids and days?

From: Case, Michael
Sent: Tuesday, March 22, 2011 2:54 PM
To: Skeen, David; Gray, Kathy; Uhle, Jennifer; Brown, Frederick; Ruland, William; Hiland, Patrick
Cc: Thorp, John; Thomas, Eric; Cunningham, Liza
Subject: RE: ACTION: Confirmation requested for RST Director Schedule - 3/26-4/2/2011

It looks like I'm very moveable since we're both on mids. Just propose which ones you want to do and I'll do the rest.

From: Skeen, David
Sent: Tuesday, March 22, 2011 2:48 PM
To: Gray, Kathy; Uhle, Jennifer; Brown, Frederick; Ruland, William; Hiland, Patrick; Case, Michael
Cc: Thorp, John; Thomas, Eric; Cunningham, Liza
Subject: RE: ACTION: Confirmation requested for RST Director Schedule - 3/26-4/2/2011

All,

I will be unable to support the RST from April 1 – April 14, since I will be in Vienna for the Convention on Nuclear Safety. I can swap with someone and take one of the shifts earlier in the week, if someone would care to swap (maybe Fred or Mike?).

Thanks!

From: Gray, Kathy
Sent: Tuesday, March 22, 2011 12:04 PM
To: Skeen, David; Uhle, Jennifer; Brown, Frederick; Ruland, William; Hiland, Patrick; Case, Michael
Cc: Thorp, John; Thomas, Eric; Cunningham, Liza; Gray, Kathy
Subject: ACTION: Confirmation requested for RST Director Schedule - 3/26-4/2/2011
Importance: High

3/23

Please confirm that you are available to provide coverage in the Ops Center, as the RST Director, as follows:

Reactor Safety Team (RST) Director Schedule

March 26 – April 2, 2011

Shift	3/26 (Sat)	3/27 (Sun)	3/28 (Mon)	3/29 (Tues)	3/30 (Wed)	3/31 (Thur)	4/1 (Fri)	4/2 (Sat)
7am–3pm	Pat Hiland	Pat Hiland	Pat Hiland	Jennifer Uhle	Jennifer Uhle	Jennifer Uhle	Jennifer Uhle	Brian Holian
3pm–11pm	Bill Ruland	Fred Brown	Fred Brown	Fred Brown	Fred Brown	Bill Ruland	Bill Ruland	Bill Ruland
11pm–7am	Mike Case	Mike Case	Mike Case	Mike Case	Dave Skeen	Dave Skeen	Dave Skeen	Dave Skeen

Thanks very much.

Kathy A. Gray
Information Management Asst.
Operating Experience Branch, DIRS/NRR
Rm. O-7F04, Phone: 301-415-1166
Kathy.Gray@nrc.gov

From: Case, Michael
To: Skeen, David; Gray, Kathy; Uhle, Jennifer; Brown, Frederick; Ruland, William; Hiland, Patrick; Holian, Brian
Cc: Thorp, John; Thomas, Eric; Cunningham, Liza
Subject: RE: ACTION: Confirmation requested for RST Director Schedule - 3/26-4/2/2011
Date: Wednesday, March 23, 2011 2:27:00 PM

Sounds great. Kathy can you make that change?

From: Skeen, David
Sent: Wednesday, March 23, 2011 1:59 PM
To: Case, Michael; Gray, Kathy; Uhle, Jennifer; Brown, Frederick; Ruland, William; Hiland, Patrick; Holian, Brian
Cc: Thorp, John; Thomas, Eric; Cunningham, Liza
Subject: RE: ACTION: Confirmation requested for RST Director Schedule - 3/26-4/2/2011

Thanks for being flexible, Mike.

In that case, I'll take mid-shift on 3/26-3/29, and you can take it from 3/30-4/2.

From: Case, Michael
Sent: Tuesday, March 22, 2011 2:54 PM
To: Skeen, David; Gray, Kathy; Uhle, Jennifer; Brown, Frederick; Ruland, William; Hiland, Patrick
Cc: Thorp, John; Thomas, Eric; Cunningham, Liza
Subject: RE: ACTION: Confirmation requested for RST Director Schedule - 3/26-4/2/2011

It looks like I'm very moveable since we're both on mids. Just propose which ones you want to do and I'll do the rest.

From: Skeen, David
Sent: Tuesday, March 22, 2011 2:48 PM
To: Gray, Kathy; Uhle, Jennifer; Brown, Frederick; Ruland, William; Hiland, Patrick; Case, Michael
Cc: Thorp, John; Thomas, Eric; Cunningham, Liza
Subject: RE: ACTION: Confirmation requested for RST Director Schedule - 3/26-4/2/2011

All,

I will be unable to support the RST from April 1 – April 14, since I will be in Vienna for the Convention on Nuclear Safety. I can swap with someone and take one of the shifts earlier in the week, if someone would care to swap (maybe Fred or Mike?).

Thanks!

From: Gray, Kathy
Sent: Tuesday, March 22, 2011 12:04 PM
To: Skeen, David; Uhle, Jennifer; Brown, Frederick; Ruland, William; Hiland, Patrick; Case, Michael
Cc: Thorp, John; Thomas, Eric; Cunningham, Liza; Gray, Kathy
Subject: ACTION: Confirmation requested for RST Director Schedule - 3/26-4/2/2011
Importance: High

Please confirm that you are available to provide coverage in the Ops Center, as the RST Director, as

4/2/13

follows:

Reactor Safety Team (RST) Director Schedule

March 26 – April 2, 2011

Shift	3/26 (Sat)	3/27 (Sun)	3/28 (Mon)	3/29 (Tues)	3/30 (Wed)	3/31 (Thur)	4/1 (Fri)	4/2 (Sat)
7am–3pm	Pat Hiland	Pat Hiland	Pat Hiland	Jennifer Uhle	Jennifer Uhle	Jennifer Uhle	Jennifer Uhle	Brian Holian
3pm–11pm	Bill Ruland	Fred Brown	Fred Brown	Fred Brown	Fred Brown	Bill Ruland	Bill Ruland	Bill Ruland
11pm–7am	Mike Case	Mike Case	Mike Case	Mike Case	Dave Skeen	Dave Skeen	Dave Skeen	Dave Skeen

Thanks very much.

Kathy A. Gray
Information Management Asst.
Operating Experience Branch, DIRS/NRR
Rm. O-7F04, Phone: 301-415-1166
Kathy.Gray@nrc.gov

From: Bowman, Gregory
To: Richards, Stuart
Cc: Case, Michael; Gibson, Kathy; Scott, Michael; Rini, Brett
Subject: RE: Ops Center Action Item for Ticketing
Date: Wednesday, March 23, 2011 1:45:23 PM
Attachments: Decommissioning Type Information.msg

Sorry if my e-mail wasn't clear...we only need a response to the four questions from the 11:23 am e-mail from RST01 Hoc.

I would recommend coordinating with George Deegan and Larry Camper in FSME. I was CC'd on the attached e-mail from Larry a little while ago, and it looks like they might be best equipped to cover most (or all) of the questions.

From: Richards, Stuart
Sent: Wednesday, March 23, 2011 1:07 PM
To: Bowman, Gregory
Cc: Case, Michael; Gibson, Kathy; Scott, Michael
Subject: RE: Ops Center Action Item for Ticketing
Importance: High

Greg

Are we trying to respond to all of the issues in Dan Dorman's e-mail, or just the items highlighted in the 11:23 am e-mail from RST01 Hoc ?

Thanks
Stu

From: Bowman, Gregory
Sent: Wednesday, March 23, 2011 12:08 PM
To: Case, Michael; Richards, Stuart; Gibson, Kathy; Scott, Michael
Subject: FW: Ops Center Action Item for Ticketing
Importance: High

FYI – I just sent this information request from the Ops Center to Brett. I sent it to him because I wasn't sure which division in RES would be the right one to help with this, but I figured I'd pass it along to you, as well, given that the Ops Center is looking for a response by the end of the day.

From: Bowman, Gregory
Sent: Wednesday, March 23, 2011 11:51 AM
To: Rini, Brett; Deegan, George
Cc: Frazier, Alan; Brock, Kathryn
Subject: FW: Ops Center Action Item for Ticketing
Importance: High

Brett and George,

We got the request below from the Ops Center. We think there should be one coordinated response back to the Ops Center from RES and FSME, but none of us are sure which division would be best able to respond. Can you help with this? Note that the Ops Center

4/24

has asked for a response by 18:00 tonight.

Greg

From: RST01 Hoc
Sent: Wednesday, March 23, 2011 11:23 AM
To: Andersen, James; Muessle, Mary
Cc: Brown, Frederick
Subject: Ops Center Action Item for Ticketing

Jim and Mary,

Per Fred Brown, RST Director here in the Ops Center, Please ticket the following item to RES and FSME:

"Respond to Dan Dorman's email on long-term issue questions from Japan. Provide responses or estimates of when the responses can be expected to Dan by 18:00 EDT. If additional information is needed, let the site team know of any questions that can be brought back to NISA.

-Regarding the best type of enclosure for the plant, does NRC have any thoughts? Do we have any regulations applicable to this condition or thoughts on the role of the regulatory authority in this decision?

-What licensing requirements apply to decommissioning and regulatory review of the decommissioning plan?

-What should the Japanese be considering with respect to criticality prevention and decay heat removal during the entombment period?

-The NRC's TMI fact sheet notes that the first manned entry into the Unit 2 reactor building occurred after a venting of Krypton in July 1980 (16 months after the accident). WHat actions occurred during those 16 months that could inform their planning?"

Dan Dorman's email pasted below:

From: Dorman, Dan
Sent: Tuesday, March 22, 2011 3:05 AM
To: OST01 HOC; Casto, Greg; Monninger, John; ET07 Hoc
Subject: RE:

Additional tasks from meeting with NISA et al this morning. Lower prirority than the Cabinet level issues we just discussed on the phone, but any responses available by 1800 EDT on 3/22 would be greatly appreciated along with an estimate of when the remainder may be expected. If you need additional info, please identify any questions we can bring back to NISA (keeping in mind please that their plant data is also very limited, i.e., keep your data expectations modest).

1. Sea water injection continues to reactors 1-3. NISA is concerned about the radiolytic disassociation of H2 and O2. NISA would like NRC's perspective on the significance of this concern and how to treat this concern as they transition to freshwater injection.
2. At what point does salt deposits become a problem for flow during pending freshwater injection?

3. NISA is conducting simulations to project the extent of damage to fuel in the reactors. Has NRC developed any views on the extent of fuel damage?
4. NISA is interested to obtain any reference material regarding core-concrete interaction (not because they think they have a current issue but against that eventuality) including the conditions under which that occurs and any associated data.
5. In addition to the H2/O2 disassociation in item 1 above, they are concerned that there may be residual H2 in the containments and welcome NRC's thoughts on how to treat such a condition.

NISA is beginning to look at long term issues and has the following Qs in this area (note some of these may only apply to Japan's regulatory framework, but if we have insights from our post-TMI actions they would be greatly appreciated):
6. Regarding the best type of enclosure for the plant, does NRC have any thoughts? Do we have any regulations applicable to this condition or thoughts on the role of the regulatory authority in this deicision?
7. What licensing requirements apply to decommissioning and regulatory review of the decommissioning plan?
8. What should they be considering with respect to criticality prevention and decay heat removal during the entombment period?
9. The NRC's TMI Fact Sheet notes that the first manned entry into the Unit 2 reactor building occurred after a venting of Krypton in July 1980 (16 months after the accident). What actions occurred during those 16 months that could inform their planning?

Regarding the spent fuel pools, NISA asserted that the Unit 1 SFP is above TAF with over 20 days margin due to low decay heat. They are not injecting to the UNit 1 SFP. For Unit 2, they are injecting seawater to the SFP via installed piping. For Units 3 and 4, they are spraying from pumper trucks within the RBs to put water on the top of the pools (In response to a question, they indicated that these sprays were put in place after the explosive events in those buildings.) Based on this information, NISA is assuming that the SFPs are all below 100C. The team here has questions relative to the latter buildings and other information available, for example, lack of visual evidence of steaming on Unit 4. We would appreciate HQ's thoughts on the SFPs and apparent inconsistencies with the status provided by NISA.

Dan Dorman

Thanks,
Eric Thomas
RST Coordinator

Attachment Decommissioning Type Information.msg (2560 Bytes) cannot be converted to PDF format.

From: Richards, Stuart
To: Bowman, Gregory
Cc: Case, Michael; Gibson, Kathy; Scott, Michael; Rini, Brett; Campbell, Larry; McConnell, Keith; Watson, Bruce
Subject: RE: Ops Center Action Item for Ticketing
Date: Wednesday, March 23, 2011 1:31:01 PM
Importance: High

Greg

Regarding the following question:

-What licensing requirements apply to decommissioning and regulatory review of the decommissioning plan?

The NRC basic requirements on decommissioning of plants is 10 CFR 50.82, "Termination of license."

I believe that FMSE has responsibility for decommissioning, so it would be best if they respond to this question. I have cc'd FSME staff on this e-mail.

FSME staff: note the due date is 6 PM tonight to respond!

Thanks
Stu

From: Bowman, Gregory
Sent: Wednesday, March 23, 2011 12:08 PM
To: Case, Michael; Richards, Stuart; Gibson, Kathy; Scott, Michael
Subject: FW: Ops Center Action Item for Ticketing
Importance: High

FYI – I just sent this information request from the Ops Center to Brett. I sent it to him because I wasn't sure which division in RES would be the right one to help with this, but I figured I'd pass it along to you, as well, given that the Ops Center is looking for a response by the end of the day.

From: Bowman, Gregory
Sent: Wednesday, March 23, 2011 11:51 AM
To: Rini, Brett; Deegan, George
Cc: Frazier, Alan; Brock, Kathryn
Subject: FW: Ops Center Action Item for Ticketing
Importance: High

Brett and George,

We got the request below from the Ops Center. We think there should be one coordinated response back to the Ops Center from RES and FSME, but none of us are sure which division would be best able to respond. Can you help with this? Note that the Ops Center has asked for a response by 18:00 tonight.

Greg

4/21

From: RST01 Hoc
Sent: Wednesday, March 23, 2011 11:23 AM
To: Andersen, James; Muessle, Mary
Cc: Brown, Frederick
Subject: Ops Center Action Item for Ticketing

Jim and Mary,

Per Fred Brown, RST Director here in the Ops Center, Please ticket the following item to RES and FSME:

"Respond to Dan Dorman's email on long-term issue questions from Japan. Provide responses or estimates of when the responses can be expected to Dan by 18:00 EDT. If additional information is needed, let the site team know of any questions that can be brought back to NISA.

-Regarding the best type of enclosure for the plant, does NRC have any thoughts? Do we have any regulations applicable to this condition or thoughts on the role of the regulatory authority in this decision?

-What licensing requirements apply to decommissioning and regulatory review of the decommissioning plan?

-What should the Japanese be considering with respect to criticality prevention and decay heat removal during the entombment period?

-The NRC's TMI fact sheet notes that the first manned entry into the Unit 2 reactor building occurred after a venting of Krypton in July 1980 (16 months after the accident). WHat actions occurred during those 16 months that could inform their planning?"

Dan Dorman's email pasted below:

From: Dorman, Dan
Sent: Tuesday, March 22, 2011 3:05 AM
To: OST01 HOC; Casto, Greg; Monninger, John; ET07 Hoc
Subject: RE:

Additional tasks from meeting with NISA et al this morning. Lower prirority than the Cabinet level issues we just discussed on the phone, but any responses available by 1800 EDT on 3/22 would be greatly appreciated along with an estimate of when the remainder may be expected. If you need additional info, please identify any questions we can bring back to NISA (keeping in mind please that their plant data is also very limited, i.e., keep your data expectations modest).

1. Sea water injection continues to reactors 1-3. NISA is concerned about the radiolytic disassociation of H2 and O2. NISA would like NRC's perspective on the significance of this concern and how to treat this concern as they transition to freshwater injection.
2. At what point does salt deposits become a problem for flow during pending freshwater injection?
3. NISA is conducting simulations to project the extent of damage to fuel in the reactors. Has NRC developed any views on the extent of fuel damage?
4. NISA is interested to obtain any reference material regarding core-concrete interaction (not because they think they have a current issue but against that eventuality) including the conditions under which that occurs and any associated data.

5. In addition to the H2/O2 disassociation in item 1 above, they are concerned that there may be residual H2 in the containments and welcome NRC's thoughts on how to treat such a condition.

NISA is beginning to look at long term issues and has the following Qs in this area (note some of these may only apply to Japan's regulatory framework, but if we have insights from our post-TMI actions they would be greatly appreciated):
6. Regarding the best type of enclosure for the plant, does NRC have any thoughts? Do we have any regulations applicable to this condition or thoughts on the role of the regulatory authority in this deicision?
7. What licensing requirements apply to decommissioning and regulatory review of the decommissioning plan?
8. What should they be considering with respect to criticality prevention and decay heat removal during the entombment period?
9. The NRC's TMI Fact Sheet notes that the first manned entry into the Unit 2 reactor building occurred after a venting of Krypton in July 1980 (16 months after the accident). What actions occurred during those 16 months that could inform their planning?

Regarding the spent fuel pools, NISA asserted that the Unit 1 SFP is above TAF with over 20 days margin due to low decay heat. They are not injecting to the UNit 1 SFP. For Unit 2, they are injecting seawater to the SFP via installed piping. For Units 3 and 4, they are spraying from pumper trucks within the RBs to put water on the top of the pools (In response to a question, they indicated that these sprays were put in place after the explosive events in those buildings.) Based on this information, NISA is assuming that the SFPs are all below 100C. The team here has questions relative to the latter buildings and other information available, for example, lack of visual evidence of steaming on Unit 4. We would appreciate HQ's thoughts on the SFPs and apparent inconsistencies with the status provided by NISA.

Dan Dorman

Thanks,
Eric Thomas
RST Coordinator

Lee, Richard

From: Lee, Richard
Sent: Wednesday, April 20, 2011 10:48 AM
To: Algama, Don
Subject: RE: Ops Center: Severe Accident Analysis

o.k.

From: Algama, Don
Sent: Wednesday, April 20, 2011 10:12 AM
To: Lee, Richard
Subject: Ops Center: Severe Accident Analysis

Richard:

FYI

The OpsCenter is really hurting for people. So I have signed up for a position as an Accident Analyst for this Friday from 0700-1500hrs.

-Don

4/216

From: Case, Michael
To: Kammerer, Annie; Richards, Stuart
Cc: Rini, Brett
Subject: RE: ACTION: DRAFT SRM - COMGBJ-11-0002 (NRC Actions Following the Events in Japan)
Date: Wednesday, March 23, 2011 6:43:00 AM

I sort of get a bunch of email ideas as well. Like you suggest, save them and we'll see if there is a future opportunity to pass them along to the 90 day team.

From: Kammerer, Annie
Sent: Tuesday, March 22, 2011 8:56 PM
To: Case, Michael; Richards, Stuart
Cc: Rini, Brett
Subject: FW: ACTION: DRAFT SRM - COMGBJ-11-0002 (NRC Actions Following the Events in Japan)
Importance: High

Ummmm. Not sure why I got this except that Brett doesn't realize I'm just a low level government functionary.

I don't see a problem, except that the agency is challenged human resource wise at the moment in the sense that the supporting technical staff can't do this and do our regular jobs too. Deadlines are going to have to slip, particularly for NRO staff. Another problem is that it is going to take a while to get the input to really understand what happened. It took me nearly 3 years to get full set of KKNPP data! Maybe this will be different because it went wrong instead of going right. A 90 day time frame is good for the first part, but I don't think we'll have much data in 90 days.

This actually gives me a chance to ask a question. I'm getting a lot of ideas, issues, etc. sent to me simply because people don't know where else to send them. Should I file them all and provide to the panel once it get's going? That's all I can see to do at the moment. For example, some are comments on spent fuel pools and the fact that the pools are rated, but not all the systems that feed them water are. I got a similar thing today from a plant where a Cat 1 piece of equipment relies on a piece that is not Cat 1. She wrote that we assure that the equipment survives, but we don't assure that the "functionality" of important equipment survives.

Cheers,
Annie

From: Rini, Brett
Sent: Tuesday, March 22, 2011 3:47 PM
To: Rivera-Lugo, Richard; Ibarra, Jose; Armstrong, Kenneth; Kammerer, Annie
Subject: FW: ACTION: DRAFT SRM - COMGBJ-11-0002 (NRC Actions Following the Events in Japan)
Importance: High

I know everyone's busy, so these ASAP requests are rather annoying.

Can you print out the attached SRM that I sent out and run it past your management for any showstoppers?

Thanks,

3/21

Brett

From: Rini, Brett
Sent: Tuesday, March 22, 2011 3:27 PM
To: Case, Michael; Richards, Stuart; Gibson, Kathy; Elkins, Scott; Coe, Doug; Coyne, Kevin
Cc: Rivera-Lugo, Richard; Armstrong, Kenneth; Ibarra, Jose; Ramirez, Annie; Sheron, Brian; Uhle, Jennifer
Subject: ACTION: DRAFT SRM - COMGBJ-11-0002 (NRC Actions Following the Events in Japan)
Importance: High

Division Directors,

Please see the attached SRM regarding follow-up actions from the events in Japan. As indicated below, "as provided in the Internal Commission Procedures, the staff is "...afforded an opportunity to review the SRM to ensure that the Commission decision is clear and understandable and that resource, schedular, and legal constraints are properly considered."

Please send me any major problems that you see with the attached by COB today.

Thank you in advance for addressing this (additional) short turnaround request.

Brett

From: Sheron, Brian
Sent: Tuesday, March 22, 2011 2:04 PM
To: Rini, Brett
Subject: FW: DRAFT SRM - COMGBJ-11-0002 (NRC Actions Following the Events in Japan)
Importance: High

Brett, please have division review and let me know if any major problems or show-stoppers.

From: RidsEdoDraftSrmVote Resource
Sent: Tuesday, March 22, 2011 1:58 PM
To: Ash, Darren; Borchardt, Bill; Boyd, Lena; Buckley, Patricia; Clarke, Deanna; Cohen, Miriam; EDO_Staff_Assistants; Flory, Shirley; Fry, Jeannie; Garland, Stephanie; Johnson, Michael; Mamish, Nader; Matakas, Gina; Miles, Patricia; Miller, Charles; Owen, Lucy; Riddick, Nicole; RidsAdmMailCenter Resource; RidsCsoMailCenter Resource; RidsFsmeOd Resource; RidsHrMailCenter Resource; RidsNmssOd Resource; RidsNroMailCenter Resource; RidsNrrOd Resource; RidsNsirMailCenter Resource; RidsOeMailCenter Resource; RidsOiMailCenter Resource; RidsOIS Resource; RidsResOd Resource; RidsRgn1MailCenter Resource; RidsRgn2MailCenter Resource; RidsRgn3MailCenter Resource; RidsRgn4MailCenter Resource; RidsSbcrMailCenter Resource; Thomas, Loretta; Virgilio, Martin; Walker, Dwight; Weber, Michael
Subject: FW: DRAFT SRM - COMGBJ-11-0002 (NRC Actions Following the Events in Japan)
Importance: High

From: Wright, Darlene
Sent: Tuesday, March 22, 2011 1:19 PM
To: Baggett, Steven; Bates, Andrew; Batkin, Joshua; Bavol, Rochelle; Blake, Kathleen; Bozin, Sunny; Bradford, Anna; Bubar, Patrice; Bupp, Margaret; Burns, Stephen; Chairman Temp; Clark, Lisa; Coggins, Angela; Cordes, John; Crawford, Carrie; Davis, Roger; Fopma, Melody; Franovich, Mike; Gibbs, Catina; Hackett, Edwin; Hart, Ken; Harves, Carolyn; Henderson, Karen; Herr, Linda; Hipschman, Thomas; Hudson, Sharon; Joosten, Sandy; KLS Temp; Kock, Andrea; Laufer, Richard; Lepre, Janet; Loyd, Susan; Mamish, Nader; Marshall, Michael; Monninger, John; Moore, Scott; Orders, William; Pace, Patti; Poole,

Brooke; Reddick, Darani; RidsEdoDraftSrmVote Resource; Rothschild, Trip; Savoy, Carmel; Sharkey, Jeffry; Shea, Pamela; Snodderly, Michael; Sosa, Belkys; Speiser, Herald; Svinicki, Kristine; Temp, GEA; Temp, WCO; Temp, WDM; Thoma, John; Vietti-Cook, Annette; Warren, Roberta; Zorn, Jason; Tadesse, Rebecca; Joosten, Sandy; Castleman, Patrick; Montes, David; Dhir, Neha; Adler, James; Jimenez, Patricia; Muessle, Mary; Nieh, Ho; Ostendorff, William; Warnick, Greg; Apostolakis, George; Pearson, Laura; Lui, Christiana; Lisann, Elizabeth
Cc: Lewis, Antoinette
Subject: DRAFT SRM - COMGBJ-11-0002 (NRC Actions Following the Events in Japan)
Importance: High

The attached file contains a draft SRM which is being circulated for Commission review. Your response is requested as soon as practical today. As provided in the Internal Commission Procedures, the staff is "...afforded an opportunity to review the SRM to ensure that the Commission decision is clear and understandable and that resource, schedular, and legal constraints are properly considered." Please provide any responses to Ken Hart (KRH), Richard Laufer (RJL), Rochelle Bavol (RCB5), and Pam Shea (PWS).

From:	Case, Michael
To:	Sheron, Brian; Rini, Brett; Coe, Doug; Correia, Richard; Gibson, Kathy; Richards, Stuart; Scott, Michael; Uhle, Jennifer; Valentin, Andrea
Subject:	RE: Impacts
Date:	Wednesday, March 23, 2011 11:43:00 AM

Brian

Current Activities:

Annie has been working full time on support to the event. Jon has also been called to support to a lesser degree. Jon has been supporting NRR on the GI-199 GL to a limited degree but will likely escalate substantially. Other members of our seismic team have also contributed. Additionally, we can see a bow-wave of additionally seismic work rapidly approaching (congressional letters, GI-199 additional emphasis, etc).

Syed Ali is going to Japan tomorrow for two weeks. We canceled out his participation in the CSNI Working Group meetings as a result.

Mike Case, Tom Boyce, Sapna Hurd, and Rick Jervey have been part of the response team in the Ops Center. This has delayed some of their work on normal duties.

Our materials staff have been called on to support questions, such as the impact of salt on the primary piping. We anticipate that materials and structural type questions may increase in the future.

The issues related to the SBO and batteries will also likely impact us in the future, but not yet.

Impacts:

Seismic Area: Jon and Annie provide oversight (not necessarily day to day direction) to almost all the seismic and tsunami related projects in the branch. They are likely to be delayed somewhat as we adjust. Some of the more important projects like our studies on CEUS that are part of the solution will be tough to keep on track because we need Annie and Jon input on the products. The seismic area has about 18 RGs that are in need of revision. They will go really slow because the key folks internally and externally in the program offices won't be there. We were planning to support NRR on the seismic review of Diablo Canyon Shoreline Fault. That timetable will be affected.

Electrical Area: Some workload shifting but not a large impact because we got a new person coming.

RG Program: We're scheduled to get about 36 out the door this year. Very unlikely because key people throughout the agency will not be focused on this lower priority work.
Materials Area: Unless Japan related work blossoms, we can probably keep up with current plans.

Mike

4/218

From: Sheron, Brian
Sent: Wednesday, March 23, 2011 10:04 AM
To: Rini, Brett; Case, Michael; Coe, Doug; Correia, Richard; Gibson, Kathy; Richards, Stuart; Scott, Michael; Uhle, Jennifer; Valentin, Andrea
Subject: Impacts

Bill Borchardt is having a meeting from 12;30 pm to 1:30 pm today with Office Directors and RAs to discuss how the Japanese event is impacting our work. So far, I am aware of the impact on SOARCA, and I am assuming there will be some impact on our seismic work.

1.) Mike, can I get a little more detail on what the impact is, if any, on our seismic work because of Annie's and Jon Ake's participation.

2.) Please let me know if there are other areas that are or will be impacted by the Japanese event. I need this by about 11:30 am today. Thanks.

Helton, Donald

From: Salay, Michael
Sent: Wednesday, March 23, 2011 7:39 AM
To: Schaperow, Jason; Tinkler, Charles; Helton, Donald; Esmaili, Hossein
Subject: Areva Fukushima Assessment
Attachments: Areva_Fukuchima event Assessment_eng_20110320.pps

In case you haven't already seen an Areva assessment of the Fukushima event is attached. It contains some chronology info.

-Mike

Michael Salay
United States Nuclear Regulatory Commission
Washington, DC 20555
MS: C3-C07M
michael.salay@nrc.gov
tel: 301-251-7543
fax: 301-251-7436

The attachment is readily accessible from numerous public web-sites

3/29

AREVA

The Fukushima Daiichi Incident

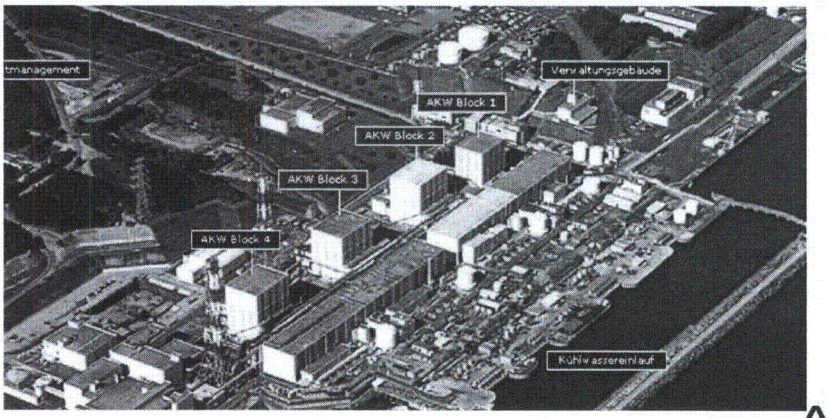
1. Plant Design
2. Accident Progression
3. Radiological releases
4. Spent fuel pools
5. Sources of Information

Matthias Braun
PEPA4-G, AREVA–NP GmbH
Matthias.Braun@AREVA.com

note that this is simply the date it was printed; it auto-updates the date

The Fukushima Daiichi Incident
1. Plant Design

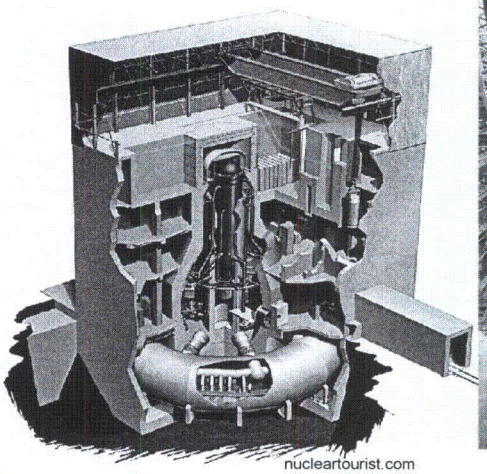
- Fukushima Daiichi (Plant I)
  - Unit I - GE Mark I BWR (439 MW), Operating since 1971
  - Unit II-IV - GE Mark I BWR (760 MW), Operating since 1974



AREVA

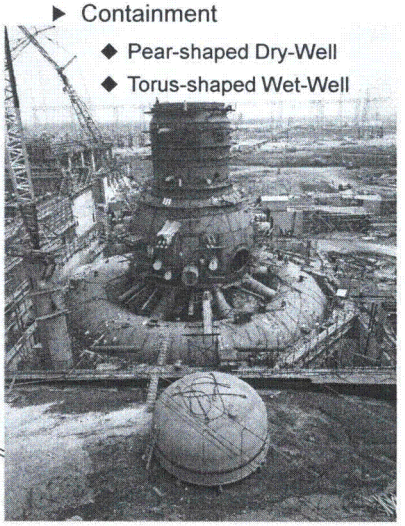
The Fukushima Daiichi Incident
1. Plant Design

- Building structure
  - Concrete Building
  - Steel-framed Service Floor



nucleartourist.com

- Containment
  - Pear-shaped Dry-Well
  - Torus-shaped Wet-Well

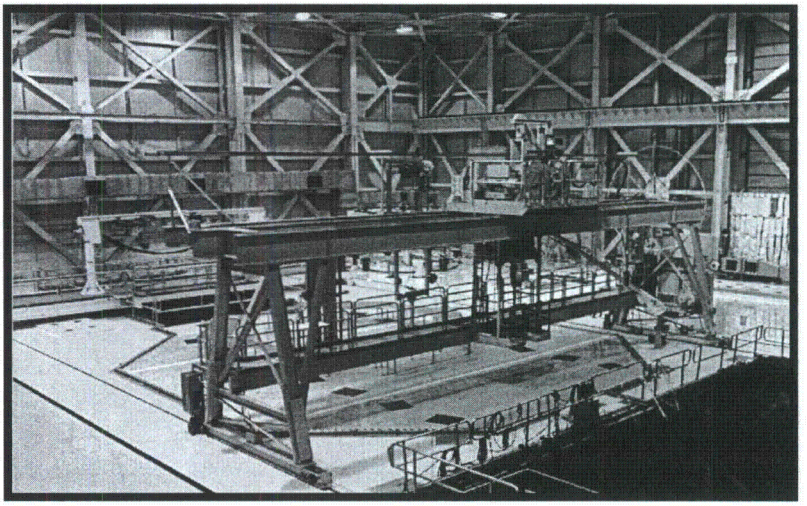


en.wikipedia.org/wiki/Browns_Ferry_Nuclear_Power_Plant

AREVA

The Fukushima Daiichi Incident
1. Plant Design

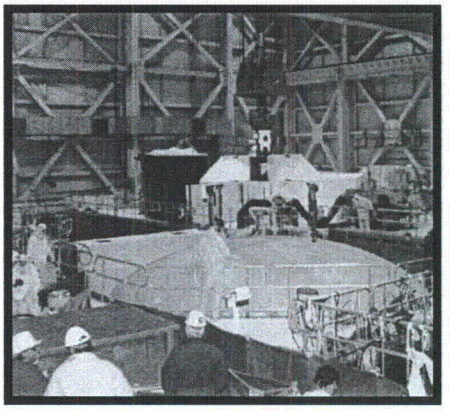
- Service Floor

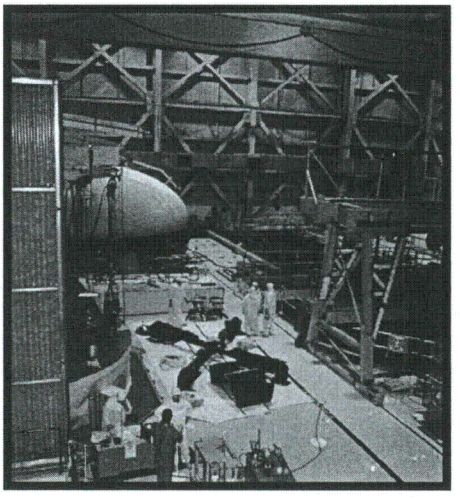


AREVA

The Fukushima Daiichi Incident
1. Plant Design

- Lifting the Containment closure head

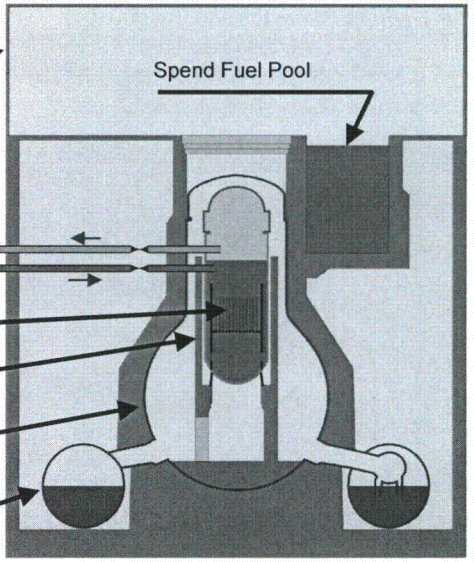




AREVA

The Fukushima Daiichi Incident
1. Plant Design

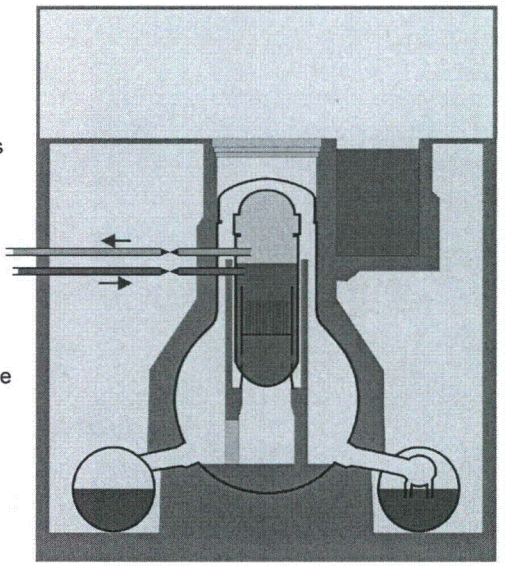
- Reactor Service Floor (Steel Construction)
- Concrete Reactor Building (secondary Containment)
- Reactor Core
- Reactor Pressure Vessel
- Containment (Dry well)
- Containment (Wet Well) / Condensation Chamber



AREVA

The Fukushima Daiichi Incident
2. Accident progression

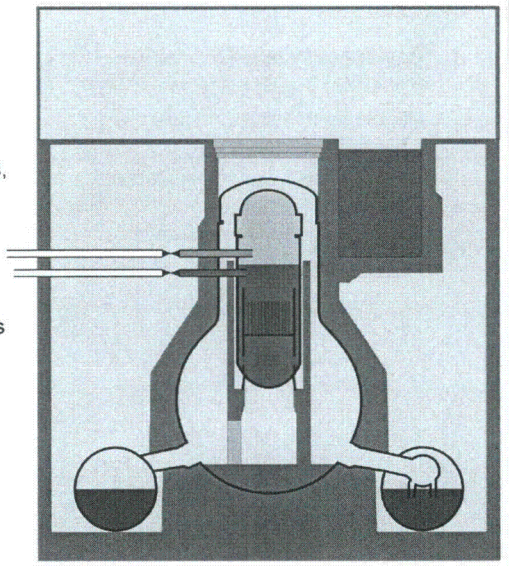
- 11.3.2011 14:46 - Earthquake
  - Magnitude 9
  - Power grid in northern Japan fails
  - Reactors itself are mainly undamaged
- SCRAM
  - Power generation due to Fission of Uranium stops
  - Heat generation due to radioactive Decay of Fission Products
    - After Scram ~6%
    - After 1 Day ~1%
    - After 5 Days ~0.5%



AREVA

The Fukushima Daiichi Incident
2. Accident progression

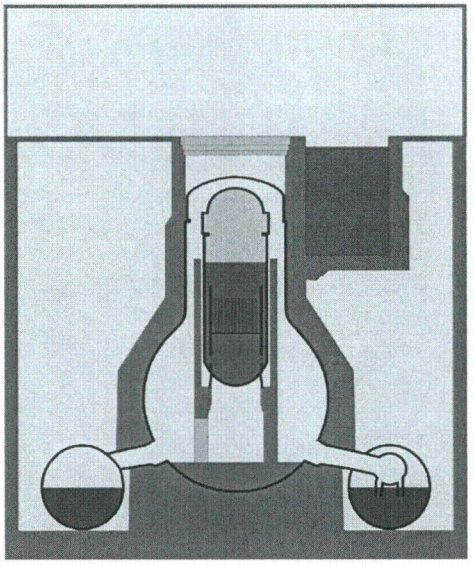
- Containment Isolation
  - Closing of all non-safety related Penetrations of the containment
  - Cuts off Machine hall
  - If containment isolation succeeds, a large early release of fission products is highly unlikely
- Diesel generators start
  - Emergency Core cooling systems are supplied
- Plant is in a stable save state



AREVA

The Fukushima Daiichi Incident
2. Accident progression

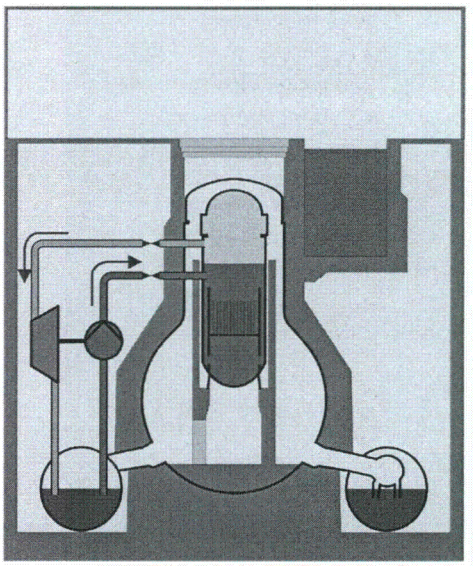
- 11.3. 15:41 Tsunami hits the plant
  - Plant Design for Tsunami height of up to 6.5m
  - Actual Tsunami height >7m
  - Flooding of
    - Diesel Generators and/or
    - Essential service water building cooling the generators
- Station Blackout
  - Common cause failure of the power supply
  - Only Batteries are still available
  - Failure of all but one Emergency core cooling systems



AREVA

The Fukushima Daiichi Incident
2. Accident progression

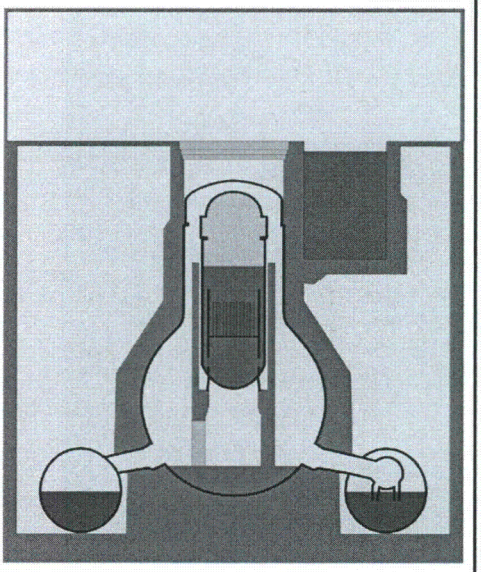
- Reactor Core Isolation Pump still available
  - Steam from the Reactor drives a Turbine
  - Steam gets condensed in the Wet-Well
  - Turbine drives a Pump
  - Water from the Wet-Well gets pumped in Reactor
  - Necessary:
    - Battery power
    - Temperature in the wet-well must be below 100°C
- As there is no heat removal from the building, the Core isolation pump cant work infinitely



AREVA

The Fukushima Daiichi Incident
2. Accident progression

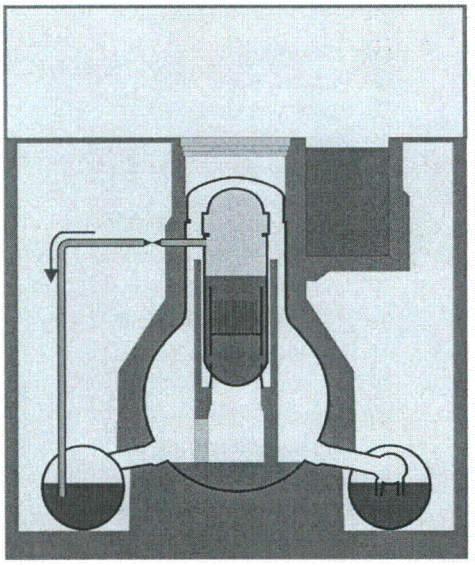
- Reactor Isolation pump stops
  - 11.3. 16:36 in Unit 1 (Batteries empty)
  - 14.3. 13:25 in Unit 2 (Pump failure)
  - 13.3. 2:44 in Unit 3 (Batteries empty)
- Decay Heat produces still steam in Reactor pressure Vessel
  - Pressure rising
- Opening the steam relieve valves
  - Discharge Steam into the Wet-Well
- Descending of the Liquid Level in the Reactor pressure vessel



AREVA

The Fukushima Daiichi Incident
2. Accident progression

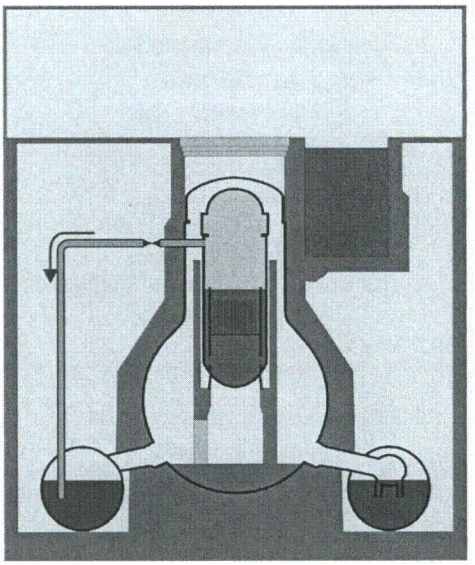
- Reactor Isolation pump stops
  - 11.3. 16:36 in Unit 1 (Batteries empty)
  - 14.3. 13:25 in Unit 2 (Pump failure)
  - 13.3. 2:44 in Unit 3 (Batteries empty)
- Decay Heat produces still steam in Reactor pressure Vessel
  - Pressure rising
- Opening the steam relieve valves
  - Discharge Steam into the Wet-Well
- Descending of the Liquid Level in the Reactor pressure vessel



AREVA

The Fukushima Daiichi Incident
2. Accident progression

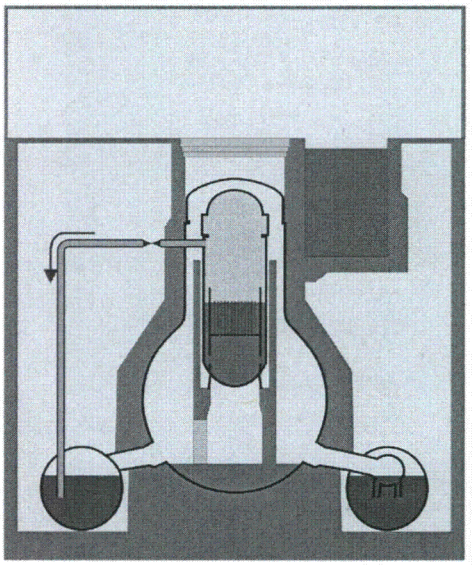
- Reactor Isolation pump stops
  - 11.3. 16:36 in Unit 1 (Batteries empty)
  - 14.3. 13:25 in Unit 2 (Pump failure)
  - 13.3. 2:44 in Unit 3 (Batteries empty)
- Decay Heat produces still steam in Reactor pressure Vessel
  - Pressure rising
- Opening the steam relieve valves
  - Discharge Steam into the Wet-Well
- Descending of the Liquid Level in the Reactor pressure vessel



AREVA

The Fukushima Daiichi Incident
2. Accident progression

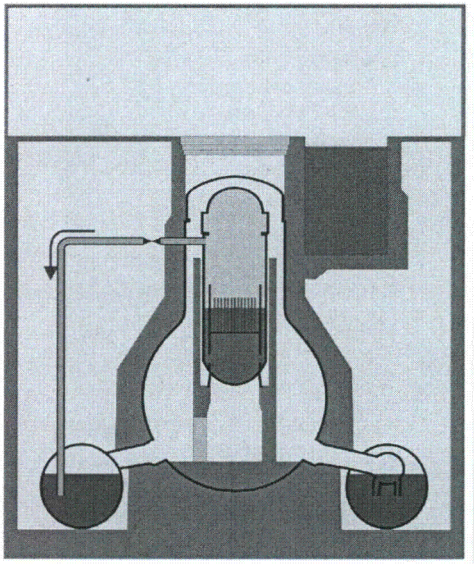
- Reactor Isolation pump stops
  - 11.3. 16:36 in Unit 1 (Batteries empty)
  - 14.3. 13:25 in Unit 2 (Pump failure)
  - 13.3. 2:44 in Unit 3 (Batteries empty)
- Decay Heat produces still steam in Reactor pressure Vessel
  - Pressure rising
- Opening the steam relieve valves
  - Discharge Steam into the Wet-Well
- Descending of the Liquid Level in the Reactor pressure vessel



AREVA

The Fukushima Daiichi Incident
2. Accident progression

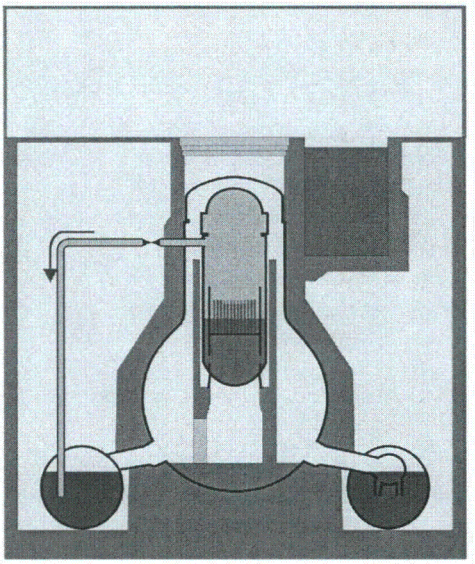
- Reactor Isolation pump stops
  - 11.3. 16:36 in Unit 1 (Batteries empty)
  - 14.3. 13:25 in Unit 2 (Pump failure)
  - 13.3. 2:44 in Unit 3 (Batteries empty)
- Decay Heat produces still steam in Reactor pressure Vessel
  - Pressure rising
- Opening the steam relieve valves
  - Discharge Steam into the Wet-Well
- Descending of the Liquid Level in the Reactor pressure vessel



AREVA

The Fukushima Daiichi Incident
2. Accident progression

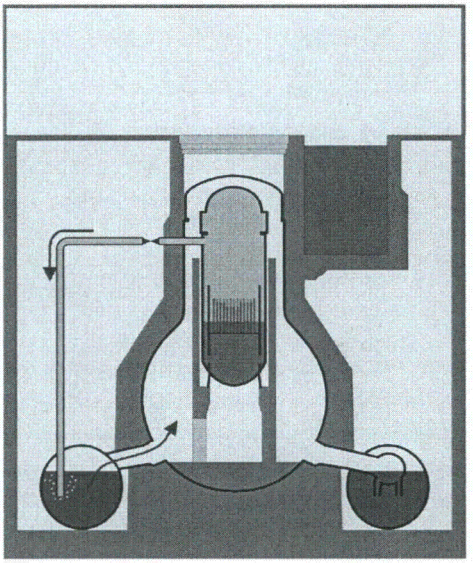
- Measured, and here referenced Liquid level is the collapsed level. The actual liquid level lies higher due to the steam bubbles in the liquid
- ~50% of the core exposed
  - Cladding temperatures rise, but still no significant core damage
- ~2/3 of the core exposed
  - Cladding temperature exceeds ~900°C
  - Ballooning / Breaking of the cladding
  - Release of fission products form the fuel rod gaps



AREVA

The Fukushima Daiichi Incident
2. Accident progression

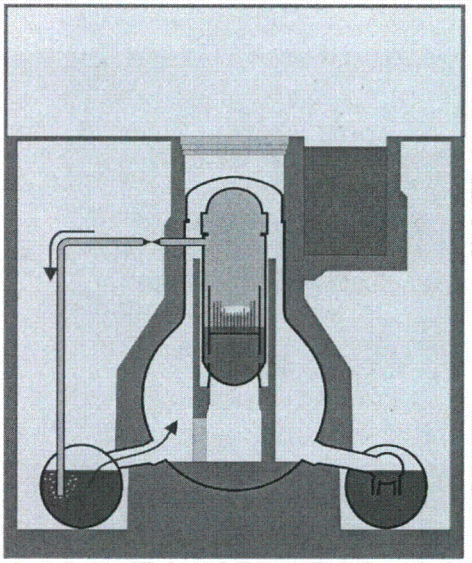
- ~3/4 of the core exposed
  - Cladding exceeds ~1200°C
  - Zirconium in the cladding starts to burn under Steam atmosphere
  - **$Zr + 2H_20 \rightarrow ZrO_2 + 2H_2$**
  - Exothermal reaction further heats the core
  - Generation of hydrogen
    - Unit 1: 300-600kg
    - Unit 2/3: 300-1000kg
  - Hydrogen gets pushed via the wet-well, the wet-well vacuum breakers into the dry-well



AREVA

The Fukushima Daiichi Incident
2. Accident progression

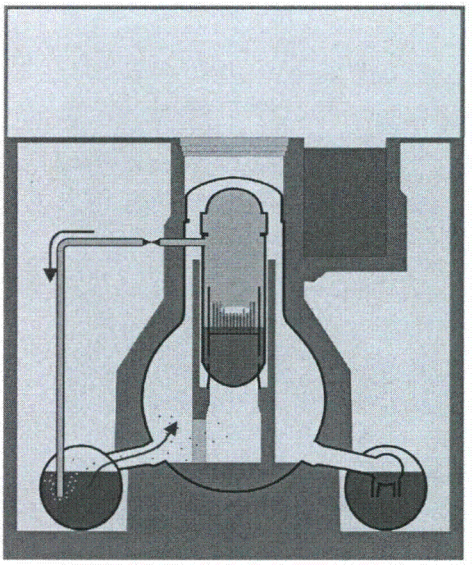
- at ~1800°C [Unit 1,2,3]
  - Melting of the Cladding
  - Melting of the steel structures
- at ~2500°C [Block 1,2]
  - Breaking of the fuel rods
  - debris bed inside the core
- at ~2700°C [Block 1]
  - Melting of Uranium-Zirconium eutectics
- Restoration of the water supply stops accident in all 3 Units
  - Unit 1: 12.3. 20:20 (27h w.o. water)
  - Unit 2: 14.3. 20:33 (7h w.o. water)
  - Unit 3: 13.3. 9:38 (7h w.o. water)



AREVA

The Fukushima Daiichi Incident
2. Accident progression

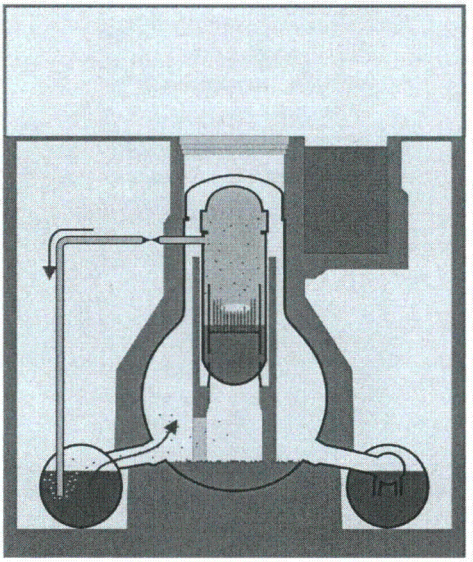
- Release of fission products during melt down
  - Xenon, Cesium, Iodine,...
  - Uranium/Plutonium remain in core
  - Fission products condensate to airborne Aerosols
- Discharge through valves into water of the condensation chamber
  - Pool scrubbing binds a fraction of Aerosols in the water
- Xenon and remaining aerosols enter the Dry-Well
  - Deposition of aerosols on surfaces further decontaminates air



AREVA

The Fukushima Daiichi Incident
2. Accident progression

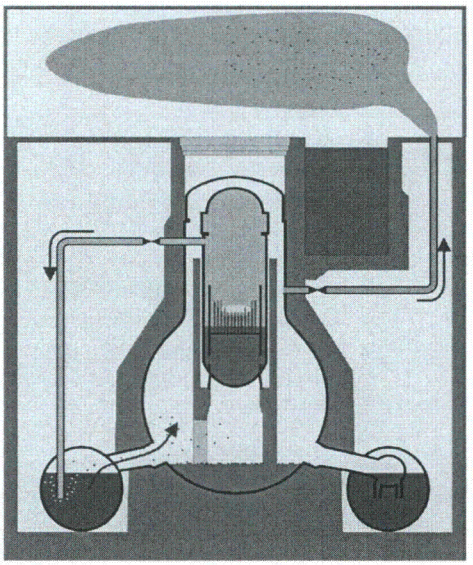
- Containment
  - Last barrier between Fission Products and Environment
  - Wall thickness ~3cm
  - Design Pressure 4-5bar
- Actual pressure up to 8 bars
  - Normal inert gas filling (Nitrogen)
  - Hydrogen from core oxidation
  - Boiling condensation chamber (like a pressure cooker)
- Depressurization of the containment
  - Unit 1: 12.3. 4:00
  - Unit 2: 13.3 00:00
  - Unit 3: 13.3. 8.41



AREVA

The Fukushima Daiichi Incident
2. Accident progression

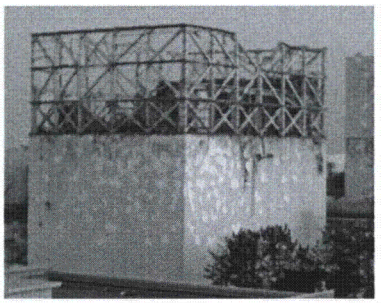
- Positive und negative Aspects of depressurizing the containment
  - Removes Energy from the Reactor building (only way left)
  - Reducing the pressure to ~4 bar
  - Release of small amounts of Aerosols (Iodine, Cesium ~0.1%)
  - Release of all noble gases
  - Release of Hydrogen
- Gas is released into the reactor service floor
  - Hydrogen is flammable

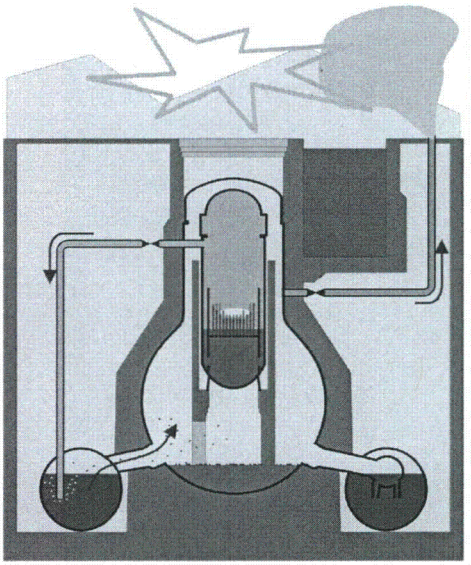


AREVA

The Fukushima Daiichi Incident
2. Accident progression

- Unit 1 und 3
  - Hydrogen burn inside the reactor service floor
  - Destruction of the steel-frame roof
  - Reinforced concrete reactor building seems undamaged
  - Spectacular but minor safety relevant

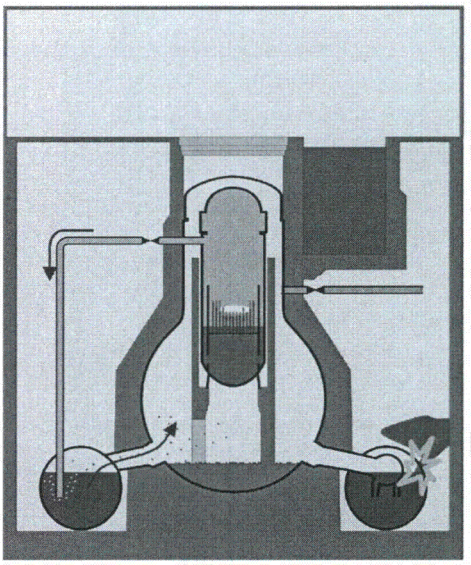




AREVA

The Fukushima Daiichi Incident
2. Accident progression

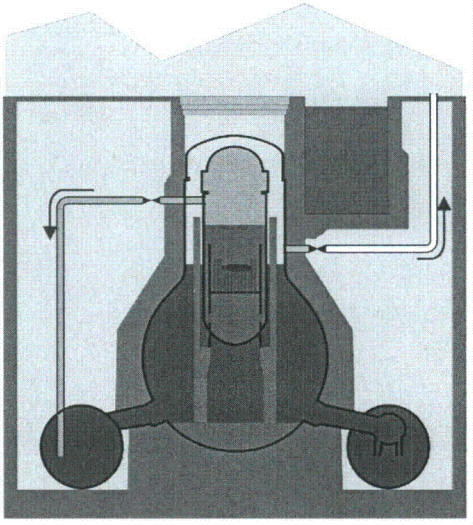
- Unit 2
  - Hydrogen burn inside the reactor building
  - Probably damage to the condensation chamber (highly contaminated water)
  - Uncontrolled release of gas from the containment
  - **Release of fission products**
  - Temporal evacuation of the plant
  - High local dose rates on the plant site due to wreckage hinder further recovery work
- No clear information's why Unit 2 behaved differently



AREVA

The Fukushima Daiichi Incident
2. Accident progression

- Current status of the Reactors
  - Core Damage in Unit 1,2, 3
  - Building damage due to various burns Unit 1-4
  - Reactor pressure vessels floode in all Units with mobile pumps
  - At least containment in Unit 1 flooded
- Further cooling of the Reactors by releasing steam to the atmospher
- Only small further releases of fission products can be expected



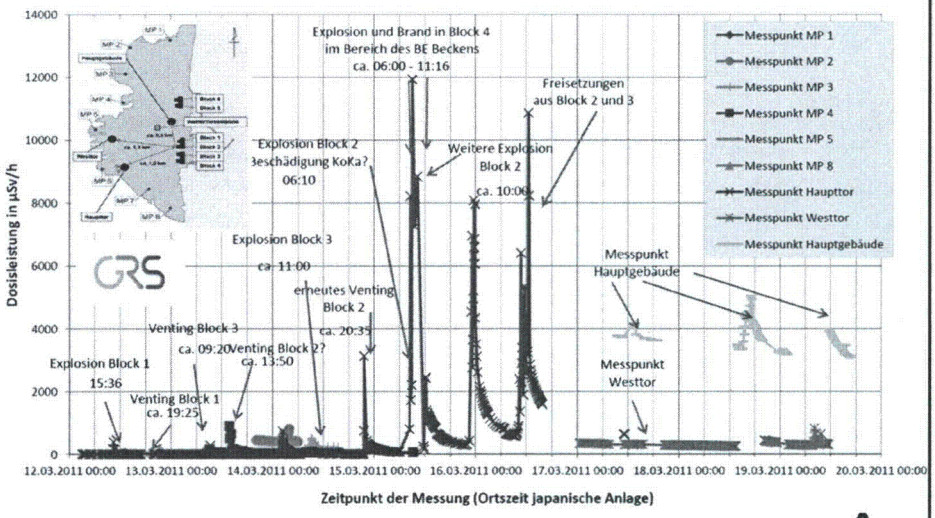
AREVA

The Fukushima Daiichi Incident
3. Radiological releases

- Directly on the plant site
  - Before Explosion in Unit Block 2
    - Below 2mSv / h
    - Mainly due to released radioactive noble gases
    - Measuring posts on west side. Maybe too small values measured due to wind
  - After Explosion in Unit 2 (Damage of the Containment)
    - Temporal peak values 12mSv / h
    - (Origin not entirely clear)
    - Local peak values on site up to 400mSv /h (wreckage / fragments?)
    - Currently stable dose on site at 5mSv /h
    - Inside the buildings a lot more
  - Limiting time of exposure of the workers necessary

AREVA

The Fukushima Daiichi Incident
3. Radiological releases



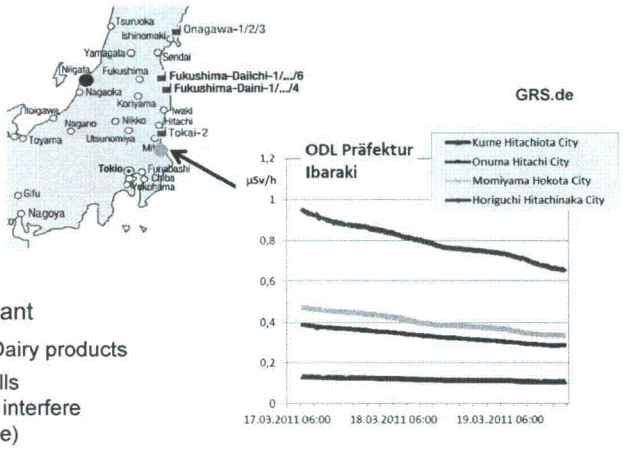
AREVA

The Fukushima Daiichi Incident
3. Radiological releases

- Outside the Plant site
  - As reactor building mostly intact
    => reduced release of Aerosols (not Chernobyl-like)
  - Fission product release in steam
    => fast Aerosol grows, large fraction falls down in the proximity of the plant
  - Main contribution to the radioactive dose outside plant are the radioactive noble gases
  - Carried / distributed by the wind, decreasing dose with time
  - No „Fall-out" of the noble gases, so no local high contamination of soil
- ~20km around the plant
  - Evacuations were adequate
  - Measured dose up to 0.3mSv/h for short times
  - Maybe destruction of crops / dairy products this year
  - Probably no permanent evacuation of land necessary

AREVA

The Fukushima Daiichi Incident
3. Radiological releases

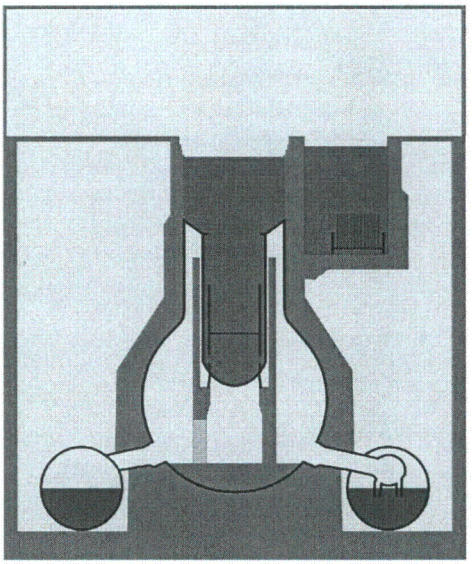


- ~50km around the plant
  - Control of Crop / Dairy products
  - Usage of Iodine pills (Caution, pills can interfere with heart medicine)

AREVA

The Fukushima Daiichi Incident
4. Spend fuel pools

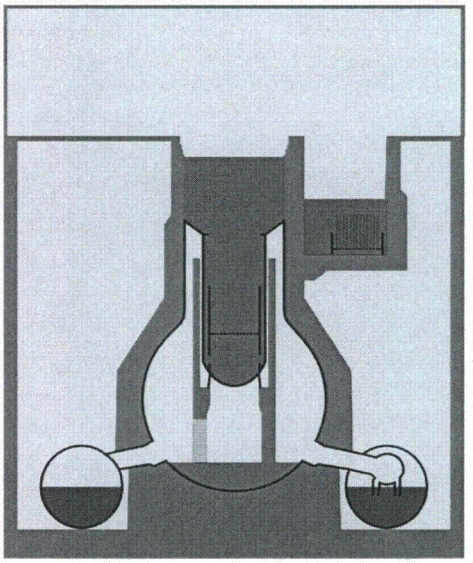
- Spend fuel stored in Pool on Reactor service floor
  - Due to maintenance in Unit 4 entire core stored in Fuel pool
  - Dry-out of the pools
    - Unit 4: in 10 days
    - Unit 1-3,5,6 in few weeks
  - **Leakage of the pools due to Earthquake?**
- Consequences
  - Core melt „on fresh air "
  - Nearly no retention of fission products
  - Large release



AREVA

The Fukushima Daiichi Incident
4. Spend fuel pools

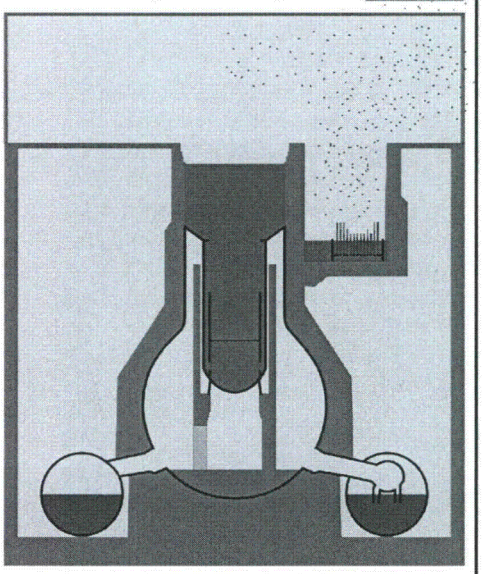
- Spend fuel stored in Pool on Reactor service floor
  - Due to maintenance in Unit 4 entire core stored in Fuel pool
  - Dry-out of the pools
    - Unit 4: in 10 days
    - Unit 1-3,5,6 in few weeks
  - **Leakage of the pools due to Earthquake?**
- Consequences
  - Core melt „on fresh air "
  - Nearly no retention of fission products
  - Large release



AREVA

The Fukushima Daiichi Incident
4. Spend fuel pools

- Spend fuel stored in Pool on Reactor service floor
  - Due to maintenance in Unit 4 entire core stored in Fuel pool
  - Dry-out of the pools
    - Unit 4: in 10 days
    - Unit 1-3,5,6 in few weeks
  - **Leakage of the pools due to Earthquake?**
- Consequences
  - Core melt „on fresh air "
  - Nearly no retention of fission products
  - Large release
- **It is currently unclear if release from fuel pool already happened**



AREVA

The Fukushima Daiichi Incident
5. Sources of Information

- Good sources of Information
  - Gesellschaft für Reaktorsicherheit [GRS.de]
    - Up to date
    - Radiological measurements published
    - German translation of japanese/englisch web pages
  - *Japan Atomic Industrial Forum [jaif.or.jp/english/]*
    - Current Status of the plants
    - Measurement values of the reactors (pressure liquid level)
  - Tokyo Electric Power Company [Tepco.co.jp]
    - Status of the recovery work
    - Casualties
- May too few information are released by TEPCO, the operator of the plant

AREVA

Helton, Donald

From: Schaperow, Jason
Sent: Wednesday, March 23, 2011 9:01 AM
To: Salay, Michael; Tinkler, Charles; Helton, Donald; Esmaili, Hossein
Subject: RE: Areva Fukushima Assessment

Thanks Michael.

It looks to me that GRS may have the most detailed and most informed timelines of the Fukushima accident:

http://www.grs.de/en/news/information-updates-japanese-nuclear-power-plants

---

From: Salay, Michael
Sent: Wednesday, March 23, 2011 7:39 AM
To: Schaperow, Jason; Tinkler, Charles; Helton, Donald; Esmaili, Hossein
Subject: Areva Fukushima Assessment

In case you haven't already seen an Areva assessment of the Fukushima event is attached. It contains some chronology info.

-Mike

Michael Salay
United States Nuclear Regulatory Commission
Washington, DC 20555
MS: C3-C07M
michael.salay@nrc.gov
tel: 301-251-7543
fax: 301-251-7436

4/220

Schaperow, Jason

From: Schaperow, Jason
Sent: Wednesday, March 23, 2011 9:02 AM
To: Marksberry, Don
Subject: RE: Please let me know if you plan to participate in a morning call Japan

Hi Don,
Charlie is planning to get in around 10 a.m. I am planning to speak with him sometime after that.

Thanks,
Jason

From: Marksberry, Don
Sent: Wednesday, March 23, 2011 8:00 AM
To: Schaperow, Jason; Tinkler, Charles
Subject: Please let me know if you plan to participate in a morning call Japan

Thanks.

3/22/1

Schaperow, Jason

From: Schaperow, Jason
Sent: Wednesday, March 23, 2011 9:12 AM
To: Santiago, Patricia
Subject: FW: PMT REQUEST TO RST for REALISTIC SOURCE TERM.doc
Attachments: PMT REQUEST TO RST for REALISTIC SOURCE TERM.doc

FYI.

From: RST09 Hoc
Sent: Wednesday, March 23, 2011 6:48 AM
To: Tinkler, Charles; Schaperow, Jason; Helton, Donald
Subject: FW: PMT REQUEST TO RST for REALISTIC SOURCE TERM.doc

I just talked to Tony regarding a more realistic source term (see attached). We think that both units 2 & 3 containments may be damaged (based on fax from embassy control room from Japan). The rationale for damaged containment is that "there is virtually no indication of pressure in U2/U3 ..". The question is that does the PB LTSBO source term apply (release path was line melt thru), or can we do a better analysis assuming the release is from SP. I don't think we have core on the floor as in the PB analysis. Please advise. I will be off in 15 minutes, but will let my replacement know to forward to PMT.

hossein

From: RST01 Hoc
Sent: Wednesday, March 23, 2011 6:34 AM
To: RST09 Hoc
Subject: FW: PMT REQUEST TO RST for REALISTIC SOURCE TERM.doc

---

From: Hoc, PMT12
Sent: Wednesday, March 23, 2011 6:33 AM
To: RST01 Hoc
Subject: FW: PMT REQUEST TO RST for REALISTIC SOURCE TERM.doc

---

From: PMT11 Hoc
Sent: Wednesday, March 23, 2011 6:31 AM
To: Hoc, PMT12
Subject: PMT REQUEST TO RST for REALISTIC SOURCE TERM.doc

attached

4/22

PMT REQUEST TO RST TO PROVIDE A REALISTIC, UP-TO-DATE ESTIMATION OF PLANT CONDITIONS AND SOURCE TERMS FOR DOSE PROJECTIONS

3-23-2011

During the first shift of March 23rd, a member of the Executive Team requested a realistic dose projection that takes into account current plant conditions at the Fukushima site. The PMT, in turn, is requesting from the RST information to inform the basis of our dose projection calculations. This request is consistent with RST responsibilities to provide core damage and release pathway information to the PMT.

Last week, RES/DSA developed a "best estimate – worst case" source term using insights from a contemporary consequence study that assumed a long-term station blackout event modeled after a domestic BWR/4 Mark I plant. The current request is for updated analyses for suspected damaged containments for Unit 2 and Unit 3 and the spent fuel pool for unit 4, taking into account recent site information. Additional analyses should be conducted, if recommended by the RST. This information is needed in support of estimating radiological doses to U.S. personnel in Japan and other locations, as directed by the PMT.

Bensi, Michelle

From: Bensi, Michelle
Sent: Wednesday, March 23, 2011 10:01 AM
To: Devlin, Stephanie
Subject: RE: ACRONYMS for the Seismic Q&A doc attached.

Wow! Thanks!

-Shelby

From: Devlin, Stephanie
Sent: Tuesday, March 22, 2011 7:30 PM
To: Kammerer, Annie; Bensi, Michelle
Subject: ACRONYMS for the Seismic Q&A doc attached.

the acronym doc is complete, as of the (Seismic Questions for Incident Response 3-21-11 4pm_MB.docx) document and the definitions document i sent you yesterday.

stephanie

From: Devlin, Stephanie
Sent: Monday, March 21, 2011 11:28 PM
To: Kammerer, Annie; Bensi, Michelle
Subject: ACRONYMS for the Seismic Q&A doc started.

i started the acronym list, but it's far from complete. it is attached. i scanned (using Bensi's help) up to approx. page 41 of the Q&A doc. i'll see you ladies tomorrow and we can figure out how to finish this list up.

stephanie

From: Devlin, Stephanie
Sent: Monday, March 21, 2011 9:31 PM
To: Kammerer, Annie; Bensi, Michelle
Subject: Definitions for the Seismic Q&A doc attached.

this document contains the defintions that were in (Seismic Questions for Incident Response 3-21-11 4pm_MB.docx) and i added the defintions contained in (ANS 2.29 PSHA) and (ANS 58.21 External Events PRA Methodology)

stephanie

4/223

Schaperow, Jason

From: Schaperow, Jason
Sent: Wednesday, March 23, 2011 10:02 AM
To: Mohseni, Aby
Subject: RE: BRC

Thanks. I will coordinate with Brit.

From: Mohseni, Aby
Sent: Wednesday, March 23, 2011 10:00 AM
To: Schaperow, Jason
Cc: Tinkler, Charles; Hill, Brittain
Subject: RE: BRC

Jason,
Thanks for your support. Brit has all the details and will contact you to confirm the plan.
Aby

From: Schaperow, Jason
Sent: Wednesday, March 23, 2011 9:57 AM
To: Mohseni, Aby
Cc: Tinkler, Charles
Subject: RE: BRC

Hi Aby,

I look forward to supporting Monday's briefing for Rep Hamilton of the BRC. Please confirm the following details as I understand them:
I will arrive at Cathy Haney's office (E1C2) in the EBB at 7:30 a.m. on Monday.
We will go over the slides that we will use for the briefing. We will be using the same slides that we used on Feb 3 to brief the BRC. Those slides are attached.
We will travel to the briefing location, and I will brief Rep Hamilton using slides 5 through 16 of the attached PowerPoint file.

Where will the briefing for Rep Hamilton be held?
How will we get there?
Any idea what time we will get back?

Thanks,
Jason

From: Tinkler, Charles
Sent: Wednesday, March 23, 2011 9:40 AM
To: Mohseni, Aby
Cc: Schaperow, Jason
Subject: BRC

Aby-

4234

I left a message late yesterday. We will support Kathy Haney briefing. Jason Schaperow will attend – he gave the first briefing to BRC with Dorman and will be able to meet with Haney et al at 7:30 at EBB Monday morning before traveling to BRC for briefing. We will use same presentation material as before.

Charles Tinkler
Charles.Tinkler@nrc.gov

Coyne, Kevin

From: Coyne, Kevin
Sent: Wednesday, March 23, 2011 10:19 AM
To: RES_DRA
Cc: Correia, Richard
Subject: Thanks to all DRA Staff

Doug and I want to express our sincere appreciation for everyone's support of the agency's ongoing response to the Japanese event over the last two weeks. Several folks have directly supported the Incident Response Center and briefings for various stakeholders, including the news media and congressional staff. As a Division, we have been able to provide accurate, timely, and much needed information at a critical time. In addition, we also want to thank everyone who has kept the core Division activities running smoothly despite the additional challenges imposed by both these events and the ongoing continuing resolution. We value all the work that is being churned out by the Division and want to make sure you know that your efforts during these challenging times are noted and very much appreciated.

The hard work will continue over the coming weeks and we look forward to seeing the continued high level performance from DRA.

4/25

Schaperow, Jason

Subject:	Support for Fukushima accident
Location:	Charlie's office
Start:	Wed 3/23/2011 10:30 AM
End:	Wed 3/23/2011 11:30 AM
Show Time As:	Tentative
Recurrence:	(none)
Meeting Status:	Not yet responded
Organizer:	Schaperow, Jason
Required Attendees:	Esmaili, Hossein; Salay, Michael

Request you come to Charlie's office at 10:30 a.m. to meet with Charlie, Don Helton, and me.

4/226

Lee, Richard

From: Algama, Don
Sent: Wednesday, March 23, 2011 10:48 AM
To: Lee, Richard
Subject: NRC Ops Center

Richard:

I have been allotted two shifts at the NRC Ops Center. They are on March 26th from 1500hrs to 2300hrs and on April 1st-2nd from 2300hrs to 0700hrs. I will be in the EST Actions Officer role and will be shadowing someone tomorrow in the afternoon (I hope).

-Don

W/22

Schaperow, Jason

From: Schaperow, Jason
Sent: Wednesday, March 23, 2011 12:56 PM
To: Tinkler, Charles
Subject: RE: projection of pool boiloff

O.K. Thanks.

From: Tinkler, Charles
Sent: Wednesday, March 23, 2011 12:55 PM
To: Schaperow, Jason
Subject: RE: projection of pool boiloff

I would minimize requests to essential items, and would not include these yet

---

From: Schaperow, Jason
Sent: Wednesday, March 23, 2011 12:48 PM
To: Tinkler, Charles
Subject: projection of pool boiloff

How do you feel about our asking KC to make a single plot with 4 curves, each curve showing the boiloff of one of the 4 spent fuel pools? It might be handy to have this, and it might be quick for KC to make. Alternatively, if KC could provide us the decay power for each of the 4 pools, we could make this plot ourselves.

4228

Bensi, Michelle

From: OST02 HOC
Sent: Wednesday, March 23, 2011 1:22 PM
To: Abrams, Charlotte; Abu-Eid, Boby; Adams, John; Afshar-Tous, Mugeh; Ahn, Hosung; Alemu, Bezakulu; Algama, Don; Alter, Peter; Anderson, Brian; Anderson, James; Arndt, Steven; Arribas-Colon, Maria; Ashkeboussi, Nima; Athey, George; Baker, Stephen; Ballam, Nick; Barnhurst, Daniel; Barr, Cynthia; Barss, Dan; Bazian, Samuel; Bensi, Michelle; Bergman, Thomas; Berry, Rollie; Bhachu, Ujagar; Bloom, Steven; Blount, Tom; Boger, Bruce; Bonnette, Cassandra; Borchardt, Bill; Bowers, Anthony; Bowman, Gregory; Boyce, Tom (RES); Brandon, Lou; Brandt, Philip; Brenner, Eliot; Brock, Kathryn; Brown, Cris; Brown, David; Brown, Eva; Brown, Frederick; Brown, Michael; Bukharin, Oleg; Burnell, Scott; Bush-Goddard, Stephanie; Campbell, Stephen; Camper, Larry; Carpenter, Cynthia; Carter, Mary; Case, Michael; Casto, Greg; Cecere, Bethany; Cervera, Margaret; Chazell, Russell; Chen, Yen-Ju; Cheok, Michael; Chokshi, Nilesh; Chowdhury, Prosanta; Circle, Jeff; Clement, Richard; Clinton, Rebecca; Coggins, Angela; Collins, Frank; Cool, Donald; Correia, Richard; Costa, Arlon; Couret, Ivonne; Crutchley, Mary Glenn; Cruz, Zahira; Cuadrado, Leira; Dacus, Eugene; DeCicco, Joseph; Decker, David; Dembek, Stephen; Devlin, Stephanie; Dimmick, Lisa; Doane, Margaret; Dorman, Dan; Dorsey, Cynthia; Dozier, Jerry; Drake, Margaret; Droggitis, Spiros; Dube, Donald; Dudes, Laura; Eads, Johnny; Emche, Danielle; English, Lance; Erlanger, Craig; Esmaili, Hossein; Figueroa, Roberto; Fiske, Jonathan; Flannery, Cindy; Floyd, Daphene; Foggie, Kirk; Foster, Jack; Fragoyannis, Nancy; Franovich, Rani; Frazier, Alan; Freshman, Steve; Fuller, Edward; Galletta, Thomas; Gambone, Kimberly; Gardocki, Stanley; Gartman, Michael; Gibson, Kathy; Giitter, Joseph; Gilmer, James; Gordon, Dennis; Gott, William; Grant, Jeffery; Greenwood, Carol; Grimes, Kelly; Grobe, Jack; Gross, Allen; Gulla, Gerald; Hale, Jerry; Hardesty, Duane; Hardin, Kimberly; Hardin, Leroy; Harrington, Holly; Harris, Tim; Hart, Ken; Hart, Michelle; Harvey, Brad; Hasselberg, Rick; Hayden, Elizabeth; Helton, Donald; Henderson, Karen; Hiland, Patrick; Holahan, Patricia; Holahan, Vincent; Holian, Brian; Howard, Arlette; Howard, Tabitha; Huffert, Anthony; Hurd, Sapna; Huyck, Doug; Imboden, Andy; Isom, James; Jackson, Karen; Jacobson, Jeffrey; Jervey, Richard; Jessie, Janelle; Johnson, Michael; Jolicoeur, John; Jones, Andrea; Jones, Cynthia; Jones, Henry; Kahler, Carolyn; Kammerer, Annie; Karas, Rebecca; Kauffman, John; Khan, Omar; Kolb, Timothy; Kotzalas, Margie; Kowalczik, Jeffrey; Kratchman, Jessica; Kugler, Andrew; Lamb, Christopher; Lane, John; Larson, Emily; Laur, Steven; LaVie, Steve; Lewis, Robert; Li, Yong; Lichatz, Taylor; Lising, Jason; Lombard, Mark; Lubinski, John; Lui, Christiana; Lukes, Kim; Lynch, Jeffery; Ma, John; Mamish, Nader; Manahan, Michelle; Marksberry, Don; Marshall, Jane; Masao, Nagai; Maupin, Cardelia; Mayros, Lauren; Mazaika, Michael; McConnell, Keith; McCoppin, Michael; McDermott, Brian; McGinty, Tim; McGovern, Denise; McIntyre, David; McMurtray, Anthony; Merritt, Christina; Meyer, Karen; Miller, Charles; Miller, Chris; Milligan, Patricia; Miranda, Samuel; Mohseni, Aby; Moore, Scott; Morlang, Gary; Morris, Scott; Mroz (Sahm), Sara; Munson, Clifford; Murray, Charles; Nerret, Amanda; Nguyen, Caroline; Norris, Michael; Norton, Charles; Opara, Stella; Ordaz, Vonna; Owens, Janice; Padovan, Mark; Parillo, John; Patel, Jay; Patel, Pravin; Patrick, Mark; Perin, Vanice; Pope, Tia; Powell, Amy; Purdy, Gary; Quinlan, Kevin; Raddatz, Michael; Ragland, Robert; Ralph, Melissa; Ramsey, Jack; Reed, Elizabeth; Reed, Sara; Reed, Wendy; Reis, Terrence; Resner, Mark; Riley (OCA), Timothy; Riner, Kelly; Rini, Brett; Robinson, Edward; Rodriguez-Luccioni, Hector; Roggenbrodt, William; Ropon, Kimberly; Rosales-Cooper, Cindy; Rosenberg, Stacey; Ross-Lee, MaryJane; Roundtree, Amy; Ruland, William; Ryan, Michelle; Salay, Michael; Salter, Susan; Salus, Amy; Sanfilippo, Nathan; Scarbrough, Thomas; Schaperow, Jason; Schmidt, Duane; Schmidt, Rebecca; Schoenebeck, Greg; Schrader, Eric; Schwartzman, Jennifer; Seber, Dogan; See, Kenneth; Shane, Raeann; Shea, James; Shepherd, Jill; Sheron, Brian; Skarda, Raymond; Skeen, David; Sloan, Scott; Smiroldo, Elizabeth; Smith, Brooke; Smith, Stacy; Smith, Theodore; Stahl, Eric; Stang, Annette; Steger (Tucci), Christine; Stieve, Alice; Stone, Rebecca; Stransky, Robert; Sturz, Fritz; Sullivan, Randy; Summers, Robert; Sun, Casper; Tappert, John; Tegeler, Bret; Temple, Jeffrey; Thaggard, Mark; Thomas, Eric; Thorp, John; Tiruneh, Nebiyu; Tobin, Jennifer; Trefethen, Jean; Tschiltz, Michael; Turtil, Richard; Uhle, Jennifer; Valencia, Sandra; Vaughn, James; Vick, Lawrence; Virgilio, Martin; Virgilio, Rosetta; Ward, Leonard; Ward, William; Wastler, Sandra; Watson, Bruce; Webber, Robert; Weber, Michael; White, Bernard; Wiggins, Jim; Williams, Donna; Williams, Joseph; Williamson, Linda; Willis, Dori; Wimbush, Andrea; Wittick, Brian; Wray, John; Wright, Lisa (Gibney); Wright, Ned; Wunder, George; Young, Francis; Zimmerman, Jacob; Zimmerman, Roy

W239

Subject: Revised -- EAP Breifing to all Participants Working the Japan Event

NRC's Employee Assistance Program (EAP) will be briefing the Ops Center Staff on the issue of critical incident stress on Thursday, March 24th at: 7:00a.m.-7:30a.m., 2:00p.m. – 2:30p.m., and 3:00p.m.-3:30p.m.. We understand the high level of stress that staff has experienced during the current traumatic Japanese incident and we want to bring you the support you deserve during this heightened time of stress. We strongly encourage all employees to attend! The briefing will be held in T4B3.

Michele Evans, Acting Deputy Director
Office of Nuclear Security and Incident Response

Schaperow, Jason

From: Schaperow, Jason
Sent: Wednesday, March 23, 2011 1:27 PM
To: Helton, Donald
Cc: Marksberry, Don
Subject: questions

Here are some questions for the list:

Reactor questions

For each reactor, could we get a plot (or enough data points to make a plot) for each of the following critical indications?
Reactor vessel pressure
Reactor vessel water level
Primary containment pressure
Primary containment hydrogen concentration

Is the purpose of spraying water into reactor buildings for units 1, 3, and 4 to cool the primary containment by external spray onto the torus? For reactor building 2, spraying water is not being done, so what is being done to cool the primary containment?

Spent fuel pool questions

How much water is in each of the spent fuel pools for units 1, 2, 3, and 4?

Did the concrete pump used to put water in the unit 4 spent fuel pool have a camera on it? If so, please provide pictures from it. Why was the pump stopped after delivering 150 tons of water? 150 tons is not enough to fill the spent fuel pool.

General
What particular concern do the Japanese have regarding hydrogen that unit 2?
-Is it that there is a lot of hydrogen in primary containment, and that when they cool down the primary containment and suppression pool air could be drawn into containment and cause an explosion?
-Is it that there is a lot of hydrogen in the top of the reactor building and that an ignition source such as a spark could damage the reactor building and hurt people?
-Why is salt water being used for cooling instead of fresh water?

Also, suggest that the Severe Accident Analyst on duty in the Ops Center speak with the PMT at the beginning of the shift to let them know that we are on duty to provide source terms for RASCAL and/or NARAC calculations.

4/230

From: Tinkler, Charles
Sent: Wednesday, March 23, 2011 2:37 PM
To: Helton, Donald
Cc: Marksberry, Don; Schaperow, Jason
Subject: questions

My questions are

1. Please confirm the present status of the spent fuel pools (particularly pools for units 2,3,4). Present water levels and temps.

2. Summarize extent and duration of fuel uncovery in the pools. Provide any transient/timeline description of pool conditions.

3. Please summarize chronology of unit 3 containment integrity. Has unit 3 containment been judged to fail at any time, if so when?Why so determined?

4. RPV water levels have continuously been reported to be 1.7-2.0 m below TAF, are these measurements believed to be accurate?

   If so, is this intentional management of water level.

5. Provide current status of containment flooding for units 1,2,and 3. Provide transient history
6. Provide latest view of containment integrity for units 1,2 and 3. Provide transient history

These questions are not in priority order and unfortunately are not worded well, sorry

Charles Tinkler
Charles.Tinkler@nrc.gov

W231

Helton, Donald

From: Tinkler, Charles
Sent: Wednesday, March 23, 2011 2:48 PM
To: Helton, Donald
Attachments: Suggested Questions of Interest for the RST Severe Accident Analyst - 032311.rev.docx

Suggestions,

Charles Tinkler
Charles.Tinkler@nrc.gov

4232

Suggested Questions of Interest for the RST Severe Accident Analyst:

Reminder: The RST Severe Accident Analyst should touch base with the PMT RASCAL analyst at the beginning of each shift, and periodically throughout the shift (recall that the RST/PMT liaison positions are not being staffed).

Reactors:

- Venting:
  - ~~What were the vent paths used for the primary containment venting: drywell versus suppression pool airspace?~~
- (Potential) primary containment failure:
  - What is the basis for reports that the Unit 3 primary containment may be failed? Reports had previously indicated that the Unit 3 primary containment was pressurized, well after the initiating events and the hydrogen deflagration/detonation in the reactor building.
- Hydrogen:
  - What particular concern do the Japanese have regarding hydrogen accumulation on Unit 2? Is this a concern about primary containment becoming de-interted in the long-term, or due to containment failure, or is it a concern regarding a deflagration/detonation in the reactor building?
- Water injection:
  - ~~What are the current estimated injection rates in to Units 1-3? Is the injection in to the RPV or the suppression pool?~~
- Water spraying:
  - ~~Is the purpose of spraying water into reactor buildings for units 1, 3, and 4 to cool the primary containment by external spray onto the torus?~~
  - ~~For reactor building 2, spraying water is not being done, so what is being done to cool the primary containment?~~
  - Is water spraying also intended to cool the outside of the containment (assuming the primary purpose is spent fuel pool makeup)
- Data requests:
  - For each reactor, could we get a plot (or enough data points to make a plot) for each of the critical indications listed below? If not, could we at least get a current, verified reading for these?
    - Reactor vessel pressure
    - Reactor vessel water level
    - Primary containment pressure
    - Primary containment (dry/wetwell) hydrogen concentration

Spent Fuel Pools:

- Coolant inventory:
  - How much water is in each of the spent fuel pools for units 1, 2, 3, and 4?

- Did the concrete pump used to put water in the unit 4 spent fuel pool have a camera on it? If so, what did the video show?
  - Why was the pump stopped after delivering 150 tons of water? 150 tons is not enough to fill the spent fuel pool.

Other:

- Are any of the NRC in-country representatives stationed in the TEPCO or NISA Emergency Operations Facilities? If so, are they in a position to relay some of the measurements that are available (such as ones that would answer the above questions)?
- Has any assessment been done of the I-131/Cs-137 ratios that are being observed via field measurements, to determine if they originated from a reactor release versus a spent fuel pool release?
- What is the status of replacing spray/injection sources with potable water, rather than continuing to use seawater?
- Has water been observed draining from the loading bay door (or other areas) of any of the reactor buildings, coincident with the spraying operations?

From: Tinkler, Charles
Sent: Wednesday, March 23, 2011 3:26 PM
To: Helton, Donald; Marksberry, Don; Salay, Michael; Schaperow, Jason; Esmaili, Hossein
Subject: RE: Questions from our Hallway Discussion

My thinking on venting was that we know they vented into the reactor building – asking them why seems not essential to our understanding and may make them defensive

I might place some priority on the Cs/Iodine ratio question.

From: Helton, Donald
Sent: Wednesday, March 23, 2011 3:06 PM
To: Tinkler, Charles; Marksberry, Don; Salay, Michael; Schaperow, Jason; Esmaili, Hossein
Subject: RE: Questions from our Hallway Discussion

All – An updated version based on input from Charlie.

Charlie – I included input from your markup and your email that was sent simultaneous to me sending out the earlier version. I did not understand why you deleted the venting question, so I left it in, but moved it further down the list

---

From: Helton, Donald
Sent: Wednesday, March 23, 2011 2:36 PM
To: Tinkler, Charles; Marksberry, Don; Salay, Michael; Schaperow, Jason; Esmaili, Hossein
Subject: Questions from our Hallway Discussion

All,

These are the questions that I compiled from our hallway discussion this morning...

Don

Don Helton
Senior Reliability & Risk Engineer
Division of Risk Analysis
NRC Office of Nuclear Regulatory Research
Physical address: 21 Church Street, CSB4-C9, Rockville, MD 20850
Postal address: US NRC / MS CSB4-C7M / Washington, DC 20555
Ph: 301 251-7594, Donald.Helton@nrc.gov

4/233

Suggested Questions of Interest for the RST Severe Accident Analyst:

Reminder: The RST Severe Accident Analyst should touch base with the PMT RASCAL analyst at the beginning of each shift, and periodically throughout the shift (recall that the RST/PMT liaison positions are not being staffed).

Reactors:

- (Potential) primary containment failure:
  - What is the basis for reports that the Unit 3 primary containment may be failed? Reports had previously indicated that the Unit 3 primary containment was pressurized, well after the initiating events and the hydrogen deflagration/detonation in the reactor building.
  - What is the current estimate on containment integrity for Units 1 and 2?
- Hydrogen:
  - What particular concern do the Japanese have regarding hydrogen accumulation on Unit 2? Is this a concern about primary containment becoming de-interted in the long-term, or due to containment failure, or is it a concern regarding a deflagration/detonation in the reactor building?
- Water injection:
  - Various RPV water levels in Units 1-3 have been reported, many suggesting that the level is being maintained around core mid-plane. Is this the case, and if so, what is the rationale?
  - What is the status (and if possible timeline) regarding containment flooding, including current water level?
- Water spraying:
  - Is water spraying also intended to cool the outside of the containment (assuming the primary purpose is spent fuel pool makeup)?
- Venting:
  - What were the vent paths used for the primary containment venting: drywell versus suppression pool airspace?
- Data requests:
  - For each reactor, could we get a plot (or enough data points to make a plot) for each of the critical indications listed below? If not, could we at least get a current, verified reading for these?
    - Reactor vessel pressure
    - Reactor vessel water level
    - Primary containment pressure
    - Primary containment (drywell/wetwell) hydrogen concentration

Spent Fuel Pools:

- Coolant inventory:
  - How much water is in each of the spent fuel pools for units 1, 2, 3, and 4? Are there any reliable temperature measurements?

- Please provide any timeline information available regarding fuel uncovery and makeup/spray injection.
- Did the concrete pump used to put water in the unit 4 spent fuel pool have a camera on it? If so, what did the video show?
  - Why was the pump stopped after delivering 150 tons of water? 150 tons is not enough to fill the spent fuel pool.

Other:

- Are any of the NRC in-country representatives stationed in the TEPCO or NISA Emergency Operations Facilities? If so, are they in a position to relay some of the measurements that are available (such as ones that would answer the above questions)?
- Has any assessment been done of the I-131/Cs-137 ratios that are being observed via field measurements, to determine if they originated from a reactor release versus a spent fuel pool release?
- What is the status of replacing spray/injection sources with potable water, rather than continuing to use seawater?
- Has water been observed draining from the loading bay door (or other areas) of any of the reactor buildings, coincident with the spraying operations?

Beasley, Benjamin

From: Beasley, Benjamin
Sent: Wednesday, April 20, 2011 4:09 PM
To: Sheron, Brian
Cc: Uhle, Jennifer; Correia, Richard; Case, Michael; Gibson, Kathy; Coe, Doug; Kauffman, John
Subject: RE: Useful presentation from http://allthingsnuclear.org of April 14, and a SUGGESTION for improving our BWRs
Attachments: image001.png; image002.gif; image003.gif

Brian,

I understand your question to be about the regulatory feasibility of the suggestion to have a "magneto" on the RCIC shaft, like that on a piston-driven aircraft engine, so that whenever the pump is running there is electrical power generated for the RCIC valves and other emergency loads. The electrical power might also be used to charge the batteries and operate control room indicators and lights. Before addressing your backfit question, there are some system implications associated with the suggestion. (John Kauffman drafted these thoughts and they reflect comments from Rich and Doug.)

System implications

In a LOOP event, RCIC typically runs (along with HPCI/HPCS to restore/maintain reactor water level). However, these systems have more capacity than is needed and either trip on high level or require operator intervention to throttle them back. The point is that RCIC only runs intermittently. It also does not run at constant speed, which would be problematic for making stable, useable AC.

Connecting a magneto to the RCIC shaft would create a "load," so RCIC would either need to draw more steam to produce the same injection flow or be de-rated. If the RCIC turbine were run continuously, it could depressurize the RCS, causing a loss of motive force. A separate turbine or a generator connected to the RCIC turbine only when RCIC is not injecting would address the de-rating issue but not the depressurization issue. Either of these would likely be more costly than alternatives.

In summary; this idea would present challenging implementation hurdles. A more straight-forward approach would be to have pre-arranged temporary AC sources, e.g. skid mounted EDGs, and ways to connect them to the station's emergency/vital buses.

Backfit discussion

The probability of a LOOP followed by failure of the onsite EPS (a station blackout) is, at most, on the order of 3E-5 per year. This is based on simply multiplying LOOP initiating event frequency data and onsite EPS failure probability (8 hour mission time). To calculate a CDF frequency from this SBO probability, credit would need to be given for recovery actions (such as grid restoration) and alternate AC capabilities (SBO or B5B diesels). Plants also take action when expecting severe weather (hurricanes) that can affect the grid, such as shutting down the reactor and pre-positioning skid-mounted EDGs. Based on the above, the CDF due to station blackout is less than 1E-05. Under the agency's Regulatory Analysis Guidelines (page 14), with a delta CDF below E-5, we are in the zone of "Management decision whether to proceed." We could well be below E-6 and in the "No action" zone altogether (see figure below).

The Regulatory Analysis Guidelines (page 13) discuss the uncertainties associated with extreme external events:

> However, the uncertainties associated with certain external event risk contributions (especially seismic) can be relatively large. Therefore, to supplement any available quantitative information, qualitative insights should be used for issues involving external events.

W234

This is just a quick consideration. The numbers and discussion above indicate that the answer is not a definitive "no," but, that it will be difficult to impose substantial additional protection (cost-justified) backfits on station blackout.

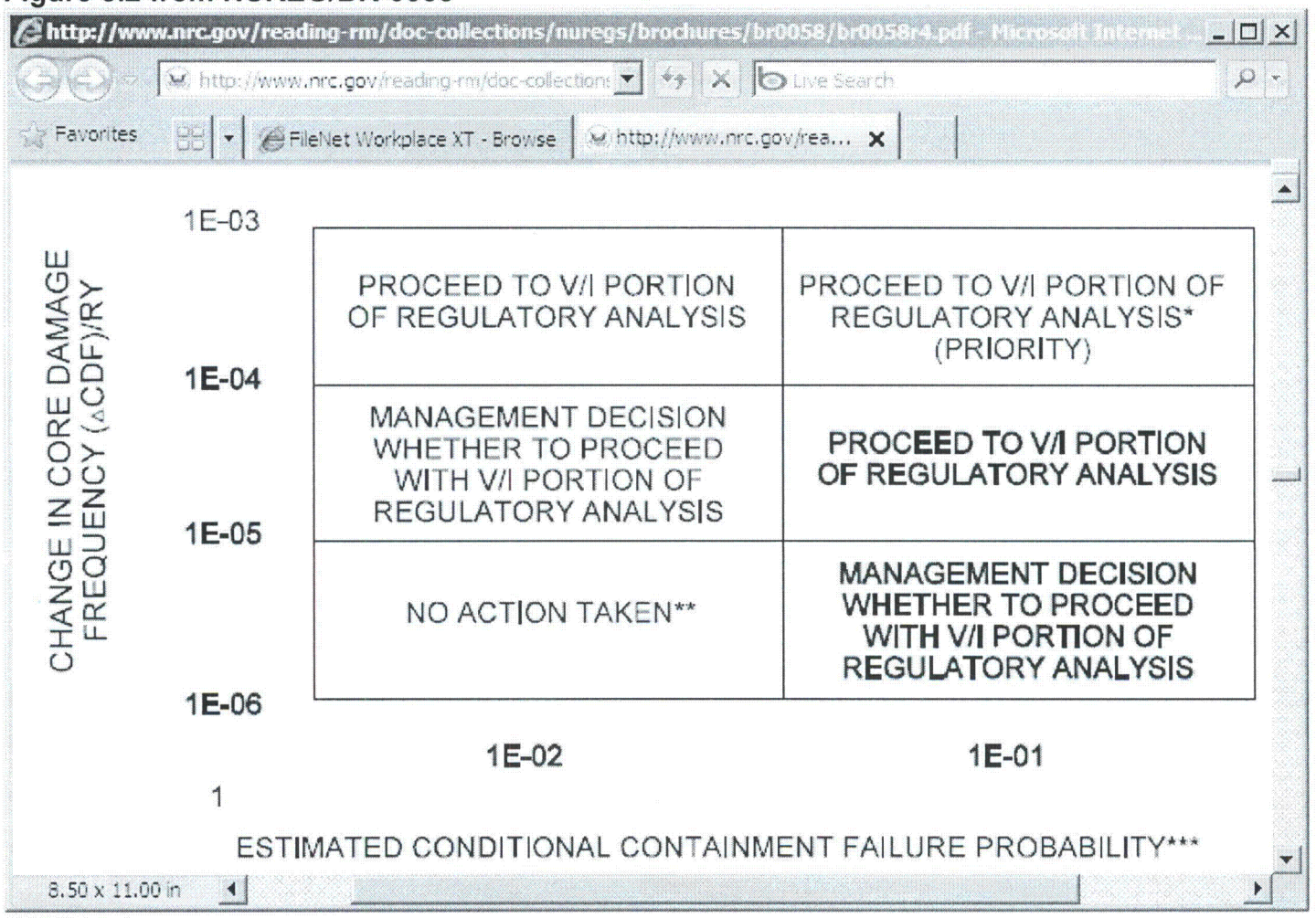
Regards,
Ben

Additional comments from Doug:

1. You need to do the analysis and shouldn't SWAG this. As I read the discussion, it is focused on core damage, whereas the regulatory analysis must consider consequences (i.e. person-rem avoided). The core damage piece doesn't apparently consider SBO coping equipment/procedures (I'm not sure why) and the regulatory analysis guidelines do not (I believe) address multi-unit severe external events. So…. back to 'you shouldn't SWAG this.'

2. Second, I would resist zeroing in on specific 'solutions' without a full and integrated review of how any/all 'solutions' would impact the overall reactor plant system and its risk profile. Adding any new backfit carries the potential for creating new vulnerabilities even as you are attempting to resolve known vulnerabilities. I would advocate continuing to collect ideas such as this one, but not to do any 'cost-benefit' or similar analysis until we can look at them in an integrated manner.

Figure 3.2 from NUREG/BR-0058



From: Sheron, Brian
Sent: Monday, April 18, 2011 11:20 AM
To: Beasley, Benjamin
Cc: Correia, Richard; Coe, Doug
Subject: FW: Useful presentation from http://allthingsnuclear.org of April 14, and a SUGGESTION for improving our BWRs

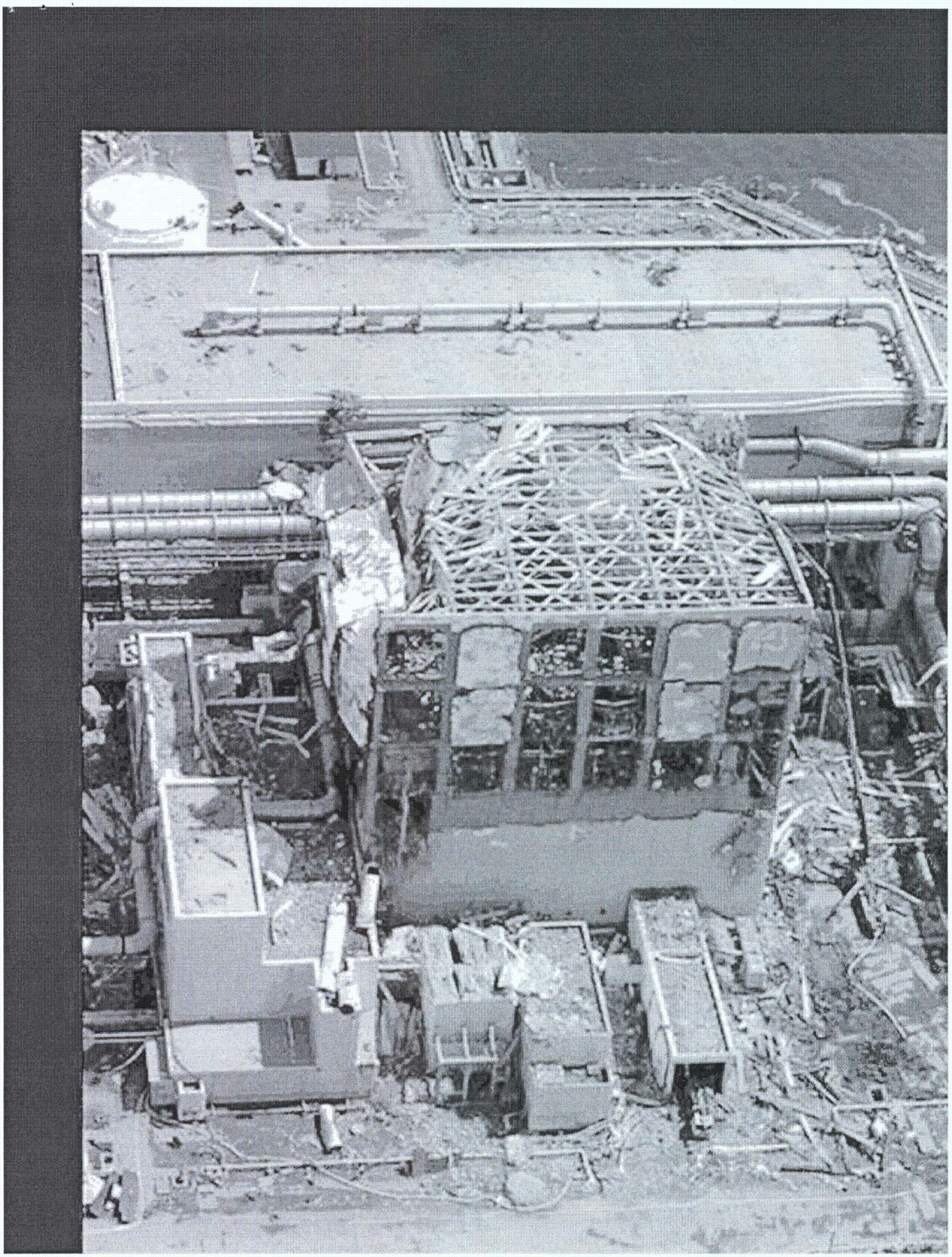
See below. Would this likely pass a cost-benefit backfit test?

From: Richard L Garwin [mailto:rlg2@us.ibm.com]
Sent: Sunday, April 17, 2011 4:25 PM
To: Larzelere, Alex
Cc: Caponiti, Alice; Busby, Jeremy T; DL-NITsolutions; Schneider, Steve
Subject: Useful presentation from http://allthingsnuclear.org of April 14, and a SUGGESTION for improving our BWRs

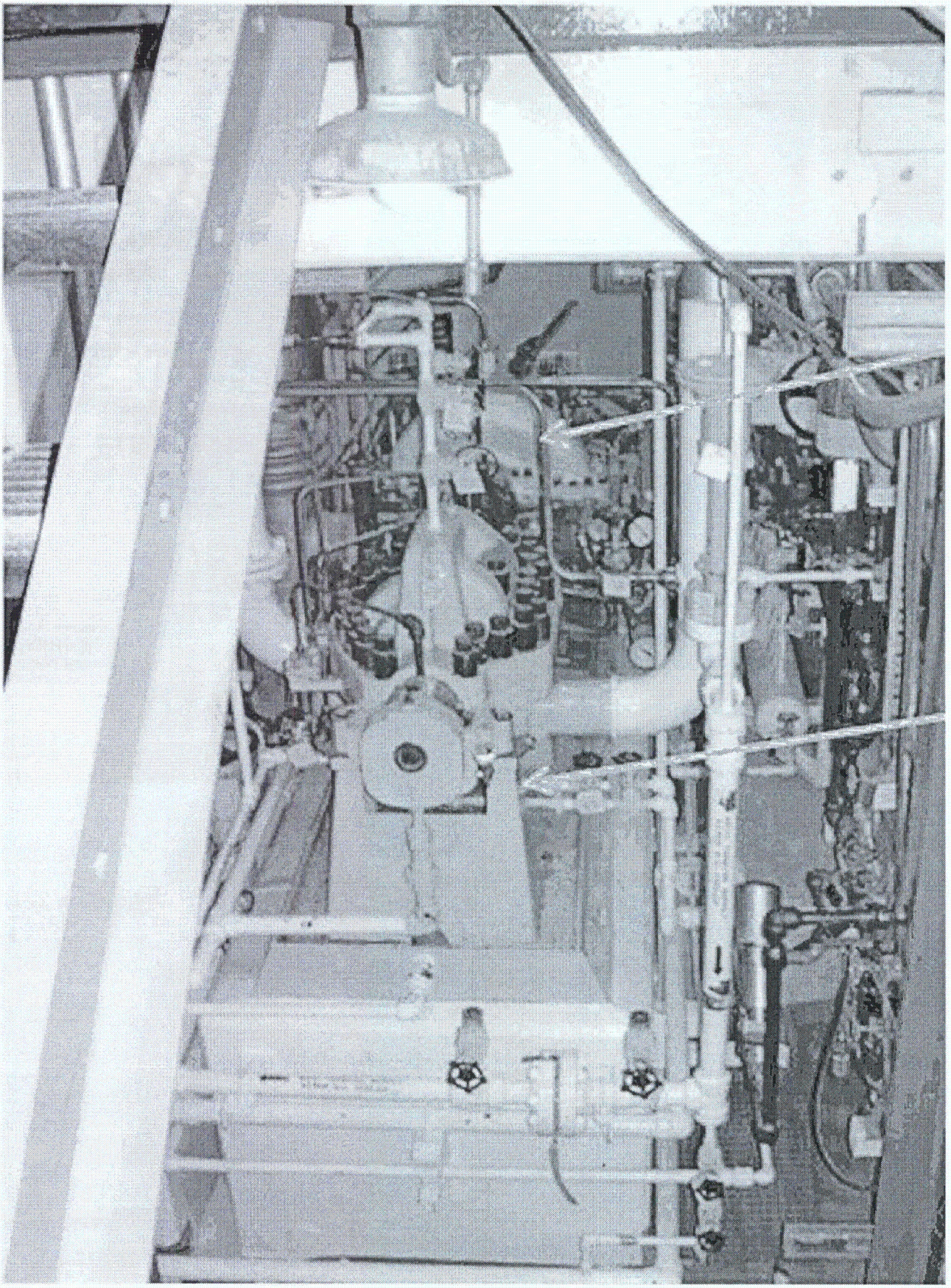
Dear Colleagues,

http://allthingsnuclear.org of April 14 has a very useful presentation of the Fukushima Dai-ichi problem.

I attach the first slide and also a detail of the steam-driven "isolation turbine and pump," and provide also
a SUGGESTION by Bill Press.



Reactor Core Isolation Co



Bill Press (William H. Press, University of Texas at Austin, and LANL) asks why the RCIC turbine/pump does not have a "magneto" on the shaft, like that on a piston-driven aircraft engine, so that whenever the pump is running there is electrical power generated for the RCIC valves and other emergency loads. This might well be used to charge the batteries, too, and operate the control room indicators and lights.

This seems to me an eminently practical suggestion, which I am passing on for communication to NE and NRC.

Dick Garwin

Helton, Donald

From: Helton, Donald
Sent: Wednesday, March 23, 2011 5:21 PM
To: Salay, Michael
Subject: Additional SFP Question

Mike,

I've updated the list to include an additional SFP question from Charlie, as follows:

- For Unit 4, can you confirm that there are 1,200 assemblies in the pool? Also, what is the rack configuration (whole pool is racked with assemblies spaced throughout vs. whole pool is racked with assemblies in one area vs. only a portion of the pool is racked)?

Don

Don Helton
Senior Reliability & Risk Engineer
Division of Risk Analysis
NRC Office of Nuclear Regulatory Research
Physical address: 21 Church Street, CSB4-C9, Rockville, MD 20850
Postal address: US NRC / MS CSB4-C7M / Washington, DC 20555
Ph: 301 251-7594, Donald.Helton@nrc.gov

W235

Bensi, Michelle

From: Kammerer, Annie
Sent: Wednesday, March 23, 2011 5:35 PM
To: Anooshehpoor, Rasool; Ake, Jon
Cc: Bensi, Michelle
Subject: RE: FYI

Thanks.

From: Anooshehpoor, Rasool
Sent: Wednesday, March 23, 2011 3:49 PM
To: Kammerer, Annie; Ake, Jon
Subject: FYI

Please see the attached file showing coseismic slip during the M9.0 earthquake. Also FYI,

KiK-net stations:

- Sensors are on the free surface and in boreholes
- Borehole sensors are placed down in the bedrock
- Most borehole sensors are at ~ 100 m depth

K-net stations are in urban settings, outside the buildings.

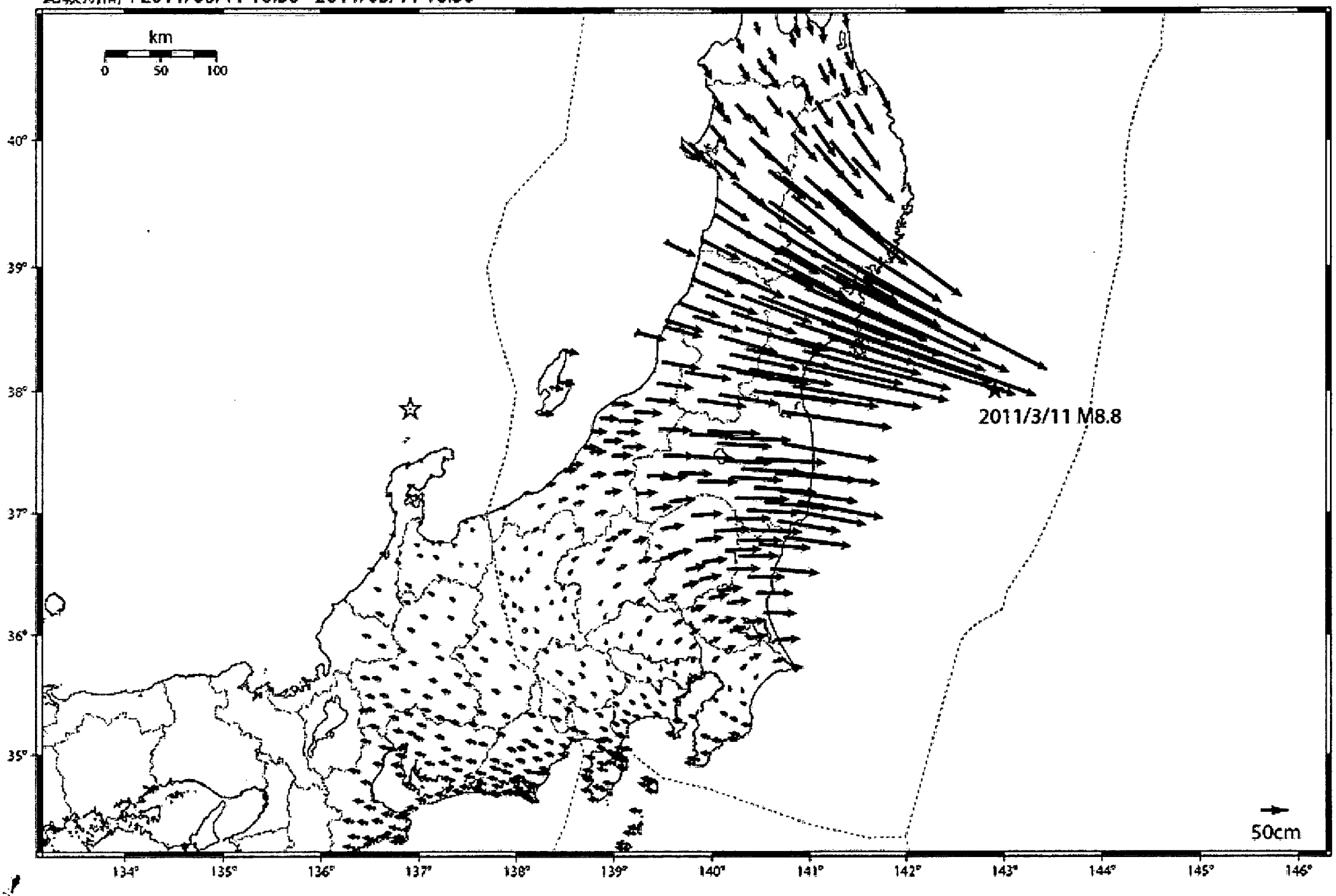
Rasool

Rasool Anooshehpoor
U.S. Nuclear Regulatory Commission
MS C5A24M
Washington, DC 20555-0001
301-251-7620
Fax: 301-251-7425

4/236

変動ベクトル図（水平）

基準期間：2011/03/01 21:00 - 2011/03/08 21:00
比較期間：2011/03/11 16:30 - 2011/03/11 16:30



［基準：Ｒ３速報解　比較：Ｓ３迅速解］

☆固定局：鮎倉島（９５０２５２）

国土地理院

Schaperow, Jason

From: Schaperow, Jason
Sent: Wednesday, March 23, 2011 10:22 PM
To: Schaperow, Jason; Tinkler, Charles

http://www.nisa.meti.go.jp/english/files/en20110323-4.html

The link above has a decent timeline for each reactor and spent fuel pool.

4/237

Esmaili, Hossein

From: Lee, Richard
Sent: Wednesday, March 23, 2011 7:35 AM
To: Esmaili, Hossein; Salay, Michael
Subject: FW: RST Requested Evaluations to be Performed by RES

Fyi:

Mike: please get an answer on MCCI from Mitch Farmer (ANL)
I will get answers to (1) and (3)

Richard

From: RST01 Hoc
Sent: Wednesday, March 23, 2011 5:39 AM
To: Lee, Richard
Cc: Gibson, Kathy; RST01 Hoc
Subject: FW: RST Requested Evaluations to be Performed by RES

From: Hoc, RST16
Sent: Wednesday, March 23, 2011 5:37 AM
To: RST01 Hoc
Subject: RST Requested Evaluations to be Performed by RES

RST Coordinator,

Please forward the e-mail text below to Richard Lee and cc: Kathy Gibson from RES.

Thank you,

RST Communicator

****

Dear Mr. Lee,

The Reactor Safety Team (RST) in the Operations Center has been given your name as the lead Point of Contact (POC) for the Office of Research to manage all incoming requests from the RST.

As such, here is a request to investigate the topics related to queries 1, 3, and 4 from our Site Team located over in Japan. FYI, this request was entered into the WEB EOC Task Tracker software as Record # 2098 on 3/22/2011 @ 11:42 AM. Items 2 and 5 have been evaluated by our team and other sources and have been determined to be complete and require no further action.

Per Site Team e-mail, they would like RST to provide input on the following:

1. Sea water injection continues to reactors 1-3. NISA is concerned about the radiolytic disassociation of H2 and O2. NISA would like NRC's perspective on the significance of this concern and how to treat this concern as they transition to freshwater injection.
2. At what point does salt deposits become a problem for flow during pending freshwater injection?

w/238

3. NISA is conducting simulations to project the extent of damage to fuel in the reactors. Has NRC developed any views on the extent of fuel damage?
4. NISA is interested to obtain any reference material regarding core-concrete interaction (not because they think they have a current issue but against that eventuality) including the conditions under which that occurs and any associated data.
5. In addition to the H2/O2 disassociation in item 1 above, they are concerned that there may be residual H2 in the containments and welcome NRC's thoughts on how to treat such a condition.

The RST requests an progress update via e-mail, at least once daily in order for us to be able to track your progress for each of the three issues.

Thank you for your time and consideration.

Bill Roggenbrodt
RST Communicator
301-816-5504

Basu, Sudhamay

From: Michael Corradini [corradini@engr.wisc.edu]
Sent: Wednesday, March 23, 2011 9:26 PM
To: Basu, Sudhamay
Subject: Re: FW: German Document that Describes Accident Progression at Fukushima

thanks
--

Michael Corradini, Chair
Engineering Physics
University of Wisconsin
(608)263-1648 [Fax: 3-7451]
corradini@engr.wisc.edu
http://www.engr.wisc.edu/ep

Quoting "Basu, Sudhamay" <Sudhamay.Basu@nrc.gov>:

>
>
> Sudhamay Basu
> Senior Nuclear Engineer
> 1 301 415 6774
> sudhamay.basu@nrc.gov<mailto:sudhamay.basu@nrc.gov>
>
> From: Lee, Richard
> Sent: Wednesday, March 23, 2011 3:30 PM
> To: Basu, Sudhamay
> Subject: FW: German Document that Describes Accident Progression at
> Fukushima
>
> fyi
>
> From: Algama, Don
> Sent: Tuesday, March 22, 2011 6:23 PM
> To: Lee, Richard; Aissa, Mourad
> Subject: German Document that Describes Accident Progression at
> Fukushima
>
> Richard and Mourad:
>
> Drew just sent me a copy of the German document of their anticipated
> events that describe the accident progression at Fukushima. Please
> find it attached.
>
> -Don
>

W239

Lee, Richard

From: Hoxie, Chris
Sent: Thursday, March 24, 2011 4:14 AM
To: Lee, Richard; Wagner, Katie
Cc: Gibson, Kathy
Subject: FW: BWR-3 and Mark I

First request from a CAMP member for information...
Richard, I will be by to discuss.

-----Original Message-----
From: Tomasz Kozlowski [mailto:tomasz@safety.sci.kth.se]
Sent: Wednesday, March 23, 2011 7:26 PM
To: Hoxie, Chris
Subject: BWR-3 and Mark I

Hi Chris,

I assume that you and NRC get this a lot these days, but I would like to ask if you have any BWR-3 and/or Mark I documentation that is publicly available that you could send me?

Is there MELCOR input for BWR-3 that could be made available, also?

We would like to do some simulations of Fukushima.

Thank you!

Tomasz

Rivera-Lugo, Richard

From: Waterman, Michael
Sent: Wednesday, March 23, 2011 3:57 PM
To: Rivera-Lugo, Richard
Subject: FW: Status of Japan's Nuclear Power Plants - possible FOIA communication with thread included

Categories: Green Category

From: Waterman, Michael
Sent: Friday, March 18, 2011 1:25 PM
To: Betancourt, Luis; RES_DE_DICB
Subject: RE: Status of Japan's Nuclear Power Plants

Luis

Here is some radionuclide information that might give you a feel for some of the radionuclides that are being released.

Radionuclide	U-235 Fission Yield (%)	Half-Life (years)	β^- Decay Yield (MeV)	γ Decay Yield (MeV)
^{60}Co	17.7	5.272	0.318	1.3325, 1.1732, . . .
^{85}Kr	1.33	10.730	0.687	0.514
^{90}Sr	5.9	29.000	0.546, 2.29, . . .	1.761
^{106}Ru	0.39	1.01	0.0394, 3.54, . . .	0.5118, 0.622, 0.328
^{134}Cs	7.19	2.060	0.658, 0.089	0.6047, 0.7358, 0.2427, 1.365
^{137}Cs	6.23	30.100	0.512, 1.173	0.6616
^{144}Ce	5.45	0.78	0.316, 0.182	0.0336, 0.1335, 0.6964
^{147}Pm	2.26	2.6234	0.225, . . .	0.1212, . . .

These are some of the nastier radionuclides because their half-lives coupled with their fission yields means they are highly radioactive and there is a lot of each one available for release. In other words, these radionuclides decay fast enough to produce a lot of gamma radiation while they are around, but do not decay fast enough to decay away in a short time. In five half lives, an element will decay to about 0.7% of its original mass. Assuming the fuel rods in the spent fuel pools are the primary source of leakage, the radionuclides that are likely to be producing energy in abundance are ^{60}Co, ^{85}Kr, ^{90}Sr, and ^{137}Cs because the spent fuel rods are likely less than 10 years old. At that age, the mass of these radionuclides are at least half their original mass or more.

The other nuclides in the list are there because of their fission yield values and their half lives. For example, while the ^{134}Cs will decay to half its original mass in 2 years, there is so much of it that the remaining mass is still significant.

I hope this helps

W240

Mike

From: Betancourt, Luis
Sent: Thursday, March 17, 2011 3:28 PM
To: RES_DE_DICB; NRO_DE_ICE1 Distribution; NRO_DE_ICE2 Distribution; NRR_DE_EICB Distribution
Subject: Status of Japan's Nuclear Power Plants

Folks,

The attachment gives an informative, up-to-date summary of the status of the ten Fukushima Boiling Water Reactors. It is provided by the Japan Atomic Industrial Forum (JAIF) and I believe it is updated from time to time at http://www.jaif.or.jp/english/. The attachment also provides the latest radiation readings at the site boundary. What is lacking is information on what radionuclides are causing that dose rate.

Enjoy!

Luis D. Betancourt, EIT

Digital I&C Engineer
U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Digital Instrumentation and Control Branch
21 Church Street, Rockville MD, 20850, USA
C-2A07M
301-251-7409
301-251-7422
Luis.Betancourt@nrc.gov

"We are what we believe we are" - C.S. Lewis
Please consider the environment before printing this e-mail

Schaperow, Jason

From: Schaperow, Jason
Sent: Wednesday, March 23, 2011 9:22 AM
To: Chang, Richard
Cc: 'M.T. Leonard'; ymcclel@sandia.gov; rogaunt@sandia.gov; Tinkler, Charles; Santiago, Patricia; 'kcw@dycoda.com'
Subject: RE: Request for SFP Calculations

Importance: High

Hi Richard,

I request you send an email to SNL with KC on cc authorizing KC to do SFP analysis in support of the NRC's response to the Fukushima accident.

Thanks,
Jason

From: Casey Wagner [mailto:kcw@dycoda.com]
Sent: Tuesday, March 22, 2011 4:32 PM
To: Schaperow, Jason; Tinkler, Charles
Cc: 'M.T. Leonard'; ymcclel@sandia.gov; rogaunt@sandia.gov
Subject: Request for SFP Calculations
Importance: High

Hi Jason,

My direction from SNL, who pays my "Fukushima bills (including last week), said the following.

"Richard and Patricia want all Fukushima work to go through Richard or Tina to request work."

I am instructed not to perform any work without these authorizations. Could you have Tina or Richard send along authorization to SNL with me on cc:? I am very sorry for this inconvenience.

Thank-you,
KC

W241

From: Csontos, Aladar
To: Case, Michael
Subject: Re: Nominees for 3rd Team to Japan
Date: Thursday, March 24, 2011 2:54:51 PM

Nope from CIB.

From: Case, Michael
To: Hogan, Rosemary; Boyce, Tom (RES); Csontos, Aladar; Koshy, Thomas; Sydnor, Russell; Gavrilas, Mirela
Cc: Richards, Stuart; Rivera-Lugo, Richard
Sent: Thu Mar 24 13:57:36 2011
Subject: FW: Nominees for 3rd Team to Japan

Hey folks. Can you take a look at the attached to see if we have any nominees for the 3rd team to Japan? They are looking for severe accident, SAMG, B.5.b, and accident recovery skills that are not traditional DE skills but we may have folks out there with hidden talents.

Let me know names as soon as you can but before Monday 0900.

For your info, they are putting together the task force doing the 90 day evaluation of the Japan event. So far, Marty Virgilio is the head and is joined on the team by Gary Holahan, Charlie Miller, Jack Grobe, Bruce Mallet, an OGC rep, an admin rep and Nathan Sanfilippo from the EDO's staff.

From: Case, Michael
Sent: Thursday, March 24, 2011 1:47 PM
To: Coyne, Kevin; Correia, Richard; Gibson, Kathy; Richards, Stuart; Case, Michael
Cc: Rini, Brett; Sheron, Brian; Uhle, Jennifer
Subject: Nominees for 3rd Team to Japan

The Agency is trying to put together another team to go to Japan leaving on or about April 2nd and returning April 16th. They are seeking individuals willing to go with skills in the following areas:

Severe Accident Management Knowledge
B.5.b Knowledge
Accident Recovery Knowledge
Political Savvy

Additional background info is on the attached sheet. **Please forward your nominees to Brian/Jennifer/Brett by 0800 Monday** (due at noon to Michele Evans). DSA currently has one nominee that will be forwarded shortly. Background info on nominated candidates should include the person's skills in relation to those identified areas above, any OD endorsement, and passport status.

March 24, 2011

Background Information for Third Team to Japan

Overall:

We are planning to replace the current site team with a six person team that would include four members with a collective, good understanding of severe accident management, B5b and accident recovery, and two members with the management and political savvy to deal with the ambassador and Japanese regulators, military and cabinet. (One of these will be an Executive SES level to replace Dan Dorman)

Next phase would be to replace that 6 person team with a two person team. (Composition TBD)

Specific Request of OD/RAs:

1. Identify staff with all or some of following skill sets who are willing to travel to Japan on or about April 2. The staff would return on about April 16.

    a. Severe Accident management knowledge
    b. B5b knowledge
    c. Accident Recovery knowledge
    d. Political Savvy

    Please provide nominees to Michele Evans **by noon on Monday, March 28**. Brief summary of staff's background as it applies to the above skill sets and any endorsement by OD/RA will be greatly appreciated.

2. Not immediately needed would be nominees for the 4th team of two who may depart USA on or before April 13. Composition is TBD.

Please Note: Identification of the Next Executive to send to replace Dan Dorman, is being made by DEDOs, and is not part of this request.

59

Huffert, Anthony

From: Huffert, Anthony
Sent: Thursday, April 21, 2011 1:04 AM
To: Holahan, Vincent
Cc: Reynolds, Steven; Gepford, Heather; Meighan, Sean
Subject: RE: Lead Federal Agency

Vince,

The NRC is the lead Federal coordinating agency.

On another topic, NRC staff from the US embassy in Tokyo are scheduled to visit the Yokota base on Friday, March 22. Below is the agenda:

1000 - Depart AMEMB via USFJ supplied vehicle
1100-1130 - Arrive Yokota AFB -
1130 - 1300 Lunch on base at the exchange
1300 - 1700 Meeting with Dr Michaud/Dr Harvis and DTRA
1700 Depart Yokota
1800-1830 Arrive back at AMEMB

It's my understanding that Dr Michaud and Dr Harvis are points of contact for our visit.

Please contact Dr. Heather Gepford (heather.gepford@nrc.gov / 240-460-7715) for additional information regarding this trip.

Best,

Tony

From: Holahan, Vincent
Sent: Wednesday, April 20, 2011 8:03 PM
To: Huffert, Anthony
Subject: Lead Federal Agency

Hi Tony,

Quick question for you. Can you tell me who the lead US Federal agency is for technical issues associated with Fukushima NPP response? Is the NRC the lead federal agency or a supporting agency? If not the lead Federal agency, who is?

Responding to a question here at PACOM.

If you or the team need anything from Honolulu, please let me know.

cheers,
Vince

4/243

Lee, Richard

From: Dozier, Jerry
Sent: Tuesday, April 26, 2011 11:30 AM
To: Lee, Richard
Subject: RE: Critical Needs: Need Accident Analyst for Tuesday 4/26 midnights ...reply to this e-mail if you can serve (Please volunteer today...it will be very hard to fill this tomorrow)

Thanks, we got a volunteer for midnights....there are more time slots that we could use him....see the S: drive.

From: Lee, Richard
Sent: Monday, April 25, 2011 4:46 PM
To: Dozier, Jerry
Cc: Sun, Casper
Subject: RE: Critical Needs: Need Accident Analyst for Tuesday 4/26 midnights ...reply to this e-mail if you can serve (Please volunteer today...it will be very hard to fill this tomorrow)

Please call Casper Sun. He is available.

From: Dozier, Jerry
Sent: Monday, April 25, 2011 3:41 PM
To: Aissa, Mourad; Algama, Don; Alter, Peter; Armstrong, Kenneth; Bajorek, Stephen; Beasley, Benjamin; Blumberg, Mark; Caruso, Mark; Cheok, Michael; Coe, Doug; Coyne, Kevin; Dorn, Jaclyn; Dozier, Jerry; Drozd, Andrzej; Dube, Donald; Elkins, Scott; Esmaili, Hossein; Fuller, Edward; Gavrilas, Mirela; Ghosh, Tina; Gilmer, James; Harrison, Donnie; Hart, Michelle; Hasselberg, Rick; Helton, Donald; Howe, Andrew; Hudson, Nathanael; Ibarra, Jose; Kauffman, John; Kelly, Joseph; Koshy, Thomas; Krepel, Scott; Lane, John; Lee, Richard; Lee, Samson; Lien, Peter; Malliakos, Asimios; Marshall, Shawn; Mitman, Jeffrey; Mrowca, Lynn; Notafrancesco, Allen; Phan, Hanh; Rini, Brett; Rodriguez, Veronica; Rubin, MichaelB; Rubin, Stuart; Salay, Michael; Schaperow, Jason; Skarda, Raymond; Staudenmeier, Joseph; Thomas, Eric; Thurston, Carl; Tinkler, Charles; Velazquez-Lozada, Alexander; Wong, See-Meng; Yarsky, Peter; Zoulis, Antonios
Cc: Hasselberg, Rick
Subject: Critical Needs: Need Accident Analyst for Tuesday 4/26 midnights ...reply to this e-mail if you can serve (Please volunteer today...it will be very hard to fill this tomorrow)
Importance: High

We also need other shifts as shown on the S: drive but 4/26 midnight is the most critical.

Jerry Dozier
Sr. Risk and Reliability Analyst
Division of Risk Assessment
Room 010D10 MS 010C15
(301) 415-3925
Jerry.Dozier@nrc.gov

4/24/11

From: Case, Michael
To: N.Tricot@iaea.org
Subject: RE: IAEA Safety Guide on "Design of Auxiliary and Supporting Systems in Nuclear Power Plants"
Date: Thursday, March 24, 2011 6:56:00 AM

Good morning Nicolas. I'll follow up on this today. When I get these types of requests, I need to get them into our formal process through our Office of International Programs. It is often difficult to get them started (and it also has been complicated by events in Japan). As I get better acquainted with how we process these requests, I hope to do a better job for you. Thanks for your patience!

Best regards,

Mike Case

From: N.Tricot@iaea.org [mailto:N.Tricot@iaea.org]
Sent: Thursday, March 24, 2011 6:51 AM
To: Case, Michael
Subject: RE: IAEA Safety Guide on "Design of Auxiliary and Supporting Systems in Nuclear Power Plants"

Dear Dr Case

This is a reminder as we are getting closer to the Consultancy Meeting. Should you be able to assign one expert, for IAEA logistic aspects, I would appreciate it if you could let me know his name as soon as possible. The meeting will be held from 4 to 8 April 2011.

I would like to thank you again for your kind support.

With my best regards,

Nicolas

Nicolas TRICOT
Safety Assessment Section
Division of Nuclear Installation Safety
Wagramer Strasse 5, Room B0649
A-1400 Vienna, Austria
Tel: 0043 1 2600 25992

From: Michael.Case@nrc.gov [mailto:Michael.Case@nrc.gov]
Sent: Monday,07 March 2011 14:06
To: TRICOT, Nicolas
Subject: RE: IAEA Safety Guide on "Design of Auxiliary and Supporting Systems in Nuclear Power Plants"

Good morning Dr. Tricot. I just wanted to let you know that we're working on this. I'll update you when I hear back from the offices with the appropriate experts.

Best regards,

Mike Case

From: N.Tricot@iaea.org [mailto:N.Tricot@iaea.org]
Sent: Tuesday, March 01, 2011 8:39 AM
To: Case, Michael
Subject: IAEA Safety Guide on "Design of Auxiliary and Supporting Systems in Nuclear Power Plants"

Dear Dr Case

As you probably know already, I am working on developing a new IAEA Safety Guide on **"Design of Auxiliary and Supporting Systems in Nuclear Power Plants".** The development of this IAEA Safety Guide has been approved by the IAEA Commission of Safety Standards last November 2010 and the related Document Preparation Profile (DPP) that includes the roadmap for development is also attached herewith.

However, the following should be considered:

a) the choice to include cross references to existing recommendation to avoid duplication of recommendations;

b) a step on performing the inventory of current recommendations in various existing safety guides prior to the commencement of the drafting of the guide in the guide development process. NUSSC requested the Secretariat to present this inventory (b) item) at its meeting in June 2011.

To fulfil these requests, in priority item b/, and to launch the drafting of the safety guide, I would appreciate it if you could assign a Japanese representative (either from the USNRC side or from the Industry side) who would be able to participate in an IAEA Consultancy Meeting, on a cost free basis to the IAEA, that is tentatively scheduled from 4 to 8 April 2011 or 11 to 15 April (these dates are still flexible). Please let me know.

I would like to thank you in advance for your support.

With my kind regards,

Nicolas TRICOT

Safety Assessment Section

Division of Nuclear Installation Safety

Wagramer Strasse 5, Room B0649

A-1400 Vienna, Austria

Tel: 0043 1 2600 25992

<<dpp440.pdf>>

From: Case, Michael
To: Elkins, Scott
Subject: RE: 77" foot tsunami peak article
Date: Thursday, March 24, 2011 2:35:00 PM

Thanks. That's pretty amazing!

From: Elkins, Scott
Sent: Thursday, March 24, 2011 2:15 PM
To: Case, Michael
Subject: 77' foot tsunami peak article

Mike, based on the discussion at the standup meeting this morning I thought you might find this interesting:

http://www.npr.org/blogs/thetwo-way/2011/03/23/134793643/tsunami-was-more-than-77-feet-high-at-its-peak?ft=1&f=1001&sc=tw&utm_source=twitterfeed&utm_medium=twitter

4/24/6

From: Case, Michael
To: Williams, Shawn; Brach, Bill; Camper, Larry; Lewis, Robert
Subject: RE: Your thoughts ...
Date: Thursday, March 24, 2011 5:01:00 PM

It's a reasonable question given the times.

From: Williams, Shawn
Sent: Thursday, March 24, 2011 4:27 PM
To: Brach, Bill; Camper, Larry; Lewis, Robert; Case, Michael
Subject: Your thoughts ...

I was about to send the below e-mail to my normal CSS distribution but I wanted to get your thoughts first...

I am wondering if you think I should assign an office to create a "Position Sheet" for Agenda Item 2, "Possible future implication on IAEA Safety Standards of the recent events in Japan" or if you agree with me, that it is too early and out of process.

All,

We just received the official 29th CSS Provisional Agenda (attached).

There are two additional Agenda Items from the draft version I previously provided.

Agenda Item 2: Possible future implication on IAEA Safety Standards of the recent events in Japan

2.1 Presentations from the Japanese CSS member

2.2 IAEA Response

2.3 Future activities

Agenda Item 3: Feedback from the CNS review meeting (Position Sheet assigned to NRR)

I revised the Green Ticket to match the new Agenda and I am ready to issue the Green Ticket except, I have one question for the SSCs.

(1) Concerning Agenda Item 2, the normal process is for the SSC's to first evaluate the issue (during their SSC meetings), and then bring forth their recommendations to the CSS. I am guessing an Action from the 29th CSS will be for this to happen. Given that, and given that it seems that the Agenda Item is mostly information on IAEA 's Japan response and future activities, and given that we really know little about the accident at this time, and given that we have a Task Force that will be evaluating the issues, I tend to think it is too early to assign an Office the lead to create a "Position Sheet." As background for this Agenda Item, I would include any proposals from the Task Force.

W247

Do you think I should assign an office to create a "Position Sheet" for Agenda Item 2? If so, what office do you think should have the lead? Or is it too early as I propose.

From: D.Delattre@iaea.org [mailto:D.Delattre@iaea.org]
Sent: Thursday, March 24, 2011 11:38 AM
To: agonzale@sede.arn.gov.ar; abel_j_gonzalez@yahoo.com; carl-magnus.larsson@arpansa.gov.au; Jean-Paul.Samain@wr-cs.be; lavinhas@cnen.gov.br; ramzi.jammal@cnsc-ccsn.gc.ca; Liu.hua@bbn.cn; mbarakat49@yahoo.com; Jukka.Laaksonen@stuk.fi; andre-claude.lacoste@asn.fr; Dieter.majer@bmu.bund.de; ssbajaj@aerb.gov.in; ilevanon@iaec.gov.il; nakamura-koichiro1@meti.go.jp; chyun@kins.re.kr; shakil@pnra.org; m.shakil@mobilink.blackberry.com; vbezz@gan.ru; gclapiss@nnr.co.za; agurgui@csn.es; Leif.Moberg@ssm.se; mykolaichuk@hq.snrc.gov.ua; mike.weightman@hse.gsi.gov.uk; Virgilio, Martin; lcdung@most.gov.vn; peter.faross@ec.europa.eu; claire.cousins@addenbrookes.nhs.uk; rmeserve@ciw.edu; uichiro.yoshimura@oecd.org; raja.dg@aelb.gov.my
Cc: TPather@nnr.co.za; thiagan@netactive.co.za; Geoff.Williams@arpansa.gov.au; smm@gr.is; gmassera@arn.gob.ar; Geoffrey.Vaughan@hse.gsi.gov.uk; geoff_vaughan1@btopenworld.com; Fabien.FERON@asn.fr; Brach, Bill; RSwanepoel@nnr.co.za; ss.icrp@rogers.com; sci.sec@icrp.org; jean-luc.lachaume@asn.fr; Gail.Scowcroft@hse.gsi.gov.uk; marie-laure.peyrat@oecd.org; diana.heick@grs.de; dcc@csn.es; peng.jun@sepa.gov.cn; yujun@sepa.gov.cn; Williams, Shawn; Isabelle.FOREST@asn.fr; AstwoodHM@state.gov; Arnaud.ATGER@diplomatie.gouv.fr; a.atger@yahoo.fr; audree.paquette@ssi.se; Len.Creswell@hse.gsi.gov.uk; I.Sokolova@gosnadzor.ru; hschang@kins.re.kr; Lasse.Reiman@stuk.fi; fujiensc@163.com; m.demcenko@vatesi.lt; paulikas@vatesi.lt; D.Flory@iaea.org; a.nilsson@iaea.org; P.Hahn@iaea.org; J.Lyons@iaea.org; K.Mrabit@iaea.org; P.Woodhouse@iaea.org; H.Abouyehia@iaea.org; A.Al-Khatibeh@iaea.org; E.Buglova@iaea.org; G.Caruso@iaea.org; R.CZARWINSKI@iaea.org; p.colgan@iaea.org; m.gregoric@iaea.org; M.Lipar@iaea.org; M.Modro@iaea.org; S.Samaddar@iaea.org; M.Vesterlind@iaea.org; G.Andrew@iaea.org; N.Castek@iaea.org; A.Boussaha@iaea.org; J.A.Casas-Zamora@iaea.org; P.Vincze@iaea.org; A.Meghzifene@iaea.org; S.Fesenko@iaea.org; T.Colgan@iaea.org; G.Siraky@iaea.org; jim.stewart@iaea.org; M.Svab@iaea.org; g.moore@iaea.org; K.K.Varley@iaea.org; D.Delves@iaea.org; K.E.Asfaw@iaea.org; B.Jeannin@iaea.org; E.Luraschi@iaea.org; F.Klimscha@iaea.org; M.Ch.Schirfeneder@iaea.org; W.Tonhauser@iaea.org; olivier.gupta@asn.fr; M.Gasparini@iaea.org; D.Winfield@iaea.org; G.Bruno@iaea.org; C.Wong@unido.org; Y.Zhao@iaea.org; Y.Inoue@iaea.org
Subject: IAEA - Commission on Safety Standards - meeting from 25 to 27 May 2011 - message #1

Dear CSS members.

The next CSS meeting is planned from 25 to 27 May 2011 and I am pleased to inform you that the invitation letters are being prepared. For your convenience, I attach here an electronic version of the provisional agenda.

<<CSSagn29 rev3.doc>>

I have started to post last week on the CSS web site, i.e. more than two and a half months in advance to the meeting, the material for submission to you. You may find these at the following address: http://www-ns.iaea.org/committees/css/ in the folder "*CSS documents for comment*". Other material for information is available in the folder "*Documents provided by the Secretariat for information*".

The only draft that still need to be posted is the draft safety requirement DS414 on Safety of Nuclear Power Plants: Design. It is currently under review by the NUSSC Chair in order to verify that changes proposed by the Technical Editors and agreed to by the Technical Officer don't affect the substance of the draft after its approval by the Committees. I intend to post the final draft at the latest on 29 March so as to comply with the eight weeks deadline.

Among the drafts, you will also find the draft safety requirement DS379 on Radiation Protection and Safety of Radiation Sources, the revised International BSS. You will note that on part will need to be updated taking into account the result of the ICRP deliberation on the exposure to the eye lenses. It is expected to receive the result in April 2011 and this will be mentioned to you as soon as we receive it.

You therefore have most of the material available for your review around nine weeks in advance to the meeting. I would appreciate it very much if, as agreed to be the standard practice, you also post your comments on the documents submitted for approval two weeks in advance to the meeting, i.e. by 6 May 2011. This will also allow you to see in advance the comments from other members and the responsible Technical Officers to take them into account and provide you, at the meeting, with their proposed answer for your consideration.

Please read the general information available on this CSS web page, as well as the instructions on how to use it, in particular on how to register, login and post comments on the documents submitted to you. I attach here again these instructions.

<<GuidanceontheuseoftheCSSmembersarea.doc>>

For your presentations on 8.1 (Topical discussion on the Use of Safety Standards) and 8.2 (Regulatory Issues), I would also appreciate it very much if you could send to me in advance to the meeting (also two weeks) your input for these two items, with a preference for separate papers for each of these items. I will upload them on the web site as soon as I receive them. In particular for the agenda item 8.1, I would appreciate if you could indicate recent use of IAEA safety standards for preparing regulatory documents or performing other regulatory activities.

For Mr Laaksonen, Vinhas and Virgilio who are CSS representatives at the Joint AdSec CSS task force, I confirm that the meeting of the task force will be held on 24 May 2011, starting at 8:30.

Finally, please don't hesitate to contact my Secretary Frances Klimscha for any assistance needed for the meeting arrangements. Her email address is f.klimscha@iaea.org. Her telephone is +43 1 26 00 22286. In this regard, I'd like to request that you confirm soon to her your participation at the next CSS meeting as well as the name of any assistant at the meeting (one assistant normally according to the Terms of Reference).

Best regards.

Dominique Delattre

Scientific Secretary of the CSS

Head, Safety Standards and Application Unit

From: Case, Michael
To: Murphy, Andrew
Cc: Richards, Stuart; Hogan, Rosemary
Subject: FW: Question
Date: Thursday, March 24, 2011 10:17:00 AM

FYI. This type of confusion and questioning relates to your Brian/Jennifer presentation.

From: Sheron, Brian
Sent: Thursday, March 24, 2011 8:28 AM
To: Kammerer, Annie
Cc: Case, Michael; Richards, Stuart; Hogan, Rosemary; Uhle, Jennifer
Subject: Question

I am seeing a spectrum of tsunami wave heights that reportedly hit the Fukushima plant. I saw in one of your briefing packages that was a USGS calculation that showed the peak wave height at about 30 feet. I saw some slides from TEPCO yesterday that said the tsunami wave height at the plant was "more than 10 meters". In today's "Nucleonics Week" on page 11 it says "Tepco discovered by checking the walls of Fukushima 1 ....and the nearby Fukushima 2 .....March 21 that the tsunamis had reached higher than 14 meters (about 46 feet) above sea level...." It then said the design basis for Fukushima 1 &2 was 5.7 and 5.2 meters respectively.

Without any accurate measurements, are we limited to educated guesses and expert judgment?

I think one question we will be asked is how well can we predict a tsunami wave height? I seem to recall you said the USGS calculations (wave height versus time at various locations) were probably pretty good because they had a well validated model. However, it would now appear they significantly under-predicted the wave height.

Am I missing something?

Helton, Donald

From: Helton, Donald
Sent: Friday, April 29, 2011 8:35 AM
To: Wong, See-Meng
Subject: FW: New RST Tasker: 5068 - perform risk assessment for SFPs and provide insights

FYI – I will be down at HQ for a Commissioner briefing from roughly 9:30 – 11:30 today...so if we need to talk this morning, it either needs to be before or after that... (I do not have a Blackberry, so I won't see any emails sent during that time...)

Best,
Don

From: Marksberry, Don
Sent: Friday, April 29, 2011 8:26 AM
To: Helton, Donald; Coyne, Kevin
Subject: FW: New RST Tasker: 5068 - perform risk assessment for SFPs and provide insights

See-Meng will call you this morning

From: Wong, See-Meng
Sent: Friday, April 29, 2011 8:23 AM
To: Marksberry, Don
Subject: FW: New RST Tasker: 5068 - perform risk assessment for SFPs and provide insights

FYI.

From: RST01 Hoc
Sent: Friday, April 29, 2011 12:20 AM
To: Wong, See-Meng
Subject: FYI: New RST Tasker: 5068 - perform risk assessment for SFPs and provide insights

---

From: RST02 Hoc
Sent: Thursday, April 28, 2011 2:44 PM
To: Hiland, Patrick; Holian, Brian; Cheok, Michael; Skeen, David; RST01 Hoc
Subject: New RST Tasker: 5068 - perform risk assessment for SFPs and provide insights

RST Tasker Record: 5068

Tasker Description: NRR to perform simplified risk assessment of affected spent fuel pools (similar to Draft Risk Assessment of the affected reactors performed by Jeff Mittman of the Japan Team) and provide key insights from that assessment

Due: 05/02/2011 13:24:43

4/249

Sturzebecher, Karl

From: Sydnor, Russell
Sent: Thursday, March 24, 2011 2:03 PM
To: Betancourt, Luis; Birla, Sushil; Burton, Thomas; Concepcion, Milton; Dion, Jeanne; Halverson, Derek; Hardin, Leroy; Rebstock, Paul; Sturzebecher, Karl; Waterman, Michael; Yang, Yaguang
Subject: FW: Nominees for 3rd Team to Japan
Attachments: Background 3rd team to Japan .docx

If any of you have skill sets listed in the attached and would be available for a temporary duty, let me know ASAP>

Russell Sydnor
Branch Chief
NRC/RES/DE/DICB
301-251-7405
Russell.Sydnor@nrc.gov

From: Case, Michael
Sent: Thursday, March 24, 2011 1:58 PM
To: Hogan, Rosemary; Boyce, Tom (RES); Csontos, Aladar; Koshy, Thomas; Sydnor, Russell; Gavrilas, Mirela
Cc: Richards, Stuart; Rivera-Lugo, Richard
Subject: FW: Nominees for 3rd Team to Japan

Hey folks. Can you take a look at the attached to see if we have any nominees for the 3rd team to Japan? They are looking for severe accident, SAMG, B.5.b, and accident recovery skills that are not traditional DE skills but we may have folks out there with hidden talents.

Let me know names as soon as you can but before Monday 0900.

For your info, they are putting together the task force doing the 90 day evaluation of the Japan event. So far, Marty Virgilio is the head and is joined on the team by Gary Holahan, Charlie Miller, Jack Grobe, Bruce Mallet, an OGC rep, an admin rep and Nathan Sanfilippo from the EDO's staff.

From: Case, Michael
Sent: Thursday, March 24, 2011 1:47 PM
To: Coyne, Kevin; Correia, Richard; Gibson, Kathy; Richards, Stuart; Case, Michael
Cc: Rini, Brett; Sheron, Brian; Uhle, Jennifer
Subject: Nominees for 3rd Team to Japan

The Agency is trying to put together another team to go to Japan leaving on or about April 2nd and returning April 16th. They are seeking individuals willing to go with skills in the following areas:

Severe Accident Management Knowledge
B.5.b Knowledge
Accident Recovery Knowledge
Political Savvy

Additional background info is on the attached sheet. **Please forward your nominees to Brian/Jennifer/Brett by 0800 Monday** (due at noon to Michele Evans). DSA currently has one nominee that will be forwarded shortly. Background info on nominated candidates should include the person's skills in relation to those identified areas above, any OD endorsement, and passport status.

4/25

March 24, 2011

Background Information for Third Team to Japan

Overall:

We are planning to replace the current site team with a six person team that would include four members with a collective, good understanding of severe accident management, B5b and accident recovery, and two members with the management and political savvy to deal with the ambassador and Japanese regulators, military and cabinet. (One of these will be an Executive SES level to replace Dan Dorman)

Next phase would be to replace that 6 person team with a two person team. (Composition TBD)

Specific Request of OD/RAs:

1. Identify staff with all or some of following skill sets who are willing to travel to Japan on or about April 2. The staff would return on about April 16.

    a. Severe Accident management knowledge
    b. B5b knowledge
    c. Accident Recovery knowledge
    d. Political Savvy

    Please provide nominees to Michele Evans **by noon on Monday, March 28**. Brief summary of staff's background as it applies to the above skill sets and any endorsement by OD/RA will be greatly appreciated.

2. Not immediately needed would be nominees for the 4th team of two who may depart USA on or before April 13. Composition is TBD.

Please Note: Identification of the Next Executive to send to replace Dan Dorman, is being made by DEDOs, and is not part of this request.

Schaperow, Jason

Subject:	Support for Fukushima accident
Location:	Charlie's office
Start:	Thu 3/24/2011 10:00 AM
End:	Thu 3/24/2011 11:00 AM
Show Time As:	Tentative
Recurrence:	(none)
Meeting Status:	Not yet responded
Organizer:	Schaperow, Jason
Required Attendees:	Esmaili, Hossein; Salay, Michael; Marksberry, Don; Helton, Donald; Tinkler, Charles

Request you come to Charlie's office at 10:00 a.m. to meet.

W251

Schaperow, Jason

From: Schaperow, Jason
Sent: Thursday, March 24, 2011 12:00 PM
To: Gonzalez, Sergio
Subject: RE: Please stop by or call me!

I should be around tomorrow. I will probably be tied up much of the morning.

From: Gonzalez, Sergio
Sent: Thursday, March 24, 2011 11:55 AM
To: Schaperow, Jason
Subject: RE: Please stop by or call me!

Let's meet tomorrow if it is possible for you.

I have to leave in 7 minutes.

Thanks,

Sergio

From: Schaperow, Jason
Sent: Thursday, March 24, 2011 11:53 AM
To: Gonzalez, Sergio
Subject: RE: Please stop by or call me!

I am here. I am kind of busy responding to the accident in Japan. You can stop by when you get a chance.

From: Gonzalez, Sergio
Sent: Thursday, March 24, 2011 10:11 AM
To: Schaperow, Jason
Subject: Please stop by or call me!

Please stop by or call me!

Sergio E. Gonzalez

Program Manager (NSPDP), Special Projects Branch
Division of Systems Analysis
Office of Nuclear Regulatory Research
Phone- 301-251-7453
Sergio.Gonzalez@nrc.gov

W252

Schaperow, Jason

From: Schaperow, Jason
Sent: Thursday, March 24, 2011 12:39 PM
To: Helton, Donald
Subject: RE: Support for Fukushima accident

O.K. Thanks.

-----Original Appointment-----
From: Helton, Donald
Sent: Thursday, March 24, 2011 12:35 PM
To: Schaperow, Jason
Subject: Declined: Support for Fukushima accident
When: Friday, March 25, 2011 10:00 AM-11:00 AM (GMT-05:00) Eastern Time (US & Canada).
Where: Charlie's office

Jason - I need to be asleep during that time...I'll try to give Charlie or Don M. a call after I get off shift around 8 AM to let them know the latest...

4/253

Schaperow, Jason

From: Schaperow, Jason
Sent: Thursday, March 24, 2011 1:01 PM
To: Helton, Donald
Cc: Tinkler, Charles
Subject: RE: Support for Fukushima accident

Importance: High

We met this morning, and we are confused about the reactor vessel water level. (Water level is measured in the downcomer.) Michael Salay gave us an RST assessment from last night's shift. From that assessment, it looks like the water level in the downcomer is below the top of the jet pump. Therefore, it is impossible to tell what the water level in the core region is. The water level in the core region may be very, very low. Can you find out anything about this while you are on shift?

Thanks,
Jason

-----Original Appointment-----
From: Helton, Donald
Sent: Thursday, March 24, 2011 12:35 PM
To: Schaperow, Jason
Subject: Declined: Support for Fukushima accident
When: Friday, March 25, 2011 10:00 AM-11:00 AM (GMT-05:00) Eastern Time (US & Canada).
Where: Charlie's office

Jason - I need to be asleep during that time...I'll try to give Charlie or Don M. a call after I get off shift around 8 AM to let them know the latest...

W252

Schaperow, Jason

From: Schaperow, Jason
Sent: Thursday, March 24, 2011 1:23 PM
To: Huffert, Anthony
Subject: source terms

Hi Tony,

Could you send me the source terms you provided to NARAC on your shift (Friday, March 18 at 11:00 p.m. until Saturday, March 19, at 7:00 a.m.)?

Thanks,
Jason

Kuritzky, Alan

From: Joe Colvin [president@ans.org]
Sent: Thursday, March 24, 2011 1:30 AM
To: Kuritzky, Alan
Subject: ANS Japan Relief Fund

Dear ANS Member,

In response to your feedback, ANS has established the Japan Relief Fund to help our friends, colleagues, and their families in Japan who have been affected by the earthquake and tsunami. The beneficiaries of this fund will be determined by the ANS and sister organizations in Japan. We'll work to be sure the fund benefits the nuclear power plant employees and their families.

Please visit the ANS Japan Relief Fund page today at http://www.new.ans.org/about/japanrelief/.

ANS has also made Japan Relief Fund icons available for download at the link above. I urge you to include these icons on your websites (with any necessary authorizations, of course) and link to the Japan Relief Fund page.

Respectfully,

Joe Colvin
ANS President

4/25a

Siu, Nathan

From: Siu, Nathan
Sent: Thursday, March 24, 2011 1:17 PM
To: Coyne, Kevin
Subject: Information mess

In case you get caught up in this...

- Got a call yesterday from a Thomas Albert who says he's from DHS and an old friend of Marty Stutzke's. Wants information on state of Fukushima seismic PRA (if any) and also a classified National Academy report on the safety and security of spent fuel pools. Didn't know if he was bona fide (although he did follow up with an email giving his DHS contact info). Told him I wasn't sure about agency-to-agency protocol and I'd check.
- Consulted with Doug, who told me to call the usual Op Ctr number (301-415-8200) and get guidance.
- OPA rep on line told me to pass inquiry on to Ron Deavers, which I did via email. Ron confirms via email that they'll take care of it.
- Today I get an email from Amy Bonaccorso saying that OPA is asking RES to handle this. OPA refers to a "long, somewhat garbled e-mail string" and expresses confusion as to what T. Albert wants. (I thought it was pretty clear in my message to Deavers.)

I've told Amy that DE is the keeper and she should contact Rosemary Hogan. We'll see what happens next.

Sounds like routing this Fukushima-related information request has led to one big circle leaving some NRC staff confused and probably not making us look very competent to outsiders.

Nathan

4/25?

Schaperow, Jason

From: Schaperow, Jason
Sent: Thursday, March 24, 2011 1:50 PM
To: Helton, Donald
Subject: RE: Support for Fukushima accident

Thanks!

From: Helton, Donald
Sent: Thursday, March 24, 2011 1:50 PM
To: Schaperow, Jason
Cc: Tinkler, Charles
Subject: RE: Support for Fukushima accident

I'll see what I can find out tonight...

From: Schaperow, Jason
Sent: Thursday, March 24, 2011 1:01 PM
To: Helton, Donald
Cc: Tinkler, Charles
Subject: RE: Support for Fukushima accident
Importance: High

We met this morning, and we are confused about the reactor vessel water level. (Water level is measured in the downcomer.) Michael Salay gave us an RST assessment from last night's shift. From that assessment, it looks like the water level in the downcomer is below the top of the jet pump. Therefore, it is impossible to tell what the water level in the core region is. The water level in the core region may be very, very low. Can you find out anything about this while you are on shift?

Thanks,
Jason

-----Original Appointment-----
From: Helton, Donald
Sent: Thursday, March 24, 2011 12:35 PM
To: Schaperow, Jason
Subject: Declined: Support for Fukushima accident
When: Friday, March 25, 2011 10:00 AM-11:00 AM (GMT-05:00) Eastern Time (US & Canada).
Where: Charlie's office

Jason - I need to be asleep during that time...I'll try to give Charlie or Don M. a call after I get off shift around 8 AM to let them know the latest...

4258

From: Helton, Donald
Sent: Thursday, March 24, 2011 5:13 PM
To: Tinkler, Charles; Schaperow, Jason
Subject: Unit 4 SFP

Charlie / Jason:

I'll have all of the questions in mind tonight while on shift, including the racking questions on Unit 4…in the meantime, I wanted to make sure you've seen what IAEA posted, which has slightly different numbers than I recall you talking about.

http://www.iaea.org/newscenter/news/tsunamiupdate01.html
(look for the table about halfway down the page)

Of note, it states a rack capacity (1,590) well below what we would expect. It suggests that only a portion of the pool is racked (if they do indeed use high density racking) but that doesn't dispositively answer that question. Also note the 204 unirradiated assemblies (obviously not a decay heat source, but would be an additional zirconium oxidation source, depending on propagation).

Don

4259

Lee, Richard

From: Gauntt, Randall O [rogaunt@sandia.gov]
Sent: Thursday, March 24, 2011 6:23 PM
To: Lee, Richard
Subject: do you have slides?

4260

Lee, Richard

From: Gauntt, Randall O [rogaunt@sandia.gov]
Sent: Thursday, March 24, 2011 6:26 PM
To: Lee, Richard
Subject: are you getting slides from doe?

4261

From: Kammerer, Annie
To: Richards, Stuart; RES_DE
Cc: Coe, Doug; Coyne, Kevin; Gibson, Kathy; Case, Michael; West, Stephanie; Karas, Rebecca
Subject: RE: Volunteers needed - Ops Center RST Schedule 3/26-4/2 (input needed by noon today)
Date: Friday, March 25, 2011 11:28:30 AM

Stu, please be aware that the seismology Q&A is not part of the typical process as it requires continuity in the ongoing work with OPA's efforts.

Becky Karas leads the coordination of staff on that topic.

Cheers,
Annie

From: Richards, Stuart
Sent: Friday, March 25, 2011 9:39 AM
To: RES_DE
Cc: Coe, Doug; Coyne, Kevin; Gibson, Kathy; Case, Michael; West, Stephanie
Subject: Volunteers needed - Ops Center RST Schedule 3/26-4/2 (input needed by noon today)
Importance: High

The Ops Center is seeking volunteers for the Reactor Safety Team.

The watchbill is in this e-mail below, with the slots needing to be filled indicated.

If you want to volunteer, please check with your BC and let Stephanie West know by noon today.

Thanks
Stu

From: RST01 Hoc
Sent: Wednesday, March 23, 2011 12:05 PM
To: Alter, Peter; Morlang, Gary; Hasselberg, Rick; Berry, Rollie; Collins, Frank; Thomas, Eric; Schoenebeck, Greg; McGovern, Denise; Rini, Brett; Bukharin, Oleg; Sloan, Scott; Circle, Jeff; Esmaili, Hossein; Ward, Leonard; Laur, Steven; Salay, Michael; Fuller, Edward; Schaperow, Jason; Marksberry, Don; Gilmer, James; Miranda, Samuel; Arndt, Steven; Helton, Donald; Norton, Charles; Kolb, Timothy; Brown, Eva; Shea, James; Vick, Lawrence; Brown, Michael; Williams, Donna; Roggenbrodt, William; Thorp, John; Kugler, Andrew; Williams, Joseph; Padovan, Mark; Isom, James; Hart, Ken; Bloom, Steven; Jervey, Richard
Subject: FW: RST Schedule 3/26-4/2

All,

Please look at current watchbills from the OST. Ed Fuller has signed up for swing shifts for Accident Analyst on 3/29 and 4/5. Other than that, please reply to RST01 so we can start filling in the holes on the watchbill.

Thanks for all of your support.

Eric Thomas
RST Coordinator

From: OST02 HOC
Sent: Wednesday, March 23, 2011 8:44 AM
To: RST01 Hoc
Subject: RST Schedule 3/26-4/2

Reactor Safety Team

4/262

RST Director			
Sat	26-Mar	7am - 3pm	Pat Hiland
Sat	26-Mar	3pm-11pm	Bill Ruland
Sat-Sun	3/26-3/27	11pm - 7am	Mike Case
Sun	27-Mar	7am - 3pm	Pat Hiland
Sun	27-Mar	3pm-11pm	Fred Brown
Sun-Mon	3/27-3/28	11pm - 7am	Mike Case
Mon	28-Mar	7am - 3pm	Pat Hiland
Mon	28-Mar	3pm-11pm	Fred Brown
Mon-Tue	3/28-3/29	11pm - 7am	Mike Case
Tue	29-Mar	7am - 3pm	Jennifer Uhle
Tue	29-Mar	3pm-11pm	Fred Brown
Tue-Wed	3/29-3/30	11pm - 7am	Mike Case
Wed	30-Mar	7am - 3pm	Jennifer Uhle
Wed	30-Mar	3pm-11pm	Fred Brown
Wed-Thur	3/30-3/31	11pm - 7am	Dave Skeen
Thur	31-Mar	7am - 3pm	Jennifer Uhle
Thur	31-Mar	3pm-11pm	Bill Ruland
Thur-Fri	3/31-4/1	11pm - 7am	Dave Skeen
Fri	1-Apr	7am - 3pm	Jennifer Uhle
Fri	1-Apr	3pm-11pm	Bill Ruland
Fri-Sat	4/1-4/2	11pm-7am	Dave Skeen
RST Coordinator			
Fri-Sat	3/25-3/26	11pm-7am	Frank Collins
Sat	26-Mar	7am - 3pm	Eric Thomas
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Peter Alter
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	Frank Collins
Mon	28-Mar	7am - 3pm	Rick Hasselberg
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	Mike Morlang
Tue	29-Mar	7am - 3pm	Peter Alter
Tue	29-Mar	3pm-11pm	Greg Schoenebeck
Tue-Wed	3/29-3/30	11pm - 7am	Mike Morlang
Wed	30-Mar	7am - 3pm	Rick Hasselberg
Wed	30-Mar	3pm-11pm	Greg Schoenebeck
Wed-Thur	3/30-3/31	11pm - 7am	Frank Collins
Thur	31-Mar	7am - 3pm	Peter Alter
Thur	31-Mar	3pm-11pm	Greg Schoenebeck
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	Rick Hasselberg
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	Frank Collins

Severe Accident/PRA			
Sat	26-Mar	7am - 3pm	Steven Arndt
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Jeff Circle
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	Hossein Esmaili
Tue	29-Mar	3pm-11pm	
Tue-Wed	3/29-3/30	11pm - 7am	
Wed	30-Mar	7am - 3pm	Jim Gilmer?
Wed	30-Mar	3pm-11pm	Hossein Esmaili
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	
Thur	31-Mar	3pm-11pm	Hossein Esmaili
Thur-Fri	3/31-4/1	11pm - 7am	Ray Skarda
Fri	1-Apr	7am - 3pm	
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	Ray Skarda
BWR Expertise			
Sat	26-Mar	7am - 3pm	Mike Brown
Sat	26-Mar	3pm-11pm	Chuck Norton
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Mike Brown
Sun	27-Mar	3pm-11pm	Chuck Norton
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Mike Brown
Mon	28-Mar	3pm-11pm	Chuck Norton
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	Mike Brown
Tue	29-Mar	3pm-11pm	Chuck Norton
Tue-Wed	3/29-3/30	11pm - 7am	
Wed	30-Mar	7am - 3pm	Mike Brown
Wed	30-Mar	3pm-11pm	Chuck Norton
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	Mike Brown
Thur	31-Mar	3pm-11pm	Chuck Norton
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	Mike Brown
Fri	1-Apr	3pm-11pm	Chuck Norton
Fri-Sat	4/1-4/2	11pm-7am	
RST Comm/ERDS Operator			

Sat	26-Mar	7am - 3pm	Donna Williams
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Mark Padovan
Sun	27-Mar	3pm-11pm	Bill Roggenbrodt
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Mark Padovan
Mon	28-Mar	3pm-11pm	Bill Roggenbrodt
Mon-Tue	3/28-3/29	11pm - 7am	Andy Kugler
Tue	29-Mar	7am - 3pm	Mark Padovan
Tue	29-Mar	3pm-11pm	Bill Roggenbrodt
Tue-Wed	3/29-3/30	11pm - 7am	Andy Kugler
Wed	30-Mar	7am - 3pm	Mark Padovan
Wed	30-Mar	3pm-11pm	Bill Roggenbrodt
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	Andy Kugler
Thur	31-Mar	3pm-11pm	Bill Roggenbrodt
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	Mark Padovan
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	
RST Support (Seismology Q&A)			
Sat	26-Mar	7am - 3pm	
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	
Tue	29-Mar	3pm-11pm	
Tue-Wed	3/29-3/30	11pm - 7am	
Wed	30-Mar	7am - 3pm	
Wed	30-Mar	3pm-11pm	
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	
Thur	31-Mar	3pm-11pm	
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	
RST Support (Structural)			
Sat	26-Mar	7am - 3pm	Off (On Call)

Sat	26-Mar	3pm-11pm	Off (On Call)
Sat-Sun	3/26-3/27	11pm - 7am	Off (On Call)
Sun	27-Mar	7am - 3pm	Off (On Call)
Sun	27-Mar	3pm-11pm	Off (On Call)
Sun-Mon	3/27-3/28	11pm - 7am	Off (On Call)
Mon	28-Mar	7am - 3pm	Off (On Call)
Mon	28-Mar	3pm-11pm	Off (On Call)
Mon-Tues	3/28-3/29	11pm - 7am	Off (On Call)
Tues	29-Mar	7am - 3pm	Off (On Call)
Tues	29-Mar	3pm-11pm	Off (On Call)
Tues-Wed	3/29-3/30	11pm - 7am	Off (On Call)
Wed	30-Mar	7am - 3pm	Off (On Call)
Wed	30-Mar	3pm-11pm	Off (On Call)
Wed-Thur	3/30-3/31	11pm - 7am	Off (On Call)
Thur	31-Mar	7am - 3pm	Off (On Call)
Thur	31-Mar	3pm-11pm	Off (On Call)
Thur-Fri	3/31-4/1	11pm - 7am	Off (On Call)
Fri	1-Apr	7am - 3pm	Off (On Call)
Fri	1-Apr	3pm-11pm	Off (On Call)
Fri-Sat	4/1-4/2	11pm-7am	Off (On Call)

From: Boyce, Tom (RES)
To: RST01 Hoc
Cc: Case, Michael; West, Stephanie; Richards, Stuart
Subject: RE: Volunteers needed - Ops Center RST Schedule 3/26-4/2 (input needed by noon today)
Date: Friday, March 25, 2011 9:43:20 AM

Eric,

I can take Monday 3-11 as RST Coordinator.

Tom

From: RST01 Hoc
Sent: Wednesday, March 23, 2011 12:05 PM
To: Alter, Peter; Morlang, Gary; Hasselberg, Rick; Berry, Rollie; Collins, Frank; Thomas, Eric; Schoenebeck, Greg; McGovern, Denise; Rini, Brett; Bukharin, Oleg; Sloan, Scott; Circle, Jeff; Esmaili, Hossein; Ward, Leonard; Laur, Steven; Salay, Michael; Fuller, Edward; Schaperow, Jason; Marksberry, Don; Gilmer, James; Miranda, Samuel; Arndt, Steven; Helton, Donald; Norton, Charles; Kolb, Timothy; Brown, Eva; Shea, James; Vick, Lawrence; Brown, Michael; Williams, Donna; Roggenbrodt, William; Thorp, John; Kugler, Andrew; Williams, Joseph; Padovan, Mark; Isom, James; Hart, Ken; Bloom, Steven; Jervey, Richard
Subject: FW: RST Schedule 3/26-4/2

All,

Please look at current watchbills from the OST. Ed Fuller has signed up for swing shifts for Accident Analyst on 3/29 and 4/5. Other than that, please reply to RST01 so we can start filling in the holes on the watchbill.

Thanks for all of your support.

Eric Thomas
RST Coordinator

From: OST02 HOC
Sent: Wednesday, March 23, 2011 8:44 AM
To: RST01 Hoc
Subject: RST Schedule 3/26-4/2

Reactor Safety Team			
RST Director			
Sat	26-Mar	7am - 3pm	Pat Hiland
Sat	26-Mar	3pm-11pm	Bill Ruland
Sat-Sun	3/26-3/27	11pm - 7am	Mike Case
Sun	27-Mar	7am - 3pm	Pat Hiland
Sun	27-Mar	3pm-11pm	Fred Brown
Sun-Mon	3/27-3/28	11pm - 7am	Mike Case
Mon	28-Mar	7am - 3pm	Pat Hiland
Mon	28-Mar	3pm-11pm	Fred Brown
Mon-Tue	3/28-3/29	11pm - 7am	Mike Case
Tue	29-Mar	7am - 3pm	Jennifer Uhle
Tue	29-Mar	3pm-11pm	Fred Brown
Tue-Wed	3/29-3/30	11pm - 7am	Mike Case
Wed	30-Mar	7am - 3pm	Jennifer Uhle

4/263

Wed	30-Mar	3pm-11pm	Fred Brown
Wed-Thur	3/30-3/31	11pm - 7am	Dave Skeen
Thur	31-Mar	7am - 3pm	Jennifer Uhle
Thur	31-Mar	3pm-11pm	Bill Ruland
Thur-Fri	3/31-4/1	11pm - 7am	Dave Skeen
Fri	1-Apr	7am - 3pm	Jennifer Uhle
Fri	1-Apr	3pm-11pm	Bill Ruland
Fri-Sat	4/1-4/2	11pm-7am	Dave Skeen
RST Coordinator			
Fri-Sat	3/25-3/26	11pm-7am	Frank Collins
Sat	26-Mar	7am - 3pm	Eric Thomas
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Peter Alter
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	Frank Collins
Mon	28-Mar	7am - 3pm	Rick Hasselberg
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	Mike Morlang
Tue	29-Mar	7am - 3pm	Peter Alter
Tue	29-Mar	3pm-11pm	Greg Schoenebeck
Tue-Wed	3/29-3/30	11pm - 7am	Mike Morlang
Wed	30-Mar	7am - 3pm	Rick Hasselberg
Wed	30-Mar	3pm-11pm	Greg Schoenebeck
Wed-Thur	3/30-3/31	11pm - 7am	Frank Collins
Thur	31-Mar	7am - 3pm	Peter Alter
Thur	31-Mar	3pm-11pm	Greg Schoenebeck
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	Rick Hasselberg
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	Frank Collins
Severe Accident/PRA			
Sat	26-Mar	7am - 3pm	Steven Arndt
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Jeff Circle
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	Hossein Esmaili
Tue	29-Mar	3pm-11pm	
Tue-Wed	3/29-3/30	11pm - 7am	
Wed	30-Mar	7am - 3pm	Jim Gilmer?

Wed	30-Mar	3pm-11pm	Hossein Esmaili
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	
Thur	31-Mar	3pm-11pm	Hossein Esmaili
Thur-Fri	3/31-4/1	11pm - 7am	Ray Skarda
Fri	1-Apr	7am - 3pm	
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	Ray Skarda
BWR Expertise			
Sat	26-Mar	7am - 3pm	Mike Brown
Sat	26-Mar	3pm-11pm	Chuck Norton
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Mike Brown
Sun	27-Mar	3pm-11pm	Chuck Norton
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Mike Brown
Mon	28-Mar	3pm-11pm	Chuck Norton
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	Mike Brown
Tue	29-Mar	3pm-11pm	Chuck Norton
Tue-Wed	3/29-3/30	11pm - 7am	
Wed	30-Mar	7am - 3pm	Mike Brown
Wed	30-Mar	3pm-11pm	Chuck Norton
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	Mike Brown
Thur	31-Mar	3pm-11pm	Chuck Norton
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	Mike Brown
Fri	1-Apr	3pm-11pm	Chuck Norton
Fri-Sat	4/1-4/2	11pm-7am	
RST Comm/ERDS Operator			
Sat	26-Mar	7am - 3pm	Donna Williams
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Mark Padovan
Sun	27-Mar	3pm-11pm	Bill Roggenbrodt
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Mark Padovan
Mon	28-Mar	3pm-11pm	Bill Roggenbrodt
Mon-Tue	3/28-3/29	11pm - 7am	Andy Kugler
Tue	29-Mar	7am - 3pm	Mark Padovan
Tue	29-Mar	3pm-11pm	Bill Roggenbrodt
Tue-Wed	3/29-3/30	11pm - 7am	Andy Kugler
Wed	30-Mar	7am - 3pm	Mark Padovan
Wed	30-Mar	3pm-11pm	Bill Roggenbrodt

Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	Andy Kugler
Thur	31-Mar	3pm-11pm	Bill Roggenbrodt
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	Mark Padovan
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	
RST Support (Seismology Q&A)			
Sat	26-Mar	7am - 3pm	
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	
Tue	29-Mar	3pm-11pm	
Tue-Wed	3/29-3/30	11pm - 7am	
Wed	30-Mar	7am - 3pm	
Wed	30-Mar	3pm-11pm	
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	
Thur	31-Mar	3pm-11pm	
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	
RST Support (Structural)			
Sat	26-Mar	7am - 3pm	Off (On Call)
Sat	26-Mar	3pm-11pm	Off (On Call)
Sat-Sun	3/26-3/27	11pm - 7am	Off (On Call)
Sun	27-Mar	7am - 3pm	Off (On Call)
Sun	27-Mar	3pm-11pm	Off (On Call)
Sun-Mon	3/27-3/28	11pm - 7am	Off (On Call)
Mon	28-Mar	7am - 3pm	Off (On Call)
Mon	28-Mar	3pm-11pm	Off (On Call)
Mon-Tues	3/28-3/29	11pm - 7am	Off (On Call)
Tues	29-Mar	7am - 3pm	Off (On Call)
Tues	29-Mar	3pm-11pm	Off (On Call)
Tues-Wed	3/29-3/30	11pm - 7am	Off (On Call)
Wed	30-Mar	7am - 3pm	Off (On Call)
Wed	30-Mar	3pm-11pm	Off (On Call)
Wed-Thur	3/30-3/31	11pm - 7am	Off (On Call)

Thur	31-Mar	7am - 3pm	Off (On Call)
Thur	31-Mar	3pm-11pm	Off (On Call)
Thur-Fri	3/31-4/1	11pm - 7am	Off (On Call)
Fri	1-Apr	7am - 3pm	Off (On Call)
Fri	1-Apr	3pm-11pm	Off (On Call)
Fri-Sat	4/1-4/2	11pm-7am	Off (On Call)

From: Richards, Stuart
To: Dion, Jeanne
Cc: Sydnor, Russell; Case, Michael
Subject: RE: Volunteers needed - Ops Center RST Schedule 3/26-4/2 (input needed by noon today)
Date: Friday, March 25, 2011 10:09:07 AM

Jeanne

Thanks!! We'll forward your name.

Stu

From: Dion, Jeanne
Sent: Friday, March 25, 2011 9:43 AM
To: Richards, Stuart
Cc: Sydnor, Russell
Subject: FW: Volunteers needed - Ops Center RST Schedule 3/26-4/2 (input needed by noon today)
Importance: High

Stu,
I can volunteer for RST coordinator- Sat 3-111pm OR 11pm- 7am
And Monday 3pm-11pm.

I'm on annual leave next week and can't cover the other dates.

Jeanne

From: Richards, Stuart
Sent: Friday, March 25, 2011 9:39 AM
To: RES_DE
Cc: Coe, Doug; Coyne, Kevin; Gibson, Kathy; Case, Michael; West, Stephanie
Subject: Volunteers needed - Ops Center RST Schedule 3/26-4/2 (input needed by noon today)
Importance: High

The Ops Center is seeking volunteers for the Reactor Safety Team.

The watchbill is in this e-mail below, with the slots needing to be filled indicated.

If you want to volunteer, please check with your BC and let Stephanie West know by noon today.

Thanks
Stu

From: RST01 Hoc
Sent: Wednesday, March 23, 2011 12:05 PM
To: Alter, Peter; Morlang, Gary; Hasselberg, Rick; Berry, Rollie; Collins, Frank; Thomas, Eric; Schoenebeck, Greg; McGovern, Denise; Rini, Brett; Bukharin, Oleg; Sloan, Scott; Circle, Jeff; Esmaili, Hossein; Ward, Leonard; Laur, Steven; Salay, Michael; Fuller, Edward; Schaperow, Jason; Marksberry, Don; Gilmer, James; Miranda, Samuel; Arndt, Steven; Helton, Donald; Norton, Charles; Kolb, Timothy; Brown, Eva; Shea, James; Vick, Lawrence; Brown, Michael; Williams, Donna; Roggenbrodt, William; Thorp, John; Kugler, Andrew; Williams, Joseph; Padovan, Mark; Isom, James; Hart, Ken; Bloom, Steven; Jervey, Richard
Subject: FW: RST Schedule 3/26-4/2

All,

Please look at current watchbills from the OST. Ed Fuller has signed up for swing shifts for Accident Analyst

4264

on 3/29 and 4/5. Other than that, please reply to RST01 so we can start filling in the holes on the watchbill.

Thanks for all of your support.

Eric Thomas
RST Coordinator

From: OST02 HOC
Sent: Wednesday, March 23, 2011 8:44 AM
To: RST01 Hoc
Subject: RST Schedule 3/26-4/2

Reactor Safety Team			
RST Director			
Sat	26-Mar	7am - 3pm	Pat Hiland
Sat	26-Mar	3pm-11pm	Bill Ruland
Sat-Sun	3/26-3/27	11pm - 7am	Mike Case
Sun	27-Mar	7am - 3pm	Pat Hiland
Sun	27-Mar	3pm-11pm	Fred Brown
Sun-Mon	3/27-3/28	11pm - 7am	Mike Case
Mon	28-Mar	7am - 3pm	Pat Hiland
Mon	28-Mar	3pm-11pm	Fred Brown
Mon-Tue	3/28-3/29	11pm - 7am	Mike Case
Tue	29-Mar	7am - 3pm	Jennifer Uhle
Tue	29-Mar	3pm-11pm	Fred Brown
Tue-Wed	3/29-3/30	11pm - 7am	Mike Case
Wed	30-Mar	7am - 3pm	Jennifer Uhle
Wed	30-Mar	3pm-11pm	Fred Brown
Wed-Thur	3/30-3/31	11pm - 7am	Dave Skeen
Thur	31-Mar	7am - 3pm	Jennifer Uhle
Thur	31-Mar	3pm-11pm	Bill Ruland
Thur-Fri	3/31-4/1	11pm - 7am	Dave Skeen
Fri	1-Apr	7am - 3pm	Jennifer Uhle
Fri	1-Apr	3pm-11pm	Bill Ruland
Fri-Sat	4/1-4/2	11pm-7am	Dave Skeen
RST Coordinator			
Fri-Sat	3/25-3/26	11pm-7am	Frank Collins
Sat	26-Mar	7am - 3pm	Eric Thomas
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Peter Alter
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	Frank Collins
Mon	28-Mar	7am - 3pm	Rick Hasselberg
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	Mike Morlang
Tue	29-Mar	7am - 3pm	Peter Alter

Tue	29-Mar	3pm-11pm	Greg Schoenebeck
Tue-Wed	3/29-3/30	11pm - 7am	Mike Morlang
Wed	30-Mar	7am - 3pm	Rick Hasselberg
Wed	30-Mar	3pm-11pm	Greg Schoenebeck
Wed-Thur	3/30-3/31	11pm - 7am	Frank Collins
Thur	31-Mar	7am - 3pm	Peter Alter
Thur	31-Mar	3pm-11pm	Greg Schoenebeck
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	Rick Hasselberg
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	Frank Collins
Severe Accident/PRA			
Sat	26-Mar	7am - 3pm	Steven Arndt
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Jeff Circle
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	Hossein Esmaili
Tue	29-Mar	3pm-11pm	
Tue-Wed	3/29-3/30	11pm - 7am	
Wed	30-Mar	7am - 3pm	Jim Gilmer?
Wed	30-Mar	3pm-11pm	Hossein Esmaili
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	
Thur	31-Mar	3pm-11pm	Hossein Esmaili
Thur-Fri	3/31-4/1	11pm - 7am	Ray Skarda
Fri	1-Apr	7am - 3pm	
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	Ray Skarda
BWR Expertise			
Sat	26-Mar	7am - 3pm	Mike Brown
Sat	26-Mar	3pm-11pm	Chuck Norton
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Mike Brown
Sun	27-Mar	3pm-11pm	Chuck Norton
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Mike Brown
Mon	28-Mar	3pm-11pm	Chuck Norton
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	Mike Brown
Tue	29-Mar	3pm-11pm	Chuck Norton

Tue-Wed	3/29-3/30	11pm - 7am	
Wed	30-Mar	7am - 3pm	Mike Brown
Wed	30-Mar	3pm-11pm	Chuck Norton
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	Mike Brown
Thur	31-Mar	3pm-11pm	Chuck Norton
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	Mike Brown
Fri	1-Apr	3pm-11pm	Chuck Norton
Fri-Sat	4/1-4/2	11pm-7am	
RST Comm/ERDS Operator			
Sat	26-Mar	7am - 3pm	Donna Williams
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Mark Padovan
Sun	27-Mar	3pm-11pm	Bill Roggenbrodt
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Mark Padovan
Mon	28-Mar	3pm-11pm	Bill Roggenbrodt
Mon-Tue	3/28-3/29	11pm - 7am	Andy Kugler
Tue	29-Mar	7am - 3pm	Mark Padovan
Tue	29-Mar	3pm-11pm	Bill Roggenbrodt
Tue-Wed	3/29-3/30	11pm - 7am	Andy Kugler
Wed	30-Mar	7am - 3pm	Mark Padovan
Wed	30-Mar	3pm-11pm	Bill Roggenbrodt
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	Andy Kugler
Thur	31-Mar	3pm-11pm	Bill Roggenbrodt
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	Mark Padovan
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	
RST Support (Seismology Q&A)			
Sat	26-Mar	7am - 3pm	
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	
Tue	29-Mar	3pm-11pm	
Tue-Wed	3/29-3/30	11pm - 7am	

Wed	30-Mar	7am - 3pm	
Wed	30-Mar	3pm-11pm	
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	
Thur	31-Mar	3pm-11pm	
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	
RST Support (Structural)			
Sat	26-Mar	7am - 3pm	Off (On Call)
Sat	26-Mar	3pm-11pm	Off (On Call)
Sat-Sun	3/26-3/27	11pm - 7am	Off (On Call)
Sun	27-Mar	7am - 3pm	Off (On Call)
Sun	27-Mar	3pm-11pm	Off (On Call)
Sun-Mon	3/27-3/28	11pm - 7am	Off (On Call)
Mon	28-Mar	7am - 3pm	Off (On Call)
Mon	28-Mar	3pm-11pm	Off (On Call)
Mon-Tues	3/28-3/29	11pm - 7am	Off (On Call)
Tues	29-Mar	7am - 3pm	Off (On Call)
Tues	29-Mar	3pm-11pm	Off (On Call)
Tues-Wed	3/29-3/30	11pm - 7am	Off (On Call)
Wed	30-Mar	7am - 3pm	Off (On Call)
Wed	30-Mar	3pm-11pm	Off (On Call)
Wed-Thur	3/30-3/31	11pm - 7am	Off (On Call)
Thur	31-Mar	7am - 3pm	Off (On Call)
Thur	31-Mar	3pm-11pm	Off (On Call)
Thur-Fri	3/31-4/1	11pm - 7am	Off (On Call)
Fri	1-Apr	7am - 3pm	Off (On Call)
Fri	1-Apr	3pm-11pm	Off (On Call)
Fri-Sat	4/1-4/2	11pm-7am	Off (On Call)

From:	Rivera-Lugo, Richard
To:	Valentin, Andrea
Cc:	Case, Michael; Richards, Stuart
Subject:	UPDATE: DE staff supporting the Japan Events
Date:	Friday, March 25, 2011 6:19:14 PM
Attachments:	DE Staff Supporting Japan Events.xlsx

Andrea,

Here is the most recent update for pay period 7 (attached).

Richie

Richard Rivera-Lugo, EIT, MEM
Technical Assistant (Acting)
U.S. Nuclear Regulatory Commission – HQ
RES/DE
Ph. 301-251-7652
Fax 301-251-7420
Mail M.S. C5C07M
E-mail Richard.Rivera-Lugo@nrc.gov


Please consider the Environment before printing this e-mail.

4265

RES/DE Staff Supporting the Japan Events

TAC # ZG0061

Updated: 25-Mar-2011

DE Staff	Sunday	Monday	Tuesday	Wednesday	Thursday
	13-Mar	14-Mar	15-Mar	16-Mar	17-Mar
Andrew Murphy				2.5	2.5
Jose Pires		1.5	1.5	1.5	4.0
Madhumita Sircar					2.0
Jeannie Dion		2.0	2.0	2.0	6.0
Annie Kammerer					
Jon Ake					
Richard Jervey					
Sapna Hurd					
Syed Ali		2.0	2.0	3.0	2.0
Hector Rodriguez-Luccioni					
Michael Case					
Leroy Hardin					
Tom Boyce					
Richard Rivera-Lugo					

Hours per day / Pay Period #7

Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday
18-Mar	19-Mar	20-Mar	21-Mar	22-Mar	23-Mar	24-Mar
5.0			6.0	6.0	4.0	4.0
5.0			6.0	6.0	6.0	6.0
6.0						
			8.0			
			2.0	3.0	4.0	21.0

Friday	Saturday
25-Mar	26-Mar
8.0	
8.0	
	8.0

Nathan
Sun

no.nukes
Ten Years After Chernobyl

Subject: Calendar of Nuclear Accidents and Events (Updated 21st March)

Calendar of Nuclear Accidents

Below is a calendar that shows the threat that humanity faces from the atom bomb and the nuclear fuel cycle. This calendar gives some examples of the everyday nuclear incidents that have occurred all over the world. It demonstrates how technological failures coupled with human error risk public health and the environment on an almost daily basis.

January

1-1992: Four tons of heavy water spilt at Rajasthan nuclear power plant (India)
2-1993: Leak at Kozloduy nuclear power plant, release of radioactive steam (Bulgaria)
3-1961: Explosion in reactor Idaho Falls (USA); three people killed
4-1965: 6.5 kg plutonium sludge released from Savannah River reprocessing plant (USA)
5-1976: Two workers killed by radioactive carbon dioxide at Bohunice nuclear power plant (Slovakia)
6-1981: Accident at La Hague reprocessing plant (France)
7-1974: Explosion at Leningrad nuclear power plant (Russia)
8-1975: Release of radioactivity from Mihama nuclear power plant (Japan)
9-1993: Radioactive release from leaking fuel rods at Perry nuclear power plant (USA)
10-1987: Nuclear transport accident in the UK
11-1985: In Heilbronn (Germany), a Pershing-II nuclear missile catches fire, three people killed
12-1960: Technicians trying to restart a reactor at Savannah River reprocessing plant almost send it out of control (USA)
13-1964: A B-52 plane crashes with nuclear bombs on board in Maryland (USA)
14-1969: USS Enterprise, nuclear aircraft-carrier, suffers fires and explosions, killing 28 crew members
15-
16-1990: Loss of offsite power with multiple equipment failures at Dresden nuclear power plant (USA)

4/2006

17-1966: A B-52 plane crashes in Spain causing plutonium contamination
18-1989: Eight workers are contaminated at Savannah River reprocessing plant (USA)
19-1992: Radioactive leak, reactor shut-down at Kola nuclear power plant (Russia)
20-1993: Technical failure at Paluel causes subcooling accident (France)
21-1969: Technical failure at Swiss experimental nuclear reactor causes release of radioactive water
22-1992: Technical failure in shut-down system at Balakovo nuclear power plant (Russia)
23- 1978: Radioactive helium released from Colorado reactor (USA)
24-1978: Soviet nuclear-powered satellite Cosmos-954 crashes in Canada
25-1982: Steam generator ruptures at R.E. Ginna nuclear power plant (USA)
26-1988: Dangerous temperature rise in a nuclear reactor on board a British submarine
27-1992: Leak causes a shut-down at Darlington nuclear power plant (Canada)
28-1990: Pump failure during a shut-down at Gravelines nuclear power plant (France)
29-1961: A B-52 plane carrying nuclear bombs crashes, the bombs do not explode but three of the eight crew members are killed (USA)
30-
31 -1996: Leakage of radiation due to human error and technical failure at Dimitrovgrad nuclear research centre (Russia)

February

1-1982: Release of 100 cubic metres of radioactive water from Salem nuclear power plant (USA)
2-1993: Breakdown of cooling system for two hours at Kola nuclear power plant (Russia)
3-1992: Failure of cooling pumps at Kozloduy nuclear power plant (Bulgaria)
4-
5-1986: "Amber alert" (indicating an emergency in one building and a threat to the rest of the plant)" at Sellafield reprocessing plant, UK
6-1974: Explosion and radiation leak at Leningrad nuclear power plant, three people killed (Russia)
7-
8-1991: Release of radioactivity from Fukui nuclear power plant (Japan)
9-1991: Rupture of steam generator pipe causes release of

radioactivity at Mihama nuclear power plant (Japan)
10-1992: Technical failure in pump system at Zaporozhe nuclear power plant (Ukraine)
11-1986: Release of 13 tonnes of radioactive carbon dioxide from Transfynydd nuclear power plant (UK)
12-1968: A B-52 plane with nuclear bombs on board crashes near Toronto (Canada)
13-1960: First French nuclear test
14-
15-1993: Spillage of 18,000 litres of heavy water at Darlington nuclear power plant (Canada)
16-1973: Container filled with Cobalt-60 lost in the North Sea
17-1984: Accident at Kozloduy nuclear power plant (Bulgaria)
18-1988: Report of core melt in the nuclear reactor of the Soviet Ice-Breaker "Rossiya"
19-1986: Three workers suffer contamination at the Sellafield reprocessing plant (UK)
20-1990: Eight employees receive radiation exposure at Point Lepreau (Canada)
21-1976: Accident at Bohunice nuclear power plant (Slovakia)
22-1993: High pressure steam accident kills one worker and injures two others at Fukushima nuclear power plant (Japan)
23-1981: Accidental explosion of a Pershing-II missile in Germany
24-1972: Accident on board Soviet nuclear-powered submarine causes vessel to lose all power
25-1983: Failure of automatic shut-down at Salem nuclear power plant (USA)
26-1988: Increased levels of radioactivity at Bohunice nuclear power plant (Slovakia)
27-1983: Nuclear powered satellite falls into the Indian Ocean
28-1992: Software failure in the control computer at Embalse nuclear power plant (Argentina)

March

1-1954: Fall-out of US nuclear weapons test "Bravo" contaminates the inhabitants of the Pacific island of Rongelap.
2-1994: Breakdown of cooling system at Kola nuclear power plant (Russia)
3-1992: Technical failure at Novovoronezh nuclear power plant (Russia)
4-1977: Kozloduy nuclear power plant affected by an earthquake (Bulgaria)
5-
6-1985: Emergency cooling system out of order at the Grohnde nuclear power plant (Germany)
7-

8-1972: Radioactive water has to be pumped out of the Indian Point nuclear power plant (USA)
9-1992: Fire at Kola nuclear power plant (Russia)
10-1956: A B-47 plane disappears with nuclear weapons on board in the Atlantic Ocean
11-1958: A B-47 plane loses nuclear bomb in South Carolina (USA)
12-1981: Tornado washes nuclear waste from Moruroa into the lagoon (Pacific)
13-1986: US nuclear submarine runs aground and suffers damage
14-1961: A B-52 plane crashes with nuclear bombs on board in California (USA)
15-1989: Technical failure of fuel roads at Pickering nuclear power plant (Canada)
16-
17-1984: Emergency cooling system at San Onofere nuclear power plant fails (USA)
18-1987: Fire and release of radioactivity at Australian nuclear research facility
19-
20-1977: Temperature increase at Rancho Seco nuclear power plant (USA)
21-1984: Soviet nuclear submarine collides with US aircraft carrier "Kitty Hawk"
22-1975: Fire in reactor at Browns Ferry nuclear power plant (USA)
23-
24-1992: Incident with radiation leakage, shut-down of reactor at Leningrad nuclear power plant (Russia)
25-1992: Technical failure at Leningrad nuclear power plant (Russia)
26-1991: Refuelling accident at Wuergassen nuclear power plant (Germany)
27-
28-1979: Partial core meltdown at Three Mile Island nuclear power plant (USA)
29-1992: Failure of shut-down system at Ignalina nuclear power plant (Lithuania)
30-
31-1992: Automatic shut-down due to failure of pump system at Kalinin nuclear power plant (Russia)

April

1-1989: Control rod failure at Gravelines nuclear power plant (France)
2-1979: Two workers suffer radioactive contamination at Tokaimura nuclear complex (Japan)
3-1960: Melting of fuel elements cause a release of

radioactivity at the Test Reactor at Waltz Mills (USA)
4-
5-
6-1993: Explosion at the Tomsk-7 nuclear complex (Russia)
7-1992: Failure of automatic shut-down system at Novovoronezh nuclear power plant (Russia)
8-1989: Soviet nuclear submarine "Komsomolets" sinks off Norway
9-1981: US-nuclear submarine "George Washington" crashes against a freighter ship
10-1963: US-nuclear submarine sinks with 123 crew members in the Atlantic
11-1950: A B-29 plane crashes in New Mexico, thirteen people killed.
12-1970: Soviet nuclear submarine sinks in the Atlantic
13-1979: Fire in the generator of the Baersbeck nuclear power plant (Sweden)
14-1970: Soviet nuclear submarine sinks with 52 crew members in Indian ocean
15-1983: Incident at Turkey Point nuclear power plant (USA)
16-1992: Technical failure of reactor shut-down system at Kola nuclear power plant (Russia)
17-1970: Incident involving a vehicle at a French nuclear test site in the South Pacific causes a plutonium spillage into the ocean.
18-1992: Technical failure during refuelling at Kola nuclear power plant (Russia)
19-1984: Technical failure at Sequoyah nuclear power plant causes spillage of radioactive coolant water. (USA)
20-1973: Thousands of cubic meters of radioactive waste flow out of Hanford nuclear weapons complex (USA)
21-1964: US-satellite disperses 1.2.kg plutonium into the atmosphere.
22-1983: Reactor shut-down due to failure of fuel rods at Kursk nuclear power plant (Russia)
23-1991: Lost of offsite power cause technical failure at "Vermont Yankee" nuclear submarine (USA)
24-
25-1990: Flooding of building due to increase of coolant level at Bohunice nuclear power plant (Slovakia)
26-1986: Explosion of reactor 4 at Chernobyl nuclear power plant; the worst civilian nuclear accident to date.
27-
28-1988: Release of 5000 Curies of tritium gas from the Bruyere le Chatel military nuclear complex (France)
29-1986: US-nuclear submarine "Atlanta" hits the ground off Gibralta
30-1992: Breakdown of cooling system at Novovoronezh nuclear power plant (Russia)

May

1-1992: Technical failure at Ignalina nuclear power plant (Lithuania)
2-1979: Technical fault at the Oyster Creek nuclear power plant triggers emergency shut-down (USA)
3-1974: Leakage at Hanford nuclear weapons complex (USA)
4-1986: Release of radiation from Hamm-Uentrop nuclear power plant (Germany)
5-1987: Pershing nuclear missile ends up in a ditch after a transport accident at Heilbronn (Germany)
6-1989: Fire of pump equipment at Bohunice nuclear power plant (Slovakia)
7-1992: Failure of emergency system at Smolensk nuclear power plant (Russia)
8-1964: First Chinese nuclear test
9-1992: Technical failure of cooling system at Hatch nuclear power plant (USA)
10-1965: Release of eight cubic metres of cooling water from Savannah River reprocessing plant (USA)
11-1969: Fire at Rocky Flats nuclear weapons plant causes plutonium to spontaneously ignite. (USA)
12-1984: Uncontrolled power surge at Bohunice nuclear power plant (Slovakia)
13-1992: Tube leak causes a radioactive release of 12 Curies of radioactivity from Tarapur nuclear power station (India)
14-1986: The power lines to the Palo Verde nuclear power plant are sabotaged (USA)
15-
16-1992: Reactor shut-down at Kola nuclear power plant (Russia)
17-1984: Fire on board the US-nuclear submarine "Guitarro"
18-1968: Accident during launch of US satellite, radioactive materials fall into ocean near Califiornia coast
19-
20-1974: First Indian nuclear test
21-1968: US-nuclear submarine "Scorpion" sinks off the Acores, 99 people die
22-1957: Human error causes a B-36 plane to release a nuclear bomb in New Mexico
23-1958: Accident and release of radioactivity at the Chalk River experimental reactor (Canada)
24-1968: Incident on board of Soviet nuclear submarine "K-27", 5 crew members killed by radiation release
25-
26-1990: During refuelling, five cubic meters of radioactive water spilled at the Fessenheim nuclear power plant (France)
27-1993: Reactor shut-down due to breakdown of cooling system at Kola nuclear power plant (Russia)
28-1970: Collision of the US-nuclear submarine "Daniel

Boone"
29-
30-
31-

June

1-1991: Failure of core cooling system at Belleville nuclear power plant (France)
2-1992: Total failure of centralised control system at the Smolensk nuclear power plant (Russia)
3-1980: Computer fault causes full-scale alert for US Military Strategic Command
4-1989: Fire in the cables of the cooling pumps at the Bohunice nuclear power plant (Slovakia)
5-1989:
6-1994: Fire at Beloyarsk nuclear power plant (Russia)
7-1960: Fire in a BOMARC-rocket in New Jersey causes plutonium release into the atmosphere (USA)
8-1992: Failure of cooling system at Kola nuclear power plant (Russia)
9-1985: Malfunction in the cooling system at Davis Blesse nuclear power plant (USA)
10-1985: Collision of a British nuclear submarine off the coast of Florida (USA)
11-1989: Spent fuel element dropped in the storage pool and damaged at Kruemmel nuclear power plant (Germany)
12-
13-
14-
15-1992: Technical failure at Sizewell nuclear power plant (UK)
16-1988: Technical failure at Zorita nuclear power plant (Spain)
17-1967: First Chinese hydrogen nuclear bomb test
18-1978: Release of two tons of radioactive steam from Brunsbuettel nuclear power plant (Germany)
19-1992: Leak in pipe conducting sea water to cooling system at Leningrad nuclear power plant (Russia)
20-1985 Collision of two trucks carrying nuclear bombs in Scotland (UK)
21-
22-
23-1986: Twelve people receive `slight' plutonium contamination while inspecting a store room at Tokaimura nuclear complex (Japan)
24-1992: Technical failure of control system at Leningrad nuclear power plant (Russia)
25-
26-1989: Fire and reactor damage in a Soviet submarine

27-1985: Explosion and steam leakage killed 14 workers at Balakovo nuclear power plant (Russia)
28-
29-1991: Power limited due to error between actual and indicated power at Pickering nuclear power plant(Canada).
30-1983: Total loss of coolant at Embalse nuclear power plant (Argentina)

July

1-1983: Technical failure causes release of Iodine-131 from Phillipsburg nuclear power plant (Germany)
2-1966: French nuclear testing in the South Pacific begins 3-1981: Fire at North Anna nuclear power plant (USA)
4-1961: Incident on board of Soviet nuclear submarine "K-19", radiation release kills 9 crew members
5-
6-1959: US plane carrying nuclear weapons crashes and catches on fire
7-
8-
9-1991: Flaw in cooling system at Wurgassen nuclear power plant (Russia)
10-1991: Leakage of radiation at Bilibino nuclear power plant (Russia)
11-
12-1993: Failure of control system at Susquehanna nuclear power plant (USA)
13-
14-1992: Reactor shut-down due to failure of cooling system at Novovoronezh nuclear power plant (Russia)
15-
16-1945: First explosion of a nuclear bomb ("Trinity") in New Mexico (USA)
17-1991: Reactor shut-down due to break of control system at Sendai nuclear power plant (Japan)
18-1991: Steam leakage causes reactor shut-down at Paks nuclear power plant (Hungary)
19-
20-1992: Leakage of radiation due to breakdown of cooling system at Ignalina nuclear power plant (Lithuania)
21-
22-1992: Two workers contaminated at Dampierre nuclear power plant (France)
23-
24-1989: Refuelling accident at Isar nuclear power plant (Germany)
25-1946: US nuclear test "Baker" causes unexpected plutonium contamination on target vessels
26-1992: Temperature rise in storage pool at Gravelines

nuclear power plant (France)
27-1956: US plane crashes into nuclear ammunition storage in the UK
28-1957: US plane loses two nuclear bombs in the Atlantic
29-
30-1986: Human error causes the nuclear warhead to be knocked off a Pershing rocket (Germany)
31-1993: Refuelling machine malfunctions at the Wylfa nuclear power plant (UK)

August

1-1983: An engineer receives a fatal radiation dose at a research reactor in Argentina
2-1987: Elevated radiation level after Soviet nuclear test
3-1983: Argentinean engineer dies from radiation dose received two days earlier
4-
5-1950: B-29 plane with nuclear weapons on board crashes; 19 people killed (USA)
6-1945: Nuclear bomb dropped on the Japanese city of Hiroshima
7-
8-
9-1945: Nuclear bomb dropped on the Japanese city of Nagasaki
10-1985: Explosion on board a Soviet nuclear submarine
11-1988: Damage detected at Atucha nuclear power plant (Argentina)
12-
13-
14-1989: Instrumentation and control failure at Grand Gulf nuclear power plant (USA)
15-1992:
16-1991: Eight control rods show delays in emergency shut-down insertion time at Millstone Point nuclear power plant (USA)
17-1991: Automatic shut-down due to technical problems at Sendai nuclear power plant (Japan)
18-1953: First explosion of Soviet hydrogen bomb
19-1986: Flooding at the Cattenom nuclear power plant (France)
20-1974 Incident at Beznau nuclear power plant (Switzerland)
21-1980: Accident on board Soviet nuclear submarine, believed to kill at least nine crew members
22-1992: Failure of shut-down system at Novovoronezh nuclear power plant (Russia)
23-
24-
25-1984: French freighter sinks in the English Channel with

375 tonnes of uraniumhexafluoride on board
26-1989: Technical failure at Ignalina nuclear power plant (Lithuania)
27-1990: Cable fire causes loss of control of the position of control rods at Chernobyl nuclear power plant (Ukraine)
28-1992: Fire in electro-generator at St.Alban nuclear power plant (France)
29-1949: First explosion of Soviet atomic bomb
30-1985: Fire in a barrel of radioactive waste at Karlsruhe nuclear complex (Germany)
31-1985: Fire at Fukushima nuclear power plant during routine shut-down (Japan)

September

1-1993: Fire at Balakovo nuclear power plant (Russia)
2-
3-1974: Release of radioactive water at Los Alamos nuclear weapons Laboratory (USA)
4-1988: Fire at Perry nuclear power plant (USA)
5-1988: Fire at Ignalina nuclear power plant (Lithuania)
6-1991: Incident and steam leak during refueling at Barsebeck nuclear power plant (Sweden)
7-
8-
9-1989: Control rod failure at Olkiluoto nuclear power plant (Finland)
10-
11-1957: 15 kgs of plutonium catch fire at Rocky Flats nuclear weapons complex (USA)
12-1992: Leakage of radioactive water at Kola nuclear power plant (Russia)
13-1987: 249 people are contaminated in Brazil, due to handling discarded nuclear medical equipment, four people subsequently die
14-1991: Leakage at Kozloduy nuclear power plant (Bulgaria)
15-1986: Fire on board a US plane carrying nuclear weapons
16-1990: Superphenix Fast Breeder Reactor is closed down due to technical failures (France)
17-1988: Nuclear weapons convoy road accident kills one person (UK)
18-1988: Technical failure at Stade nuclear power plant (Germany)
19-1984: Collision of a Soviet nuclear submarine
20-1977: US-nuclear submarine "Ray" hits the sea-bed, three crew members are injured
21-1989: Manual shut-down of WNP nuclear power plant (USA)
22-1980: Pump failure causes accidental release of radioactive water at La Hague reprocessing plant (France)

23-1969: Radioactive contamination of atmosphere during the unsuccessful launch of a Soviet spaceship.
24-1973: 35 workers at the Sellafield reprocessing plant are contaminated following a technical failure (UK)
25-1955: First Soviet underwater nuclear explosion near Novaya Zemlya (Arctic Ocean)
26-
27-1974: Soviet nuclear-capable destroyer sinks in the Black Sea
28-1990: Cables for reactor control and protection system supply overheat at Bohunice nuclear power plant (Slovakia)
29-1957: Thousands of square miles contaminated by accident at the Chelyabinsk nuclear complex (Russia)
30-1990: Failure of reactor core cooling system at Palisades nuclear power plant (USA)

October

1-1983: Technical failure and human error cause accident at Blayas nuclear power plant(France)
2-1968: Leakage at La Hague reprocessing plant (France) 3-1952: First UK nuclear test
4-1981: Release of 300-times the normal discharge level of Iodine-131 at Sellafield reprocessing plant (UK)
5-1966: Partial core meltdown at the Fermi fast breeder reactor (USA)
6-1986: Soviet nuclear submarine sinks off the coast of Bermuda
7-1984: Emergency shut-down of Paks nuclear power plant (Hungary)
8-1985: Accidental radioactive release into the sea from Hinkley Point nuclear power station (UK)
9-1991: Technical failure at Yugno-Ukrainskaya nuclear power plant (Ukraine)
10-1957: Three tonnes of uranium catch fire at the Windscale reprocessing plant (now Sellafield UK)
11-1957: US nuclear bomber crashes in Florida and catches fire
12-
13-1977: Sea water runs into the cooling circuit of Hunterston nuclear power plant (UK)
14-1953: Fall-out from British nuclear test "Totem" contaminates Aborigines in the Australian desert
15-1988: French officials carry out an experiment to test the effects of releasing 7000 Curies of radioactivity
16-1964: First Chinese nuclear test
17-1969: Fuel elements melt at St Laurent des Eaux nuclear power plant (France)
18-1991: Technical failure at Zaporozhe nuclear power plant (Ukraine)

19-1991: Offsite power failure at Smolensk nuclear power plant (Russia)
20-
21-1991: Fire on board "Sceptre" nuclear submarine in Scotland
22-1993: Instrumentation and Control failure at Saint Alban nuclear power plant (France)
23-1989: Failure of core cooling system at Dresdan nuclear power plant (USA)
24-
25-1991: Failure of shut-down system during refuelling at Novovoronezh nuclear power plant (Russia)
26-1991: Incident during refueling at Vogtle nuclear power plant (USA)
27-1991: Technical failure of shut-down system at Zaporozhe nuclear power plant (Ukraine)
28-
29-1991: Technical failure causes automatic shut-down at Kalinin nuclear power plant (Russia)
30-1991:
31-1986: US-nuclear submarine "Augusta" involved in collision

November

1-1992: Cracks in cooling system equipment at Brunsbuttel nuclear power plant (Germany)
2-1982: Nuclear missile transporter crashes killing one person and injuring two others (Germany)
3-1990: Failure of core cooling equipment at Doel nuclear power plant (Belgium)
4-1970: Explosion on board a nuclear-capable US-destroyer kills two sailors
5-1967: UK nuclear-powered ballistic missile submarine `HMS Repulse' runs aground 30 minutes after its launch
6-
7-1967: Release of radioactivity at Grenoble nuclear power plant (France)
8-
9-1955: Core meltdown at EBR fast breeder reactor (USA)
10-
11-1988: Accident during refueling on board of Soviet nuclear powered ice-breaker "Lenin"
12-1993: London Convention bans the dumping of nuclear waste into the sea
13-1974: Karen Silkwood, a worker at a US nuclear plant, dies mysteriously on her way to hand important documents to a Trade Union Official and a journalist
14-1989: Breakdown of fuel rod control system at Oconee nuclear power plant (USA)

15-1989: Fire on board US-nuclear submarine "Finback"
16-1983: Sellafield reprocessing plant discharges highly radioactive wastes directly into the sea (UK)
17-
18-1991: Reactor shut-down due to technical failure at Balakovo nuclear power plant (Russia)
19-1980: US nuclear-missile almost launched during a drill exercise.
20-1989: Fire in turbine equipment at Kozloduy nuclear power plant (Bulgaria)
21-
22-
23-1991: Leak of 190,000 litres of water from cooling system, reactor shut-down at Oconee nuclear power plant (USA)
24-1989: Technical failure nearly causes core meltdown at Greifswald nuclear power plant (Germany)
25-1991: Failure of cooling system causes automatic reactor shut-down at Kursk nuclear power plant (Russia)
26-1958: B-47 plane catches fire, destroying one nuclear weapon (USA)
27-1991: Disfunction of automatic shut-down system at Bilibino nuclear power plant (Russia)
28-1991: Failure of control system causes reactor shut- down at Kursk nuclear power plant (Russia)
29-1982: US nuclear submarine collides with US-destroyer
30-1975: 1.5 million Curies released from Leningrad nuclear power plant (Russia)

December

1-1991: Technical failure at Beloyarsk nuclear power plant (Russia)
2-1949: US experiment "Green Run" contaminates communities up to 70 miles away from the Hanford nuclear weapons complex (USA)
3-1988: Explosion at the Burghfield Atomic Weapons Establishment (UK)
4-1990: 2 workers irradiated during refuelling at Blayais nuclear power plant (France)
5-1965: Plane crashes with nuclear bombs on board off the coast of Japan
6-1991: Failure of control system during refuelling causes reactor shut-down at Smolensk nuclear power plant (Russia)
7-1991: Failure of cooling system at Kola nuclear power plant (Russia)
8-1995: Fire due to leakage of sodium coolant from Monju fast breeder reactor, Japanese nuclear industry attempts to cover up full extent of accident, reactor shut-down
9-1986: Explosion at Surry nuclear power plant, four people killed (USA).

10-1991: Failure of turbo-generator causes reactor shut- down at Balakovo nuclear power plant (Russia)
11-1991: Human error causes failure of automatic reactor shut-down equipment at Kola nuclear power plant (Russia)
12-1952: World's first major nuclear reactor disaster, Chalk River experimental reactor (Canada)
13-1988: Four of the eight emergency installations discovered out of order at Brokdorf nuclear power plant (Germany)
14-1991: Technical failure causes automatic shut-down at Balakovo nuclear power plant (Russia)
15-1991: Technical failure at Kalinin nuclear power plant (Russia)
16-1991: Technical failure at Kola nuclear power plant (Russia)
17-1987: Severe incident at Biblis nuclear power plant (Germany)
18-1984: Fire at Kalinin nuclear power plant (Russia)
19-1980: Plutonium transport accident in the USA
20-1990: Control element discovered damaged at Novovoronezh nuclear power plant (Russia)
21-1991: Radiation leakage at Kolskaya nuclear power plant (Russia)
22-1987: Accidental release of 50 tonnes of water from Atucha nuclear power plant (Argentina)
23-1988: Two control rods jammed at Blayais nuclear power plant (France)
24-1991: Reactor shut-down due to technical failure at Kalinin nuclear power plant (Russia)
25-1992: Radioactive water leakage at Beloyarsk nuclear power plant (Russia)
26-
27-1991: Automatic shut-down Balakovo nuclear power plant (Russia)
28-1990: Incident and radiation leakage at Leningrad nuclear power plant (Russia)
29-
30-1988: Reactor shut-down due to failure of control equipment at Pilgrim nuclear power plant (USA)
31-1978: Fire and loss of reactor control, 8 workers irradiated at Beloyarsk nuclear power plant (Russia)

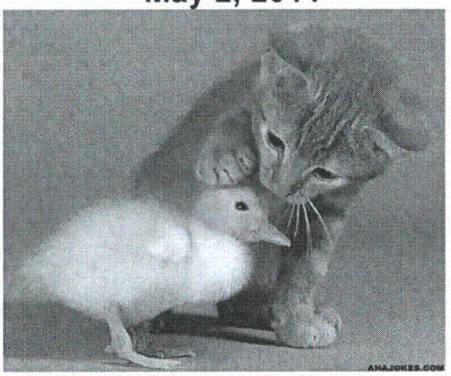
Ibarra, Jose

From: Wegner, Mary
Sent: Friday, April 29, 2011 3:16 PM
To: Ibarra, Jose
Subject: FOIA

I put a copy of everything I have on Fukushima on your chair. Have the secretary or someone make the copies you need for the lazy reporters.

OFFICE OF NUCLEAR REGULATORY RESEARCH PLAN OF THE DAY

May 2, 2011

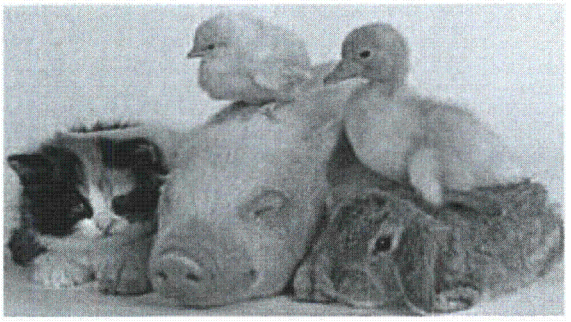


REMINDER:
Please remember to submit items for the EDO Daily Notes!
NRR Monday Morning Meetings, 8:45 AM, Room O-13G4: DE (Carpenter) to provide coverage.
NMSS Monday Morning Meetings, 8:30-9:30 AM, EBB: DRA (Gonzalez) to provide coverage.
FSME Monday Morning Meetings, 9:30-10:30, Room T-8A1: DSA (Huffert) to cover.
NRO Monday Morning Meetings, 8:30 AM, Room T-6A1: DSA (T. Zaki) to provide coverage.

TIME	PURPOSE	LOCATION	PARTICIPANTS
8:45-9:45	RES Staff Meeting	C- 6B1	Sheron, Uhle, Div. Dirs., et al.
9:00-10:00	SPB Weekly Meeting	C- 2C17	Santiago and SPB Branch Participants
10:00-10:30	Conference Call with SNL (SOARCA)	C- 6A1	Sheron, et al.
10:00-11:00	50.46(b) Management Meeting	**O- 6B4** or 1-800-779-2586 Passcode 27971	Gibson, et al.
10:00-11:00	PMDA Weekly Branch Chief Meeting	C- 6A5	PMDA Staff Participants
10:00-11:00	DRA Management Meeting	C- 4C19	DRA Staff Participants
10:30-11:30	DSA Weekly Branch Chief Meeting	C- 3C19	DSA Staff Participants
11:00-11:30	Discuss International Meetings	C- 6A11	Donaldson, Sangimino
11:00-12:00	DE's Weekly Staff Meeting	C- 5A19	DE Staff Participants
1:30-2:30	Spending Plan with CMB	C- 5A4	Case, Richards, Cherry, Hurd, Gavrilas, Srinivasan
1:30-2:30	DRA SLS Weekly Meeting	C- 4A4	DRA Staff Participants
2:00-2:45	3WFN Steering Committee Meeting	**O- 17B4**	Sheron, et al.
2:00-3:00	SOARCA Briefing for Commissioners Svinicki and Magwood	**18th Fl. Conf. Rm.**	Gibson, Scott, Schaperow, Santiago, Chang
3:00-4:00	Spending Plan with CIB	C- 5A4	Case, Richards, Cherry, Hurd, Csontos
3:00-4:00	Weekly Counterparts Meeting	Teleconf.	Gibson, Scott
3:00-4:30	Brief Commissioner Magwood on SFP	**O- 18E1**	Coe, et al.
4:00-5:00	Weekly RES, NRO & NRR Divisions of Risk Analysis Directors Call	**Teleconf.**	Correia, Coe

DELEGATIONS

T. Zaki, Acting NARB Branch Chief
L. Donaldson, Acting PMDA Deputy Director (April 18-May 13)
E. Oklesson Acting HCC Branch Chief (4/18-5/13)
D. Chan Acting HCCB Team Leader (4/18-5/13)
A. Valentin, Deputy Director when Mary Muessle Returns
H. Karagiannis for T. Boyce (4/15-5/9)
D. Stroup for M. Salley (4/29 & 5/2)



From: Sheron, Brian
To: Kammerer, Annie
Cc: Case, Michael; Richards, Stuart; Hogan, Rosemary; Uhle, Jennifer
Subject: RE: Question
Date: Friday, March 25, 2011 5:56:58 PM

I think what you told me is that we can calculate the open ocean wave height very well. It is when it runs up on the shore, you need to know the near shore topography in detail in order to accurately calculate the runup wave height? If we know the near shore topography, are the models valid?

From: Kammerer, Annie
Sent: Friday, March 25, 2011 5:33 PM
To: Sheron, Brian
Cc: Case, Michael; Richards, Stuart; Hogan, Rosemary; Uhle, Jennifer
Subject: RE: Question

Hi Brian,

Sorry for the delay in getting back to you.

First let me clarify. NOAA's real time prediction of a tsunami wave have nothing to do with TEPCO's design basis tsunami. In terns of the real time wave, NOAA hasn't under predicted anything (8m offshore and 14m runup onshore are consistent quantities).

The best estimate of the wave at daiichi from NOAA was a 8 meters offshore (at the 5 meter bathymetric line—where the water at mean tide is 15 meters deep). This is a calculation performed using what is widely believed to be the best available global model for tsunami. So, that wasn't either a educated guess or professional judgment, it was a calculation using a well validated modeling tool. However, the numbers do have uncertainly based on the fact that the model does not have the preferred very high resolution bathymetric information in the very near shore area (that's why NOAA's calculations can push only to the 5meter bathy line). The NOAA model results were also informed by (and checked against) the recordings on the closest DART buoys, these are actual measurements of wave height and the pressure front in the open ocean.

A tsunami has two phases of response. In the open ocean if is very well behaved and calculations are highly accurate. As it gets close to shore and the shoaling effect begins, the behavior starts to go non-linear and very high resolution bathymetric (an topographic) information is required for a very precise prediction of runup (onto land) at any particular point on the coastline. However, it is well understood that as a tsunami wave comes onshore it grows in size significantly. Therefore, NOAA's calculation of 8 meters offshore and TEPCO's (most recently) announcement of 14 meters onshore are consistent.

My previous comment (before this event) was actually that NOAA's tsunami warning system models (NOAA, not the USGS) have been extremely well validated over time (with hundreds of real tsunami), and that continues to be the case. But, again, that is up to water depth where they have the necessary resolution of bathymetric data (and where the non-linear response begins in earnest). As a result of this fact, there is an effort currently to collect very high resolution data for the entire US pacific coast and to implement it into the NOAA database (currently the resolution of US data is not uniform). This will make US Pacific coast onshore runup predictions highly accurate. As part of the recent UW/NOAA contract, NOAA will give us a tool (ComMIT) that will provide NRC staff with very accurate run-up predictions in the areas around SONGS and Diablo during future tsunami warnings (it will allow us to do independent PTHA at SONGS and Diablo). We had recently pushed that technology transfer back to slow the burn rate on the UW/NOAA contract (due to budget cuts) but we may find that we need to find the money sooner rather than later so that we can run some analyses.

As noted, TEPCO has recently said the tsunami had a 14meters runup (onshore). However this is the 3rd time they have provided numbers. I didn't believe (and didn't post) their initial 2 postings because

4/267

they were lower than NOAA's offshore measurements and calculations (which is inconsistent with basic physics). Also, we knew that it had to at least exceed the elevation of the equipment that was impacted. TEPCO is most likely (in my opinion) getting the measurements from watermarks on the buildings, or something similar. It's hard for me to believe that their tide gauges survived the tsunami, but one of NOAA's top experts in tide gauges and offshore measurements is my brother Carl (who, ironically was named after the Carl Kammerer who used to work at the NRC, who was my father's cousin). I can ask him about the chance of survival of equipment at the site. There are a lot of uncertainties with this, obviously, but 14 meters onshore is believable.

With regard to TEPCO's design basis tsunami, I have long gone on record as saying that the Japanese should be using PTHA, which would have predicted this water level, instead of the deterministic method that they use. Many of the tsunami specialists in Japan agree, and JNES had come around to that way of thinking due to their new concept of "residual risk". I think everyone was eagerly awaiting the new JSCE codes that detailed the PTHA technique to be used in Japan. Also, FYI, developing guidance on PTHA was identified as the #1 priority for the tsunami working group of the IAEA ISSC and NRC, JNES, and NOAA were going to jointly lead the work. We were supposed to have a kick of conference call to start the work the week after the earthquake hit. As we all know, fate intervened.

I hope this answers your questions.

Cheers,
Annie

From: Sheron, Brian
Sent: Thursday, March 24, 2011 8:27 AM
To: Kammerer, Annie
Cc: Case, Michael; Richards, Stuart; Hogan, Rosemary; Uhle, Jennifer
Subject: Question

I am seeing a spectrum of tsunami wave heights that reportedly hit the Fukushima plant. I saw in one of your briefing packages that was a USGS calculation that showed the peak wave height at about 30 feet. I saw some slides from TEPCO yesterday that said the tsunami wave height at the plant was "more than 10 meters". In today's "Nucleonics Week" on page 11 it says "Tepco discovered by checking the walls of Fukushima 1 ....and the nearby Fukushima 2 .....March 21 that the tsunamis had reached higher than 14 meters (about 46 feet) above sea level...." It then said the design basis for Fukushima 1 &2 was 5.7 and 5.2 meters respectively.

Without any accurate measurements, are we limited to educated guesses and expert judgment?

I think one question we will be asked is how well can we predict a tsunami wave height? I seem to recall you said the USGS calculations (wave height versus time at various locations) were probably pretty good because they had a well validated model. However, it would now appear they significantly under-predicted the wave height.

Am I missing something?

From: Gray, Kathy
To: Hiland, Patrick; Hackett, Edwin; Holian, Brian; Howe, Allen; Ruland, William; Brown, Frederick; Skeen, David; Case, Michael; Dudes, Laura
Cc: Thorp, John
Subject: RST Director Schedule sent to RST01 Coordinator for March 26 - April 8, 2011
Date: Friday, March 25, 2011 9:34:26 AM

Per the request of the RST Coordinator, the following RST Director schedules were provided to them yesterday afternoon.

Reactor Safety Team (RST) Director Schedule

March 26 – April 2, 2011

Shift	3/26 (Sat)	3/27 (Sun)	3/28 (Mon)	3/29 (Tues)	3/30 (Wed)	3/31 (Thur)	4/1 (Fri)	4/2 (Sat)
7am–3pm	Pat Hiland	Pat Hiland	Pat Hiland	Ed Hackett	Brian Holian	Ed Hackett	Allen Howe	Brian Holian
3pm–11pm	Bill Ruland	Fred Brown	Fred Brown	Fred Brown	Fred Brown	Bill Ruland	Bill Ruland	VACANT
11pm–7am	Dave Skeen	Dave Skeen	Dave Skeen	Dave Skeen	Mike Case	Mike Case	Mike Case	Mike Case

April 3 – April 10, 2011

Shift	4/3 (Sun)	4/4 (Mon)	4/5 (Tues)	4/6 (Wed)	4/7 (Thur)	4/8 (Fri)	4/9 (Sat)	4/10 (Sun)
7am–3pm	Brian Holian	Brian Holian	Brian Holian	Mike Case	Mike Case	Mike Case	~~Mike Case~~	~~VACANT~~
3pm–11pm	Bill Ruland	VACANT	VACANT	Ed Hackett	Brian Holian (?)	~~Pat Hiland~~	~~Pat Hiland~~	~~Pat Hiland~~
11pm–7am	Laura Dudes	Laura Dudes	Laura Dudes	Laura Dudes	Fred Brown	~~Fred Brown~~	~~Fred Brown~~	~~Fred Brown~~

4/268

From: RST01 Hoc
To: Richards, Stuart; Thomas, Eric
Cc: Hogan, Rosemary; Case, Michael
Subject: RE: RST Schedule 3/26-4/2
Date: Friday, March 25, 2011 9:34:09 AM

Hi Stu,

Yes, these individuals are just needed in an "on call" capacity. Rick Hasselberg and Peter Alter are over here working on getting those slots filled in.

Thanks, Eric

From: Richards, Stuart
Sent: Friday, March 25, 2011 9:31 AM
To: Thomas, Eric; RST01 Hoc
Cc: Hogan, Rosemary; Case, Michael
Subject: RE: RST Schedule 3/26-4/2

Eric

The watchbill below has staffing slots for "RST Support (Seismology Q&A)" for this weekend and next week.

I'm wondering if the staffing for this function can be "on call." There's a lot of seismic work that we need to get on as part of the agency response to Congressional interest and the issues that have been raised by the event. It would help if the situation is such that the "on call" staffing would work for the Ops Center.

Thanks
Stu

From: RST01 Hoc
Sent: Wednesday, March 23, 2011 12:05 PM
To: Alter, Peter; Morlang, Gary; Hasselberg, Rick; Berry, Rollie; Collins, Frank; Thomas, Eric; Schoenebeck, Greg; McGovern, Denise; Rini, Brett; Bukharin, Oleg; Sloan, Scott; Circle, Jeff; Esmaili, Hossein; Ward, Leonard; Laur, Steven; Salay, Michael; Fuller, Edward; Schaperow, Jason; Marksberry, Don; Gilmer, James; Miranda, Samuel; Arndt, Steven; Helton, Donald; Norton, Charles; Kolb, Timothy; Brown, Eva; Shea, James; Vick, Lawrence; Brown, Michael; Williams, Donna; Roggenbrodt, William; Thorp, John; Kugler, Andrew; Williams, Joseph; Padovan, Mark; Isom, James; Hart, Ken; Bloom, Steven; Jervey, Richard
Subject: FW: RST Schedule 3/26-4/2

All,

Please look at current watchbills from the OST. Ed Fuller has signed up for swing shifts for Accident Analyst on 3/29 and 4/5. Other than that, please reply to RST01 so we can start filling in the holes on the watchbill.

Thanks for all of your support.

Eric Thomas
RST Coordinator

From: OST02 HOC
Sent: Wednesday, March 23, 2011 8:44 AM

To: RST01 Hoc
Subject: RST Schedule 3/26-4/2

Reactor Safety Team			
RST Director			
Sat	26-Mar	7am - 3pm	Pat Hiland
Sat	26-Mar	3pm-11pm	Bill Ruland
Sat-Sun	3/26-3/27	11pm - 7am	Mike Case
Sun	27-Mar	7am - 3pm	Pat Hiland
Sun	27-Mar	3pm-11pm	Fred Brown
Sun-Mon	3/27-3/28	11pm - 7am	Mike Case
Mon	28-Mar	7am - 3pm	Pat Hiland
Mon	28-Mar	3pm-11pm	Fred Brown
Mon-Tue	3/28-3/29	11pm - 7am	Mike Case
Tue	29-Mar	7am - 3pm	Jennifer Uhle
Tue	29-Mar	3pm-11pm	Fred Brown
Tue-Wed	3/29-3/30	11pm - 7am	Mike Case
Wed	30-Mar	7am - 3pm	Jennifer Uhle
Wed	30-Mar	3pm-11pm	Fred Brown
Wed-Thur	3/30-3/31	11pm - 7am	Dave Skeen
Thur	31-Mar	7am - 3pm	Jennifer Uhle
Thur	31-Mar	3pm-11pm	Bill Ruland
Thur-Fri	3/31-4/1	11pm - 7am	Dave Skeen
Fri	1-Apr	7am - 3pm	Jennifer Uhle
Fri	1-Apr	3pm-11pm	Bill Ruland
Fri-Sat	4/1-4/2	11pm-7am	Dave Skeen
RST Coordinator			
Fri-Sat	3/25-3/26	11pm-7am	Frank Collins
Sat	26-Mar	7am - 3pm	Eric Thomas
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Peter Alter
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	Frank Collins
Mon	28-Mar	7am - 3pm	Rick Hasselberg
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	Mike Morlang
Tue	29-Mar	7am - 3pm	Peter Alter
Tue	29-Mar	3pm-11pm	Greg Schoenebeck
Tue-Wed	3/29-3/30	11pm - 7am	Mike Morlang
Wed	30-Mar	7am - 3pm	Rick Hasselberg
Wed	30-Mar	3pm-11pm	Greg Schoenebeck
Wed-Thur	3/30-3/31	11pm - 7am	Frank Collins
Thur	31-Mar	7am - 3pm	Peter Alter
Thur	31-Mar	3pm-11pm	Greg Schoenebeck
Thur-Fri	3/31-4/1	11pm - 7am	

Fri	1-Apr	7am - 3pm	Rick Hasselberg
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	Frank Collins
Severe Accident/PRA			
Sat	26-Mar	7am - 3pm	Steven Arndt
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Jeff Circle
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	Hossein Esmaili
Tue	29-Mar	3pm-11pm	
Tue-Wed	3/29-3/30	11pm - 7am	
Wed	30-Mar	7am - 3pm	Jim Gilmer?
Wed	30-Mar	3pm-11pm	Hossein Esmaili
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	
Thur	31-Mar	3pm-11pm	Hossein Esmaili
Thur-Fri	3/31-4/1	11pm - 7am	Ray Skarda
Fri	1-Apr	7am - 3pm	
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	Ray Skarda
BWR Expertise			
Sat	26-Mar	7am - 3pm	Mike Brown
Sat	26-Mar	3pm-11pm	Chuck Norton
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Mike Brown
Sun	27-Mar	3pm-11pm	Chuck Norton
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Mike Brown
Mon	28-Mar	3pm-11pm	Chuck Norton
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	Mike Brown
Tue	29-Mar	3pm-11pm	Chuck Norton
Tue-Wed	3/29-3/30	11pm - 7am	
Wed	30-Mar	7am - 3pm	Mike Brown
Wed	30-Mar	3pm-11pm	Chuck Norton
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	Mike Brown
Thur	31-Mar	3pm-11pm	Chuck Norton
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	Mike Brown

Fri	1-Apr	3pm-11pm	Chuck Norton
Fri-Sat	4/1-4/2	11pm-7am	
RST Comm/ERDS Operator			
Sat	26-Mar	7am - 3pm	Donna Williams
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	Mark Padovan
Sun	27-Mar	3pm-11pm	Bill Roggenbrodt
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	Mark Padovan
Mon	28-Mar	3pm-11pm	Bill Roggenbrodt
Mon-Tue	3/28-3/29	11pm - 7am	Andy Kugler
Tue	29-Mar	7am - 3pm	Mark Padovan
Tue	29-Mar	3pm-11pm	Bill Roggenbrodt
Tue-Wed	3/29-3/30	11pm - 7am	Andy Kugler
Wed	30-Mar	7am - 3pm	Mark Padovan
Wed	30-Mar	3pm-11pm	Bill Roggenbrodt
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	Andy Kugler
Thur	31-Mar	3pm-11pm	Bill Roggenbrodt
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	Mark Padovan
Fri	1-Apr	3pm-11pm	
Fri-Sat	4/1-4/2	11pm-7am	
RST Support (Seismology Q&A)			
Sat	26-Mar	7am - 3pm	
Sat	26-Mar	3pm-11pm	
Sat-Sun	3/26-3/27	11pm - 7am	
Sun	27-Mar	7am - 3pm	
Sun	27-Mar	3pm-11pm	
Sun-Mon	3/27-3/28	11pm - 7am	
Mon	28-Mar	7am - 3pm	
Mon	28-Mar	3pm-11pm	
Mon-Tue	3/28-3/29	11pm - 7am	
Tue	29-Mar	7am - 3pm	
Tue	29-Mar	3pm-11pm	
Tue-Wed	3/29-3/30	11pm - 7am	
Wed	30-Mar	7am - 3pm	
Wed	30-Mar	3pm-11pm	
Wed-Thur	3/30-3/31	11pm - 7am	
Thur	31-Mar	7am - 3pm	
Thur	31-Mar	3pm-11pm	
Thur-Fri	3/31-4/1	11pm - 7am	
Fri	1-Apr	7am - 3pm	
Fri	1-Apr	3pm-11pm	

Fri-Sat	4/1-4/2	11pm-7am	
RST Support (Structural)			
Sat	26-Mar	7am - 3pm	Off (On Call)
Sat	26-Mar	3pm-11pm	Off (On Call)
Sat-Sun	3/26-3/27	11pm - 7am	Off (On Call)
Sun	27-Mar	7am - 3pm	Off (On Call)
Sun	27-Mar	3pm-11pm	Off (On Call)
Sun-Mon	3/27-3/28	11pm - 7am	Off (On Call)
Mon	28-Mar	7am - 3pm	Off (On Call)
Mon	28-Mar	3pm-11pm	Off (On Call)
Mon-Tues	3/28-3/29	11pm - 7am	Off (On Call)
Tues	29-Mar	7am - 3pm	Off (On Call)
Tues	29-Mar	3pm-11pm	Off (On Call)
Tues-Wed	3/29-3/30	11pm - 7am	Off (On Call)
Wed	30-Mar	7am - 3pm	Off (On Call)
Wed	30-Mar	3pm-11pm	Off (On Call)
Wed-Thur	3/30-3/31	11pm - 7am	Off (On Call)
Thur	31-Mar	7am - 3pm	Off (On Call)
Thur	31-Mar	3pm-11pm	Off (On Call)
Thur-Fri	3/31-4/1	11pm - 7am	Off (On Call)
Fri	1-Apr	7am - 3pm	Off (On Call)
Fri	1-Apr	3pm-11pm	Off (On Call)
Fri-Sat	4/1-4/2	11pm-7am	Off (On Call)

From: OST02 HOC

To: Abrams, Charlotte; Abu-Eid, Boby; Adams, John; Afshar-Tous, Mugeh; Ahn, Hosung; Alemu, Bezakulu; Algama, Don; Alter, Peter; Anderson, Brian; Anderson, James; Arndt, Steven; Arribas-Colon, Maria; Ashkeboussi, Nima; Athey, George; Baker, Stephen; Ballam, Nick; Barnhurst, Daniel; Barr, Cynthia; Barss, Dan; Bazian, Samuel; Bensi, Michelle; Bergman, Thomas; Berry, Rollie; Bhachu, Ujagar; Bloom, Steven; Blount, Tom; Boger, Bruce; Bonnette, Cassandra; Borchardt, Bill; Bowers, Anthony; Bowman, Gregory; Boyce, Tom (RES); Brandon, Lou; Brandt, Philip; Brenner, Eliot; Brock, Kathryn; Brown, Cris; Brown, David; Brown, Eva; Brown, Frederick; Brown, Michael; Bukharin, Oleg; Burnell, Scott; Bush-Goddard, Stephanie; Campbell, Stephen; Camper, Larry; Carpenter, Cynthia; Carter, Mary; Case, Michael; Casto, Greg; Cecere, Bethany; Cervera, Margaret; Chazell, Russell; Chen, Yen-Ju; Cheok, Michael; Chokshi, Nilesh; Chowdhury, Prosanta; Chung, Donald; Circle, Jeff; Clement, Richard; Clinton, Rebecca; Coggins, Angela; Collins, Frank; Cool, Donald; Correia, Richard; Corson, James; Costa, Arlon; Couret, Ivonne; Craffey, Ryan; Crutchley, Mary Glenn; Cruz, Zahira; Cuadrado, Leira; Dacus, Eugene; DeCicco, Joseph; Decker, David; Dembek, Stephen; Devlin, Stephanie; Dimmick, Lisa; Doane, Margaret; Dorman, Dan; Dorsey, Cynthia; Dozier, Jerry; Drake, Margaret; Droggitis, Spiros; Dube, Donald; Dudes, Laura; Eads, Johnny; Emche, Danielle; English, Lance; Erlanger, Craig; Esmaili, Hossein; Figueroa, Roberto; Fiske, Jonathan; Flanders, Scott; Flannery, Cindy; Floyd, Daphene; Foggie, Kirk; Foster, Jack; Fragoyannis, Nancy; Franovich, Rani; Frazier, Alan; Freshman, Steve; Fuller, Edward; Galletta, Thomas; Gambone, Kimberly; Gardocki, Stanley; Gartman, Michael; Gibson, Kathy; Giitter, Joseph; Gilmer, James; Glenn, Nichole; Gordon, Dennis; Gott, William; Grant, Jeffery; Greenwood, Carol; Greenwood, Carol; Grimes, Kelly; Grobe, Jack; Gross, Allen; Gulla, Gerald; Hale, Jerry; Hardesty, Duane; Hardin, Kimberly; Hardin, Leroy; Harrington, Holly; Harris, Tim; Harrison, Donnie; Hart, Ken; Hart, Michelle; Harvey, Brad; Hasselberg, Rick; Hayden, Elizabeth; Helton, Donald; Henderson, Karen; Hiland, Patrick; Holahan, Patricia; Holahan, Vincent; Holian, Brian; HOO Hoc; Horn, Brian; Howard, Tabitha; Huffert, Anthony; Hurd, Sapna; Huyck, Doug; Imboden, Andy; Isom, James; Jackson, Karen; Jacobson, Jeffrey; Jervey, Richard; Jessie, Janelle; Johnson, Michael; Jolicoeur, John; Jones, Andrea; Jones, Cynthia; Jones, Henry; Kahler, Carolyn; Kammerer, Annie; Karas, Rebecca; Kauffman, John; Khan, Omar; Kolb, Timothy; Kotzalas, Margie; Kowalczik, Jeffrey; Kratchman, Jessica; Kugler, Andrew; Lamb, Christopher; Lane, John; Larson, Emily; Laur, Steven; LaVie, Steve; Lewis, Robert; Li, Yong; Lichatz, Taylor; Lising, Jason; Lombard, Mark; Lubinski, John; Lui, Christiana; Lukes, Kim; Lynch, Jeffery; Ma, John; Mamish, Nader; Manahan, Michelle; Marksberry, Don; Marshall, Jane; Masao, Nagai; Maupin, Cardelia; Mayros, Lauren; Mazaika, Michael; McConnell, Keith; McCoppin, Michael; McDermott, Brian; McGinty, Tim; McGovern, Denise; McIntyre, David; McMurtray, Anthony; Merritt, Christina; Meyer, Karen; Miller, Charles; Miller, Chris; Milligan, Patricia; Miranda, Samuel; Mohseni, Aby; Moore, Scott; Morlang, Gary; Morris, Scott; Mroz (Sahm), Sara; Munson, Clifford; Murray, Charles; Nerret, Amanda; Nguyen, Caroline; Norris, Michael; Norton, Charles; Opara, Stella; Ordaz, Vonna; Owens, Janice; Padovan, Mark; Parillo, John; Patel, Jay; Patel, Pravin; Patrick, Mark; Perin, Vanice; Pope, Tia; Powell, Amy; Purdy, Gary; Quinlan, Kevin; Raddatz, Michael; Ragland, Robert; Ralph, Melissa; Ramsey, Jack; Reed, Elizabeth; Reed, Sara; Reed, Wendy; Reeves, Rosemary; Reis, Terrence; Resner, Mark; Riley (OCA), Timothy; Riner, Kelly; Rini, Brett; Robinson, Edward; Rodriguez-Luccioni, Hector; Roggenbrodt, William; Ropon, Kimberly; Rosales-Cooper, Cindy; Rosenberg, Stacey; Ross-Lee, MaryJane; Roundtree, Amy; Ruland, William; Russell, Tonya; Ryan, Michelle; Salay, Michael; Salter, Susan; Salus, Amy; Sanfilippo, Nathan; Santos, Daniel; Scarbrough, Thomas; Schaperow, Jason; Schmidt, Duane; Schmidt, Rebecca; Schoenebeck, Greg; Schrader, Eric; Schwartzman, Jennifer; Seber, Dogan; See, Kenneth; Shane, Raeann; Shea, James; Shepherd, Jill; Sheron, Brian; Skarda, Raymond; Skeen, David; Sloan, Scott; Smiroldo, Elizabeth; Smith, Brooke; Smith, Stacy; Smith, Theodore; Stahl, Eric; Stang, Annette; Stark, Johnathan; Steger (Tucci), Christine; Stieve, Alice; Stone, Rebecca; Stransky, Robert; Sturz, Fritz; Sullivan, Randy; Summers, Robert; Sun, Casper; Tappert, John; Tegeler, Bret; Temple, Jeffrey; Thaggard, Mark; Thomas, Eric; Thorp, John; Tiruneh, Nebiyu; Tobin, Jennifer; Trefethen, Jean; Tschiltz, Michael; Turtil, Richard; Uhle, Jennifer; Valencia, Sandra; Vaughn, James; Vick, Lawrence; Virgilio, Martin; Virgilio, Rosetta; Ward, Leonard; Ward, William; Wastler, Sandra; Watson, Bruce; Webber, Robert; Weber, Michael; White, Bernard; Wiggins, Jim; Williams, Donna; Williams, Joseph; Williamson, Linda; Willis, Dori; Wimbush, Andrea; Wittick, Brian; Wray, John; Wright, Lisa (Gibney); Wright, Ned; Wunder, George; Young, Francis; Zimmerman, Jacob; Zimmerman, Roy

Subject: Suspending the PMTR GIS Analyst & PMTR Meteorologist Positions...

Date: Friday, March 25, 2011 12:12:34 PM

Importance: High

Please be advised that the position of PMTR GIS Analyst and PMTR Meteorologist has been suspended effective Pay Period 8 (Sunday, March 27).

Thank you for your support during the Japan Earthquake & Tsunami Event.

EST Admin Support
NRC Operations Center
eMail: OST02.HOC@nrc.gov
301-816-5100 x5600

4/270

From: RST13 Hoc
To: Brown, Frederick; Hasselberg, Rick; Circle, Jeff; Alter, Peter; Thorp, John; Ruland, William; Rini, Brett; Laur, Steven; Norton, Charles; Hart, Ken; Holian, Brian; Boyce, Tom (RES); Helton, Donald; Brown, Eva; Roggenbrodt, William; Hiland, Patrick; Thomas, Eric; Arndt, Steven; Summers, Raymond; Williams, Donna; Solorio, Dave; Collins, Frank; Reeves, Rosemary; Brown, Michael; Orr, Mark; Dozier, Jerry; Gardocki, Stanley; Skeen, David; Skarda, Raymond; McGovern, Denise; Howe, Andrew; Padovan, Mark; Mitman, Jeffrey; Gilmer, James; Ward, Leonard; Jervey, Richard; Morlang, Gary; Harrison, Donnie; Shea, James; Horn, Brian; Uhle, Jennifer; Esmaili, Hossein; Schoenebeck, Greg; Fuller, Edward; Kugler, Andrew; Bloom, Steven; Case, Michael; Chung, Donald; Bukharin, Oleg; Dudes, Laura; RST02 Hoc; RST03 Hoc; RST04 Hoc; RST05 Hoc; RST06 Hoc; RST07 Hoc; RST08 Hoc; RST09 Hoc; RST10 Hoc; RST11 Hoc; RST12 Hoc; RST13 Hoc; RST14 Hoc; RST15 Hoc
Cc: Dozier, Jerry; Gray, Kathy; Hasselberg, Rick; Alter, Peter; RST01 Hoc
Subject: URGENT RST Watch Bill through April 9th
Date: Friday, March 25, 2011 11:36:58 AM
Attachments: 03-24 to 04-09 RST Watch Bill.xlsx

Good Morning,

Attached and below is the Reactor Safety Team Watch Bill that goes through Saturday April 9 th [the end of the next pay period].

You have either signed up for or said you would cover the positions during the time/dates indicated.

If there are any mistakes on our part please email rst01.hoc@nrc.gov rick.hasselberg@nrc.gov peter.alter@nrc.gov as soon as possible. Also please volunteer for the RST Coordinator, BWR Expert, and RST Communicator positions that are blank.

If you wish to add to or change the RST Director Watch Bill, please contact Kathy.Gray@nrc.gov she is the POC for the RST Director Watch Bill. She will forward any changes to Rick and Peter [and RST01].

If you wish to add to or change the Accident Analyst Watch Bill, please contact Jerry.Dozier@nrc.gov he is the POC for the Accident Analyst Watch Bill. He is also trying to get some volunteers from Research and NRO. He will forward any changes to Rick and Peter [and RST01].

Rick & Peter

Date	Day	Time	Shift	RST Director	RST Coordinator	Accident Analyst	BWR Expert	RST Communicator
3/24/2011	Thursday	0700 - 1500	Day	Fred Brown	R Hasselberg	Jeff Circle	Peter Alter	John Thorp
3/24/2011	Thursday	1500 - 2300	Swing	Bill Ruland	Brett Rini	Steve Laur	Chuck Norton	Ken Hart
2/24/2011	Thursday	2300 - 0700	Midnight	Brian Holian	Tom Boyce	Don Helton	Eva Brown	Bill Roggenbrodt
3/25/2011	Friday	0700 - 1500	Day	Pat Hiland	Eric Thomas	Steve Arndt	Bob Summers	Donna Williams
3/25/2011	Friday	1500 - 2300	Swing	Bill Ruland	Brett Rini	Steve Laur	Chuck Norton	Dave Solorio
3/25/2011	Friday	2300 - 0700	Midnight	Brian Holian	Frank Collins	Don Helton	Eva Brown	R Reeves
3/26/2011	Saturday	0700 - 1500	Day	Pat Hiland	Eric Thomas	Steve Arndt	Mike Brown	John thorp
3/26/2011	Saturday	1500 - 2300	Swing	Bill Ruland	Mark Orr	Jerry Dozier	Chuck Norton	Stan Gardocki
3/26/2011	Saturday	2300 - 0700	Midnight	Dave Skeen	Bret Rini	Ray Skarda	Eva Brown	Denise McGovern
3/27/2011	Sunday	0700 - 1500	Day	Pat Hiland	Peter Alter	Andy Howe	Mike Brown	Mark Padovan
3/27/2011	Sunday	1500 - 2300	Swing	Fred Brown	R Hasselberg	Jeff Mitman	Chuck Norton	Bill Roggenbrodt
3/27/2011	Sunday	2300 - 0700	Midnight	Dave Skeen	Frank Collins	Jim Gilmer	Eva Brown	Denise McGovern
3/28/2011	Monday	0700 - 1500	Day	Pat Hiland	Peter Alter	Jeff Circle	Mike Brown	Mark Padovan
3/28/2011	Monday	1500 - 2300	Swing	Fred Brown	R Hasselberg	Len Ward	Chuck Norton	Rick Jervey
3/28/2011	Monday	2300 - 0700	Midnight	Dave Skeen	Mike Morlang	Donnie Harrison	Jim Shea	Brain Horn
3/29/2011	Tuesday	0700 - 1500	Day	Jennifer Uhle	Brett Rini	Hossein Esmaili	Mike Brown	John Thorp
3/29/2011	Tuesday	1500 - 2300	Swing	Fred Brown	G. Schoenebeck	Ed Fuller	Chuck Norton	Andy Kugler
3/29/2011	Tuesday	2300 - 0700	Midnight	Dave Skeen	Mike Morlang	Donnie Harrison	Jim Shea	Brain Horn
3/30/2011	Wednesday	0700 - 1500	Day	Jennifer Uhle	Peter Alter	Jim Gilmer	Mike Brown	Steve Bloom
3/30/2011	Wednesday	1500 - 2300	Swing	Fred Brown	G Schoenebeck	Hossein Esmaili	Chuck Norton	Bill Roggenbrodt
3/30/2011	Wednesday	2300 - 0700	Midnight	Mike Case	Frank Collins	Steve Arndt	Jim Shea	
3/31/2011	Thursday	0700 - 1500	Day	Jennifer Uhle	Peter Alter	Don Chung	Mike Brown	Jerry Dozier
3/31/2011	Thursday	1500 - 2300	Swing	Bill Ruland	G Schoenebeck	Hossein Esmaili	Chuck Norton	John Thorp
3/31/2011	Thursday	2300 - 0700	Midnight	Mike Case	Frank Collins	Steve Arndt	Jim Shea	
4/1/2011	Friday	0700 - 1500	Day	Jennifer Uhle	Brett Rini	Jeff Mitman	Mike Brown	Andy Kugler
4/1/2011	Friday	1500 - 2300	Swing	Bill Ruland		Don Helton	Chuck Norton	
4/1/2011	Friday	2300 - 0700	Midnight	Mike Case	Frank Collins	Ray Skarda	Eva Brown	
4/2/2011	Saturday	0700 - 1500	Day	Brian Holian	Peter Alter		Mike Brown	John Thorp
4/2/2011	Saturday	1500 - 2300	Swing	Bill Ruland	Brett Rini		Chuck Norton	
4/2/2011	Saturday	2300 - 0700	Midnight	Mike Case	Oleg Bukharin		Eva Brown	

4/27

4/3/2011	Sunday	0700 - 1500	Day	Brian Holian			Mike Brown	
4/3/2011	Sunday	1500 - 2300	Swing	Bill Ruland	Eric Thomas	Jerry Dozier	Chuck Norton	Andy Kugler
4/3/2011	Sunday	2300 - 0700	Midnight	Laura Dudes	Frank Collins			
4/4/2011	Monday	0700 - 1500	Day	Brian Holian	Peter Alter		Mike Brown	
4/4/2011	Monday	1500 - 2300	Swing			Hossein Esmaili	Chuck Norton	John Thorp
4/4/2011	Monday	2300 - 0700	Midnight	Laura Dudes	Mike Morlang			
4/5/2011	Tuesday	0700 - 1500	Day	Brian Holian		Jim Gilmer	Mike Brown	
4/5/2011	Tuesday	1500 - 2300	Swing		G. Schoenebeck	Ed Fuller	Chuck Norton	Andy Kugler
4/5/2011	Tuesday	2300 - 0700	Midnight	Laura Dudes	Mike Morlang			
4/6/2011	Wednesday	0700 - 1500	Day	Mike Case	Peter Alter		Mike Brown	Steve Bloom
4/6/2011	Wednesday	1500 - 2300	Swing	Brian Holian	G. Schoenebeck		Chuck Norton	
4/6/2011	Wednesday	2300 - 0700	Midnight	Fred Brown	Frank Collins			Rick Jervey
4/7/2011	Thursday	0700 - 1500	Day	Mike Case			Mike Brown	John Thorp
4/7/2011	Thursday	1500 - 2300	Swing		G. Schoenebeck		Chuck Norton	
4/7/2011	Thursday	2300 - 0700	Midnight					
4/8/2011	Friday	0700 - 1500	Day					
4/8/2011	Friday	1500 - 2300	Swing					
4/8/2011	Friday	2300 - 0700	Midnight					
4/9/2011	Saturday	0700 - 1500	Day					
4/9/2011	Saturday	1500 - 2300	Swing					
4/9/2011	Saturday	2300 - 0700	Midnight					

Date	Day	Time	Shift	RST Director	RST Coordinator	Accident Analyst	BWR Expert	RST Communicator
3/24/2011	Thursday	0700 - 1500	Day	Fred Brown	R Hasselberg	Jeff Circle	Peter Alter	John Thorp
3/24/2011	Thursday	1500 - 2300	Swing	Bill Ruland	Brett Rini	Steve Laur	Chuck Norton	Ken Hart
2/24/2011	Thursday	2300 - 0700	Midnight	Brian Holian	Tom Boyce	Don Helton	Eva Brown	Bill Roggenbrodt
3/25/2011	Friday	0700 - 1500	Day	Pat Hiland	Eric Thomas	Steve Arndt	Bob Summers	Donna Williams
3/25/2011	Friday	1500 - 2300	Swing	Bill Ruland	Brett Rini	Steve Laur	Chuck Norton	Dave Solorio
3/25/2011	Friday	2300 - 0700	Midnight	Brian Holian	Frank Collins	Don Helton	Eva Brown	R Reeves
3/26/2011	Saturday	0700 - 1500	Day	Pat Hiland	Eric Thomas	Steve Arndt	Mike Brown	John thorp
3/26/2011	Saturday	1500 - 2300	Swing	Bill Ruland	Mark Orr	Jerry Dozier	Chuck Norton	Stan Gardocki
3/26/2011	Saturday	2300 - 0700	Midnight	Dave Skeen	Bret Rini	Ray Skarda	Eva Brown	Denise McGovern
3/27/2011	Sunday	0700 - 1500	Day	Pat Hiland	Peter Alter	Andy Howe	Mike Brown	Mark Padovan
3/27/2011	Sunday	1500 - 2300	Swing	Fred Brown	R Hasselberg	Jeff Mitman	Chuck Norton	Bill Roggenbrodt
3/27/2011	Sunday	2300 - 0700	Midnight	Dave Skeen	Frank Collins	Jim Gilmer	Eva Brown	Denise McGovern
3/28/2011	Monday	0700 - 1500	Day	Pat Hiland	Peter Alter	Jeff Circle	Mike Brown	Mark Padovan
3/28/2011	Monday	1500 - 2300	Swing	Fred Brown	R Hasselberg	Len Ward	Chuck Norton	Rick Jervey
3/28/2011	Monday	2300 - 0700	Midnight	Dave Skeen	Mike Morlang	Donnie Harrison	Jim Shea	Brain Horn
3/29/2011	Tuesday	0700 - 1500	Day	Jennifer Uhle	Brett Rini	Hossein Esmaili	Mike Brown	John Thorp
3/29/2011	Tuesday	1500 - 2300	Swing	Fred Brown	G Schoenebeck	Ed Fuller	Chuck Norton	Andy Kugler
3/29/2011	Tuesday	2300 - 0700	Midnight	Dave Skeen	Mike Morlang	Donnie Harrison	Jim Shea	Brain Horn
3/30/2011	Wednesday	0700 - 1500	Day	Jennifer Uhle	Peter Alter	Jim Gilmer	Mike Brown	Steve Bloom
3/30/2011	Wednesday	1500 - 2300	Swing	Fred Brown	G Schoenebeck	Hossein Esmali	Chuck Norton	Bill Roggenbrodt
3/30/2011	Wednesday	2300 - 0700	Midnight	Mike Case	Frank Collins	Steve Arndt	Jim Shea	
3/31/2011	Thursday	0700 - 1500	Day	Jennifer Uhle	Peter Alter	Don Chung	Mike Brown	Jerry Dozier
3/31/2011	Thursday	1500 - 2300	Swing	Bill Ruland	G Schoenebeck	Hossein Esmaili	Chuck Norton	John Thorp
3/31/2011	Thursday	2300 - 0700	Midnight	Mike Case	Frank Collins	Steve Arndt	Jim Shea	
4/1/2011	Friday	0700 - 1500	Day	Jennifer Uhle	Brett Rini	Jeff Mitman	Mike Brown	Andy Kugler
4/1/2011	Friday	1500 - 2300	Swing	Bill Ruland		Don Helton	Chuck Norton	
4/1/2011	Friday	2300 - 0700	Midnight	Mike Case	Frank Collins	Ray Skarda	Eva Brown	
4/2/2011	Saturday	0700 - 1500	Day	Brian Holian	Peter Alter		Mike Brown	John Thorp
4/2/2011	Saturday	1500 - 2300	Swing	Bill Ruland	Brett Rini		Chuck Norton	
4/2/2011	Saturday	2300 - 0700	Midnight	Mike Case	Oleg Bukharin		Eva Brown	
4/3/2011	Sunday	0700 - 1500	Day	Brian Holian			Mike Brown	
4/3/2011	Sunday	1500 - 2300	Swing	Bill Ruland	Eric Thomas	Jerry Dozier	Chuck Norton	Andy Kugler
4/3/2011	Sunday	2300 - 0700	Midnight	Laura Dudes	Frank Collins			

Date	Day	Time	Shift	RST Director	RST Coordinator	Accident Analyst	BWR Expert	RST Communicator
4/4/2011	Monday	0700 - 1500	Day	Brian Holian	Peter Alter		Mike Brown	
4/4/2011	Monday	1500 - 2300	Swing			Hossein Esmali	Chuck Norton	John Thorp
4/4/2011	Monday	2300 - 0700	Midnight	Laura Dudes	Mike Morlang			
4/5/2011	Tuesday	0700 - 1500	Day	Brian Holian		Jim Gilmer	Mike Brown	
4/5/2011	Tuesday	1500 - 2300	Swing		G Schoenebeck	Ed Fuller	Chuck Norton	Andy Kugler
4/5/2011	Tuesday	2300 - 0700	Midnight	Laura Dudes	Mike Morlang			
4/6/2011	Wednesday	0700 - 1500	Day	Mike Case	Peter Alter		Mike Brown	Steve Bloom
4/6/2011	Wednesday	1500 - 2300	Swing	Brian Holian	G Schoenebeck		Chuck Norton	
4/6/2011	Wednesday	2300 - 0700	Midnight	Fred Brown	Frank Collins			Rick Jervey
4/7/2011	Thursday	0700 - 1500	Day	Mike Case			Mike Brown	John Thorp
4/7/2011	Thursday	1500 - 2300	Swing		G Schoenebeck		Chuck Norton	
4/7/2011	Thursday	2300 - 0700	Midnight					
4/8/2011	Friday	0700 - 1500	Day					
4/8/2011	Friday	1500 - 2300	Swing					
4/8/2011	Friday	2300 - 0700	Midnight					
4/9/2011	Saturday	0700 - 1500	Day					
4/9/2011	Saturday	1500 - 2300	Swing					
4/9/2011	Saturday	2300 - 0700	Midnight					

From: Gray, Kathy
To: Brown, Frederick; Ruland, William; Holian, Brian; Hiland, Patrick; Skeen, David; Case, Michael; Hackett, Edwin; Dudes, Laura; Howe, Allen
Cc: Uhle, Jennifer; Thorp, John
Subject: RE: URGENT RST Watch Bill through April 9th
Date: Friday, March 25, 2011 1:59:26 PM
Attachments: RE URGENT RST Watch Bill through April 9th.msg

Sorry for some confusion based on this email/schedule. Apparently, the proposed schedule I provided yesterday afternoon was not completely incorporated into the schedule that was recently sent out. I have provided the RST with corrections (see attached) – corrections made is **YELLOW** below.

Currently, we have 3 **VACANT** shifts that need to be filled .. please let me know if you can accommodate any of the dates/shifts.

It's been decided to complete the schedule through April 9 (to coincide with the end of the pay period). So I need to confirm the 4/7-9/11 dates/shifts in **GREEN**:

Date	Day	Time	Shift	RST Director	RST Coordinator	Accident Analyst	BWR Expert	RST Communicator
3/24/2011	Thursday	0700 – 1500	Day	Fred Brown	R Hasselberg	Jeff Circle	Peter Alter	John Thorp
3/24/2011	Thursday	1500 – 2300	Swing	Bill Ruland	Brett Rini	Steve Laur	Chuck Norton	Ken Hart
2/24/2011	Thursday	2300 – 0700	Midnight	Brian Holian	Tom Boyce	Don Helton	Eva Brown	Bill Roggenbrodt
3/25/2011	Friday	0700 – 1500	Day	Pat Hiland	Eric Thomas	Steve Arndt	Bob Summers	Donna Williams
3/25/2011	Friday	1500 – 2300	Swing	Bill Ruland	Brett Rini	Steve Laur	Chuck Norton	Dave Solorio
3/25/2011	Friday	2300 – 0700	Midnight	Brian Holian	Frank Collins	Don Helton	Eva Brown	R Reeves
3/26/2011	Saturday	0700 – 1500	Day	Pat Hiland	Eric Thomas	Steve Arndt	Mike Brown	John thorp
3/26/2011	Saturday	1500 – 2300	Swing	Bill Ruland	Mark Orr	Jerry Dozier	Chuck Norton	Stan Gardocki
3/26/2011	Saturday	2300 – 0700	Midnight	Dave Skeen	Bret Rini	Ray Skarda	Eva Brown	Denise McGovern
3/27/2011	Sunday	0700 – 1500	Day	Pat Hiland	Peter Alter	Andy Howe	Mike Brown	Mark Padovan
3/27/2011	Sunday	1500 – 2300	Swing	Fred Brown	R Hasselberg	Jeff Mitman	Chuck Norton	Bill Roggenbrodt
3/27/2011	Sunday	2300 – 0700	Midnight	Dave Skeen	Frank Collins	Jim Gilmer	Eva Brown	Denise McGovern
3/28/2011	Monday	0700 – 1500	Day	Pat Hiland	Peter Alter	Jeff Circle	Mike Brown	Mark Padovan
3/28/2011	Monday	1500 – 2300	Swing	Fred Brown	R Hasselberg	Len Ward	Chuck Norton	Rick Jervey
3/28/2011	Monday	2300 – 0700	Midnight	Dave Skeen	Mike Morlang	Donnie Harrison	Jim Shea	Brain Horn
3/29/2011	Tuesday	0700 – 1500	Day	~~Jennifer Uhle~~ **Ed Hackett**	Brett Rini	Hossein Esmaili	Mike Brown	John Thorp
3/29/2011	Tuesday	1500 - 2300	Swing	Fred Brown	G. Schoenebeck	Ed Fuller	Chuck Norton	Andy Kugler
3/29/2011	Tuesday	2300 - 0700	Midnight	Dave Skeen	Mike Morlang	Donnie Harrison	Jim Shea	Brain Horn
3/30/2011	Wednesday	0700 - 1500	Day	~~Jennifer Uhle~~ **Brian Holian**	Peter Alter	Jim Gilmer	Mike Brown	Steve Bloom
3/30/2011	Wednesday	1500 - 2300	Swing	Fred Brown	G Schoenebeck	Hossein Esmaili	Chuck Norton	Bill Roggenbrodt
3/30/2011	Wednesday	2300 - 0700	Midnight	Mike Case	Frank Collins	Steve Arndt	Jim Shea	
3/31/2011	Thursday	0700 - 1500	Day	~~Jennifer Uhle~~ **Ed Hackett**	Peter Alter	Don Chung	Mike Brown	Jerry Dozier
3/31/2011	Thursday	1500 - 2300	Swing	Bill Ruland	G Schoenebeck	Hossein Esmaili	Chuck Norton	John Thorp
3/31/2011	Thursday	2300 - 0700	Midnight	Mike Case	Frank Collins	Steve Arndt	Jim Shea	
4/1/2011	Friday	0700 - 1500	Day	~~Jennifer Uhle~~ **Allen Howe**	Brett Rini	Jeff Mitman	Mike Brown	Andy Kugler
4/1/2011	Friday	1500 - 2300	Swing	Bill Ruland		Don Helton	Chuck Norton	
4/1/2011	Friday	2300 - 0700	Midnight	Mike Case	Frank Collins	Ray Skarda	Eva Brown	
4/2/2011	Saturday	0700 - 1500	Day	Brian Holian	Peter Alter		Mike Brown	John Thorp
4/2/2011	Saturday	1500 - 2300	Swing	~~Bill Ruland~~ **VACANT**	Brett Rini		Chuck Norton	
4/2/2011	Saturday	2300 - 0700	Midnight	Mike Case	Oleg Bukharin		Eva Brown	

4/2/12

4/3/2011	Sunday	0700 - 1500	Day	Brian Holian			Mike Brown	
4/3/2011	Sunday	1500 - 2300	Swing	Bill Ruland	Eric Thomas	Jerry Dozier	Chuck Norton	Andy Kugler
4/3/2011	Sunday	2300 - 0700	Midnight	Laura Dudes	Frank Collins			
4/4/2011	Monday	0700 - 1500	Day	Brian Holian	Peter Alter		Mike Brown	
4/4/2011	Monday	1500 - 2300	Swing	**VACANT**		Hossein Esmaili	Chuck Norton	John Thorp
4/4/2011	Monday	2300 - 0700	Midnight	Laura Dudes	Mike Morlang			
4/5/2011	Tuesday	0700 - 1500	Day	Brian Holian		Jim Gilmer	Mike Brown	
4/5/2011	Tuesday	1500 - 2300	Swing	**VACANT**	G. Schoenebeck	Ed Fuller	Chuck Norton	Andy Kugler
4/5/2011	Tuesday	2300 - 0700	Midnight	Laura Dudes	Mike Morlang			
4/6/2011	Wednesday	0700 - 1500	Day	Mike Case	Peter Alter		Mike Brown	Steve Bloom
4/6/2011	Wednesday	1500 - 2300	Swing	~~**Brian Holian**~~ **Ed Hackett**	G. Schoenebeck		Chuck Norton	
4/6/2011	Wednesday	2300 - 0700	Midnight	Fred Brown	Frank Collins			Rick Jervey
4/7/2011	Thursday	0700 - 1500	Day	Mike Case			Mike Brown	John Thorp
4/7/2011	Thursday	1500 - 2300	Swing	**Brian Holian**	G. Schoenebeck		Chuck Norton	
4/7/2011	Thursday	2300 - 0700	Midnight	**Fred Brown**				
4/8/2011	Friday	0700 - 1500	Day	**Mike Case**				
4/8/2011	Friday	1500 - 2300	Swing	**Pat Hiland**				
4/8/2011	Friday	2300 - 0700	Midnight	**Fred Brown**				
4/9/2011	Saturday	0700 - 1500	Day	**Mike Case**				
4/9/2011	Saturday	1500 - 2300	Swing	**Pat Hiland**				
4/9/2011	Saturday	2300 - 0700	Midnight	**Fred Brown**				

Thank you for your continued support in the Ops Center! Have a good weekend.

From: RST13 Hoc
Sent: Friday, March 25, 2011 11:37 AM
To: Brown, Frederick; Hasselberg, Rick; Circle, Jeff; Alter, Peter; Thorp, John; Ruland, William; Rini, Brett; Laur, Steven; Norton, Charles; Hart, Ken; Holian, Brian; Boyce, Tom (RES); Helton, Donald; Brown, Eva; Roggenbrodt, William; Hiland, Patrick; Thomas, Eric; Arndt, Steven; Summers, Raymond; Williams, Donna; Solorio, Dave; Collins, Frank; Reeves, Rosemary; Brown, Michael; Orr, Mark; Dozier, Jerry; Gardocki, Stanley; Skeen, David; Skarda, Raymond; McGovern, Denise; Howe, Andrew; Padovan, Mark; Mitman, Jeffrey; Gilmer, James; Ward, Leonard; Jervey, Richard; Morlang, Gary; Harrison, Donnie; Shea, James; Horn, Brian; Uhle, Jennifer; Esmaili, Hossein; Schoenebeck, Greg; Fuller, Edward; Kugler, Andrew; Bloom, Steven; Case, Michael; Chung, Donald; Bukharin, Oleg; Dudes, Laura; RST02 Hoc; RST03 Hoc; RST04 Hoc; RST05 Hoc; RST06 Hoc; RST07 Hoc; RST08 Hoc; RST09 Hoc; RST10 Hoc; RST11 Hoc; RST12 Hoc; RST13 Hoc; RST14 Hoc; RST15 Hoc
Cc: Dozier, Jerry; Gray, Kathy; Hasselberg, Rick; Alter, Peter; RST01 Hoc
Subject: URGENT RST Watch Bill through April 9th

Good Morning,

Attached and below is the Reactor Safety Team Watch Bill that goes through Saturday April 9 th [the end of the next pay period].

You have either signed up for or said you would cover the positions during the time/dates indicated.

If there are any mistakes on our part please email rst01.hoc@nrc.gov rick.hasselberg@nrc.gov peter.alter@nrc.gov as soon as possible. Also please volunteer for the RST Coordinator, BWR Expert, and RST Communicator positions that are blank.

If you wish to add to or change the RST Director Watch Bill, please contact Kathy.Gray@nrc.gov she is the POC for the RST Director Watch Bill. She will forward any changes to Rick and Peter [and RST01].

If you wish to add to or change the Accident Analyst Watch Bill, please contact Jerry.Dozier@nrc.gov he is the POC for the Accident Analyst Watch Bill. He is also trying to get some volunteers from Research and NRO. He will forward any changes to Rick and Peter [and RST01].

Rick & Peter

Date	Day	Time	Shift	RST Director	RST Coordinator	Accident Analyst	BWR Expert	RST Communicator
3/24/2011	Thursday	0700 - 1500	Day	Fred Brown	R Hasselberg	Jeff Circle	Peter Alter	John Thorp
3/24/2011	Thursday	1500 - 2300	Swing	Bill Ruland	Brett Rini	Steve Laur	Chuck Norton	Ken Hart
2/24/2011	Thursday	2300 - 0700	Midnight	Brian Holian	Tom Boyce	Don Helton	Eva Brown	Bill Roggenbrodt
3/25/2011	Friday	0700 - 1500	Day	Pat Hiland	Eric Thomas	Steve Arndt	Bob Summers	Donna Williams

3/25/2011	Friday	1500 - 2300	Swing	Bill Ruland	Brett Rini	Steve Laur	Chuck Norton	Dave Solorio
3/25/2011	Friday	2300 - 0700	Midnight	Brian Holian	Frank Collins	Don Helton	Eva Brown	R Reeves
3/26/2011	Saturday	0700 - 1500	Day	Pat Hiland	Eric Thomas	Steve Arndt	Mike Brown	John thorp
3/26/2011	Saturday	1500 - 2300	Swing	Bill Ruland	Mark Orr	Jerry Dozier	Chuck Norton	Stan Gardocki
3/26/2011	Saturday	2300 - 0700	Midnight	Dave Skeen	Bret Rini	Ray Skarda	Eva Brown	Denise McGovern
3/27/2011	Sunday	0700 - 1500	Day	Pat Hiland	Peter Alter	Andy Howe	Mike Brown	Mark Padovan
3/27/2011	Sunday	1500 - 2300	Swing	Fred Brown	R Hasselberg	Jeff Mitman	Chuck Norton	Bill Roggenbrodt
3/27/2011	Sunday	2300 - 0700	Midnight	Dave Skeen	Frank Collins	Jim Gilmer	Eva Brown	Denise McGovern
3/28/2011	Monday	0700 - 1500	Day	Pat Hiland	Peter Alter	Jeff Circle	Mike Brown	Mark Padovan
3/28/2011	Monday	1500 - 2300	Swing	Fred Brown	R Hasselberg	Len Ward	Chuck Norton	Rick Jervey
3/28/2011	Monday	2300 - 0700	Midnight	Dave Skeen	Mike Morlang	Donnie Harrison	Jim Shea	Brain Horn
3/29/2011	Tuesday	0700 - 1500	Day	Jennifer Uhle	Brett Rini	Hossein Esmaili	Mike Brown	John Thorp
3/29/2011	Tuesday	1500 - 2300	Swing	Fred Brown	G. Schoenebeck	Ed Fuller	Chuck Norton	Andy Kugler
3/29/2011	Tuesday	2300 - 0700	Midnight	Dave Skeen	Mike Morlang	Donnie Harrison	Jim Shea	Brain Horn
3/30/2011	Wednesday	0700 - 1500	Day	Jennifer Uhle	Peter Alter	Jim Gilmer	Mike Brown	Steve Bloom
3/30/2011	Wednesday	1500 - 2300	Swing	Fred Brown	G Schoenebeck	Hossein Esmaili	Chuck Norton	Bill Roggenbrodt
3/30/2011	Wednesday	2300 - 0700	Midnight	Mike Case	Frank Collins	Steve Arndt	Jim Shea	
3/31/2011	Thursday	0700 - 1500	Day	Jennifer Uhle	Peter Alter	Don Chung	Mike Brown	Jerry Dozier
3/31/2011	Thursday	1500 - 2300	Swing	Bill Ruland	G Schoenebeck	Hossein Esmaili	Chuck Norton	John Thorp
3/31/2011	Thursday	2300 - 0700	Midnight	Mike Case	Frank Collins	Steve Arndt	Jim Shea	
4/1/2011	Friday	0700 - 1500	Day	Jennifer Uhle	Brett Rini	Jeff Mitman	Mike Brown	Andy Kugler
4/1/2011	Friday	1500 - 2300	Swing	Bill Ruland		Don Helton	Chuck Norton	
4/1/2011	Friday	2300 - 0700	Midnight	Mike Case	Frank Collins	Ray Skarda	Eva Brown	
4/2/2011	Saturday	0700 - 1500	Day	Brian Holian	Peter Alter		Mike Brown	John Thorp
4/2/2011	Saturday	1500 - 2300	Swing	Bill Ruland	Brett Rini		Chuck Norton	
4/2/2011	Saturday	2300 - 0700	Midnight	Mike Case	Oleg Bukharin		Eva Brown	
4/3/2011	Sunday	0700 - 1500	Day	Brian Holian			Mike Brown	
4/3/2011	Sunday	1500 - 2300	Swing	Bill Ruland	Eric Thomas	Jerry Dozier	Chuck Norton	Andy Kugler
4/3/2011	Sunday	2300 - 0700	Midnight	Laura Dudes	Frank Collins			
4/4/2011	Monday	0700 - 1500	Day	Brian Holian	Peter Alter		Mike Brown	
4/4/2011	Monday	1500 - 2300	Swing			Hossein Esmaili	Chuck Norton	John Thorp
4/4/2011	Monday	2300 - 0700	Midnight	Laura Dudes	Mike Morlang			
4/5/2011	Tuesday	0700 - 1500	Day	Brian Holian		Jim Gilmer	Mike Brown	
4/5/2011	Tuesday	1500 - 2300	Swing		G. Schoenebeck	Ed Fuller	Chuck Norton	Andy Kugler
4/5/2011	Tuesday	2300 - 0700	Midnight	Laura Dudes	Mike Morlang			
4/6/2011	Wednesday	0700 - 1500	Day	Mike Case	Peter Alter		Mike Brown	Steve Bloom
4/6/2011	Wednesday	1500 - 2300	Swing	Brian Holian	G. Schoenebeck		Chuck Norton	
4/6/2011	Wednesday	2300 - 0700	Midnight	Fred Brown	Frank Collins			Rick Jervey
4/7/2011	Thursday	0700 - 1500	Day	Mike Case			Mike Brown	John Thorp
4/7/2011	Thursday	1500 - 2300	Swing		G. Schoenebeck		Chuck Norton	
4/7/2011	Thursday	2300 - 0700	Midnight					
4/8/2011	Friday	0700 - 1500	Day					
4/8/2011	Friday	1500 - 2300	Swing					
4/8/2011	Friday	2300 - 0700	Midnight					
4/9/2011	Saturday	0700 - 1500	Day					
4/9/2011	Saturday	1500 - 2300	Swing					
4/9/2011	Saturday	2300 - 0700	Midnight					

Attachment RE URGENT RST Watch Bill through April 9th.msg (2560 Bytes) cannot be converted to PDF format.

Siu, Nathan

From: Siu, Nathan
Sent: Friday, March 25, 2011 7:45 AM
To: 'Dana Kelly'
Subject: per our discussion yesterday
Attachments: Questions.docx

My normal email should be working while I'm in Paris next week. Tks.

4273

Questions

- Are there previously unrecognized or underappreciated vulnerabilities?
- If so, can we analyze them using current PSA technology?
- What are the potential implications?
- What are the decision options and what should we do to support RIDM?

Event-Based Topics	PSA-Structure Based Topics

Fukushima
- Design basis vs. actual
- *Combined hazards effect (ground motion and tsunami)**
- *Procedural coverage*
- *Appropriateness/effectiveness of operator actions*
- H2 from partial core damage scenarios
- BWR venting capabilities
- Multi-unit interactions (support, failures)
- SFP damage mechanisms
- Challenges to long-term cooling/UHS
- Effects of seawater
- Limited, uncertain information
- International response (organizations, government, public)
  - Accident management
  - National program decision making
  - Emergency communication (who, what, when)
  - Explanatory communication
	Hazard
	- Source "location" and "strength"
	- Multiple hazards
	- Multiple occurrences
	- Attenuation
	- Direct challenge to SSCs
	- Challenge to power
	- Challenge to UHS
	- Challenge to AM efforts
	
	Fragility
	- Response to new loads (e.g., H2 explosion, waterborne debris impact)
	- Success criteria (e.g., SW clogging)
	- Multiple loads over time
	- Correlation (importance or lack thereof)
	
	Plant Response
	- Training and procedural coverage
	- Impact of "home and family" concern
	- Multiple unit interactions
	- PSA masking (escalation of non-catastrophic)

Extension/Abstraction
- Integrated treatment of other events with potential near- and long-term effects on UHS (volcanoes: tsunami, ash, water blockage/degradation; floods; storms)
- Success criteria (apparently bounding choices may not be the most risk significant)
- Analogous situations wrt H2 (small volume buildings)
- Ability of downsized plant staffs to cope
- PSA use in real-time AM
  - Realistic possibilities, better questions/alternatives/decisions
  - Degree of realism, ability to calibrate on the fly
	Accident Management
	- Training
	- Availability/adequacy of onsite resources
	- Time for arrival of offsite resources, time to perform actions, and adequacy of 24 hour mission time
	- Performance factors (positive and negative)
	
	Emergency Response
	- Timing and effectiveness
	- Impact of offsite effects (e.g., infrastructure damage, loss of power, aftershocks)
	
	Recovery/Restoration
	- Residual risk of damaged site
	- Fuel movement/management
	- Implications for undamaged units

*Italics = topic a little more speculative; may resolve with more event information

Schaperow, Jason

From: Schaperow, Jason
Sent: Friday, March 25, 2011 8:22 AM
To: Helton, Donald
Subject: RE: Unit 4 SFP

Thanks for the info.

From: Helton, Donald
Sent: Thursday, March 24, 2011 5:13 PM
To: Tinkler, Charles; Schaperow, Jason
Subject: Unit 4 SFP

Charlie / Jason:

I'll have all of the questions in mind tonight while on shift, including the racking questions on Unit 4...in the meantime, I wanted to make sure you've seen what IAEA posted, which has slightly different numbers than I recall you talking about.

http://www.iaea.org/newscenter/news/tsunamiupdate01.html
(look for the table about halfway down the page)

Of note, it states a rack capacity (1,590) well below what we would expect. It suggests that only a portion of the pool is racked (if they do indeed use high density racking) but that doesn't dispositively answer that question. Also note the 204 unirradiated assemblies (obviously not a decay heat source, but would be an additional zirconium oxidation source, depending on propagation).

Don

W274

Schaperow, Jason

Subject:	Support for Fukushima accident
Location:	Charlie's office
Start:	Fri 3/25/2011 10:00 AM
End:	Fri 3/25/2011 11:00 AM
Show Time As:	Tentative
Recurrence:	(none)
Meeting Status:	Not yet responded
Organizer:	Schaperow, Jason
Required Attendees:	Esmaili, Hossein; Salay, Michael; Marksberry, Don; Helton, Donald; Tinkler, Charles

Request you come to Charlie's office at 10:00 a.m. to meet.

4275

Schaperow, Jason

From: Schaperow, Jason
Sent: Friday, March 25, 2011 11:29 AM
To: Marksberry, Don
Subject: RE: Have you seen these latest reports from TEPCO

No.

Thanks for sending them.

From: Marksberry, Don
Sent: Friday, March 25, 2011 10:12 AM
To: Schaperow, Jason
Subject: Have you seen these latest reports from TEPCO

Of RM analysis?

4276

Schaperow, Jason

From: Schaperow, Jason
Sent: Friday, March 25, 2011 11:30 AM
To: Gonzalez, Sergio
Subject: RE: Documents

I don't have time to work with you on this. Sorry.

I am working pretty much full time on the Japanese accident.

From: Gonzalez, Sergio
Sent: Friday, March 25, 2011 10:13 AM
To: Schaperow, Jason
Subject: RE: Documents

Please see attachments:

I believe that the documents are available at the Legacy Library. In order to make electronic copies we will have to deal with the File Center and submit form 665 to obtain a hard copy. Then have it scanned by DPC into the Main.

Before doing all these I will like to make sure with you that the documents are the ones needed.

Regarding the BMI's, I'm not sure that these are the ones but since you have them I am guessing we can scan them into the Main.

Thanks,

Sergio

From: Schaperow, Jason
Sent: Friday, March 25, 2011 8:45 AM
To: Gonzalez, Sergio
Subject: RE: Documents

Please send me an email listing what you want to discuss. Thanks.

From: Gonzalez, Sergio
Sent: Friday, March 25, 2011 8:34 AM
To: Schaperow, Jason
Subject: Documents

Good Morning Jason:

Let me know when you have a time during the day to discuss a few things.

FYI: I will leave today at 2:30pm

Thanks,

Sergio E. Gonzalez

4277

Program Manager (NSPDP), Special Projects Branch
Division of Systems Analysis
Office of Nuclear Regulatory Research
Phone- 301-251-7453
Sergio.Gonzalez@nrc.gov

Schaperow, Jason

From: Schaperow, Jason
Sent: Friday, March 25, 2011 11:39 AM
To: Armstrong, Kenneth
Subject: FW: Support to Sergio's Projects

Hi Ken,

Since you are Acting BC on Monday, I just wanted to let you know that I am going to the Washington Navy Yard on Monday with Cathy Haney, Brittain Hill, and Phil Brockman to brief Rep. Lee Hamilton of the Blue Ribbon Commission on America's Nuclear Future. We will be taking a car from EBB to the Washington Navy Yard, and I expect to get back to CSB sometime during the afternoon.

Jason

4278

Schaperow, Jason

From: Schaperow, Jason
Sent: Friday, March 25, 2011 1:29 PM
To: 'kcw@dycoda.com'
Subject: RE: Calc on Heatup of the Containment

Thanks. Based on your plot, it takes a period of 5 days to heat up to Tsat (assuming the water was instantaneously added at 5 days into the accident).

From: Casey Wagner [mailto:kcw@dycoda.com]
Sent: Friday, March 25, 2011 1:19 PM
To: Schaperow, Jason
Subject: RE: Calc on Heatup of the Containment

Hi Jason,

Sorry, we only have 2 lines into the building and they were both in use. That is a rare occasion...

My hand calculation is an approximation of the real question. I just got off the phone with Charlie and he thinks they have probably been venting but very hard to tell.

I assumed that water got added at 5 days. By integrating the core decay power, you can calculate the amount of energy added to the containment water. It then takes time to heat that additional water to Tsat, which I calculated. If the pool maintains subcooling and there is no hydrogen production, you can assume that the pressure will not change until it gets close to Tsat. The calculation shows how much water must be added to delay heating to Tsat and the associated pressurization.

KC

From: Schaperow, Jason [mailto:Jason.Schaperow@nrc.gov]
Sent: Friday, March 25, 2011 10:48 AM
To: kcw@dycoda.com
Cc: Tinkler, Charles
Subject: RE: Calc on Heatup of the Containment

Hi KC,

Thanks for working on this. I just tried to call you at 866-4800, but I got a busy signal. I have meetings most of this afternoon.

I thought the question was "if they flood the containment in the first day or two of the accident, what would the drywell pressure be over two weeks? Would the drywell pressure stay at 1 atmosphere for 1.5 weeks, and then start rising from 1.5 to 2 weeks?"

Jason

From: Casey Wagner [mailto:kcw@dycoda.com]
Sent: Friday, March 25, 2011 12:21 PM

W279

To: Tinkler, Charles
Cc: rogaunt@sandia.gov; Schaperow, Jason
Subject: Calc on Heatup of the Containment

Hi Charlie,

I finally got this hand calculation done. Assume the water was added at 5 days to a saturated pool. It does not really explain the flat containment pressure.

KC

Helton, Donald

From: Helton, Donald
Sent: Friday, March 25, 2011 5:08 PM
To: Schaperow, Jason
Subject: Declined: Support for Fukushima accident

Jason,

I'll be out of town next week...going back on shift on Friday @ 3 PM...(along with being on shift tonight @ 11 PM of course)...

4/280

Schaperow, Jason

From: Schaperow, Jason
Sent: Friday, March 25, 2011 3:03 PM
To: Sheron, Brian
Cc: Gibson, Kathy
Subject: Question from House staffers

Hi Brian,

Regarding a question that the House staffers (Jeff Baran, Allison Cassidy) asked us today at 2:00...

I found on the NRC external web site the report they asked about. The report is NUREG/CR-6920, "Risk-Informed Assessment of Degraded Containment Vessels." The project manager was Herman Graves (RES/DE) and the Sandia analysts were Spencer, Petti, and Kunsman. Jose Pires (RES/DE) may have been involved in this work as well. The following is a link to the document:
http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6920/

Would you like me to ask Herman or Jose to come see you about this?

Thanks,
Jason

4281

Bano, Mahmooda

From: Scott, Michael
Sent: Saturday, March 26, 2011 9:27 PM
To: Gibson, Kathy
Subject: MY TIME WHILE IN JAPAN

Kathy:

I had logged straight time for pay period just ended, but have been advised that even GG-15 branch chiefs have been logging OT for the major hours involved in this work. So, not wanting to feel left out, I redid my time sheet and included all the extra hours. If view in RES is that BCs not entitled to that, I can delete or change to ADDLT (or Carol can).

I will plan to do same for upcoming pay period unless you say different.

Thanks

Mike

4282

Hoxie, Chris

From: Hoxie, Chris
Sent: Saturday, March 26, 2011 1:26 PM
To: Gibson, Kathy
Subject: FW: ANS Technical Brief: MOX Fuel & Fukushima
Attachments: ANS-Technical-Brief-MOX-Fukushima.pdf

Do you get these? Anyway, briefly it says the fact that its MOX at Japan is not a big deal....

-----Original Message-----
From: ANS Broadcasts [mailto:broadcasts@ans.org]
Sent: Saturday, March 26, 2011 5:02 AM
To: Hoxie, Chris
Subject: ANS Technical Brief: MOX Fuel & Fukushima

The ANS Special Committee on Nuclear Non-Proliferation has prepared the attached Technical Brief on The Impact of Mixed Oxide Fuel Use on Accident Consequences at Fukushima Daiichi.

For additional Fukushima resources, visit the "Featured Content" box on the front page of the American Nuclear Society's website:

http://www.ans.org/

4/283

AMERICAN NUCLEAR SOCIETY

555 North Kensington Avenue
La Grange Park, Illinois
60526-5592 USA

Tel: 708/ 352-6611
E-Mail: NUCLEUS@ans.org
http://www.ans.org
Fax: 708/ 352-0499

Date: March 25, 2011

To: Joe Colvin
ANS President

From: Michaele (Mikey) Brady Raap
Chair, ANS Professional Divisions Committee

Below please find the Technical Brief on The Impact of Mixed Oxide Fuel Use on Accident Consequences at Fukushima Daiichi. This Technical Brief contains factual information prepared by the ANS Special Committee on Nuclear Non-Proliferation.

The Impact of Mixed Oxide Fuel Use on Accident Consequences at Fukushima Daiichi

American Nuclear Society Technical Brief – March 2011

Conclusion

Mixed Oxide (MOX) fuel has been used safely in nuclear power reactors for decades. The presence of a limited number of MOX fuel assemblies at Fukushima Daiichi Unit 3 has not had a significant impact on the ability to cool the reactor or on any radioactive releases from the site due to damage from the earthquake and tsunami.

Summary

At the time of the magnitude 9.0 earthquake, Fukushima Daiichi Unit 3 was operating with 32 mixed oxide (MOX) fuel assemblies and 516 low enriched uranium (LEU) fuel assemblies in its reactor core. In other words, less than 6% of the fuel in the Unit 3 core was MOX fuel. There were no other MOX fuel assemblies (new, in operation or used) at the Fukushima Daiichi plant at the time of the accident.

MOX fuel assemblies were loaded into Fukushima Daiichi Unit 3 for the first time in the fall of 2010. The MOX fuel had been used for less than five months at the time of the accident. Differences in initial fuel composition between MOX and LEU fuel can lead to differences in consequences (prompt fatalities and latent cancers) following a core damage event with releases to the environment.

There are indications that Fukushima Daiichi Unit 3 suffered damage to some of its core. The core damage resulted from a loss of core cooling due to damage to plant systems from the tsunami that followed the earthquake. The damage was not related to the presence of MOX fuel.

There have been no prompt fatalities as a result of radiation exposure from Fukushima Daiichi. Prompt evacuation has minimized radiation exposure to the public, so long-term public health consequences from radiation exposure are expected to be small. Given the small number of MOX fuel assemblies at Fukushima Daiichi Unit 3 at the time of the event, coupled with the short time of irradiation of the MOX fuel, it can be concluded that MOX fuel has had and will have no perceptible impact on any consequences from the event.

Background

It is important to note that while LEU fuel begins its useful life with no plutonium, as it is used in a light water reactor it builds up plutonium as a result of the nuclear reactions in the core. By the end of its useful life an LEU fuel assembly contains about 1% plutonium actually generates more power from plutonium than from uranium. All reactor cores contain plutonium; those cores loaded with some MOX fuel contain more.

Mixed oxide (MOX) fuel is comprised of a blend of uranium oxide and plutonium oxide. MOX fuel is predominantly uranium, with average concentrations of plutonium that range from 3-10%. The presence of plutonium produces modest changes in some physical characteristics of the fuel material such as thermal conductivity. However, MOX fuel and low-enriched uranium (LEU) fuel are fundamentally similar. Moreover, the physical dimensions and structural material of a MOX fuel assembly are essentially identical to that of a LEU fuel assembly. To the naked eye, a MOX fuel assembly and a LEU fuel assembly are identical.

Nuclear power plants have been generating electricity for use by the public since the 1950s, and over those years the industry has compiled an enviable safety record. Today over 400 reactors worldwide generate substantial amounts of emissions-free electricity. Dozens of those reactors currently generate power using a mixture of conventional LEU fuel assemblies and MOX fuel assemblies in their reactor cores. The majority of the fuel loaded into these reactors is LEU (60-70% or more), while the remainder (30-40% or less) is MOX. The use of MOX fuel allows the re-use of plutonium that was recovered during nuclear fuel recycling operations. The fabrication and use of MOX fuel has been carried out safely and efficiently on an industrial scale since the 1970s. Safety authorities in France, Belgium, Germany, Switzerland and Japan have all approved the use of MOX fuel in light water reactors using the same rigorous standards that are applied for the licensing of LEU fuel.

Safety is the cornerstone of nuclear power plant operations. Nuclear power plant operators perform safety analyses to determine how the plants will respond during various "what if" problem scenarios. Some of those scenarios involve extreme conditions coupled with multiple equipment failures that lead to estimates of damage to the fuel in the reactor core. Scenarios with significant damage to the reactor core are referred to as severe accidents, and such accidents can result in the calculated release of radionuclides to the environment. Severe accident consequences are the adverse public health effects – fatalities and latent cancers – that arise from the offsite release of radionuclides from a damaged reactor core.

When uranium or plutonium atoms split (fission), they release a relatively large amount of energy which is converted into heat and eventually electricity. The smaller atoms left behind after fission are referred to as fission products. In addition, some of the uranium and plutonium atoms in nuclear fuel assemblies absorb neutrons without fissioning, becoming even heavier atoms called actinides. Both fission products and actinides are radioactive, posing a health hazard if they are released to the environment. Using MOX fuel alters somewhat the "source term," or mix of radionuclides in the core and available for release following a severe accident. The different source term between MOX fuel and LEU fuel leads to different calculated consequences following a postulated severe accident.

In November 1999 the Department of Energy published the Surplus Plutonium Disposition Environmental Impact Statement which documented, among other things, the consequences of four severe accident scenarios at three different reactors using some MOX fuel derived from weapons grade plutonium. Each reactor accident sequence was analyzed with two different reactor core assumptions: a reference case with all LEU fuel, and a second case with a mixed core of approximately 40% MOX fuel and the remainder LEU fuel. For each case the severe accident was assumed to progress in the same manner. Relative to the reference case with all LEU fuel, the offsite consequences to the public with the mixed MOX-LEU core ranged from 4% lower to 22% higher, depending on the reactor studied and the accident sequence. Most cases resulted in consequence increases of 10% or less. The differences between the consequences relate back to differences in the source term. The mixed MOX-LEU core consequences were generally higher because of the presence of more radioactive actinides in the MOX fuel at the time of the postulated accident. However, the differences were modest compared to the uncertainty associated with the consequence calculations for these extremely low probability events.

The type of plutonium used in MOX fuel can also impact severe accident consequences. The aforementioned analysis assumed weapons grade plutonium. If the calculations had been done for MOX fuel containing plutonium from recycled commercial nuclear fuel, as is the practice in Europe and Asia today, the difference between the all uranium cases and the 40% MOX fuel consequences would have been greater than cited above. This is again due primarily to the presence of more radioactive actinides in used "reactor grade" MOX fuel (with plutonium from recycled reactor fuel) than in used weapons grade MOX fuel (with plutonium from retired nuclear weapons).

Turning to the Fukushima Daiichi reactors in Japan, Unit 3 was using some reactor grade MOX fuel at the time of the March 2011 earthquake. Had it been using a 40% MOX fuel core, one could expect an increase in severe accident consequences on the order of 10% for weapons grade MOX. With a 40% reactor grade MOX core, and applying a bounding factor of four increase relative to weapons grade MOX, the overall increase in severe accident consequences would have been on the order of 40% relative to the all LEU fuel case. However, Unit 3 was loaded with only 32 MOX fuel assemblies during refueling operations in the fall of 2010. There are a total of 548 fuel assemblies in the Unit 3 reactor core, so this represents less than 6% of the total fuel in the core. The MOX fuel had been operating in Unit 3 for less than five months; fuel assemblies are typically used for a total of 3-4 years in reactor cores before being replaced by new fuel and discharged to used fuel pools. Therefore, the MOX fuel would have built up relatively few radioactive fission products and actinides at the time of the earthquake and subsequent damage to the reactor core. With these facts in mind – the low percentage of MOX fuel in the core and the short operation time for the MOX fuel – it is evident that the presence of MOX fuel at Fukushima Daiichi Unit 3 has had no significant impact on the offsite releases of radioactivity following the earthquake and tsunami.

Other than the 32 MOX fuel assemblies in the Unit 3 reactor core, at the time of the earthquake there were no other MOX fuel assemblies (new or used) at the Fukushima Daiichi plant. The problems encountered at Fukushima Daiichi reactors stem from plant damage due to the tsunami that followed the earthquake, not the use of MOX fuel in Unit 3.

It is also important to put the public health consequences from the event in perspective. There have been no prompt fatalities as a result of radiation exposure. Moreover, prompt evacuation has minimized the exposure of the population to radiation. At this point, the consequences of the event are expected to be small. MOX fuel effects, if any, would be a small change to an already small number.

In conclusion, MOX fuel has been used safely in nuclear power reactors for decades. The presence of a limited number of MOX fuel assemblies at Fukushima Daiichi Unit 3 has not had a significant impact on the ability to cool the reactor or on any radioactive releases from the site due to damage from the earthquake and tsunami.

Hoxie, Chris OK to release

From: Hoxie, Chris
Sent: Saturday, March 26, 2011 4:48 PM
To: Gibson, Kathy; Sheron, Brian; Lee, Richard
Cc: Uhle, Jennifer
Subject: Re: Sharing info. with DOE Science Council

Joe's calcs were very simple first order rate type hand calcs. Showed 73,000 kg salt. I will forward the email. We have not looked at the specifics of Brian's Question.

----- Original Message -----
From: Gibson, Kathy
To: Sheron, Brian; Lee, Richard; Hoxie, Chris
Cc: Uhle, Jennifer
Sent: Sat Mar 26 16:43:26 2011
Subject: Re: Sharing info. with DOE Science Council

I know Joe Staudemeier has been doing calculations and analysis re: salt at request of RST but don't know the specifics.

Chris, if you're checking email, do you know any specifics?

----- Original Message -----
From: Sheron, Brian
To: Lee, Richard
Cc: Uhle, Jennifer; Gibson, Kathy
Sent: Sat Mar 26 16:40:11 2011
Subject: RE: Sharing info. with DOE Science Council

Remember that the lower head is filled with sea salt. Thus, the melt that relocates to the lower head will be mixed with a lot of sea salt. Do we understand what impact the salt has (or doesn't have) on steam explosion dynamics?

-----Original Message-----
From: Lee, Richard
Sent: Saturday, March 26, 2011 4:10 PM
To: Sheron, Brian
Cc: Uhle, Jennifer; Gibson, Kathy
Subject: RE: Sharing info. with DOE Science Council

Brian:

Attached is the preliminary FCI analysis that would like to provide to NRC Op Center in case question on FCI is received. If you are at the Op Center, please provide to them.

Shortly, thereafter I will provide it to John Kelly.

Thanks, Richard

-----Original Message-----
From: Sheron, Brian
Sent: Saturday, March 26, 2011 4:06 PM
To: Gibson, Kathy; Lee, Richard

4284

Cc: Uhle, Jennifer
Subject: RE: Sharing info. with DOE Science Council

Richard, I agree with Kathy.

-----Original Message-----
From: Gibson, Kathy
Sent: Saturday, March 26, 2011 10:35 AM
To: Lee, Richard
Cc: Sheron, Brian; Uhle, Jennifer
Subject: Re: Sharing info. with DOE Science Council

Richard,
In general, if information is not proprietary or safeguards or otherwise restricted, we should share whatever information we have with those who can make use of it in the interest of site recovery and radiological safety. In this case, it can be shared. Also make sure Ops Center RST has whatever we have for their assessments. They can pass along to the site team whatever they think is useful.

Thanks,
Kathy

----- Original Message -----
From: Lee, Richard
To: Gibson, Kathy
Sent: Sat Mar 26 09:09:19 2011
Subject: Sharing info. with DOE Science Council

Dear Kathy:

Sud and I had asked Mike Corradini to perform an assessment on Fuel coolant interaction analysis using the NRC TEXAS code. The base calculation (which Randy, Dana, Mike Salay, Sud and I) think could be perhaps the worst case scenario of melt (with stainless steel) coming out of one control rod drive (CRD) hole into a saturated pool of water about 6-7ft from the melt expelling from the CRD hole. The load calculated is not showing a problem in breaching the primary containment structure (for e.g, the liner - assuming that it is still in reasonable condition). Additional parametric studies are ongoing. I have provided the preliminary assessment to Mike Salay and Hossein already.

This is the case where the water did not completed flooded the reactor cavity. If the cavity is completely flooded, the FCI will not be an issue. I think, flooding the reactor cavity is being considered. I know MCCI analysis been carried out by Mitch Farmer (ANL) - which is a DOE directed analysis.

Your advise (and Brian Sheron one if you need to consult with him) is sought for us to share this FCI analysis with the Science Council through John Kelly This will give us some visibility on the pro-active analyses that are on-going at different labs directed by DOE.

Richard