

July 7, 2015

MEMORANDUM TO: Richard P. Correia, Director
Division of Risk Analysis
Office of Nuclear Regulatory Research

THROUGH: Peter L. Appignani, Chief */RA/*
Probabilistic Risk Assessment Branch
Division of Risk Analysis
Office of Nuclear Regulatory Research

FROM: Fernando Ferrante, Reliability and Risk Analyst */RA/*
Probabilistic Risk Assessment Branch
Division of Risk Analysis
Office of Nuclear Regulatory Research

SUBJECT: SUMMARY OF CLOSED MEETING TO DISCUSS TECHNICAL ASPECTS
OF HIGH WINDS PROBABILISTIC RISK ASSESSMENT METHODOLOGIES

On May 28th, 2015, NRC staff held a noticed, closed meeting with Applied Research Associates (ARA) staff to discuss research topics regarding High Winds Probabilistic Risk Assessment (PRA) methodologies in a technical seminar format. The seminar involved general information exchange having no direct or substantive connection to any specific NRC regulatory decision or action. This meeting summary intends to provide additional details on the overall meeting and share the presentation slides used during the technical presentation portion of the meeting.

Dr. Lawrence Twisdale, Dr. Peter Vickery, and Dr. Jeff Sciaudone from ARA provided presentations on several topics in this area during the seminar. The motivation for this meeting was born out of a discussion at the PSA 2015, International Topical Meeting on Probabilistic Safety Assessment and Analysis, which took place between Sunday, April 26 and Thursday, April 30, 2015, in Sun Valley, Idaho. ARA staff delivered several technical presentations of interest to the NRC at this conference. Based on discussions between NRC staff and ARA staff, the subsequent meeting on May 28th, 2015, was coordinated and held at the NRC's Office of Nuclear Regulatory Research's Church Street Building, in order to share the information presented at the conference more widely with staff from other NRC Offices.

The meeting was closed because it was intended to be exclusively an information exchange not related to any specific regulatory decision. Should a member of the public wish to participate in any future discussions on this topic, please contact Fernando Ferrante, Reliability and Risk Engineer, at 301-415-8385 or at Fernando.Ferrante@nrc.gov.

CONTACT: Fernando Ferrante, RES/DRA
301-415-8385

The following agenda was provided shortly before the meeting:

1. Hazard Curve Estimation and Uncertainties
 - a. Straight Wind/Hurricanes (9:00AM to 9:15AM)
 - b. Tornadoes and Database/Modeling Issues (9:15AM to 9:30AM)
2. Walkdowns (9:30AM to 9:45AM)
3. Fragility Analysis
 - a. Wind Pressure-Code Based Fragilities (9:45AM to 10:00AM)
 - b. Detailed Progressive Failure Modeling (10:00AM to 10:15AM)
 - c. Missiles (10:15AM to 10:30AM)
4. Conditional Loop (10:30AM to 10:45AM)
5. PRA Integration and Needed Research/Projects (10:45AM to 11:00AM)

The initial presentations concentrated on an overview of available methods and challenges in the characterization of a hazard curve with respect to straight winds, hurricanes, and tornadoes. ARA staff indicated that peak wind gusts between 115 mph to 150 mph would typically represent the range where potential damage to buildings due to debris and structural impacts could be observed. The need for stochastic modeling in hazard characterization, given the potentially large uncertainties involved, and the capabilities to derive a family of hazard curves via simulation were also presented. Two important aspects not typically considered were identified: (1) consideration of directional wind analysis for vulnerable structures to reduce the level of conservatism in straight winds analysis, and (2) assessment of the impact of rain on plant equipment, as this phenomenon often accompanies high wind events.

ARA staff also discussed ongoing efforts at the National Institute of Standards and Technology (NIST) to update current guidance on tornado wind risk, aimed at leveraging new data that became available over the past decade in order to derive tornado risk maps for the United States. As part of this work, factors affecting hazard modeling, such as the inconsistent reporting of tornadoes across different time periods, path area uncertainties, and the windspeed relationship across commonly used scales (e.g., Fujita and Enhanced Fujita Scale) will be taken into account to better reflect the extremely large epistemic uncertainties associated with tornado hazard modeling.

On the topic of high winds walkdown activities, ARA staff described extensive experience gained from performing actual walkdowns at several US commercial nuclear power plants. The presentations highlighted the importance of using plant-specific information as part of developing high-quality PRAs, with several insights such as the need to perform a proper inventory of potential sources of wind-borne missiles, developing an equipment list correlated with a plant response model, and collecting relevant information (e.g., history of wind damage at the plant, impact of planned outages/construction with respect to changes in missile inventory). Specific examples where a detailed walkdown derived additional insights for consideration in PRA modeling were provided, as well as general guidelines to be considered when preparing such a walkdown.

The presentations on high wind fragilities included explicit examples of derived fragilities for doors, roof and wall structures, and exposed piping, along with a discussion of the stochastic code-based and structural-based methodologies used to derive them. A specific discussion on the use of progressive failure modeling focused on detailed 3-D models of buildings to capture the effect of components that may have different wind resistive capability, as well as the failure of weaker components leading to additional failures due to internal pressure and other factors. Insights on newer understanding regarding the response of bare frame structures versus fully framed structures were also presented.

With respect to the detailed modeling of high-wind generated missiles, ARA staff presented results obtained via the TORMIS software. A background on the complex nature of the analysis which includes winds effects, aerodynamics, large numbers of missiles, 3D geometries, and the dynamics of missile impacts, among other factors, was discussed. The examples presented highlighted critical inputs and considerations such as accounting for equipment inside vulnerable structures, missile impact damage models, and the use of simulation to quantify statistical model convergence for missile fragilities.

Finally, the modeling of loss of offsite power (LOOP) events conditional on high wind events was discussed. ARA staff presented current approaches and challenges related to establishing probabilistic thresholds for a conditional LOOP characterization (i.e., as a function of wind speed). Important inputs include the identification of the design of power lines, supporting structures, and switchyard structures, which ARA staff indicated are typically designed for winds with a return period of about 100 years. The impact of such assumptions in LOOP values typically included as weather-related LOOP events was highlighted. The presentation portion of the meeting concluded with a brief discussion of PRA modeling aspects for high wind events, such as the need to combine multiple hazards (as most sites will have 2 to 3 wind hazard contributors); the need to appropriately discretize the input hazard curve in wind speed intervals to reduce estimation errors; and the use of a broad wind speed range due to the typical inclusion of both weak and strong components in the model (i.e., from about 50 mph to over 300 mph).

The discussion portion of the meeting included an informal sharing of information on technical issues of interest, as well as items in need of additional research. Areas for further modeling, data collection, and plant response were identified by ARA staff. The potential for NRC to leverage the current efforts being undertaken at NIST, which ARA is involved with, was highlighted. NRC staff indicated the timely discussion of these items given multiple activities being undertaken, and interest in either pursuing or following the developments in this technical area.

The following NRC staff participated in the meeting:

John Lane	Nathan Siu	Lawrence Criscione	Fernando Ferrante	Alan Kuritzky
Joe Rivers	Ching Ng	Jessica Voveris	David Gennardo	Pat Madden
Jonathan DeJesus	Sean Peters	Lauren Ning	Chad Regner	
Kevin Coyne	See-Meng Wong	John Hanna	Rudy Bernhardt	

Enclosure:

ARA Slide Presentation

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Enclosure:

ARA Slide Presentation

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OFFICE	RES/DRA/PRAB	BC:RES/DRA/PRAB	D:RES/DRA
NAME	F. Ferrante	P.Appignani (AKuritzky for)	R. Correia
DATE	7/6/15	7/7 /15	7/7/15

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