



**UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS  
WASHINGTON, DC 20555 - 0001**

May 19, 2008

The Honorable Dale E. Klein  
Chairman  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555-0001

**SUBJECT: DRAFT NUREG/CR-6962, "APPROACHES FOR USING TRADITIONAL  
PROBABILISTIC RISK ASSESSMENT METHODS FOR DIGITAL SYSTEMS,"  
AND RELATED MATTERS**

Dear Chairman Klein:

During the 552<sup>nd</sup> meeting of the Advisory Committee on Reactor Safeguards, May 8-9, 2008, we reviewed the draft NUREG/CR-6962, "Approaches for Using Traditional Probabilistic Risk Assessment Methods for Digital Systems." Our Digital Instrumentation and Control (DI&C) Systems Subcommittee also reviewed this matter during a meeting on April 17, 2008. During these reviews, we had the benefit of discussions with representatives of the NRC staff and its contractor Brookhaven National Laboratory. We also had the benefit of the documents referenced.

**Conclusions and Recommendations**

1. Draft NUREG/CR-6962 provides convincing evidence that "traditional" probabilistic risk assessment (PRA) methods are not sufficient to adequately identify failure modes of DI&C systems.
2. Before publication of NUREG/CR-6962, it should be revised to state clearly that its methods do not address software failures and that it employs simulation in addition to traditional PRA methods. The revised NUREG/CR report should focus on failure mode identification only.
3. The distinction between traditional and non-traditional methods of modeling and analysis is artificial and should be abandoned. The staff should establish an integrated program that focuses on failure mode identification of DI&C systems and takes advantage of the insights gained from the investigations on traditional PRA methods and on advanced simulation methods.
4. The quantification of the reliability of DI&C systems should be given a low priority until a good understanding of the failure modes is developed.

## **Discussion**

The current NRC research plan on DI&C follows a two-pronged approach in the DI&C reliability and PRA areas, namely, one effort focused on “traditional” methods and the other on “advanced” methods. The former refers to the event tree/fault tree PRA methods and includes Markov models. The latter refers to simulation-based methods. Draft NUREG/CR-6962 is a product of the study on traditional methods.

The stated purpose of this study is to determine whether traditional PRA methods are sufficient to develop and quantify reliability models for DI&C systems. A major limitation is the fact that it deals only with the hardware components of the DI&C system and ignores potential failures of the software. This severe limitation should be stated explicitly at the beginning of the report. During our previous meetings, we have commented on the significance of errors in software logic design and specification requirements, and the role they have played in digital software failures recorded in other industries.

This study has demonstrated that, even with the exclusion of software failures, traditional PRA methods are not sufficient for the identification of the failure modes of a DI&C system. In order to determine the impact of specific failure modes of the hardware parts on the system, the investigators had to employ a dynamic simulation analysis of the DI&C system including its software. This is a computationally intensive combinatorial approach that can involve millions of fault sequences.

The draft NUREG/CR report contains a discussion on the development of reliability models for DI&C systems and the collection of data for parameter estimation. It is premature to attempt to develop such models when our understanding of the failure modes of DI&C systems is still evolving. We also have serious concerns about the usefulness of the failure rate data sources cited. The sections dealing with probabilities should be drastically reduced or deleted altogether.

This study, as well as the work on simulation methods that we reviewed in the past, leads us to conclude that, as a community, we have a poor understanding of the potential failure modes of DI&C systems, and that attempting to develop reliability models is premature.

The staff should establish an integrated program that focuses on failure mode identification of DI&C systems. The distinction between traditional and non-traditional methods of modeling and analysis should be abandoned, since this distinction is at best artificial and, in practice, it may even be counterproductive. The important question that should be answered is:

What methods and tools are effective in identifying DI&C system software-related and hardware-related failure modes including their important mutual interactions and their response to changes in process variables?

Draft NUREG/CR-6962 provides valuable information on a digital feed-water control system (DFWCS). This system has also been investigated in the NRC research project, "Dynamic Risk Modeling" that employs "advanced" methods. It can, therefore, be used as a benchmark study in the integrated program. The traditional-methods project plans to investigate a second system, the reactor protection system (RPS). The investigation of an actuation system should also be part of the integrated program.

The draft NUREG/CR-6962 contains an appendix (Appendix C) that has some useful ideas on how DI&C systems fail. These ideas should be explored in the recommended integrated program. We have been told by the staff that Appendix C will not be included in the final NUREG/CR report.

We look forward to interacting with the staff on these important matters.

Sincerely,

*/RA/*

William J. Shack  
Chairman

#### References

1. Draft NUREG/CR, "Approaches for Using Traditional PRA Methods for Digital Systems," with the following attachments, February, 28, 2008:
  - Appendix A, "Summary Report of the External Review Panel Meeting on Reliability Modeling of Digital Systems (May 23–24, 2007)"
  - Appendix B, "Detailed FMEA of the DFWCS at Different Levels"
  - Appendix C, "Modeling of Software Failures"
  - Appendix D, "Other Methods for Modeling Digital Systems"
  
2. T. Aldemir, M. P. Stovsky, J. Kirschenbaum, D. Mandelli, P. Bucci, L. A. Mangan, D. W. Miller, X. Sun, E. Ekici, S. Guarro, M. Yau, B. Johnson, C. Elks, and S. A. Arndt, "Dynamic Reliability Modeling of Digital Instrumentation and Control Systems for Nuclear Reactor Probabilistic Risk Assessments," NUREG/CR-6942, The Ohio State University, ASCA, Inc., University of Virginia, and U.S. NRC, October 2007.

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