

May 26, 2000

Dr. Dana A. Powers  
Chairman  
Advisory Committee on Reactor Safeguards  
U.S. Nuclear Regulatory Commission  
Washington D.C. 20555-0001

SUBJECT: RESPONSE TO ACRS LETTER OF APRIL 18, 2000, PROPOSED NRC  
RESEARCH PLAN FOR DIGITAL INSTRUMENTATION AND CONTROL

Dear Dr. Powers:

The staff appreciates the recommendations that the Advisory Committee on Reactor Safeguards (ACRS) made in its letter of April 18, 2000, on the proposed NRC Research Plan for Digital Instrumentation and Control (I&C). The staff is currently working to finalize the Research Plan and provide it to the Commission for their information. As stated in the ACRS letter, the digital I&C area is critically important to the NRC, and the Research Plan will be an important part of defining how the NRC will meet the challenges and embrace the opportunities presented by this technology.

As recommended in the 1997 National Research Council study (reference 1) the Research Plan is developed to provide a road map for both short-term confirmatory research needs and long-term anticipatory research needs. These short-term confirmatory needs have been articulated in an updated user need memorandum (reference 2) that spells out research that is needed by the Office of Nuclear Reactor Regulation (NRR) to ensure safety and improve the efficiency, effectiveness, and realism of the regulatory process. The Office of Nuclear Regulatory Research (RES) has coordinated with NRR to ensure that the Research Plan will meet these needs for confirmatory research and that the schedule for the research and the products support the improvement of the regulatory process.

As recommended by the National Research Council's study and by the ACRS, the Research Plan includes a section on Emerging I&C Technologies and Applications. This area is primarily anticipatory in nature and will prepare the NRC to meet predictable developments in this important field. The advancing capabilities and complexity of digital I&C systems and the inevitable increase in the use of digital I&C systems in nuclear power plants makes this anticipatory research of critical importance. Additionally long-term research will include development of appropriate methods to include digital and software systems into PRAs.

Currently, NRR staff uses the guidance in the Standard Review Plan (SRP) Chapter 7, Revision 4, June 1997, for the review of plant-specific and topical reports related to digital I&C systems. The guidance is considered to be a thorough and structured approach for evaluating digital I&C system designs and will continue to be followed until a more efficient approach is established using inputs from these RES efforts and stakeholder interaction. Chapter 7 of the SRP is also being used by regulatory agencies in several foreign countries for evaluating digital I&C system

applications. Both RES and NRR staff are currently involved in evaluating these applications of SRP Chapter 7 guidance, as recommended by the National Research Council. The experience gained and lessons learned by the reviewers and the staff will be incorporated in a future revision of SRP Chapter 7.

The ACRS provided six specific conclusions and recommendations. As part of finalizing the Research Plan, the staff will revise the plan to address the noted ACRS conclusions and recommendations as follows:

1. “Specific anticipated output or product for each research task should be identified and the way in which this output or product meets the Agency needs should be clearly established. It is not sufficient to indicate that the task output is a report or a computer program.”

In the draft of the Research Plan reviewed by the ACRS many of the research tasks provided clear outputs, highlighting the products of the research task such as proposed acceptance criteria, examples of acceptable methods and practices, and results of pilot programs. However, as pointed out, there are some task outputs that could provide additional information in this area. As recommended, as part of finalizing the Research Plan, the staff will review all the task output descriptions to ensure that they are as definitive as possible for the given research, and that the results are outcome based and tied to one or more performance goals. Where the research is in support of NRR user needs, the output descriptions will reference the requested products.

2. “The approach to be taken or tools to be developed to reduce review time or to increase the assurance of the safety of digital systems being reviewed (e.g., how the proposed task accomplishes the specified goal or research result) should be stated and justified.”

In the draft of the Research Plan reviewed by the ACRS, the approach to be taken for each task was included in the task descriptions. The staff will review all the task descriptions to ensure that they clearly show the approach each task will take to provide the desired result.

3. “Quantitative estimates of the anticipated benefits should be given where possible.”

The objective of setting detailed quantitative goals for the anticipated benefits for all of the research tasks may not be achieved in all cases. In the draft Research Plan some of the tasks descriptions provide outputs that are quantitative, such as, 3.3.2 “Investigate Criteria for Software Testing,” with a tangible goal to reduce staff review time and improve consistency by improving the criteria for performing software tests. The staff understands the desirability of quantitative goals for research programs. However, in many cases this is not practical, particularly in the case of anticipatory research in areas of emerging technology. The staff will review all the tasks to ensure that they contain the most quantitative estimates of anticipated benefits that are practical for the given research.

4. “The software systems program being conducted at the University of Virginia is currently the “magnum opus” of the Office of Nuclear Regulatory Research (RES) Digital I&C research effort. Showing how this program is meeting the research needs of NRC (or progressing toward this goal) could illustrate how activities proposed in this Research Plan could meet their specific objectives.”

The University of Virginia’s work is focused on assessment of digital failure modes based on methods that include both the software and hardware and the interaction between them. This work is an important part of research in the risk assessment of Digital I&C Systems research area. As recommended, the staff will add to the background sections of all the appropriate parts of the Research Plan a discussion of how current programs, like the one at the University of Virginia, are providing information that is needed to meet specific objectives. Additionally, the University of Virginia’s work will be highlighted in the Introduction of the Research Plan.

5. “Each proposed task should be analyzed to determine the best approach to accomplish its goal. In some cases, buying commercial software, obtaining technology from other Government Agencies or industries, or adopting industrial standards rather than research may be adequate.”

This was done for each proposed task in the draft version of the Research Plan, and where appropriate, included as part of the task description for the research, for example, 3.2.4, “Instigate Requirements Specification Assessment Methods” discussed the assessment of methods and tools in current use and a pilot program to assess the effectiveness of the recommended tools. As part of completing the final version of the Research Plan, the staff will highlight areas where current methods and standards may provide the solutions and the reasons current methods and standards are not adequate for other areas.

6. “The priorities for the various tasks should be explicitly stated in the proposed Research Plan.”

The final version of the Research Plan will include detailed time lines, including a Gantt Chart, and priorities for the research tasks based on NRR needs and projected resource levels that were not available at the time of the ACRS review.

In addition, to specific conclusions and recommendations, the ACRS letter also provided a discussion on how to improve the Research Plan. In the discussion of Systems Aspects of Digital Technology, the ACRS advised that the principal issue for NRC is how to ensure that commercial-off-the-shelf (COTS) software can safely and reliably handle safety-critical functions. Regulatory research in this area concentrates on the development of standards for acceptance of digital systems for use in nuclear power plant applications for safety-critical functions. This is particularly needed for the application of COTS systems. The Research Plan is being revised to highlight this aspect of the research. Also, in the discussion of Systems Aspects of Digital Technology, the ACRS advised that unless there are new unforeseen aspects of the stressor that are being looked at in the RES investigations of environmental stressors on

digital I&C systems, this program should be concluded expeditiously. This research, with the exception of research on lightning is scheduled to be completed in FY 2001. The research on the influence of lightning that was previously recommended by the ACRS has not proceeded in the past because of limitation on funding and the need to work on other higher priority work. The research on lightning will begin this year and is scheduled to be completed in FY 2003.

In the area of Software Quality Assurance, the ACRS advised that establishing objective criteria for the adequacy of software quality assurance based on sound principles is an important task. The ACRS supports the elements of the Research Plan that are directed toward meeting NRR's needs to improve its review process in this area. The tasks in the Research Plan are directed to meeting the needs of NRR by establishing objective criteria for the adequacy of the software quality assurance based on a sound technical basis. The research as part of task 3.3.2, Investigate Criteria for Software Testing, of the proposed Research Plan will provide the objective criteria for adequacy of software quality assurance. Research as part of task 3.3.1, Investigate Software Engineering Practices and Measures, will support improvements in NRR's review process.

The ACRS noted, as part of the discussion on the Risk Assessment of Digital I&C Systems portion of the Research Plan, that the NRC has immediate needs for databases on failure rates of systems containing digital electronic components and the failure modes of digital components and software. The ACRS advised that work to develop these databases deserved priority support. This work, which is ongoing, has produced some preliminary results that have been published in open literature (reference 4). This work will continue to receive priority support. The ACRS also advised that the NRC will need probabilistic methods to analyze the performance of systems with digital elements. This work, including an effort at the University of Virginia, will continue to be supported. This is part of the work that will provide probabilistic tools for use by the NRC.

In the area of Emerging I&C Technologies and Applications, the ACRS advised that, in the long run, automated operation of nuclear power plants with advanced features seems inevitable. The ACRS noted that NRC must be prepared to address such issues when these new systems are brought in for review. The ACRS further noted that preparing for such predictable developments is a desirable element of anticipatory research. The tasks in the Research Plan in this area are designed to provide this anticipatory research. These tasks include evaluation of the advanced features that are sited in the ACRS letter, automatic replacement of signals from faulty sensors, and self-adaption to changing conditions. Non-mechanistic models will be reviewed as part of task 3.5.3, Advanced Instrumentation, and 3.5.4, Smart Transmitters. Additionally task 3.5.1 of the Research Plan includes ongoing review of emerging technology to ensure that the research program is focused on the most important emerging technologies.

Dana A. Powers

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The staff appreciates the opportunity to work closely with the ACRS in the development of the Digital Instrumentation and Control Research Plan. Since this Research Plan will need to be updated on a regular basis as parts of the plan are accomplished and as new issues emerge, the staff anticipates providing updates to the ACRS on plan accomplishments and plan update on a continuing basis.

Sincerely,

***/RA by Carl Paperiello Acting For/***

Williams D. Travers  
Executive Director  
for Operations

cc: Chairman Meserve  
Commissioner Dicus  
Commissioner Diaz  
Commissioner McGaffigan  
Commissioner Merrifield  
SECY

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1. National Research Council. "Digital Instrumentation and Control Systems in Nuclear Power Plants (Safety and Reliability Issues)," 1997.
2. Memorandum dated March 17, 2000, from Samuel J. Collins, Office of Nuclear Reactor Regulation to Ashok C. Thadani, Office of Nuclear Regulatory Research, Subject: User Need for Digital Instrumentation and Controls Research.
3. U.S. Nuclear Regulatory Commission, NUREG-1635, Review and Evaluation of the Nuclear Regulatory Commission Safety Research Program, Volumes 1 and 2 (Volume 3 is in Print), 1998, 1999, and 2000, respectively.
4. Jackson, T.W. and R.W. Brill, "Instrumentation and Control Systems Failures in Nuclear Power Plants," Eight International Conference on Nuclear Engineering (ICONE-8), April, 2000.