N6124
DIGITAL SYSTEM DEPENDABILITY PERFORMANCE

Presentation
For
Commissioner Merrifield

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OVERVIEW

- BACKGROUND
- OBJECTIVE
- DIGITAL SYSTEM DEPENDABILITY PERFORMANCE PROJECT OVERVIEW
  - PROCESS
  - OUTCOMES
- RISK-INFORMING DIGITAL I&C REVIEWS
- SUMMARY

BACKGROUND

- NRC has approved several digital, computer-based systems for safety-related (SR) service in nuclear power plants
- These Digital Instrumentation and Control (I&C) systems are installed in operating plants
- Advanced plants will use highly integrated digital instrumentation and controls systems
- Many challenging issues facing NRC
  - Significant increase in complexity
  - Failures of software quality assurance programs (i.e., Palo Verde)
  - Embedded inter-channel communications (i.e., breakdown in separation of redundant channels)
  - Embedded communications between safety and non-safety processors (i.e., breakdown in safety/non-safety separation)
  - Un-quantified failure modes (e.g., software common-mode failures, microprocessor, communication, peripheral components)

OBJECTIVE

- Provide an independent assessment methodology for quantifying digital system safety (including software-hardware interactions) in a risk context that can be directly applicable to probability risk assessments

PLANNED ASSESSMENT OVERVIEW

- NRC will supply Contractor with a safety system as government furnished equipment
  - Potential for vendor-supplied equipment (collaborative arrangement)
- Based on safety assessment method developed by the University of Virginia (UVA) through funding from many contributors
  - NRC has collaborated with UVA since 1998 to develop this method
  - National Science Foundation, Federal Railroad Administration, NASA, Boeing, Lockheed-Martin, Maglev, Union Switch & Signal, others

PLANNED ASSESSMENT OVERVIEW, cont.

- Safety assessment method
  - Develop models representing both “safe” and “unsafe” failures
  - Perform fault-injection experiments on a model of the system (a hardware prototype, a software model, or a combination) to learn system failure characteristics
  - Analyze the results to quantify system and safety reliability
- Average of 12 months per system evaluation
  - Intent is to replicate actual nuclear plant hardware/software configuration(s) to the extent possible (one channel at most)
  - One option is the Oconee RPS/ESF, but this project is not coordinated with the NRC application review schedule

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- TELEPERM XS (TXS) is the first test case
- General Services Administration has issued the purchase order to the vendor for the TELEPERM XS safety system
  - Engineering workstations for system development/operation
  - Gateways (Linux and Windows 2000)
  - TELEPERM XS safety processor (chassis, processor modules, communications modules, some input/output modules)
  - Spare modules
  - Must configure the system prior to testing
    - Work with Oconee and/or AREVA-NP to obtain nuclear application software
    - Engineering workstations will allow NRC to develop custom configurations to support various applications

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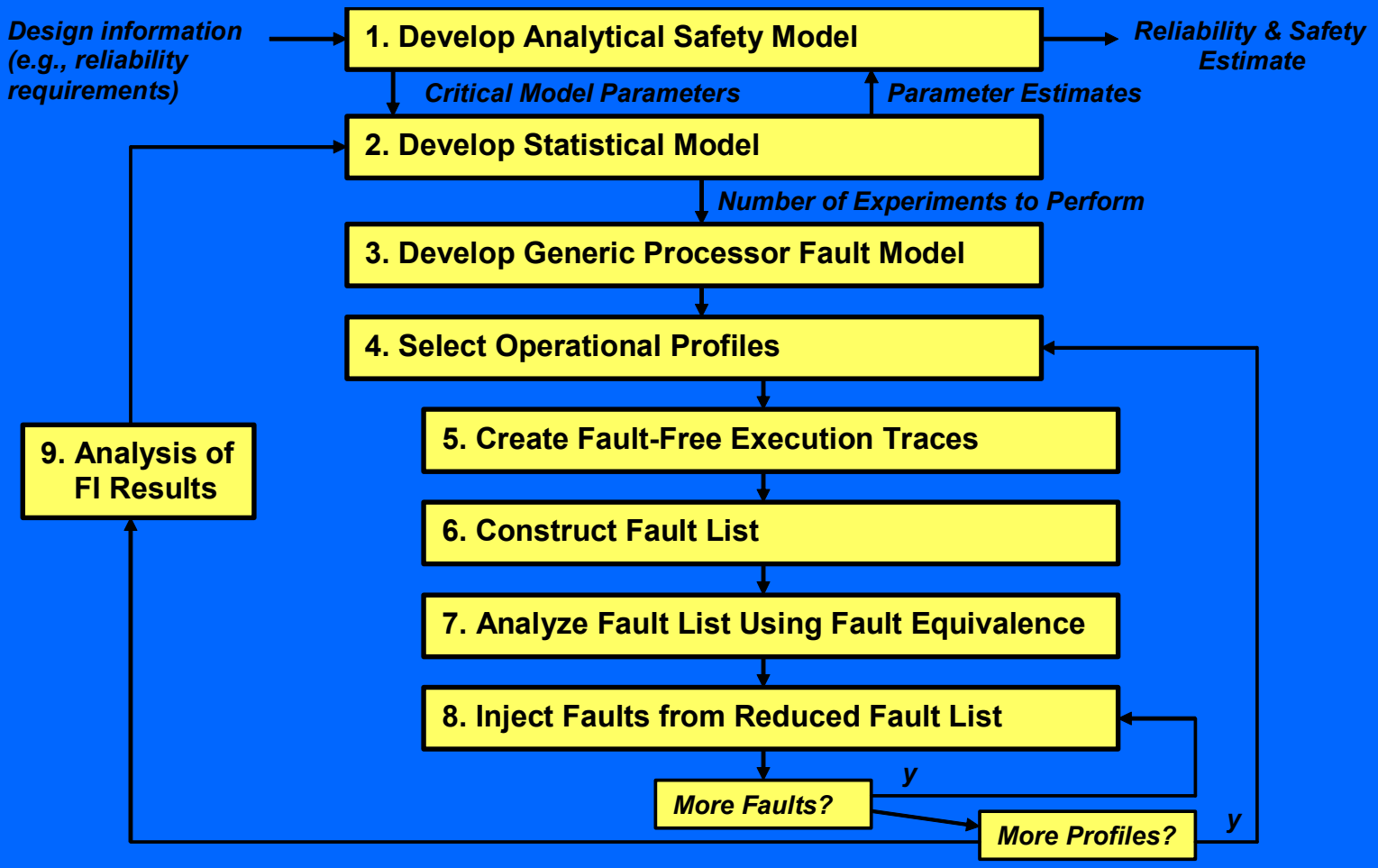
- Status
  - Chairman has concurred on project acquisition memo dated May 16, 2006
  - Source Evaluation Panel is preparing its recommendation on contract award for the Contracting Officer; final decision on vendor pending
  - Expect to award the contract for this project (N6124) by end of July
- Schedule
  - Vendor has begun building the TELEPERM XS system (ordered parts, etc.) June 2006
  - Delivery of TELEPERM XS system ~ October 2006
  - Dependability Performance testing starts January 2007
  - First system assessment completed January 2008

N6124: PROCESS



N6124: OUTCOMES

- Understand better:
  - The behavior of hardware/software systems under the influence of internal and external faults
  - Analysis of consequent errors that might produce system failures
- Analyzed and properly characterized system(s) for:
  - Performance
  - Reliability/Availability quantification
  - Failure modes under anticipated operating conditions
  - Subsystem and system interconnection safety
  - Risk-based failure information for probabilistic risk assessments
- Obtain a tool that can support independent assessment and validation of digital system performance

RESEARCH ON RISK-INFORMING DIGITAL SYSTEM REVIEWS

- NRC research is focused on development of
  - Regulatory Guidance to support risk-informed review of digital systems
    - Development of 1.174 series Regulatory Guide for digital system reviews
  - Detailed models of digital systems and development of reliability modeling methods that can integrate these models into traditional probabilistic risk assessments
    - Review of available modeling methods
    - Development of both traditional and dynamic methods
    - Investigate what models are acceptable
    - Benchmarking results

SUMMARY

- The Digital System Dependability research will augment and supplement the current regulatory process by:
  - Characterizing significant hardware, software, and interface errors;
  - Understanding potential failure modes and the criteria for detecting these failure modes;
  - Modeling of digital systems that could be used to provide empirical evidence of system reliability;
  - Identifying or developing methods and data that enable the NRC to establish the risk important aspects of digital safety systems; and
  - Modeling of digital systems that could be used to support probabilistic risk assessments
- RES plans to evaluate each digital platform approved by the NRC using the selected safety assessment method

BACKUP SLIDE: REFERENCES

- ACRS and NAS recommendations
- PSAM paper laying out the issues (2004)
- NUREG/CR-6901 “Current State of Reliability Modeling Methodologies for Digital Systems and Their Acceptance Criteria for Nuclear Power Plant Assessments” (February 2006)
- Draft NUREG/CR-XXXX “Reliability Modeling of Digital Instrumentation and Control Systems for Nuclear Reactor Probabilistic Risk ” (Currently undergoing peer review)
- Letter Report, “Review of Software-Induced Failure Events in Different Industries to Identify Failure Modes and Mechanisms/Causes”
- Draft Regulatory Guide DG-XXXX “An Approach for Plant-Specific, Risk-Informed Decisionmaking: Digital Systems” (scheduled to be sent out for public comment December 2006)