

Module II – Circuit Analysis Introduction



Joint EPRI/NRC-RES Fire PRA Workshop
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CIRCUIT ANALYSIS INTRODUCTION

Introductions

■ Instructors

- Daniel Funk, P.E. & Dane Lovelace
Power Services Group, JENSEN HUGHES
- Gabriel Taylor, P.E.
NRC, Office of Nuclear Regulatory Research

■ Who's here and why?

- Name, Organization, Experience
- What do you want from this course?

■ Logistics

- Access to building
- Breaks and lunch
- Start and stop times
- Emergency exits

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Course Prerequisites

■ Who Should Attend?

- Nuclear power utility/regulatory personnel with electrical and plant operating knowledge, but limited exposure to Appendix R Safe Shutdown Analysis (SSA) and Fire PRA
- Nuclear power utility/regulatory personnel with substantial Appendix R SSA and/or Fire PRA experience, but limited circuit analysis experience
- Anyone who has a fundamental understanding of nuclear power plant equipment electrical operation will benefit from this course
 - NOTE: This is a working level course and is NOT intended for individuals that do not have at least a fundamental understanding of electrical drawings and electrical control circuits

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What we'll cover this week...

- Overview of Module 2 – Electrical Analysis
 - Course introduction
 - Circuit analysis basics
 - Fire-induced circuit failure concepts and fault modes
 - Circuit analysis process, methods, and criteria
 - Walk through examples
 - Hands-on sample problem exercises
 - Introduce updated methods in accordance with NUREG/CR-7150, Volumes 1, 2, 3
 - Project considerations and lessons learned

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Training Approach and Ground Rules

- Our intent:
 - To deliver practical implementation training
 - To convey fundamental electrical concepts pertinent to fire-induced circuit failures
 - To illustrate and demonstrate application of circuit analysis concepts and methods
- We expect and want significant participant interaction
 - Class size allows for interactive *questions and discussion*
 - We will answer questions about *methodology* and *application*
 - We cannot answer questions about a *specific application at operating plant*
 - We cannot answer questions about *regulatory interpretations*
 - We will moderate “*constructive*” discussions, but will judge when it is time to move on...

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Background

- Module 2 covers technical tasks for analysis of fire-induced circuit failures in support of a Fire PRA
- Module 2 is geared toward PRA practitioners and fire safe shutdown analysts:
 - Fundamental understanding of the concepts and methods of fire-induced circuit failure analysis
 - Context equally useful for Fire PRA or Appendix R SSA circuit failure assessments
- Familiarity with the following topics is recommended:
 - General circuit design and operation for typical plant equipment
 - Working level knowledge of typical electrical drawings – one-line diagrams, schematic diagrams, electrical block diagrams, wiring/connection diagrams, raceway layout drawings, instrument loop diagrams, etc.
 - Appendix R SSA or Fire PRA circuit analysis industry guidance documents
 - Basic circuit analysis techniques for identifying and classifying fire-induced circuit failure modes
 - Database structure for cable and raceway systems, Appendix R SSA, and Fire PRA
 - Typical software tools used for Appendix R SSA and/or Fire PRA
 - Relevant issues and challenges associated with fire-induced circuit failures and failure probabilities

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Course Goals

- It is expected that upon completion of the Circuit Analysis Module attendees will:
 - Have a basic understanding of fire-induced circuit failure modes
 - Be able to explain how circuit design parameters influence cable failure modes and the associated functional impact on circuit operation
 - Have sufficient working knowledge of techniques and methods to perform at a practical level the electrical analysis tasks for typical plant equipment
 - Have a precise understanding of circuit analysis terms and acronyms so as to avoid common misconceptions and misapplications
 - Have an general understanding of the fire-induced circuit failure testing that has been conducted and the resulting changes in circuit analysis concepts
 - Have an appreciation for circuit analysis challenges and potential impacts on a Fire PRA project
 - Be able to explain basic circuit analysis concepts and use typical techniques to perform and document a circuit analysis
- Methodology presentations will show relationships to the **PRA Standard** and **NEI 00-01, Rev. 2** (NOTE: both documents are under revision)

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Module 2 Presentation Road Map

- Course Introduction
- Circuit Analysis Basics
- Fire-Induced Circuit Failure Concepts and Fault Modes
- Circuit Analysis Process, Methods, and Criteria
- Walk Through Sample Problems
- Hands-on Sample Problem Exercises
- Project Considerations and Lessons Learned

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Schedule / Agenda

Module II - Circuit Analysis Agenda		
Day	Title	
Monday	AM	Introduction & Overview to Circuit Analysis
	PM	Circuit Analysis Fundamentals / Fire Research
Tuesday	AM	Cable Failure Modes - Theory and Application
	PM	Circuit Failure Modes - Theory and Application
Wednesday	AM	Task 3 - Cable Selection / Task 9 - Detailed Circuit Analysis
	PM	Task 10 - Failure Mode Likelihood / Example Walk Through
Thursday	AM	Practical Exercises
	PM	Practical Exercises
Friday	AM	Practical Exercises / Summary
		Wrap up and adjourn

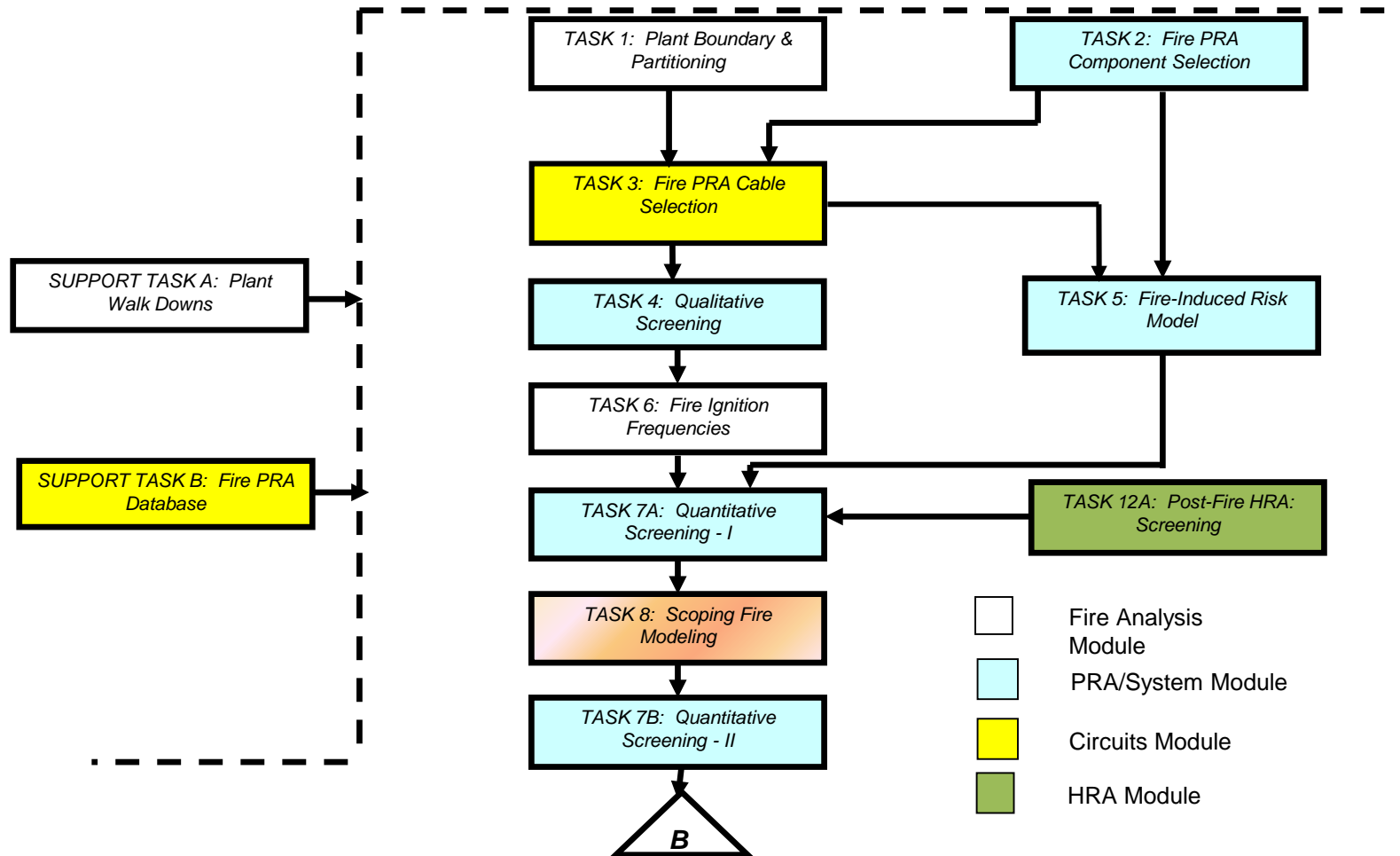
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Circuit Analysis Tasks

- Task 3: Fire PRA Cable Selection
 - What cables are associated with the FPRA components?
- Task 9: Detailed Circuit Analysis
 - Which cables can affect the equipment functionality in PRA model?
 - Task 9A / 9B Split
 - What failure modes are possible given fire damage to the cable?
- Task 10: Circuit Failure Mode Likelihood Analysis
 - Conditional probability of hot-short given cable damage
 - NUREG/CR-7150, Vol. 2, May 2014
- Support Task B: Fire PRA Database
 - Data relationships and integrity
 - Configuration control of large number of inter-related records

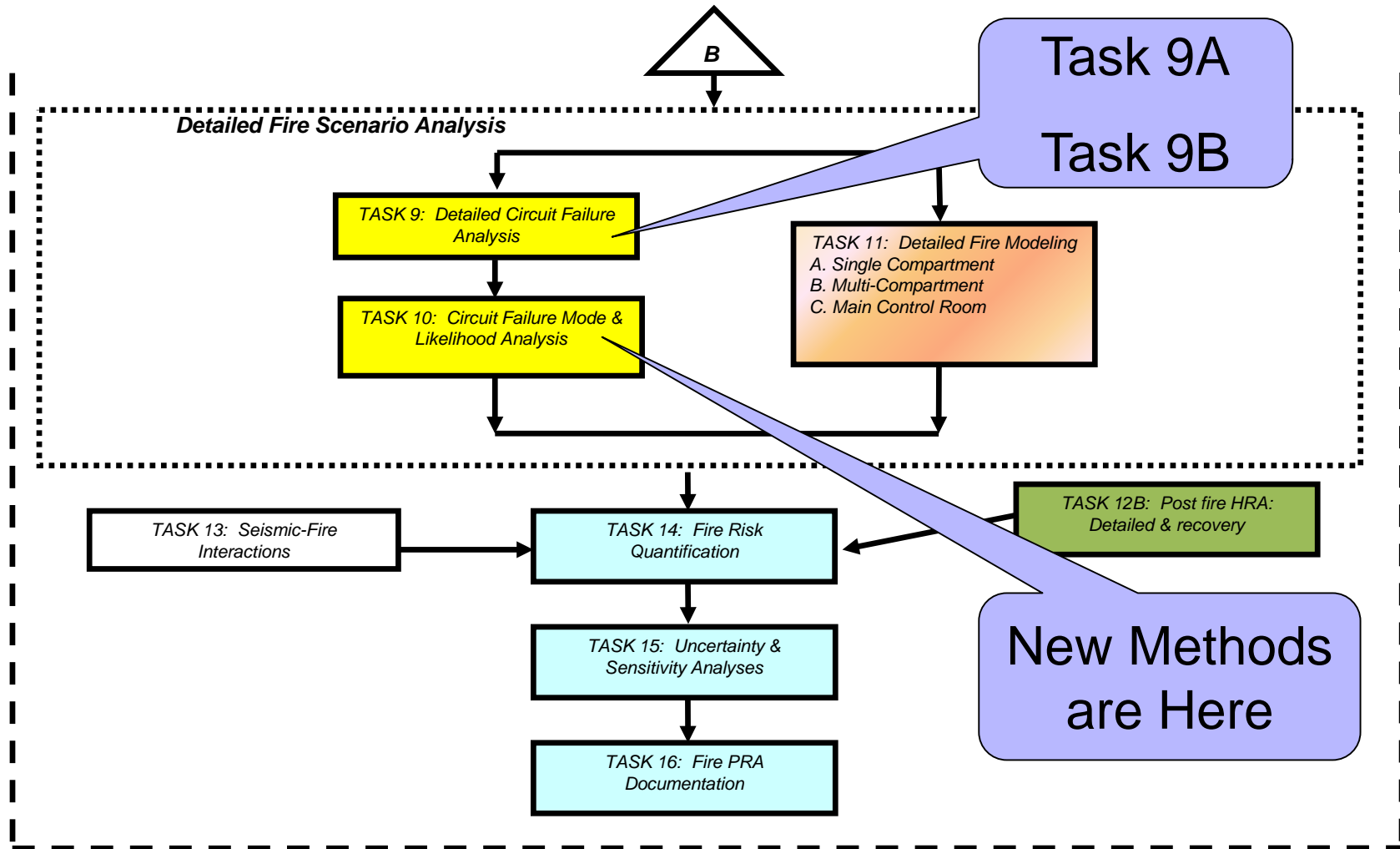
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Circuit Analysis Tasks



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Circuit Analysis Tasks, cont.



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Key Concepts & Considerations

- Each Circuit Analysis task represents a refined level of detail (i.e., graded approach)
- Existing Appendix R SSA Circuit Analysis is NOT as useful as originally envisioned
- Circuit Analysis for Fire PRA is more complex and difficult compared to Circuit Analysis for Appendix R SSA
- Circuit Analysis (including cable routing) can consume 40%-70% of overall budget
- Circuit Analysis scope **MUST** be a primary consideration during project planning

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Any questions before we start ???

