Module 0: Fundamentals – This module covers principal elements for each technical area covered in the Fire PRA Course, i.e., PRA, HRA, Electrical Analysis, and Fire Analysis. This introductory module will assist in preparing the student to understand the in-depth fire PRA training modules that follow. It is not intended to be a substitute for education and/or training in the subject matter. The sections under this module are designed for those students who are cross training, rather than for those participants that already possess the required knowledge for each in-depth module. For example, we recommend a Fire Protection Engineer (FPE) attend the section on principals of PRA prior to taking the PRA Module.
Following parallel sections will be offered on the 1st day:

Module 0a: Principles of PRA
Module 0b: Principles of Electrical Analysis
Module 0c: Principles of Fire Science and Modeling
Module 0d: Principles of HRA

Module 1: PRA - This module covers the technical tasks for development of both the system and operator response to a fire. Specifically, this module covers NUREG/CR-6850, EPRI 1011989 Volume 2, Sections 2, 4, 5, 7, 14, and 15. This module is suited for PRA practitioners responsible for the systems modeling aspects of the fire PRA. Specifically, participants in this module should possess the following knowledge:

- A general knowledge of PRA as applied to nuclear power plants, including typical approaches, modeling techniques (event trees, fault trees, interfaces between PRA and HRA), and the quantification of PRA models
- Some familiarity with plant systems typically found in nuclear power plants. A simplified, but reasonably realistic example of a few plant systems will be used to demonstrate the methodology.
- Some familiarity with P&IDs and their use in developing PRAs

Instructors:

Mr. Richard Anoba is President of Anoba Consulting Services, LLC. He holds a Master of Science degree in Nuclear Engineering from the Massachusetts Institute of Technology along with a Bachelors of Science in Nuclear Engineering from the University of California at Santa Barbara. With over thirty years of experience in the Nuclear Engineering field, Mr. Anoba has extensive experience in the areas of engineering analysis, system reliability analysis, safety analysis, Probabilistic Risk Assessment (PRA), project management, design engineering, and power plant operation. Mr. Anoba has been a key contributor in the development, update, and review of a number of Internal Events PRA models (both Level 1 and Level 2) and a number of External Events Models (seismic, fire, and flood).

Jeffrey L. LaChance is a Distinguished Member of the Technical Staff in the Risk & Reliability Department of Sandia National Laboratories. He has 30 years of experience in commercial nuclear reactor safety. He has significant experience in performing Probabilistic Risk Assessments (PRA) on a variety of facilities including nuclear reactors and fuel cycle facilities,

weapons storage facilities, and chemical plants. In addition to performing PRAs, he has developed innovative PRA methods, helped write an ASME standard on PRA, and supports the Nuclear Regulatory Commission (NRC) on developing PRA quality requirements. He has been involved in the development of risk-informed, performance-based regulations for nuclear reactors since the initiative began at the NRC in 1995. He has been instrumental in the generation of risk-informed regulatory frameworks for existing and future reactors and has been involved in establishing several risk-informed regulations. He has a Bachelors degree in General Engineering (Nuclear Option) from Idaho State University.

Module 2: Electrical Analysis – This module covers technical tasks for analysis of fire induced circuit failures in support of fire PRA analysis. Specifically, this module covers NUREG/CR-6850, EPRI 1011989 Volume 2, Sections 3, 9, and 10. The electrical analysis module is geared toward PRA practitioners and fire safe shutdown analysts with a practical understanding of the concepts and methods of fire-induced circuit failure analysis within the context of fire PRA or Appendix R post-fire safe shutdown circuit failure assessments. Specifically, participants in this module should possess the following knowledge:

- General circuit design and operational control for typical plant equipment
- Basic circuit analysis techniques for identifying and classifying fire-induced circuit failure modes
- Working level knowledge of typical electrical drawings, including one-line diagrams, schematic diagrams, electrical block diagrams, wiring/connection diagrams, raceway layout drawings, instrument loop diagrams, etc.
- Cable and raceway, Appendix R post-fire safe shutdown, and fire PRA database structures and software
- Appendix R post-fire safe shutdown circuit analysis
- Progression of events stemming from the EPRI/NRC cable fire testing to characterize fire induced circuit failures (historical perspective)
- Emerging issues and challenges associated with the analysis of multiple spurious operations

Instructors:

Mr. Gabriel Taylor is a Fire Protection Engineer employed by the U.S. Nuclear Regulatory Commission in the Office of Nuclear Regulatory Research. He has seven years of experience working for the NRC, 5 of those years working in the area of fire-induced electrical cable failure. He has a B.S. in electrical engineering from the Pennsylvania State University and a M.S. in fire protection engineering from the University of Maryland.

Mr. Dan Funk

Module 3: Fire Analysis – This module covers technical tasks involving plant partitioning, fire frequency analysis, and the development and analysis of fire scenarios from fire ignition to target impact and fire suppression. Specifically, this module covers NUREG/CR-6850, EPRI 1011989 Volume 2, Sections 1, 6, 8, and 11. This module is suited for PRA practitioners responsible for treating those aspects of the fire PRA specifically related to the fire growth and damage assessment tasks. Specifically, participants in this module should possess the following knowledge:

- A general understanding of the fire frequency calculation process as practiced in fire PRA
- Knowledge of general fire protection features and systems as typically implemented at a NPP
- A general understanding of how fire models are used in support of the fire PRA (a proficient level of fire modeling expertise is not required)
- A general understanding of fire behavior and the parameters most important to a fire growth and damage analysis (e.g., concepts such as fire spread, heat release rate (HRR), target response, and fire suppression and detection analyses)

Instructors:

Dr. Francisco Joglar is Senior Consultant with the Kleinsorg Group Risk Services. He holds a Master of Science degree in Fire Protection Engineering from the University of Maryland along with a Ph.D. in Reliability Engineering from the same institution. With over ten years of experience in fire protection for commercial nuclear plants, Dr. Joglar has extensive experience in the areas of fire modeling, and Fire Probabilistic Risk Assessment (FPRA), and project management. Dr. Joglar has been a key contributor in the development, update, and review of a number of industry methodologies associated with Fire Modeling and FPRA, and principal analyst on a number of FPRA's.

Mr. Steve Nowlen is a Distinguished Member of the Technical Staff at Sandia National Laboratories. He has over 28 years of experience with the U.S. NRC-sponsored fire protection and fire risk research programs and was RES's technical lead during development of NUREG/CR-6850, EPRI TR 1011989. Mr. Nowlen is also vice-chair of the Fire Writing Team and a member of the Subcommittee on Standards Maintenance under the ASME Committee for Nuclear Risk Management. Mr. Nowlen holds B.S. (with high honor, Phi Beta Kappa) and M.S. degrees in Mechanical Engineering from Michigan State University.

Module 4: HRA – This module covers technical tasks related to modeling human failure events (i.e., the failure of operator responses) in a fire context. This module will focus on the guidance provided in draft EPRI 1019196, NUREG-1921, "EPRI/NRC-RES Fire Human Reliability Analysis Guidelines" which largely replaces the human reliability analysis (HRA) guidance provided in EPRI 1011989, NUREG/CR-6850, Volume 2, Section 12. This module is suited for HRA/PRA practitioners responsible for the HRA aspects of the fire PRA. Specifically, participants in this module should posses the following knowledge:

- A general knowledge of PRA as applied to nuclear power plants, including typical approaches, modeling techniques (event trees, fault trees, interfaces between PRA and HRA), and the quantification of PRA models

- Some familiarity with plant systems typically found in nuclear power plants. Simplified, but reasonably realistic examples of plant systems that may be represented in PRAs and manipulated by operators will be used to demonstrate the methodology.

- Some familiarity with plant operations and operating procedures. Examples of HRA tasks, such as human failure event identification, will use typical operator actions and simplified examples of operating procedures to demonstrate the methodology.

- A general understanding of the typical influences on operator performance and how they are represented in HRA tasks such as human failure event definition and quantification

Instructors:

Dr. Susan E. Cooper is a HRA/PRA specialist employed by the USNRC. She has 25 years experience in HRA, PRA, risk-informed decision-making, and other related areas for a variety of technologies, including commercial nuclear power. She has a PhD in Nuclear Engineering from Massachusetts Institute of Technology.

Mr. Jeff Julius is a Technical Manager in the Risk and Reliability Group at Scientech. He holds a Bachelor of Science in Engineering from the University of Washington. With over 30-years of experience in the Nuclear Engineering field, Mr. Julius has extensive experience in the areas of plant operations, human reliability and engineering analyses. Mr. Julius developed a number of internal events PRA models and Fire PRA models, is project manager for the EPRI HRA Users Group, and represented the industry as an author of the joint *EPRI/NRC-RES Fire Human Reliability Analysis Guidelines* (NUREG-1921).

Ms. Erin Collins is a Senior Risk Analyst employed by Science Applications International Corporation (SAIC). She has 28 years experience in PRA specializing in Human Reliability Analysis and component reliability data collection and analysis. She has a B.S. in Environmental Science from Elmira College. Ms. Collins is a contributing author on NUREG-1921/EPRI 1023001, the EPRI/NRC-RES Fire HRA Guidelines, and has participated in four fire HRAs for utility clients.

Module 5: Advanced Fire Modeling – This module covers the fundamentals of fire science, as well as the guidance for the use of fire models to evaluate fire generated conditions that may impact the nuclear plants safety functions and/or impair operator's ability to safely shutdown the plant after a fire. This module will use the EPRI 1019195, NUREG-1934, "Nuclear Power Plant Fire Modeling Application Guide." This module is suited for fire modeling practitioners. It is recommended that the participants complete Module 3, Fire Analysis, prior to taking this Module. Specifically, participants in this module should possess the following knowledge:

- General knowledge of the fire dynamics;

- General knowledge of the behavior of compartment fires; and
- General knowledge of basic engineering principles, specifically thermodynamics, heat transfer, and fluid mechanics

All participants in Module 5 should bring laptop computers suitable for running the basic fire modeling software to be discussed (the NRC FDT's, CFAST, FDS and MAGIC). Minimum requirements are (1) Windows XP or higher operating system, (2) Microsoft .net framework version 4.0 or higher, and (3) Adobe Reader or Acrobat. It is critical that participants have software installation privileges (e.g., administrator privileges at log-in) so that the fire modeling software can be installed and/or updated if necessary. A software installation session will be conducted Monday from 2PM-5PM for participants in Module 5. All participants in Module 5 should participate in this software installation session whether or not they participate in any of the four fundamentals modules. Instructors will be present to verify installation and function for current versions of the fire modeling software.

Instructors:

Dr. Kevin McGrattan is a mathematician in the Fire Research Division of the National Institute of Standards and Technology. He is the principal developer of the Fire Dynamics Simulator, a computational fluid dynamics model of fire. He joined the staff of NIST in 1991 after receiving a doctorate from the Courant Institute of New York University. He received his bachelors from the School of Engineering and Applied Science of Columbia University in 1987.

Dr. Fred Mowrer is the Director of Fire Protection Engineering Programs at the California Polytechnic State University in San Luis Obispo, CA, as well as a Professor-in-Residence in the program. Dr. Mowrer spent 21 years on the faculty of the Department of Fire Protection Engineering at the University of Maryland before retiring with emeritus status in 2008. He was the principal developer of the quantitative methods of fire hazard analysis incorporated in the original FIVE methodology developed by EPRI in the early 1990s and has provided consulting services in the nuclear fire protection field since then. Dr. Mowrer received his PhD in Fire Protection Engineering and Combustion Science from the University of California, Berkeley, in 1987. He also received his BS degree in Fire Protection and Safety Engineering from the Illinois Institute of Technology in 1976.

Mr. David Stroup is a Senior Fire Protection Engineer employed by the U.S. Nuclear Regulatory Commission in the Office of Nuclear Regulatory Research. He has been with the NRC for five years and has over 30 years of fire protection engineering and fire modeling experience with the Federal government and private industry. He has a B.S. in fire protection engineering and an M.S. in mechanical engineering from the University of Maryland. Mr. Stroup is a registered professional engineer and fellow of the Society of Fire Protection Engineers.