IN USE: PHOENIX: ADVANCED, INTEGRATED SOFTWARE FOR NUCLEAR PLANT RISK MANAGEMENT

ISSUE STATEMENT

The comprehensive assessment and management of risk has become an essential element of the decision-making process for commercial nuclear power plants. The development and maturation of risk technology over the past several decades have led to the evolution of many tools and methods to address risk in different ways and for a broad spectrum of issues. The large number and varied nature of these tools have resulted in inefficiencies and technical challenges in integrating the results they produce. This situation is compounded as increased technical demands are placed on the tools and as new applications are developed. In addition, economic and business constraints will limit the ability to maintain and improve the software that has been developed to accomplish these functions. These constraints will also limit the ability to develop and apply new methods.

As analytical capabilities advance, a structured approach is needed to integrate them into the risk-management tools used at many operating nuclear power plants. Force-fitting advanced capabilities into existing tools can result in a complex process comprised of multiple execution steps, each requiring highly skilled analysts. This, in turn, can result in inefficient use of limited resources and the potential for less than optimal decision-making.

Finally, because the approach to the assessment and management of risks for nuclear power plants has evolved over many years, current tools do not take full advantage of modern computational capabilities (both hardware and software). This situation further limits the efficiency and effectiveness of risk-management activities.

DRIVERS

Support for Effective Risk-Informed Decision Making

The risks associated with events traditionally evaluated in detail have decreased as a result of system modifications and improved operating practices (including the implementation of formal risk-management programs). This has increasingly led to the need to consider other possible hazards that might previously have received less attention. A thorough, integrated understanding of the relative risks posed by these hazards is essential so that resources are applied most effectively to manage these risks.

New Information and Understanding

Actual events and evaluations of trends indicate that earlier assessments may have underestimated the likelihood or safety impact of hazards in some cases. Moreover, the degree to which there are uncertainties in some hazard characterizations is better understood than it may have been when current plants were designed and built. The potential impact of this new understanding is reinforced by the 2011 accident in Japan.

Public Perception

Acceptance of nuclear energy as an important source for generating electricity is profoundly influenced by confidence in the industry's ability to manage technically complex issues and ensure an adequate level of protection of public health and safety. Any event that affects nuclear power plant safety typically receives strong, worldwide media attention. Thus, to earn, maintain and enhance public confidence, it is essential that risks be understood and properly managed.

Support for Extended Operating Life and New Plants

The aging of existing plants presents new demands regarding the need to understand the risk significance of the effects of aging and other emerging nuclear-safety issues. As advanced reactors are built and operated, new tools are needed to address their unique characteristics (e.g., passive safety features). Finally, as new technologies and capabilities become available, it will be desirable to take advantage of these opportunities to enhance plant technical, safety and economic performance. In each of these situations, a comprehensive and integrated assessment of the impact on nuclear safety risk will be required to support effective and efficient decision-making and to convey the results to a broad array of stakeholders.

RESULTS IMPLEMENTATION

The integrated software package developed through this research effort, called Phoenix, will be used at operating nuclear plants and corporate engineering support centers to facilitate risk-assessment and risk-management activities. Phoenix will also serve as an effective means to assemble summary risk information useful in interactions with other parties, including regulators. The primary users of Phoenix on an ongoing basis will be risk analysts, work-week planners, those responsible for on-line and outage work

management, and licensed plant operators. In addition, technical managers, plant system engineers, design engineers, licensing engineers, and senior station management may be expected to use the tools on a less regular basis.

PROJECT PLAN

The objectives for Phoenix will be accomplished by combining the current state-of-the-art methods, tools, and capabilities into a single platform. Phoenix is being built on the existing CAFTA suite of codes to incorporate features from, for example, effective reliability data analysis and configuration risk-management software. Phoenix also supports features from other suites of PRA codes such as large event tree quantification and defense-in-depth displays. This platform will extend to incorporate new aggregation and visualization features. The Phoenix project is intended to be both evolutionary in the short term and revolutionary in the longer term. The plan is to phase Phoenix in at operating power plants over the next three to five years. After a period of transition (including product demonstration and stakeholder acceptance), Phoenix will replace most (and eventually all) of the current suite of EPRI risk tools.

To support this vision, specific activities for the short term (the next two to three years) have been identified.

The first modules of Phoenix, software for performing online and offline risk management, were completed in 2014. Following the implementation of these first modules, a second release was completed mid-2015 to further improve and enhance the features of the initial release. Project participants are now constructing actual plant models, and using the latest release as basis to completing implementation and user training. New releases of the Phoenix Risk Monitor will be completed to support these implementation efforts.

A second phase, focused on "modeling" through development of the "Phoenix Architect", was started in 2015 and will lead a Beta release at the end of 2016. With the existing tools providing the basic structure for Phoenix, additional elements will be phased in, first to include common installation packages and later tighter integration of modeling (CAFTA) tools and analysis tools such as UNCERT or PRAQUANT.).

A third phase will focus on integration with new PRA methods, including incorporation of additional basic analysis capabilities (including the reliability database module and tools for the assessment of external hazards), and the extension to more advanced capabilities (such as addressing time-dependent failure rates and interaction with physics codes and Risk Informed Safety Margin methods. This phase will be started in 2016 with additional developments in 2017

A fourth phase around new methods for data visualization and application by decision makers will be started in 2017 and continue in 2018.

The activities and milestones are depicted in the roadmap graphic.

RISKS

Phoenix is intended to provide a state-of-the-art risk-assessment and risk-management tool that addresses the inefficiencies and technical limitations of the current generation of methods and tools. If Phoenix is not developed and deployed as envisioned, the costs to the industry to meet evolving economic and regulatory challenges could increase substantially. Also, the costs to address critical infrastructure enhancements (e.g., extended power uprates, life extension, etc.) or deployment of advanced nuclear plants would be substantially higher than necessary without enhanced risk-assessment tools.

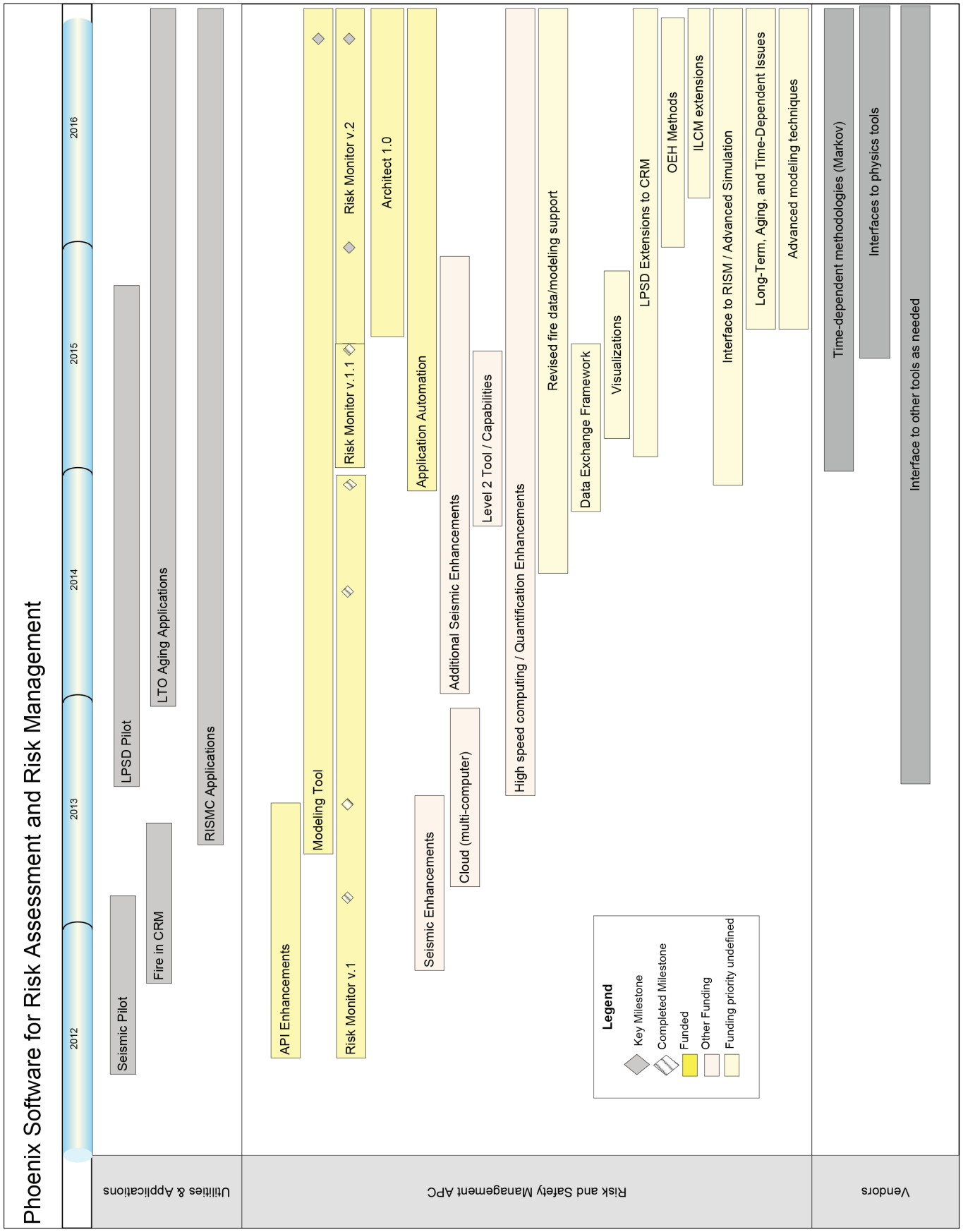
In its evolutionary phase, Phoenix will be implemented at users' sites. The level of success of these implementations can determine the perception and adoption of Phoenix as much as the long term evolutions and feature implementation. The various short term needs of the implementing utilities may not always be compatible and releases will need to offer the right balance to be applicable and useful to all members.

Because the Phoenix development plan leverages the best aspects of current generation methods and tools, significant participation by the vendors who supply this capability is needed. The most significant risk to the timely and successful deployment of Phoenix would result from decisions by various vendors either to participate in the project in a very limited way, or not to participate at all. This situation, if it were to occur, could result in limiting both the capabilities of Phoenix and the degree to which it is adopted by the industry.

RECORD OF REVISION

This record of revision will provide a high level summary of the major changes in the document and identify the Roadmap Owner.

REVISION	DESCRIPTION OF CHANGE
0	**Original Issue:** August 2011 **Roadmap Owner:** Jeff Riley
1	**Revision Issued:** August 2012 **Roadmap Owner:** Jeff Riley **Changes:** Revised to reflect change from "draft" to "in-use", and to incorporate further breakdown of major activities with associated updated schedule.
2	**Revision Issued:** August 2013 **Roadmap Owner:** Jeff Riley **Changes:** Revised flow chart to reflect updated schedule.
3	**Revision Issued:** January 2014 **Roadmap Owner:** Jeff Riley **Changes:** Added specific plan for the Risk Monitor version 2 to support needs of new participants. Shifted currently unfunded work into later in 2014. Minor adjustment of currently funded work to precisely reflect the expected deliverables in early 2014.
4	**Revision Issued:** August 2014 **Roadmap Owner:** Jean-Francois Roy **Changes:** The project plan was updated to indicate the current schedule and to reflect the tasks related to short term implementations, emphasize the various methods supported and the long term needs. The risks were expanded to reflect challenges resulting from the various users' implementations and utility specific needs.
5	**Revision Issued:** December 2014 **Roadmap Owner:** Jean-Francois Roy **Changes:** Completed milestone for Phoenix Risk Monitor version 1.0.
6	**Revision Issued:** August 2015 **Roadmap Owner:** Jean-Francois Roy **Changes:** Completed milestone for Phoenix Risk Monitor version 1.1. Extended the modeling tool and risk monitor version 2.0 to be released together at the end of 2016. Industry activities for LTO aging and RISMC applications have been extended and are continuing into 2016 and beyond. Level 3 tool development was removed and is expected to be addressed after 2016. Other RSM activities schedule changes include extending the LPSD extensions to CRM, the interface to RISM/Advanced Simulation and ILCM extension into 2016 as these projects are on-going.
7	**Revision Issued:** December 2015 **Roadmap Owner:** Jean-Francois Roy **Changes:** Updated the project plan to reflect new work planned on integration of the tools, new modeling techniques, advanced analysis features and visualization methods.


Phoenix Software for Risk Assessment and Risk Management
2012
2013
2014
2015
2016
Utilities & Applications
Seismic Pilot
Fire in CRM
LPSD Pilot
LTO Aging Applications
RISMC Applications
Risk and Safety Management APC
API Enhancements
Modeling Tool
Risk Monitor v.1
Risk Monitor v.1.1
Risk Monitor v.2
Architect 1.0
Application Automation
Seismic Enhancements
Cloud (multi-computer)
Additional Seismic Enhancements
Level 2 Tool / Capabilities
High speed computing / Quantification Enhancements
Revised fire data/modeling support
Data Exchange Framework
Visualizations
LPSD Extensions to CRM
OEH Methods
ILCM extensions
Interface to RISM / Advanced Simulation
Long-Term, Aging, and Time-Dependent Issues
Advanced modeling techniques
Legend
Key Milestone
Completed Milestone
Funded
Other Funding
Funding priority undefined
Vendors
Time-dependent methodologies (Markov)
Interfaces to physics tools
Interface to other tools as needed
NUC_RSM_04_R7 Integrated Software Tool for Risk Assessment.vsd
December 2015