

SAPHIRE ***Capabilities/Workspaces***

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OVERVIEW

- SAPHIRE Background
- SAPHIRE Quality Assurance Activities
- SAPHIRE Workspaces
 - Significance Determination Process (SDP) Workspace
 - Events and Condition Assessment (ECA) Workspace

SAPHIRE Development History

Idaho National Lab has supported the development of SAPHIRE since the 1980s.

- 1987 – Version 1 of IRRAS code (precursor to SAPHIRE)
- 1997 – SAPHIRE 6.x released for Windows
- 1999 – SAPHIRE 7.x
 - enhancements in event tree linking rules
- 2010 – SAPHIRE 8.x
 - Improved user interface and reporting
 - Use of analysis Workspaces

SAPHIRE Features and Capabilities

- SAPHIRE Version 8.1.2 latest official release
 - Event Tree with linked Fault Tree analysis software
 - Built-in uncertainty analysis (MC and LHS)
 - Integrated Common-Cause Failure module
 - Provides importance measures (fault tree/accident sequences)
 - Post-processing cut set rule editor
 - Ability to handle different Model Types (Fire, Flood, Seismic)
 - Enhanced to allow Phase Modeling (transition from Level 1 PRA to Level 2)
 - Automated generation of Plant Risk Information e-Book (PRIB)
 - Capability to use SAPHIRE's native cut set solver or an external solver (e.g., FTREX)

SAPHIRE Quality Assurance

- SAPHIRE team maintains SAPHIRE Software Quality Assurance Program
 - Design reviews
 - Requirements tracking
 - User change request and bug reporting system
 - Software acceptance testing process
- Annual QA audit performed by NRC technical monitor
- Independent Verification & Validation performed prior to initial release of SAPHIRE version 8
- Results comparisons performed using SAPHIRE solver and FTREX solver
- Periodic comparisons with licensees' PRA model results
 - SAPHIRE can reproduce licensees' results if same modeling assumptions are used

SAPHIRE Workspaces

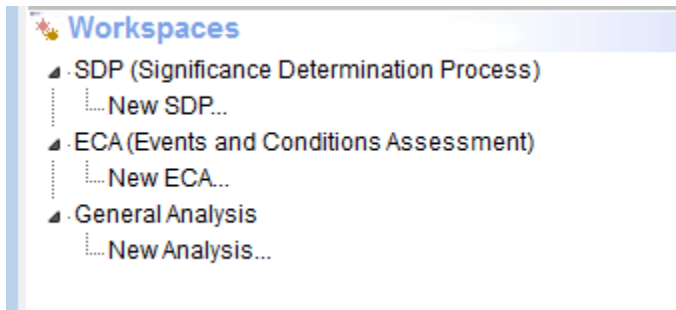
- What are Workspaces?
 - User-friendly SAPHIRE interface tools available to analysts for performing event and condition assessment
 - Creates a copy of the model with conditional settings
 - Allows user to save analysis settings and results
 - Results are summarized in pre-formatted reports
- Use of Workspaces
 - Use of Workspaces are not strictly prescribed, but allow analysts different options for performing assessments
 - Workspace functions can be replicated in general model environment using Change Sets.
 - Choice of Workspace or general model environment depends on analyst preference and type of issue being assessed
- SDP Workspace - Component-level model changes, intended for use as a screening tool
- ECA Workspace - Basic event-level model changes, Allows analyst more flexibility, Commonly used Workspace for condition assessments

SDP Workspace

- Workspace developed within SAPHIRE to analyze different identified deficiencies using the SPAR models
- SPAR models were modified in order to use this workspace directly, i.e., add system type, component type, failure mode, and specific component
- Provides analyst step by step inputs to perform analysis
- Automatically updates common cause failure (CCF) events based on input information
- Applies post-processing rules after cut set generation
- Provides output report of assessment

SDP Workspace – Screen Shots

- Example – DEMO project with failure of one train of ECS
 - SAPHIRE Workspaces



- Select New SDP – SAPHIRE makes a copy of project and has an interface screen that displays all of the systems modeled within the project
 - The analyst at this time chooses the system of interest in order to identify the deficient component

SDP Workspace – Screen Shots

- Select the appropriate system and SAPHIRE will then list all of the components identified to that system
- Select component of interest and click the Next option

Significance Determination Process [project: "DEMO-FULL - Demo Project using Advanced Related Topics" folder: "C:\Saphire 8\Demo-a..."]

Significance Determination Process

Step 1. Identify affected initiators and components *Select a system on the left to view its associated components. Mark the components/initiators affected by the condition being analyzed.*

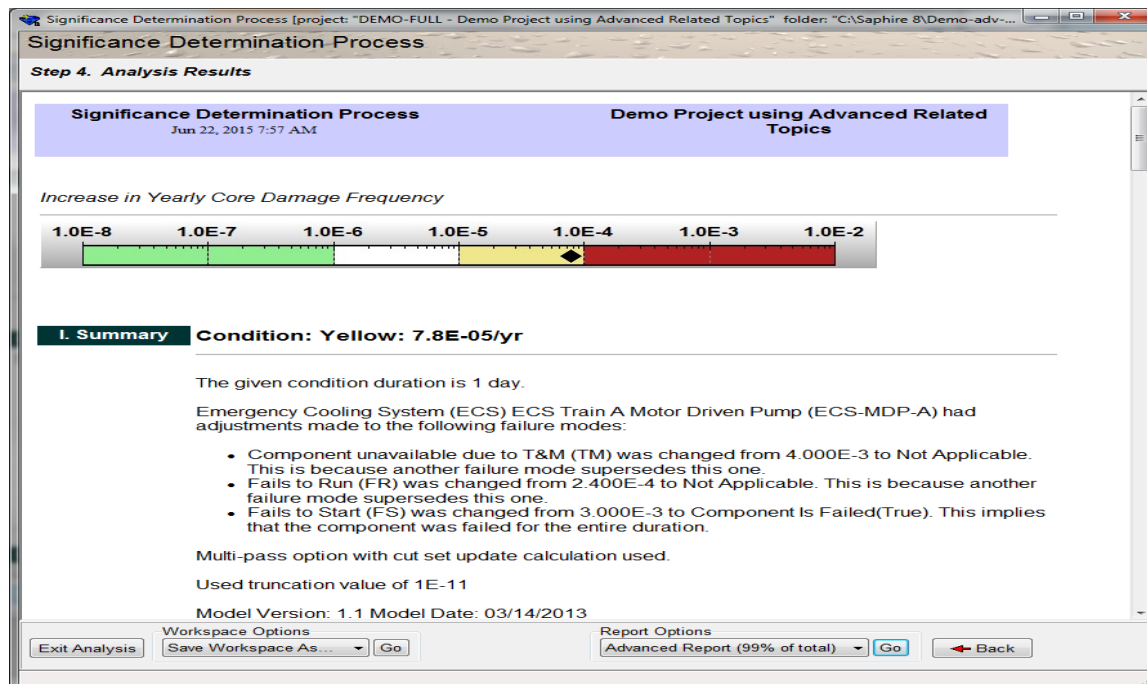
| | |
|---------------------------------------|-------------------------------|
| Initiators | Electrical Power System (EPS) |
| AC Power System (ACP) | Offsite Emergency Power (OEP) |
| Containment Cooling System (CCS) | Safety Injection System (SIS) |
| Emergency Cooling System (ECS) | Service Water System (SWS) |

Emergency Cooling System (ECS)

- ☐ ECS Suction Motor Operated Valve (ECS-MOV-SUCT)
- ☐ ECS Train 1A Check Valve (ECS-CKV-1A)
- ☐ ECS Train 1A Motor Operated Valve (ECS-MOV-1A)
- ☐ ECS Train 1B Check Valve (ECS-CKV-1B)
- ☐ ECS Train 1B Motor Operated Valve (ECS-MOV-1B)
- ☐ ECS Train 2A Check Valve (ECS-CKV-2A)
- ☐ ECS Train 2A Motor Operated Valve (ECS-MOV-2A)
- ☐ ECS Train 2B Check Valve (ECS-CKV-2B)
- ☐ ECS Train 2B Motor Operated Valve (ECS-MOV-2B)
- ☒ ECS Train A Motor Driven Pump (ECS-MDP-A)
- ☐ ECS Train B Motor Driven Pump (ECS-MDP-B)

SDP Workspace – Screen Shots


- Designate the duration of the condition and any pertinent information about the event
 - SAPHIRE will make correct adjustments based on condition, apply any post-processing rules, calculate delta CDF based on duration of condition, and provide results



SDP Workspace – Screen Shots

- Advanced Report

SDP Advanced Report (99.0%)



Significance Determination Process Advanced Report (99.0%)

Demo Project using Advanced Related Topics

Jun 22, 2015 7:57 AM

I. Assessment Summary

| | | | |
|-----------|--------------|------------------|--|
| Duration: | 1 day | Project: | Demo Project using Advanced Related Topics |
| CCDP: | 8.0E-5 | Model Version: | 1.1 |
| CDP: | 1.3E-6 | Model Date: | 03/14/2013 |
| Increase: | 7.8E-5 /year | Saphire Version: | Saphire 8.1.2 |
| Color: | Yellow | | |

II. Changed Basic Events

Summary of Conditional Event Changes

| Event | Event Description | Cond. Calc Type | Cond. Prob. | Nominal Calc. Type | Nominal Prob. |
|---------------|---|-----------------|-------------|--------------------|---------------|
| ECS-MDP-FR-A | ECS Train A motor-driven pump fails to run | 1 | 1.0E+0 | 3 | 2.4E-4 |
| ECS-MDP-FS-A | ECS Train A motor-driven pump fails to start | T | 1.0E+0 | 1 | 3.0E-3 |
| ECS-MDP-TM-A | ECS Train A motor-driven pump unavailable (T&M) | 1 | 1.0E+0 | 1 | 4.0E-3 |
| ECS-MDP-CF-FR | CCF OF ECS MDPs TO RUN | R | 8.4E-6 | R | 8.4E-6 |
| | CCF OF ECS MDPs TO RUN | | 8.4E-6 | | 8.4E-6 |
| ECS-MDP-CF-FS | CCF OF ECS MDPs TO START | R | 2.5E-2 | R | 7.5E-5 |
| | CCF OF ECS MDPs TO START | | 2.5E-2 | | 7.5E-5 |

III. Sequence Summary

Print...

Save As...

Close

ECA Workspace

- ECA Workspace is similar to the SDP workspace, except it allows for initiating event assessments (SDP is just conditional assessments)
- User defines the issue needing to be assessed
- SAPHIRE provides guidance (step by step)
- SAPHIRE performs multi-pass solution (for both SDP and ECA)
- Result is Incremental Conditional Core Damage Probability (ICCDP)

ECA Workspace – Screen Shots

- Example – DEMO project with failure of one train of ECS
 - Specify type of assessment (initiating event or condition)

Events and Conditions Assessment [project: "DEMO-FULL - Demo Project using Advanced Related Topics" fol

Events and Conditions Assessment

Select the kind of Events and Conditions Assessment you want to do.
Choose the assessment type and then identify the related inputs.

Assessment Type

☐ Initiating Event

☒ Condition

Specify the start date and time

06/22/2015 8:00:00 AM

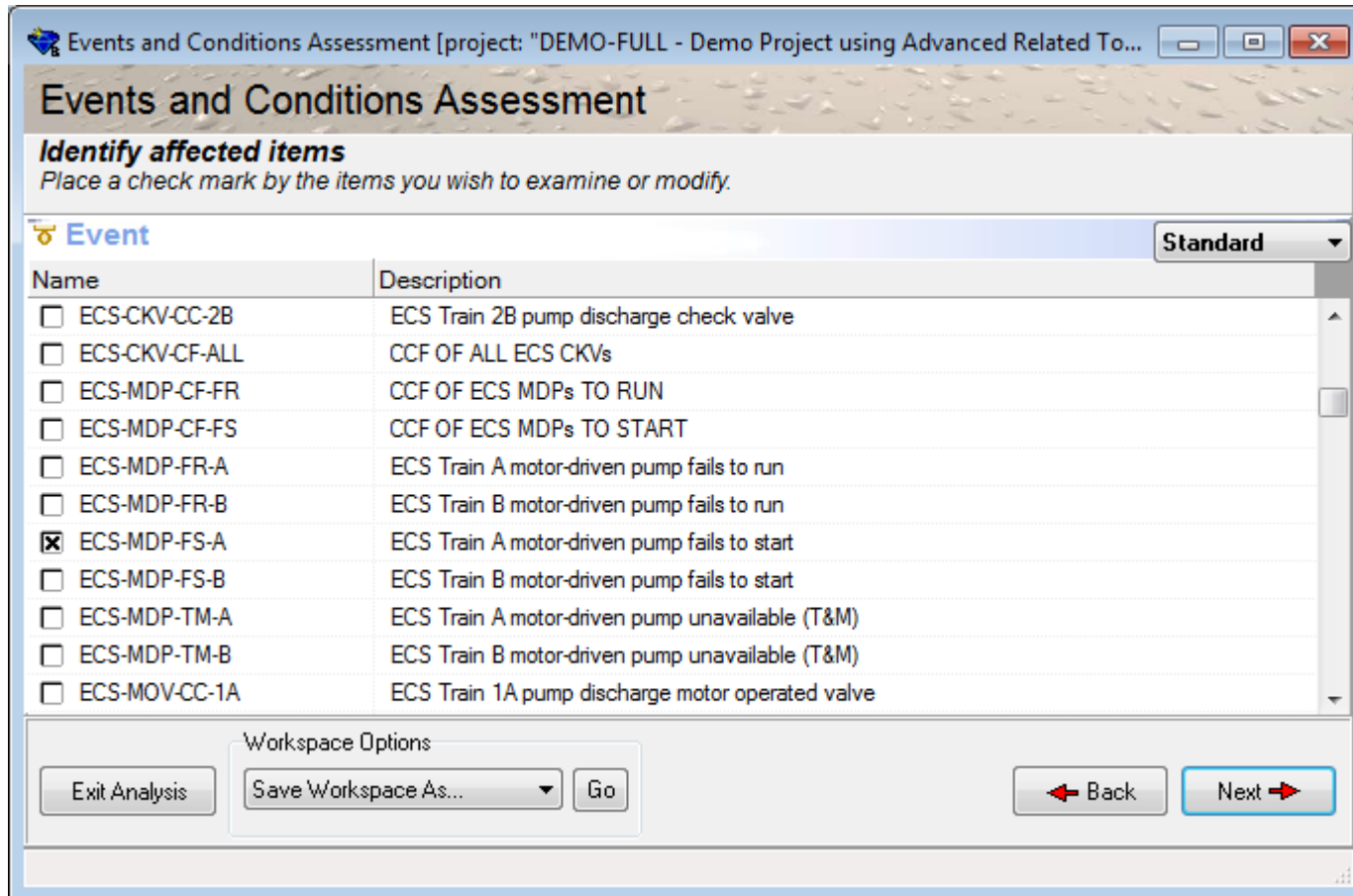
Specify the duration of the condition

☐ End Date 06/22/2015 9:00:00 AM

☒ Duration 1 hour(s)

ECA Workspace – Screen Shots

- Select of the component of interest



Events and Conditions Assessment [project: "DEMO-FULL - Demo Project using Advanced Related To...]

Events and Conditions Assessment

Identify affected items
Place a check mark by the items you wish to examine or modify.

Event Standard

| Name | Description |
|--|--|
| <input type="checkbox"/> ECS-CKV-CC-2B | ECS Train 2B pump discharge check valve |
| <input type="checkbox"/> ECS-CKV-CF-ALL | CCF OF ALL ECS CKVs |
| <input type="checkbox"/> ECS-MDP-CF-FR | CCF OF ECS MDPs TO RUN |
| <input type="checkbox"/> ECS-MDP-CF-FS | CCF OF ECS MDPs TO START |
| <input type="checkbox"/> ECS-MDP-FR-A | ECS Train A motor-driven pump fails to run |
| <input type="checkbox"/> ECS-MDP-FR-B | ECS Train B motor-driven pump fails to run |
| <input checked="" type="checkbox"/> ECS-MDP-FS-A | ECS Train A motor-driven pump fails to start |
| <input type="checkbox"/> ECS-MDP-FS-B | ECS Train B motor-driven pump fails to start |
| <input type="checkbox"/> ECS-MDP-TM-A | ECS Train A motor-driven pump unavailable (T&M) |
| <input type="checkbox"/> ECS-MDP-TM-B | ECS Train B motor-driven pump unavailable (T&M) |
| <input type="checkbox"/> ECS-MOV-CC-1A | ECS Train 1A pump discharge motor operated valve |

Workspace Options

Exit Analysis Save Workspace As... Go Back Next

ECA Workspace – Screen Shots

- Make appropriate changes (based on the observed information)

Events and Conditions Assessment

Modify the items identified in the previous step.
Further instructions here.

Event

| Event | Modification Type | New Prob/Freq | Nominal Prob/Freq |
|--------------|--|---------------|-------------------|
| ECS-MDP-FS-A | ECS Train A motor-driven pump fails to start | 3.000E-3 | 3.000E-3 |
| Edit | Edit | | |

Modify Basic Event - (ECS-MDP-FS-A)

☐ New probability / frequency 3.000E-3
☒ Single Failure (with potential shared cause)
☐ Single Failure (without potential shared cause)
☐ No failure <False>

Workspace Options

Save Workspace As...

ECA Workspace – Screen Shots

- Specify analysis options (duration, notes, etc.)

Events and Conditions Assessment [project: "DEMO-FULL - Demo Project using Advanced Related Topics" folder: "C:\Saphire 8\Demo-adv-all\W...]

Events and Conditions Assessment

Select solve options Choose your solve settings and fill in any notes to be included in the resulting report.

Method Of Solving

☐ Single pass solution ☐ with cut set update

☒ Multiple pass solution (with cut set update)

Other analysis settings

☐ Turn off all normal test and maintenance events [P (T/M) = 0].

Specify the start date and time

06/22/2015 8:00:00 AM

Specify the duration of the condition

☐ End Date 06/22/2015 9:00:00 AM

☒ Duration 1 hour(s)

Cut Set Truncation

Normal 1.000E-11

Size Truncation

None

Threads to use on solve

1

Uncertainty Method

☒ None ☐ Monte Carlo ☐ Latin Hypercube

Model Types

☐ EQ-REAL

☒ FULL_POWER

☐ CD

☐ INT-FIRE

☐ INT-FLOOD

☐ SEISMIC-BIN-1

☐ SEISMIC-BIN-3

Report Options

99% Report

Short analysis description/title

Untitled

Analysis notes or information

B I U Small Large

Workspace Options

Exit Analysis Save Workspace As... Go

Report Format

☒ HTML ☐ CVS

☐ PDF ☐ XLS

☐ RTF

Back Finish

ECA Workspace – Screen Shots

- SAPHIRE Results

Events and Conditions Assessment [project: "DEMO-FULL - Demo Project using Advanced Related Topics" folder: "C:\Saphire 8\Demo-adv-all\..."]

Events and Conditions Assessment

Analysis Results

Condition Assessment Summary

| | |
|--------------|--|
| Event Date | 6/22/2015 8:00:00 AM to 6/23/2015 8:00:00 AM |
| Duration | 1 day |
| CCDP | 7.952E-5 |
| CDP | 1.271E-6 |
| Δ CDP | 7.825E-5 |

Solve Settings

| | |
|--------------------|------------------|
| Cut set Truncation | Normal 1.000E-11 |
| Size Truncation | None |
| Solve Method | Multiple Pass |

Untitled

Summary of Conditional Event Changes

| Event | Description | Cond Type | Cond Value | Nominal Type | Nominal Value |
|---------------|--|-----------|------------|--------------|---------------|
| ECS-MDP-FS-A | ECS Train A motor-driven pump fails to start | T | True | 1 | 3.000E-3 |
| ECS-MDP-CF-FS | CCF OF ECS MDPs TO START | R | 2.500E-2 | R | 7.500E-5 |

Implied Event Changes as per RASP Guidance

| Event | Description | Cond Type | Cond Value | Nominal Type | Nominal Value |
|---------------|---|-----------|------------|--------------|---------------|
| ECS-MDP-FR-A | ECS Train A motor-driven pump fails to run | 1 | 1.000E+0 | 3 | 2.400E-4 |
| ECS-MDP-TM-A | ECS Train A motor-driven pump unavailable (T&M) | T | True | 1 | 4.000E-3 |
| ECS-MDP-CF-FR | CCF OF ECS MDPs TO RUN | R | 8.375E-6 | R | 8.375E-6 |

Workspace Options: Exit Analysis | Save Workspace As... | Go

Report Format: ☒ HTML ☐ CVS ☐ PDF ☐ XLS ☐ RTF

Report Options: Print Report... | Go | Back

SAPHIRE Resources

- SAPHIRE 8 Documentation: NUREG/CR-7039 Volumes 1-7

<http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr7039/>

- SAPHIRE Website

<https://saphire.inl.gov/saphire.cfm>

- Requesting a copy of SAPHIRE:

- Complete a non-disclosure agreement (NDA) form, found here

<http://www.nrc.gov/about-nrc/regulatory/research/obtainingcodes.html>

- Submit NDA form to safetycodes@nrc.gov or directly to jeffery.wood@nrc.gov, phone: 301-415-0953
- After review and acceptance of NDA, INL will establish access to SAPHIRE Users Group to download SAPHIRE installer
- SAPHIRE Users Group membership may require a fee depending on requestor's status and intended use of SAPHIRE