The CAFTA Conversion Methodology from SAREX PSA Model

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1. Introduction

The primary objective of this study is to provide the conversion methodology from a SAREX (Safety and Reliability Evaluation Expert) small Event Tree (ET), large Fault Tree (FT) PSA model to a CAFTA (Computer Aided Fault Tree Analysis) top logic PSA model using the APR1400 DC full power inter events (FPIE) Probabilistic Safety Assessment (PSA) model.
SAREX developed by KEPCO-ENC and CAFTA developed by EPRI (Electric Power Research Institute) are a computer software program used for developing reliability models of large complex systems, using FT and ET methodology.
EPRI's members represent approximately 90% of the electricity generated and delivered in the U.S., and international participation extends to more than 30 countries. On the other hand, SAREX are used in Korea and UAE NPP.
In preparation for the requirements of owner and/or regulatory body in the overseas project such as the APR1000 of Dukovany NPP (EPRI member), PSA model need to be developed by CAFTA of EPRI.

2. Methodology

The SAREX model conversion consists of 1) conversion of the SAREX ETs into a top logic model within CAFTA; 2) conversion of the SAREX system FTs into CAFTA system FTs and linking these system FTs to the top logic model; 3) and conversion of the SAREX reliability database to a CAFTA format.

After all other conversions and FT changes are made, the CAFTA top logic model is quantified, and the resultant cutsets are compared to the SAREX cutsets, to verify that the results produced by CAFTA are consistent with the results produced by SAREX, and any differences identified from the comparison are noted and discussed.

3. Conversion Process

The conversion consists of five main steps:

1) Convert the SAREX ETs into a single CAFTA top logic FT
2) Convert the SAREX system FTs into CAFTA system FTs and link these system FTs to the top logic model
3) Convert the reliability database from a SAREX format to a CAFTA format
4) Incorporate model changes to account for the impacts of the SAREX HDB files, and
5) Quantify the CAFTA top logic model, and compare the results to the original SAREX cutsets

3.1 ET Conversion to Top Logic Model

The conversion of an ET into a top logic model is relatively straightforward, and consists of modeling each ET accident sequence as a series of systemic failures and successes leading to an end state under a common FT gate. Note that since the PSA ultimately calculates a Core Damage Frequency (CDF), the only end states modeled are those leading to CD.

3.2 System FT Conversion and Linking to Top logic

Conversion of the SAREX system FTs into CAFTA format takes advantage of the fact that both programs can export and import the FT coding from several similar formats. Specifically, SAREX can export a FTP format file which is similar to a CAF format which can be imported by CAFTA.

3.3 Reliability Database Conversion

Similar to the FT, the format of the SAREX reliability database is different from that in CAFTA. Most notably, the distribution and common cause information is incorporated within the SAREX reliability database differently than within the CAFTA reliability database.

In CAFTA, when a Type Code (TC, Called a pattern in SAREX) is not used, both the distribution type as well as the distribution parameters are contained in the Basic Event (BE) Table. However, if a TC is used, the distribution data is contained in the TC table alongside the reliability and unavailability mean values. Table I, II and III provide the mapping of field names for the BE, Gate and TC (pattern) fields.

Table I: Basic Event Table Fieldname Conversion

SAREX Field name	CAFTA Field name
Name	Name
Mode	C
Mean	Factor
Unit	Units
Description	Description
Pattern	Type

Table II: Gate Table Fieldname Conversion

SAREX Field name	CAFTA Field name
Name	Name
Description	Description

Table III: TC (Pattern) Table Fieldname Conversion

SAREX Field name	CAFTA Field name
Name	Name
Mean	Rate
Unit	Units
Description	Description
Notes	Notes

3.4 Model Changes

Model changes are processed due to differences in the quantification process employed by SAREX and CAFTA. Most significant is the use within SAREX of ET branch house event tree files (Called HDB files in SAREX). In addition, the SAREX recovery files were re-written in a CAFTA format.

4. Quantification and Comparison to SAREX Cutsets

The PRAQuant program automates the accident sequence quantification process by employing the FT linking approach.

For the APR1400 DC PSA, the quantification engine used is FTREX and PRAQuant allows for the selection of a master flag file, master recovery file, mutually exclusive file, sequence flag files and sequence recovery files. All sequences were quantified with a truncation of 1.0E-13 since this is the truncation level of the SAREX cutsets. Truncation at the same level is necessary for cutsets comparison purposes.

Quantification input files for CAFTA Model in order to compare the SAREX cutsets are as follows;

- APR1400.qnt – PRAQuant File
- APR1400-LNK.caf – Top Logic FT
- APR1400.rr – Reliability Database
- APR1400.flg – Master Flag File
- APR1400.recv – Master Recovery File

The final CDF of the CAFTA model resulted in an approximate 0.5% increase when it was compared with that of the SAREX.

The cutsets for each initiator are developed for both the SAREX and CAFTA model from the merged cutsets files. The CDF results for each initiator are very close without initiator having a difference greater than 0.5% with the greatest difference in the LOOP initiator. There are no cases found for any initiators where are any SAREX cutsets missing from the CAFTA cutsets.

- The small difference in the overall (less than 0.5%) and initiator based CDFs for the two models
- The fact that the sample review of the over 17,000 cutsets did not identify any missing SAREX cutsets in the CAFTA results

5. Conclusions

The SAREX model of the APR1400 DC full power has been converted to the CAFTA format. The results are compared to the original SAREX model, and it is determined that the CAFTA PSA model produces correct results although the 17,000 cutsets reviewed only results in a total of about 3% of the total number of CAFTA cutsets.

In the future, it is possible to meet the requirements of owner and/or regulatory body in the overseas project by developing APR1000 CAFTA PSA model based on the CAFTA conversion methodology of the APR1400 DC.

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