Development of the U.S. Sodium Component Reliability Database

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Abstract. With the advent of the use of Probabilistic Risk Assessments (PRAs) for safety analysis of Light Water Reactors (LWRs) in the 1970s, the SFR community used PRA as a tool which can demonstrate the safety of SFR designs while avoiding the pitfalls associated with an over-reliance on highly conservative safety requirements. Throughout the 1970s, 80s, and 90s, the US compiled sodium reactor specific PRA information into the Centralized Reliability Database Organization (CREDO) database, maintained by Oak Ridge National Laboratories in collaboration with the Japanese Atomic Energy Agency (JAEA). Unfortunately, the funding for the CREDO database was cut in the 1990s and the database was lost and was regained in August of 2016. This paper will describe three databases being developed at Sandia National Laboratories(SNL): 1. CREDO-I – A summary of the state of the original CREDO database; 2. CREDO-II – Early attempts by Argonne National Laboratory (ANL) and SNL to recreate the CREDO database from operational documents; 3. The future combination of the CREDO-I and CREDO-II databases into a unified database.

Key Words: CREDO; PRA; Reliability

1. Introduction

Both the United States (US) and the international community have a long history of designing, building and operating Sodium Fast Reactors (SFRs).[6] The safety requirements for the first SFRs were determined through the use of conservative safety margins to account for unknown–unknowns associated with a technology. This approach proved particularly challenging to SFRs because infeasible events, such as Hypothetical Core Disruptive Accidents (HCDAs), had to be accommodated by SFR designs. These accidents, often proposed without a mechanistic initiator, proved to be a driver of high SFR licensing costs and eventually contributed to the withdrawal of the Clinch River Breeder Reactor (CRBR) license application to the Nuclear Regulatory Commission (NRC).[7]

With the advent of the use of Probabilistic Risk Assessments (PRAs) for safety analysis of Light Water Reactors (LWRs) in the 1970s, the SFR community used PRA as a tool which can demonstrate the safety of SFR designs while avoiding the pitfalls associated with an overreliance on highly conservative safety requirements. PRAs are logical tools which combine accident initiators, logical arguments for system availability, and basic event probabilities to provide an estimate of the overall system reliability. Throughout the 1970s, 80s, and 90s, the US compiled sodium reactor specific PRA information into the Centralized Reliability Database Organization (CREDO) database, maintained by Oak Ridge National Laboratories [8-14] in collaboration with the Japanese Atomic Energy Agency (JAEA). Unfortunately, the funding for the CREDO database was cut in the 1990s and the database was lost to the United States government. In August of 2016, the United States government received the United States facility data contained in the Japanese version of the CREDO database from JAEA. This paper documents:

1. CREDO-I – The current state of the CREDO database which was received form JAEA in August 2016;
2. CREDO-II – Early attempts by Argonne National Laboratory (ANL) and Sandia National Laboratories (SNL) to recreate the CREDO database;
3. NaSCoRD – The future combination of CREDO-I and CREDO-II; and
4. Accessibility – The current infrastructure and environment hosting the CREDO databases.

2. Reliability Databases

This section describes requirements for the layout of manuscripts to be produced by a word processor (e.g. Microsoft Word, LaTeX), which then have to be converted to PDF format for subsequent electronic submission to the IAEA.

2.1.CREDO-I

CREDO-I was received from JAEA shortly before this write-up was completed in an excel spreadsheet. A basic database structure was created from this data and the current shown in Figure 27. The CREDO-I database includes:

- 1306 event records (i.e., what, when, and why did something happened and what was done about it; Table 16),
- 408 facility operating records (i.e., describing a given facilities operating state as function of time; Table 17), and
- 8102 engineering data records (i.e. component descriptions; Table 18)

Over the next year, SNL will flush out the relationships between the Event, Facility, and Engineering data and consolidate this data with the that collected in CREDO-II as described in Section 6.3.

2.2.CREDO-II

In 2013 an effort began to reclaim the reliability data that was lost with CREDO in the 1990s. This took a two-pronged approach, involving a search for extant copies of CREDO itself and an effort to recreate CREDO using historical documents. The retrieval of data from historical sources was aided by the existence of a book which contained copies of the data submittal forms used by CREDO.[10] These forms specified the engineering, operations, and event data that would be submitted to CREDO by member facilities. They were useful in guiding the gathering of operating and event data from reactor run logs and event reports. Engineering data are not a part of the CREDO-II database, as a limited amount is available in the open and proprietary documents collected thus far.

The primary challenge in attempting to recreate the database from historical records is that the available documents were not intended to fully describe reliability-significant events. The majority of the documents are run-based or time-based summaries of activity that were written as periodic project deliverables. In many cases the starting and resolution dates of events are not given. Specific item identifiers are rarely given; rather, a narrative may simply refer to "a valve" within a specified sub-system. Strategies have been developed to deal with uncertainty in event occurrence and resolution dates, as described in Section 6.2.2.

The database and associated relationships are outlined in Figure 28. Each event is associated with a document and page number, a specific reactor, a corrective action, and a specific sub-system of that reactor. Actions may include repair, replacement, addition to, or removal from the system. The operational data are separated into run-based and daily history entries. Because reactors differed in the frequency of operational reporting, the run history table is flexible and allows a start and end date to be set for each entry. This permits data to be recorded whether it was provided for each week, quarter, or time-variable reactor run.

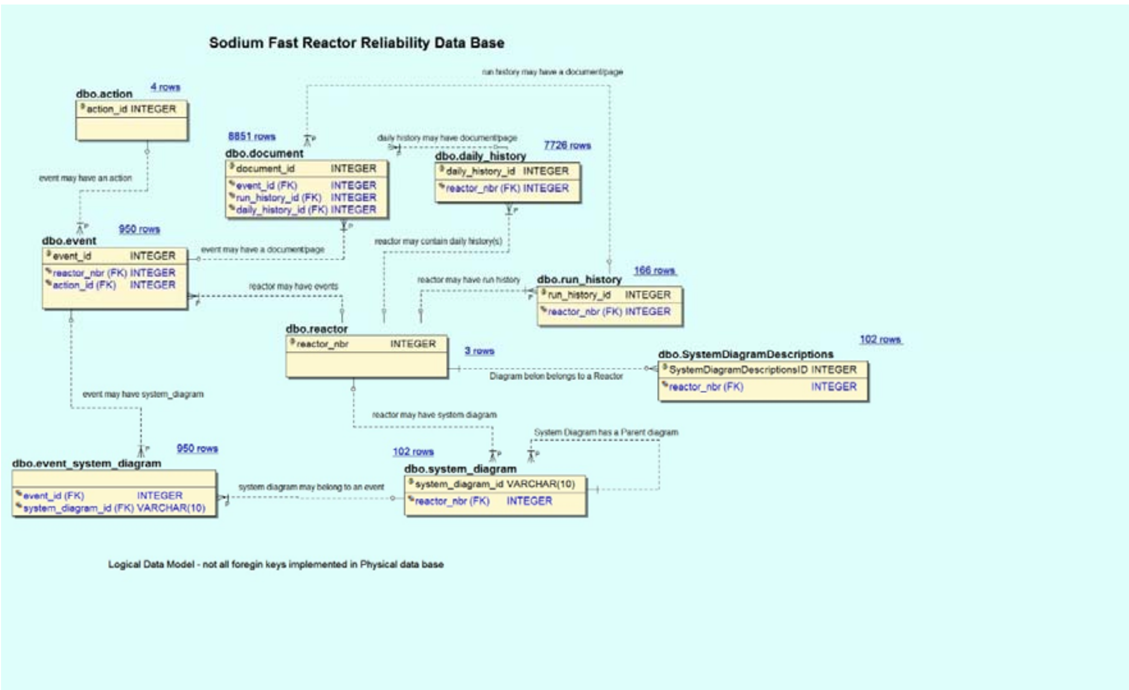

FIG. 1. IAEA logo.

A system hierarchy for each reactor has been assembled from documents and is used to sort the sub-systems affected by each event. For example, an event may be assigned to the primary coolant system (1), the primary coolant pump (1.1), the primary coolant pump motor (1.1.1), or the primary coolant pump motor clutch (1.1.1.1). The event is assigned as specifically as possible given the narrative and its context in a report.

2.3.NASCORD

Since a portion of the original CREDO database (referred to as CREDO-I) has been obtained, efforts are underway to unify it and CREDO-II into a single database. This combined database will be referred to as NaSCoRD, short for "Sodium System Component Reliability Database". A general diagram of NaSCoRD is given as Figure 32.

Analysis tools were not included with the CREDO-I recovered files; the information retrieved is a direct reflection of the reports submitted to the CREDO project. The information currently in CREDO-II is similarly raw, having undergone only classification. Additional fields will be added to both databases to facilitate merging into NaSCoRD.

CREDO-II will receive event bounding information based on the procedures in Section 6.2.2 in order to check for similarity with entries of occurrence date and resolution time in CREDO-I. Because most events in CREDO-II have definite start dates, it is likely that a first pass using occurrence date and component type will allow most events to be matched.

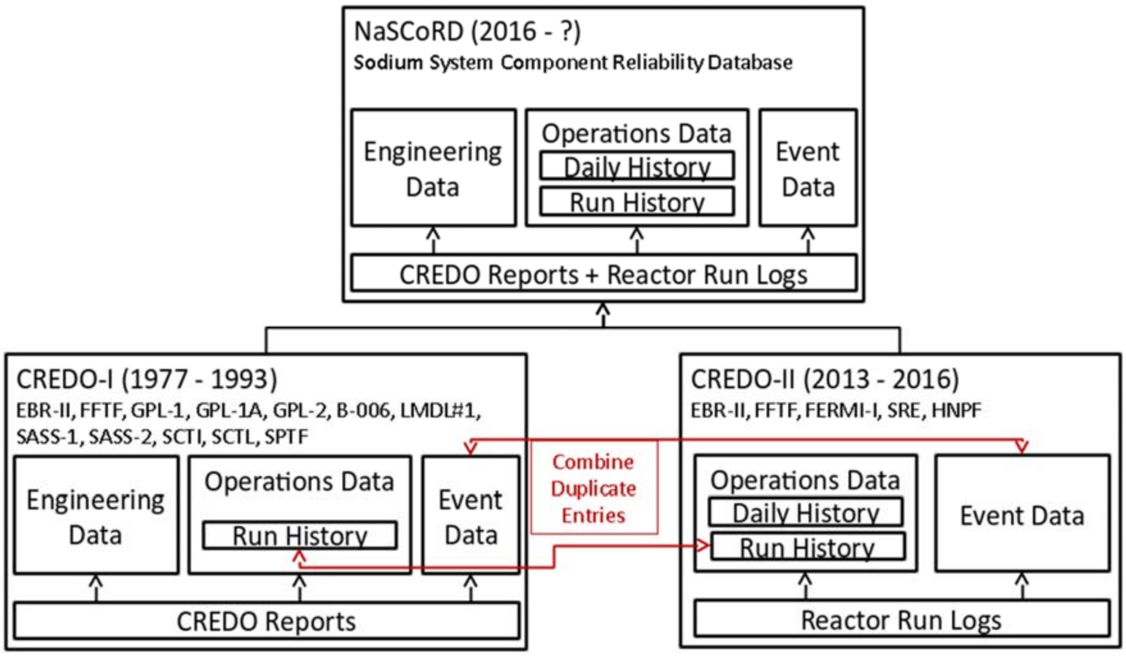

FIG. 1. IAEA logo.

CREDO-II contains significantly more events for just EBR-II than CREDO-I contains for EBR-II and FFTF. It is not certain that the events in CREDO-II completely envelop the EBR-II events in CREDO-I. Any CREDO-II event that cannot be matched with a CREDO-I event will be brought to into the NaSCoRD format with null values for data fields provided only by CREDO-I. The subset of these events with uncertain start or resolution times will be entered into NaSCoRD along with their document and reactor history bounding estimates. CREDO-I contains 63 fields for each event entry, in contrast to the 11 in CREDO-II. The fields in CREDO-I fully envelop those in CREDO-II, and so will be used as the template for events in NaSCoRD.

No daily operational data are included in CREDO-I; only run-based or interval-based data are presented. These will be merged with the run-based operational data in CREDO-II. These will be helpful in identifying gaps in knowledge of reactor history, particularly for FFTF. The operational data in CREDO-I largely envelop that available in CREDO-II. The primary exception is that CREDO-II includes electrical production and primary pump usage data, where available. These fields will be added to those in CREDO-I to create the run-based operational history in NaSCoRD.

3. Accessing the database

The CREDO databases reside on Microsoft SQL Server 2014 Database servers. This is an industry recognized enterprise level database management system. Development versions of the databases reside on the Sandia Restricted Network (SRN) and the Production versions reside on the Sandia External Collaboration Network (ECN). The production database server has 24x7 availability and support. Database backups are performed nightly with weekly backups sent to our off-site storage facility.

Reporting for the CREDO-II database is provided by Microsoft SQL Server Reporting Services (SSRS) 2014. This is an industry standard reporting environment that has been available since 2000. An initial set of reports for the CREDO-I database will be developed before the end of FY 2016. The SSRS reports are rendered through Microsoft's SharePoint web application. This environment provides a secure platform for hosting content (documents, etc.) as well as reporting on content.

The CREDO-II database reporting is available on the SharePoint environment on Sandia's External Collaboration Network. It has a security plan that supports data content up to the unclassified OUO data classification and including the DOE-AT data classification. When CREDO-I database reporting is developed it will also be available on the Sandia SharePoint ECN network. Access to the Sandia SharePoint hosting CREDO-I and CREDO-II is controlled independently through permissions granted to user accounts.

The Sandia ECN is directly available through the internet. It does require an account with a *userid* and *password* acquired from Sandia password control. DOE and Lab colleagues may acquire accounts and passwords through a Sandia Lab sponsor. The development environment for the CREDO databases is similar to the ECN but resides on the Sandia restricted network and is not available through the internet. Figure 33 illustrates the architecture described.

4. Utilization of the Database

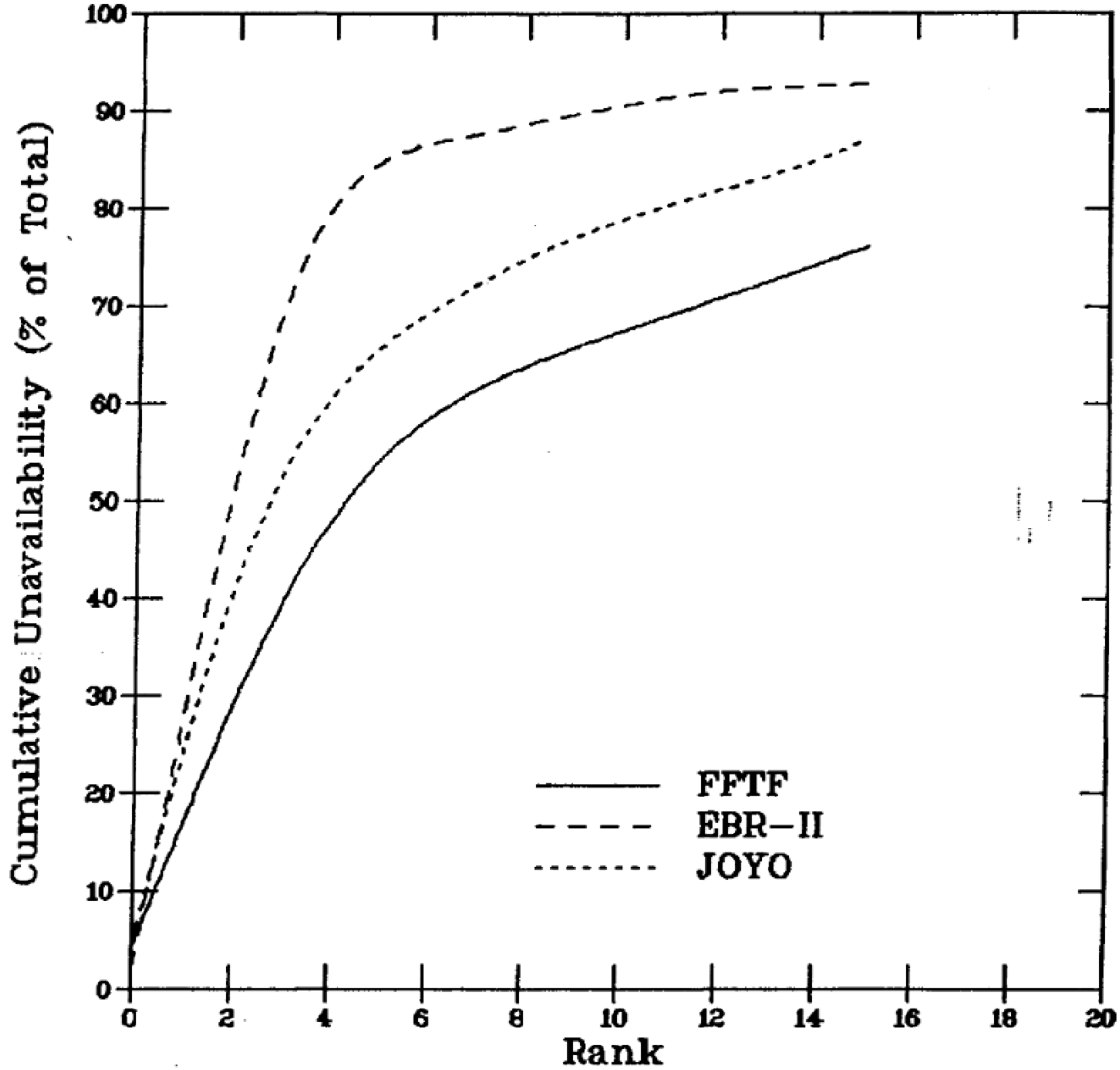

FIG. 1. IAEA logo. [9]

5. Conclusions

Appendix 1: Examples for the Reference Style

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