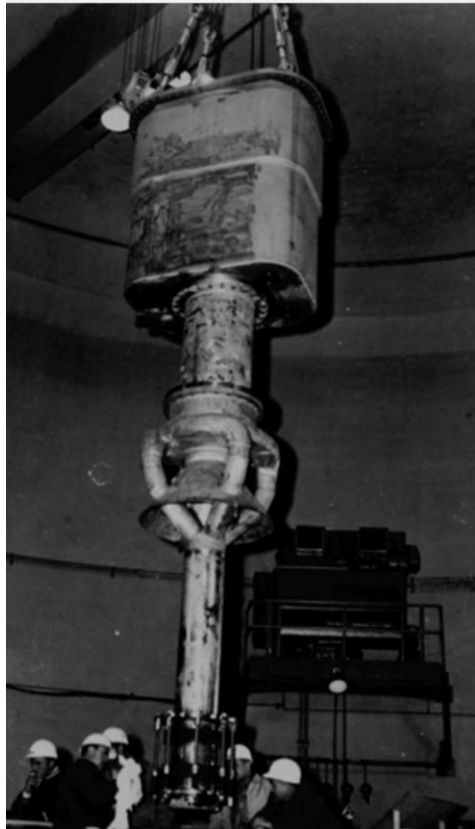




U.S. DEPARTMENT OF
ENERGY

Nuclear Energy

SAND2016-10139PE



*Primary Pump from EBR-II
ANL-EBR-100*

U.S. Sodium System Reliability Database Development

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Presentation to the GIF Risk and Safety Working Group

October 13th 2016

- **Throughout the 1980s and 1990s, SFR reliability data was collected and stored in a database at ORNL called the Centralized Reliability Engineering Database Organization (CREDO).**
 - SFR reliability data includes documentation of component maintenance events, failures, time to repair the failure, root causes, ...
 - This data then gets summarized into component failure data expressed in failures per hour or failures per demand for various failure modes.
 - This information can be used to quantify the basic event probabilities or estimate capacity factors.
- **CREDO was jointly developed by the US and Japan. This joint development stopped in 1992. Japan has expanded CREDO with information from MONJU and JOYO from this 1992 version.**

- **In the mid to late 1990s, after the defunding of the IFR program, ORNL disbanded the CREDO database.**
- **SNL and ANL were funded to recreate the CREDO database. The initial scope of this project was to re-commission the original database and bring it unto modern database standards.**
 - Other than occasional summary reports, no documentation remains of the original CREDO database
- **Since this time, SNL and ANL have attempted to create the database (CREDO-II) from raw reactor logs that have been preserved through Knowledge Preservation efforts.**
- **In August of 2016, JAEA returned the US originated portion of the CREDO database to the US (CREDO-I). Efforts are underway to combine CREDO-I and CREDO-II into the NaSCoRD database (Sodium System Component Reliability Database).**

Building a Reliability Database from Scratch

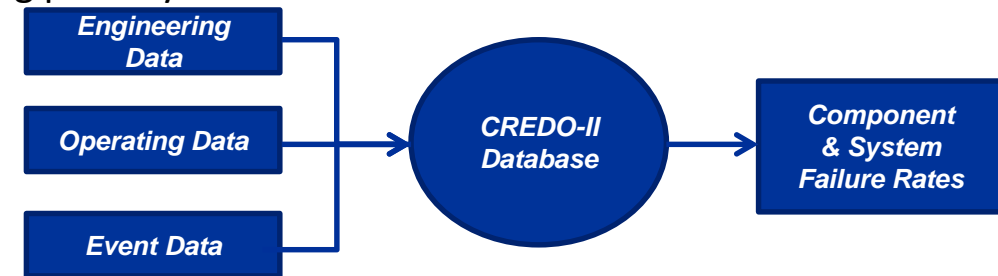
CREDO-II DEVELOPMENT

■ Centralized Reliability Data Organization (CREDO) – II

- Funded by DOE-NE under ART - collaborative work between SNL and ANL

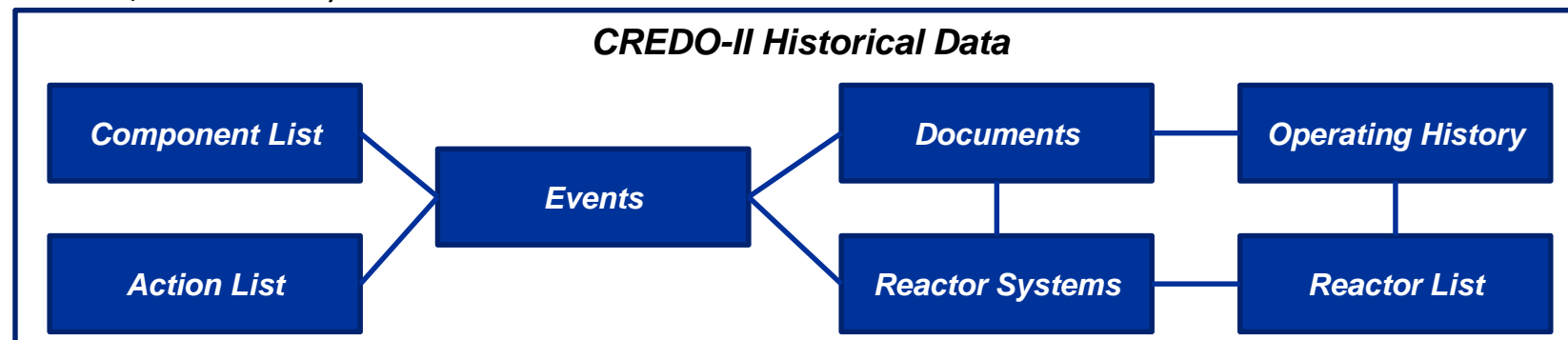
■ Objectives:

- Rebuilding sodium reactor component reliability database using primary sources
- Original lost at ORNL mid 1990s
- Support future risk assessments
- Risk-inform future SFR designs

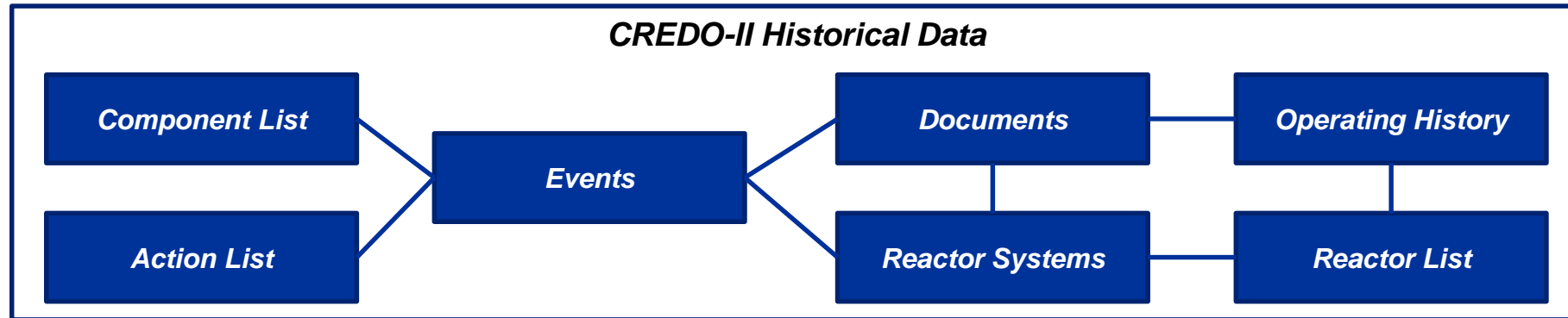


■ Data Sources

- EBR-II (Idaho, 1964-1994)
- Fermi Unit 1 (Michigan, 1966-1972)
- FFTF (Washington, 1980-1992)
- SRE, Sodium Reactor Experiment (California, 1957-1964)
- HNPF, Hallam Nuclear Power Facility (Nebraska, 1963-1964)
- SEFOR, Southwest Experimental Fast Oxide Reactor (Arkansas, 1969-1972)



■ 8 Tables of Historical Data



- *Operating History on Daily and Run basis*
 - *Thermal and electrical production, reactor and pump hours, etc.*
- *Component List matches list used in CREDO*
- *Reactor Systems hierarchy assembled for each reactor according to its unique configuration*
 - *EBR-II Example:*

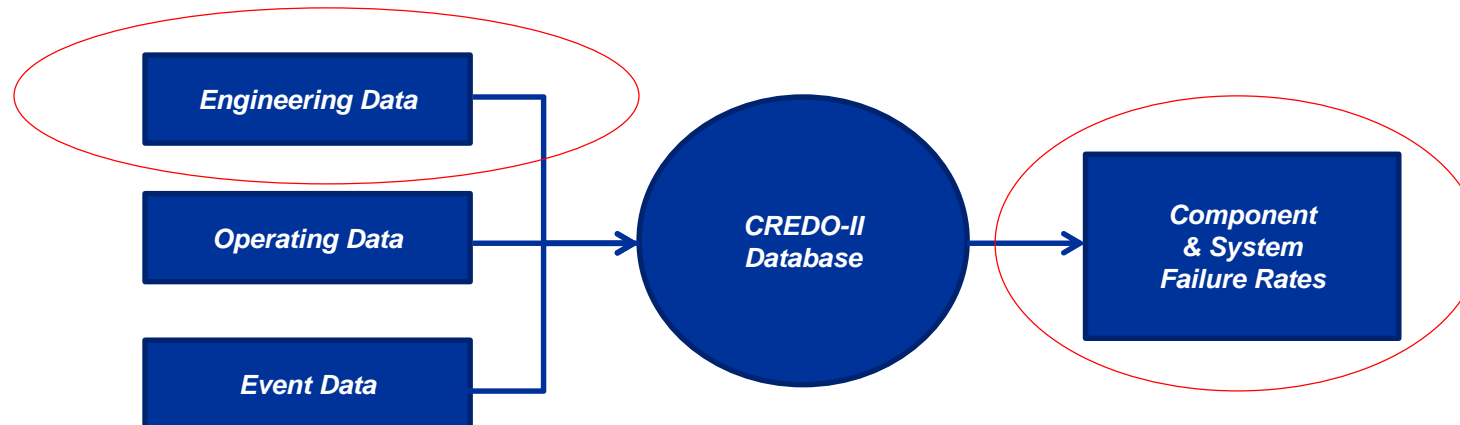
Diagram :	System Description :	Event ID :	Event Description
1	Primary Flow System	10065	Small sodium leak found at weld upstream of loop throttle valve. Loop secured and cooled.
		10636	"Performed normal shutdown because of high plugging temperature in primary sodium, 315°F (157°C). Received waiver of the Technical Specification limit of 300°F (149°C) for primary plugging temperature."
1.1	Primary Sodium Pump	10001	"Pump No. 1 failed after a few hours of low-speed operation, removed for repair. Inspection showed severe galling of lower labyrinth seal and pump shaft. New shaft and labyrinth installed, baffle plates remachined, labyrinth-seal clearances increased."
		10002	"Pump No. 2 failed after 200 hours of operation, removed for repair. Inspection showed severe galling of lower labyrinth seal and pump shaft. New shaft and labyrinth installed, baffle plates remachined, labyrinth-seal clearances increased."
1.1.1	Primary Pump Motor-Generator Set	10914	"Exciter commutators inspected, new brushes installed."
		10166	"A reactor scram resulted from high rate of change of primary system flow. The primary pumps were shut down, the control circuitry was checked, and the brushes were replaced in the MG-set generator."
		10409	Reactor restart was delayed for repairs on cooling-water strainers for the primary-pump MG sets.

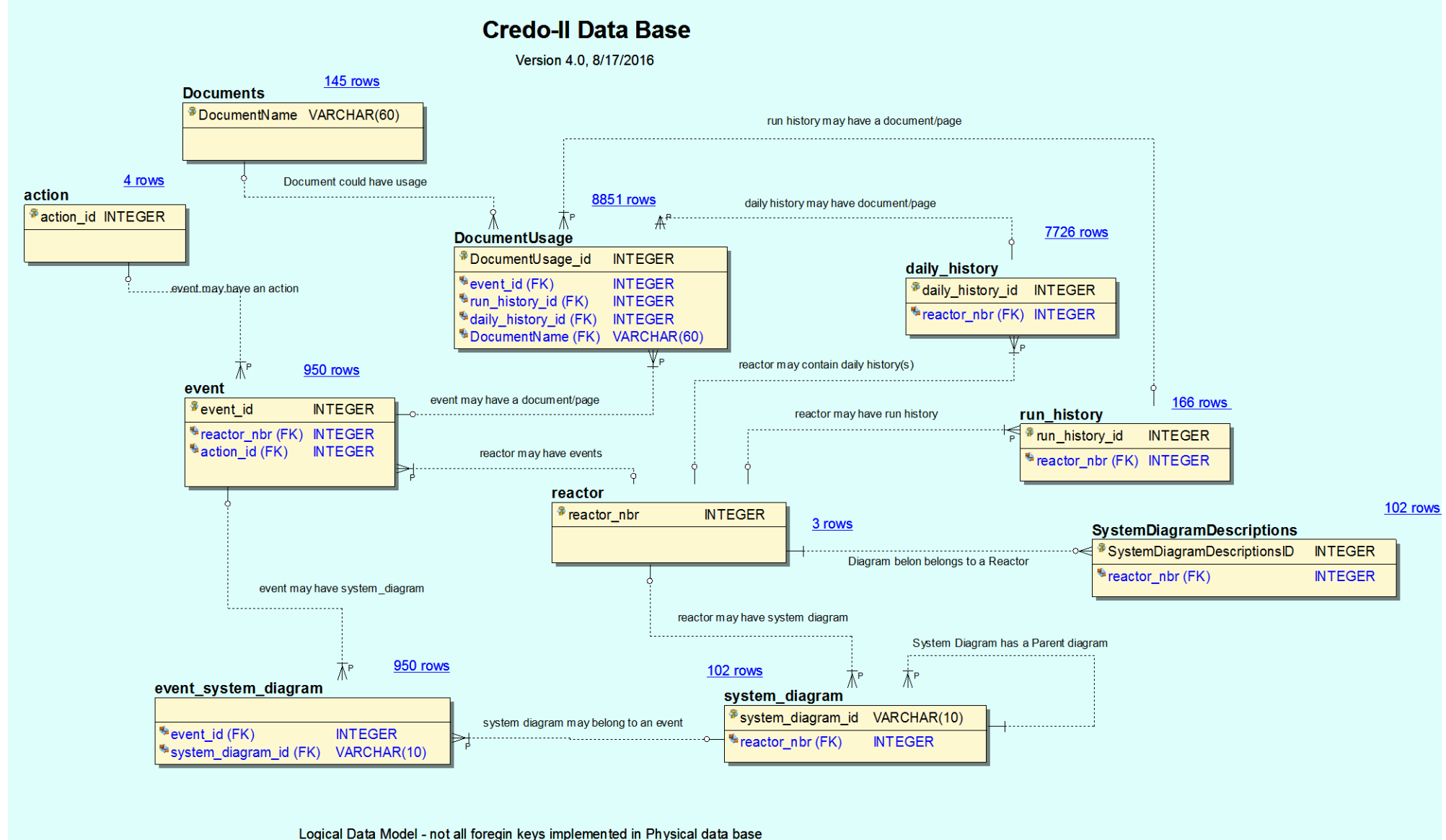
■ **Defensible Handling of Missing Data**

- *May cautiously and traceably infer missing data for some events from other tables*
- *Example:*
 - *Event requiring shutdown begins April 7, unknown end*
 - *Daily reactor history shows shutdown April 7 and startup May 2, bounding event's end date*
- *Cannot assume steady operation of experimental and research reactors*

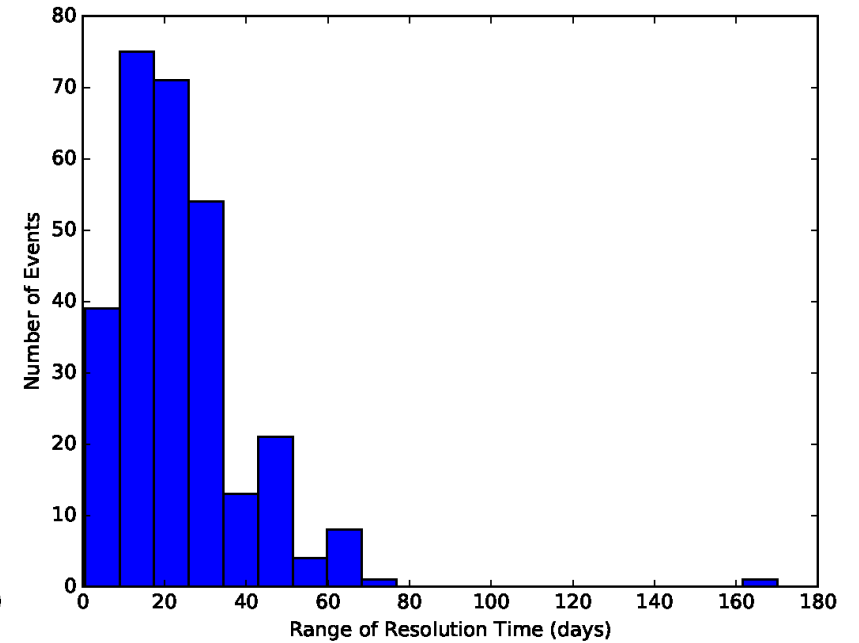
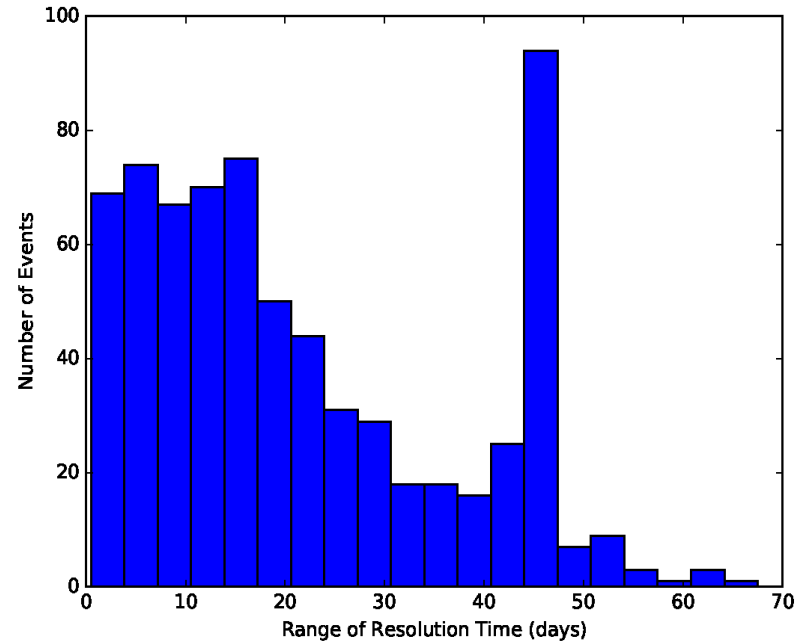
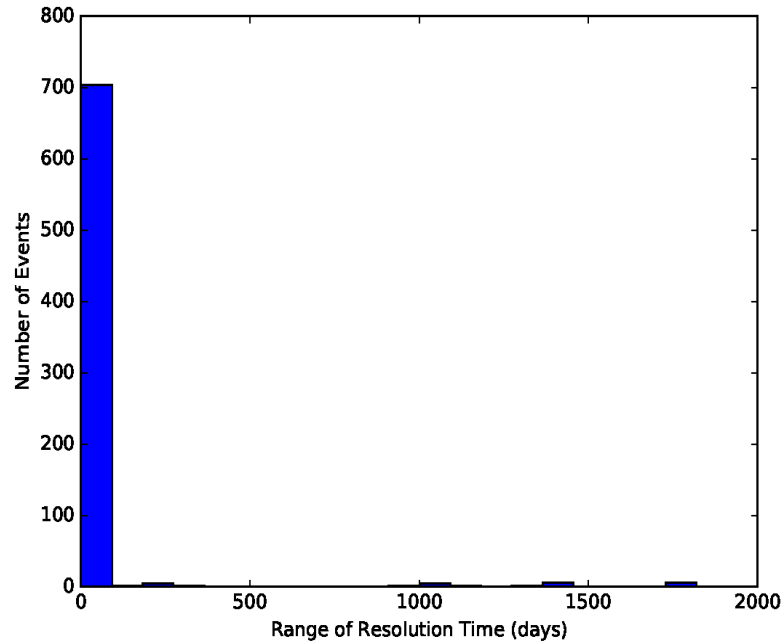
■ **Reliability Analysis**

- *Number of failures fairly well known*
- *Number of components, time, and attempts mostly unknown*
 - *Requires additional Engineering Data, which is often proprietary*





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Handling Missing Data from Run Logs

- *The majority of events were both initiated and resolved within the reporting period of a single document, which provides some bounding of the timing.*
- *Events that were so prominent as to require work over multiple reporting periods were invariably better-documented with regards to outage time.*
- *For events that required a shutdown or SCRAM of the reactor, timing may be bound using the reactor history power.*

Transferring Excel Sheets to and SQL database

CREDO-I DEVELOPMENT

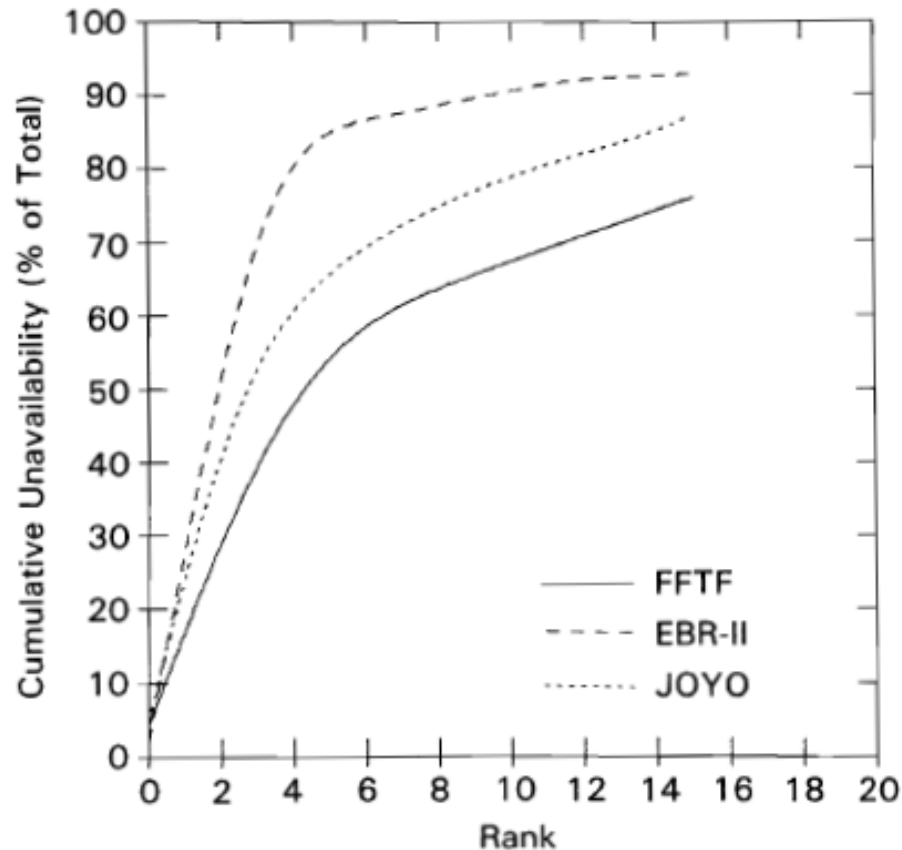
The CREDO-I database includes:

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

Facilities

- Reactors
 - FFTF
 - EBR-II
- Test Loops
 - GPL-1, GPL-1A, GPL-2
 - B-006
 - LMDL#1
 - SASS-1 and SASS-2
 - SCTI and SCTL
 - SPTF

Cumulative unavailability of a reactor as a function component



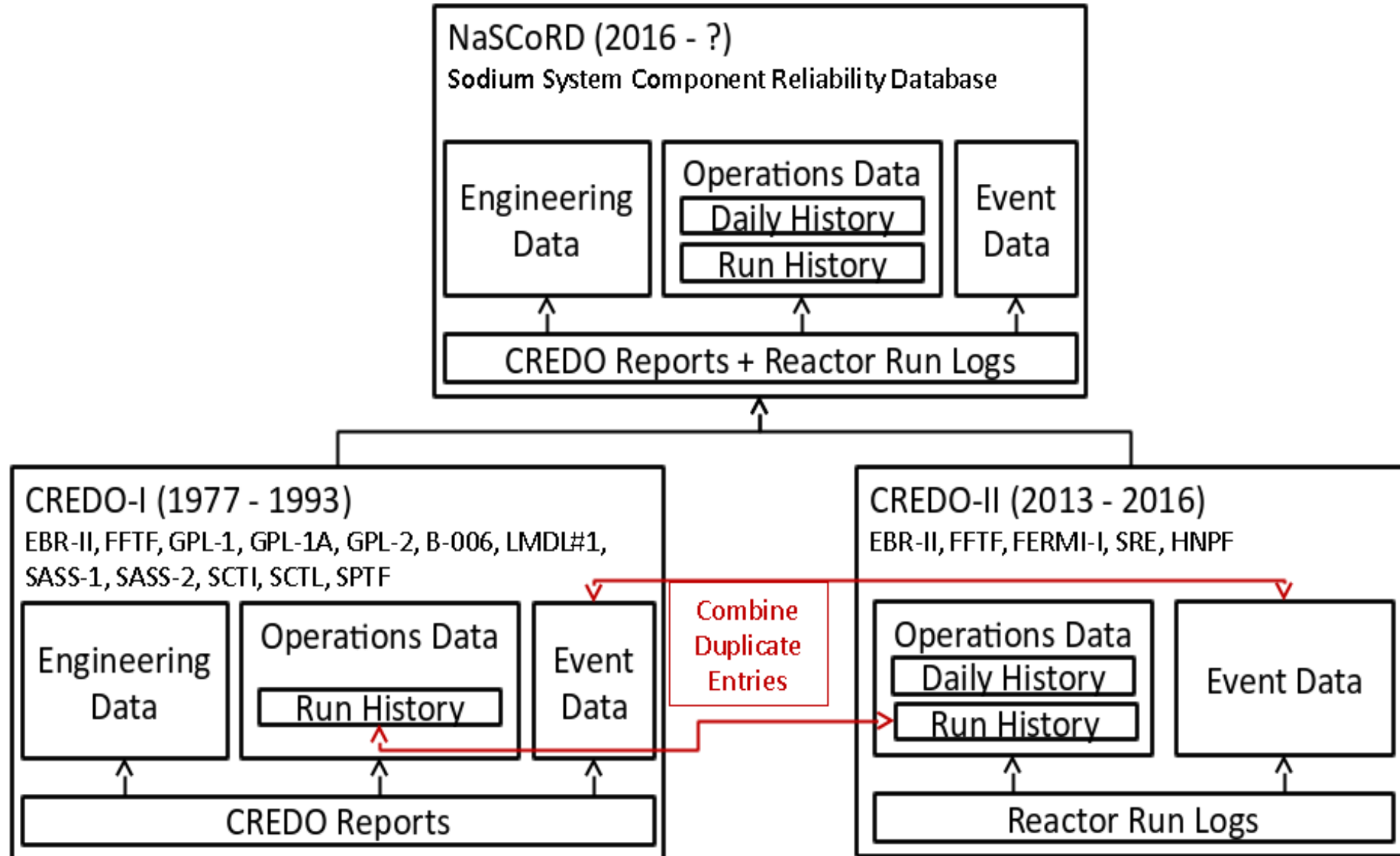
Percent of total unavailability for highest ranked components

Component	EBR-II	FFTF	JOYO
Mechanical pumps	51.9	31.2	58.1
Gas movers	29.6	8.5	---
EM pumps	2.6	2.2	8.7
Mechanical control devices	---	---	9.9
Nonnuclear sensors	---	---	5.3
Nuclear detectors	---	---	3.2
Cold traps	4.0	6.4	---
Rupture devices	---	14.1	---
Control rod drive mechanisms	---	12.1	---

*Only components that contributed more than 2% of total unavailability are listed here.

Merging of CREDO-I and CREDO-II into a unified Database

MOVING FORWARD - NASCORD



- **The US is revitalizing a component reliability database to support future SFR PRA efforts.**
- **This database will include both information originally available to CREDO as well as tractable records of failure events for reactor data.**
- **Once the database is completed, new test loops in the DOE complex can be risk-informed and reliability information can be used to support new reactor designs.**