

Shutdown Risk Management during Outage Using PSA

The Kansai Electric Power Co., Inc. (KANSAI)

Kenji MURAYAMA

Norihisa HASHIDA

Nuclear Engineering, Ltd. (NEL)

Takahiro KURAMOTO

Shinichi KOTANI

Kei OHYA

O Taichi HIGASHIYAMA

Contents

1. Company Profile (KANSAI, NEL)
2. Risk Management with In-house Rules during Outage
3. Risk Evaluation Tool Development for the Shutdown Risk Management
4. Modeling Improvements for Shutdown PSA
5. Further Enhancements
6. Conclusions

1. Company Profile

- KANSAI (The Kansai Electric Power Co., Inc.)
 - Located in the center of JAPAN and supply electrical power in the “KANSAI” area.
 - Possesses 11 PWR and is the second largest producer of electrical power in Japan.

- NEL (Nuclear Engineering, Ltd.)
 - Funded by KANSAI in order to supply and upgrade engineering services which enhance the safety and reliability of nuclear power plants.
 - Perform PSA (especially Level 1, i.e. internal, fire and seismic).
 - Use PSA for the Risk-Informed Maintenance and so on.

2. Risk Management with In-house Rules during Outage

- Purpose for Shutdown PSA

To **improve efficiency** and to **reduce risks** of the outage.

- Purpose for Setting In-house Rules

To develop **a lower-risk outage schedule** at P/S.

- How to Set In-house Rules



Refer to the cases in US and our experience before.

Determine **2 criteria** for CDF, CDF per outage (**total CDF**) and CDF per hour (**time based CDF**), as the next page.

2.1 Set the In-house Risk Criteria

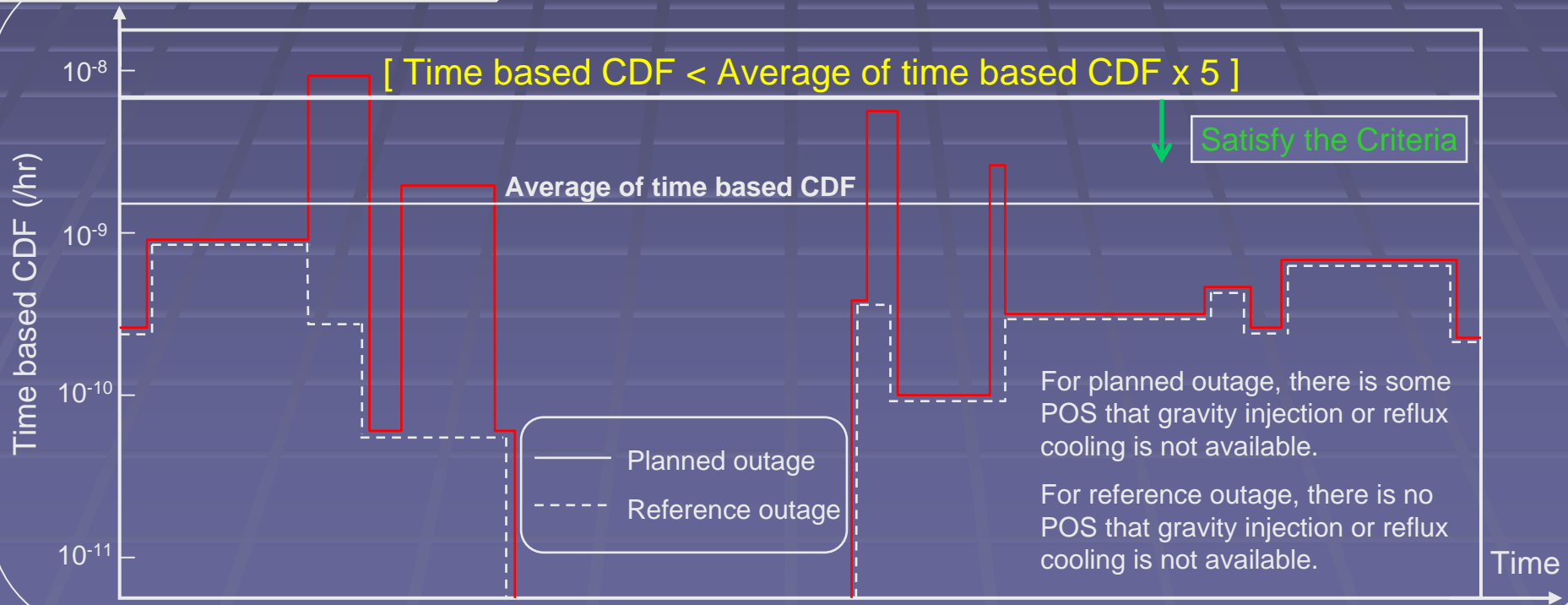
Criteria for total CDF

[Planned outage CDF < Reference outage CDF x 2]

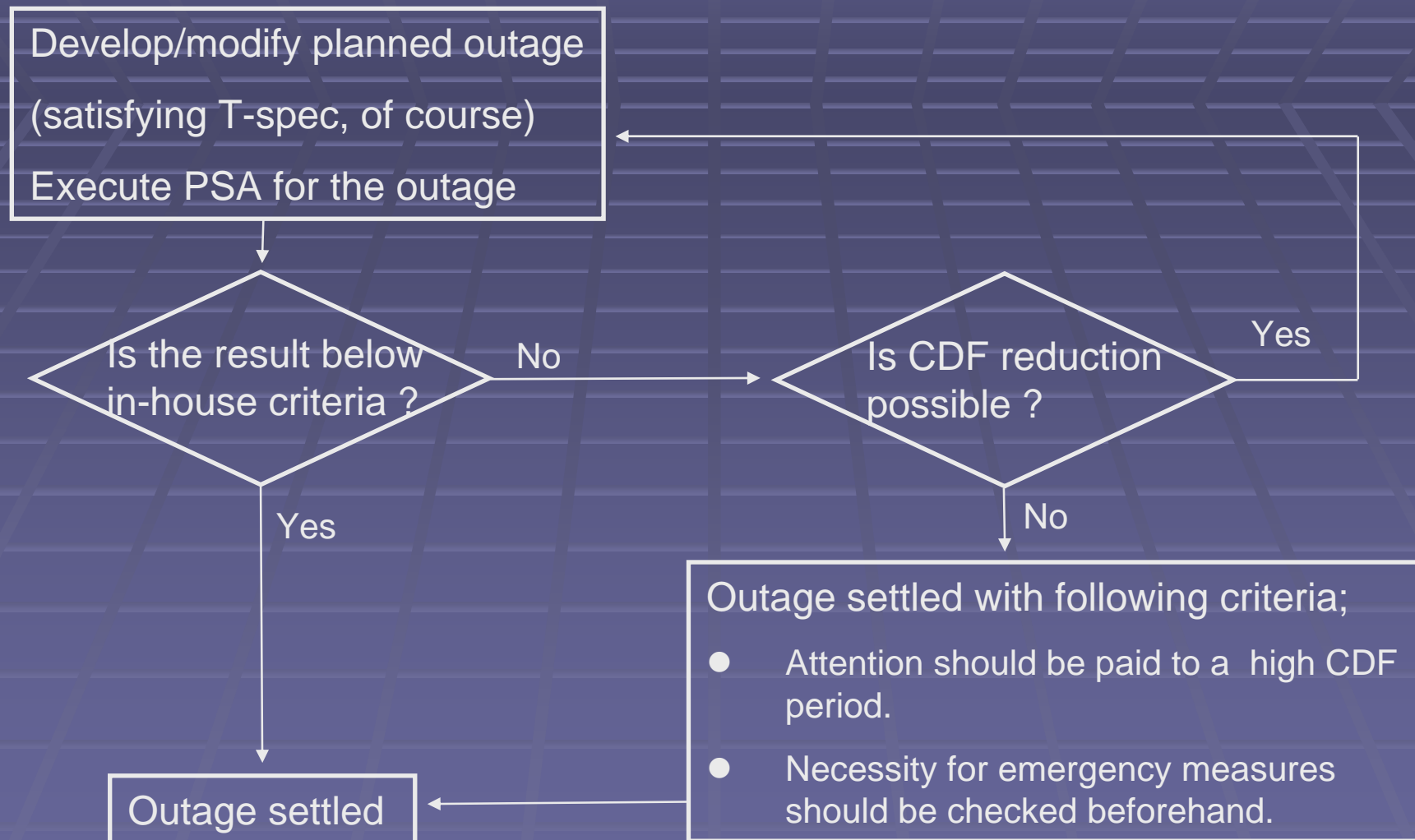
The area of  < The area of  x 2 Satisfy the Criteria

Criteria for time based CDF

[Time based CDF < Average of time based CDF x 5]



2.2 Flow of Using In-house Risk Criteria



3. Risk Evaluation Tool Development for the Shutdown Risk Management

<Progress on Performing PSA>

Stage 1

- KANSAI provided NEL with outage information **by paper**.
- NEL developed RISKMAN input after investigation of outage information **by manual**.

Stage 2



Too much volume of tasks are necessary.
Input errors might be caused.

- KANSAI/NEL have developed a tool, AuTOmatic Risk Assessment System (ATORAS).
- KANSAI provides NEL with outage information **by electronic files**, and ATORAS can create RISKMAN input **automatically**.



Both man-hours and input errors are **reduced**.

Stage 3 (at present)

- KANSAI performs shutdown PSA using ATORAS **at P/S**.
- NEL supports KANSAI to perform shutdown PSA and continues to **enhance PSA models**.

ATORAS Functions

System Composition

(1) Divide outage timeline into Plant Operating State (POS) automatically.

(2) Set the configurations for components automatically.

(3) Confirm CDF profile automatically by using the results from RISKMAN.

POS table

高3号機14日定検 計測工程					
観測月	PC	観測日	観測時間	圧縮機及び圧力工程	備考
2022.09.20	P302	2022.09.20 08:50	75	圧力調整済	
2022.09.22	P302	2022.09.22 08:50	75	圧力調整済	
2022.09.24	P304	2022.09.24 08:50	68	圧力調整済	圧力調整済(11日高圧25psi)
2022.09.26	P304	2022.09.26 08:50	68	圧力調整済	圧力調整済
2022.09.28	P304	2022.09.28 08:50	68	圧力調整済	圧力調整済
2022.09.29	P305A	2022.09.29 08:50	260	72psiより高圧調整	
2022.09.30	P305B	2022.09.30 07:58	260	72psiより高圧調整	
2022.09.27	P305C	2022.09.27 08:50	57	圧力調整済	
2022.09.28	P306	2022.09.28 08:50	680	圧力調整済	
2022.09.29	P307	2022.09.29 08:50	680	圧力調整済	
2022.10.01	P309	2022.10.01 08:50	680	圧力調整済	
2022.10.03	P309	2022.10.03 08:50	680	圧力調整済	
2022.10.05	P309	2022.10.05 08:50	680	圧力調整済	
2022.10.06	P309	2022.10.06 08:50	680	圧力調整済	
2022.10.07	P309	2022.10.07 08:50	680	圧力調整済	
2022.10.09	P309	2022.10.09 08:50	680	圧力調整済	
2022.10.10	P309	2022.10.10 08:50	680	圧力調整済	
2022.10.11	P309	2022.10.11 08:50	680	圧力調整済	
2022.10.12	P309	2022.10.12 08:50	680	圧力調整済	
2022.10.13	P309	2022.10.13 08:50	680	圧力調整済	
2022.10.14	P309	2022.10.14 08:50	680	圧力調整済	
2022.10.15	P309	2022.10.15 08:50	680	圧力調整済	
2022.10.16	P309	2022.10.16 08:50	680	圧力調整済	
2022.10.17	P309	2022.10.17 08:50	680	圧力調整済	
2022.10.18	P309	2022.10.18 08:50	680	圧力調整済	
2022.10.19	P309	2022.10.19 08:50	680	圧力調整済	
2022.10.20	P309	2022.10.20 08:50	680	圧力調整済	
2022.10.21	P309	2022.10.21 08:50	680	圧力調整済	
2022.10.22	P309	2022.10.22 08:50	680	圧力調整済	
2022.10.23	P309	2022.10.23 08:50	680	圧力調整済	
2022.10.24	P309	2022.10.24 08:50	680	圧力調整済	
2022.10.25	P309	2022.10.25 08:50	680	圧力調整済	
2022.10.26	P309	2022.10.26 08:50	680	圧力調整済	
2022.10.27	P309	2022.10.27 08:50	680	圧力調整済	
2022.10.28	P309	2022.10.28 08:50	680	圧力調整済	
2022.10.29	P309	2022.10.29 08:50	680	圧力調整済	
2022.10.30	P309	2022.10.30 08:50	680	圧力調整済	
2022.10.31	P309	2022.10.31 08:50	680	圧力調整済	
2022.11.01	P309	2022.11.01 08:50	680	圧力調整済	
2022.11.02	P309	2022.11.02 08:50	680	圧力調整済	
2022.11.03	P309	2022.11.03 08:50	680	圧力調整済	
2022.11.04	P309	2022.11.04 08:50	680	圧力調整済	
2022.11.05	P309	2022.11.05 08:50	680	圧力調整済	
2022.11.06	P309	2022.11.06 08:50	680	圧力調整済	
2022.11.07	P309	2022.11.07 08:50	680	圧力調整済	
2022.11.08	P309	2022.11.08 08:50	680	圧力調整済	
2022.11.09	P309	2022.11.09 08:50	680	圧力調整済	
2022.11.10	P309	2022.11.10 08:50	680	圧力調整済	
2022.11.11	P309	2022.11.11 08:50	680	圧力調整済	
2022.11.12	P309	2022.11.12 08:50	680	圧力調整済	
2022.11.13	P309	2022.11.13 08:50	680	圧力調整済	

Maintenance table

[illegible]

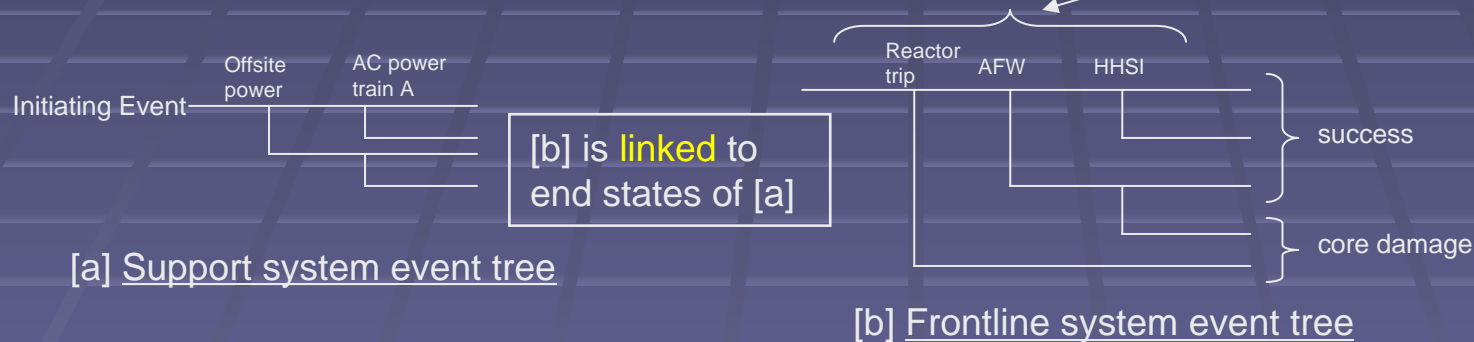
CDF profile

BASE	B3N												C3N												reflex	GI
	03N	04N	05N	06N	07N	08N	09N	10N	11N	12N	13N	14N	15N	16N	17N	18N	19N	20N	21N	22N	23N	24N				
PD53	2.161E-09	3.52	0.171	4.50E-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD54	3.953E-08	42.8	3.00	1.02E-10	3.7E-08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD59	8.067E-09	23.2	6.24	2.42E-12	3.82E-08	7.54E-08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD59	1.504E-09	0.29	0.39	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD59	1.558E-09	29.2	6.92	2.75E-11	1.6E-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD59N2	1.133E-04	2.1	8.89	2.3E-12	2.22E-09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD59N2	1.575E-09	0.57	0.73	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD59G1	3.050E-08	85.8	3.89	3.32E-11	2.81E-08	1.92E-08	2.7E-08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD59N1	8.513E-10	167.0	66.97	1.07E-10	1.54E-08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD59N1	4.576E-10	0.55	0.04	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD59G2	7.62E-08	17.5	0.05	1.03E-10	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD59G3	3.694E-10	7.0	0.02	7.4E-11	3.19E-12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD59G3	2.115E-09	0.8	0.13	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD510	4.960E-10	98.0	3.84	5.51E-10	4.89E-08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD510	1.967E-10	0.12	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD511	9.36E-10	17.0	0.08	0.00	1.27E-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD511	2.837E-09	0.53	0.24	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD511G2	8.279E-09	12.5	0.48	0.22E-10	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
PD511G2	8.279E-09	12.5	0.48	0.22E-10	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
SUM	1.723E-06		5.52E-09	1.71E-07	1.84E-08	7.09E-09	9.53E-10	2.75E-11	5.83E-09	1.29E-09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
	1.0000		0.0031	13.200	2.200	4.849	33.610	0.000	1.372	0.000	3.731	0.000	3.731	0.000	3.731	0.000	3.731	0.000	3.731	0.000	3.731	0.000	3.731			

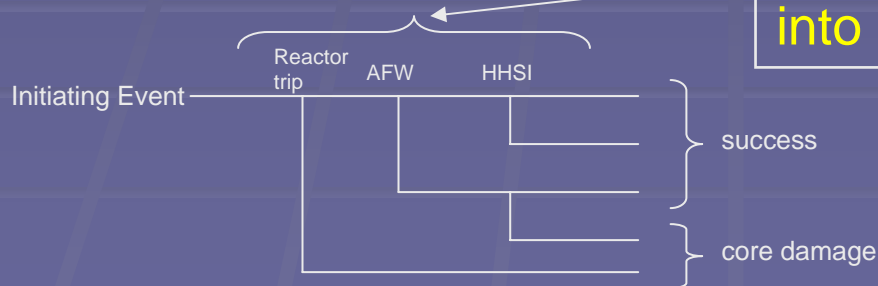
4. Modeling Improvement for the Shutdown PSA

4.1(1) Event Tree Structure

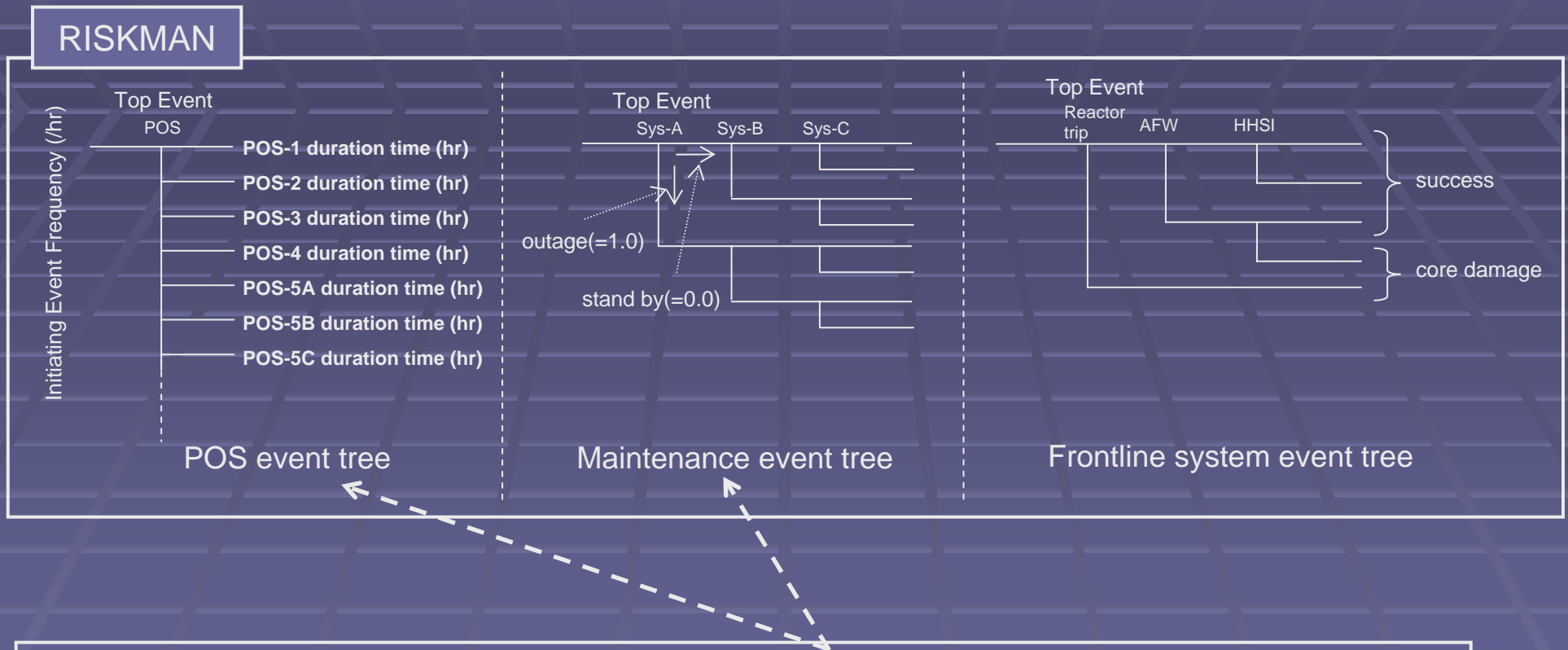
■ Event Tree Linking method (RISKMAN)



■ Fault Tree Linking method



4.1(2) Event Tree Structure



ATORAS creates RISKMAN input for the 2 event trees (POS, MT).

In order to execute shutdown risk with other condition, what we need is only changing the 2 event trees (POS, MT).

4.2 Models Taken into Consideration of Operating States

Pum p A CHPX	Pum p B CHPY	Pum p C CHPZ	Calculated align ment	Applied align ment
○	○	○		CHAL1
○	○	△		CHAL1
○	○	×		CHAL1
○	△	○	CHAL1	CHAL1
○	△	△		CHAL1
○	△	×		CHAL1
○	×	○	CHMT1	CHMT1
○	×	△		CHMT1
○	×	×		CHMT1
△	○	○	CHAL2	CHAL2
△	○	△		CHAL1
△	○	×		CHAL1
△	△	○		CHAL1
△	△	△		CHAL1
△	△	×		CHAL1
△	×	○		CHMT1
△	×	△		CHMT1
△	×	×		CHMT1
×	○	○	CHMT2	CHMT2
×	○	△		CHMT2
×	○	×		CHMT2
×	△	○		CHMT2
×	△	△		CHMT2
×	△	×		CHMT2
×	×	○		CHMT2
×	×	△		CHMT2
×	×	×		-

ATORAS Functions

the split fractions covered all operating modes for each event heading.

(4) Decide the split fraction corresponding to the specified equipments' configurations automatically.

So we prepare set of the comprehensive split fractions in advance corresponding to various combinations of equipment's configurations.

○	... operation
△	... standby
×	... out of service

5. Further Enhancements

- Evaluate effectiveness of the risk management rules and update it as needed.
- Continue to upgrade PSA models.
- Change ATORAS to complete automatic evaluation tool (i.e., Risk Monitor).
- Develop the Risk Monitoring System Tool “COSMOS” including these ATORAS functions.

Next Speaker will explain about
“COSMOS” in detail.

6. Conclusions

- KANSAI sets in-house rules for shutdown PSA and performs shutdown risk management during outage using PSA at P/S.
- KANSAI/NEL have developed a tool, ATORAS, which enables us to make RISKMAN input easily and quickly.
- ETL method enables us to execute the repetitive shutdown risk very efficiently because what we need is only changing 2 event trees.
- Also, for repetitive execution of shutdown PSA, we prepare sets of the comprehensive split fractions in advance corresponding to various combinations of equipments' configurations.
- We have a plan to develop the Risk Monitoring System Tool "COSMOS" including ATORAS functions.