The Risk Monitoring System COSMOS for At-Power and Shutdown Conditions

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1．Background

・Utilization of PSA

  - Identification of High Risk Equipments and Systems

  - Decision of Maintenance Planning of Equipments and Systems

  - Modification of Tech-Spec, etc

・Status of Utilization of Risk Information in Japan

  - Preparing Regulatory Guideline for PSA

  - Preparing Industrial Standard and Guideline for PSA

  - Preparing Application and Usage Method of Risk Information
    in NPP

In near future, the risk monitoring system is needed for utilization of risk information in each Japanese NPP.

We have developed risk monitoring system, COSMOS.
(COSMOS : Continuous Online Safety MOnitoring System)

2. Outline of COSMOS

- COSMOS is a level-1 and internal event risk monitoring tool up to now.

- COSMOS has two separated modules, COSMOS-FP (for at-power) and COSMOS-SD (for shutdown).

  - Usage method is different between at-power and shutdown, so we have developed COSMOS-FP and COSMOS-SD by different quantification methods.

- COSMOS has completely linkage to RISKMAN for Windows (RMW) and the model.

  - COSMOS does not require special PSA models for RMW and CDF sequences which previously stored.
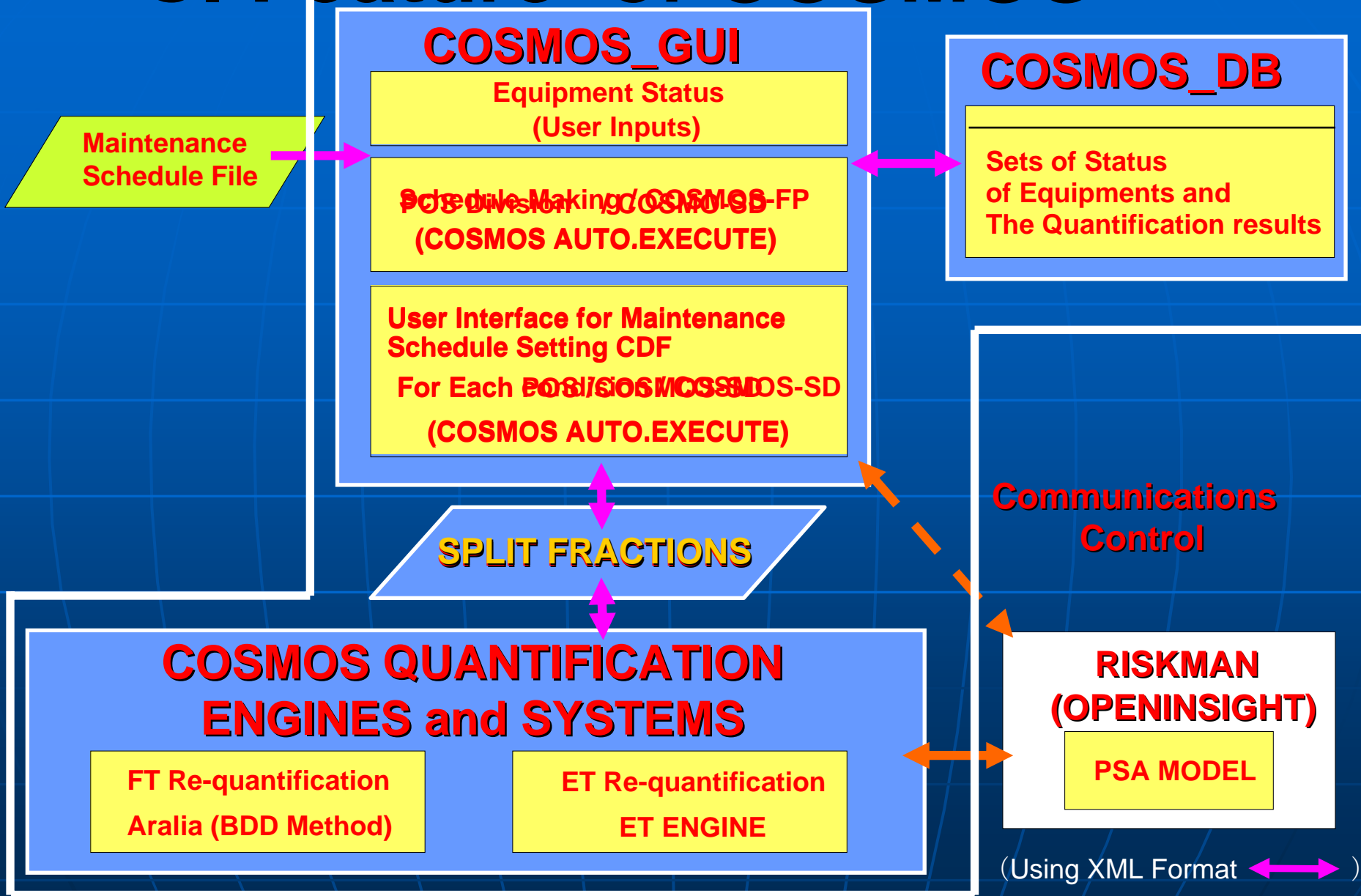
3. Feature of COSMOS

A Conventional Event Tree Linking Method Tool

- Quantify Core damage frequency based on the core damage sequences or cutsets previously stored.

  - -The calculation precision is strongly dependent on the number of the prepared sequences.

- Have to identify the outage equipments, before picking up core damage sequences.

COSMOS

- Quantify Core damage frequency directly from FTs and ETs quantification.

  - - COSMOS does not require the core damage sequences or cutsets previously stored.

- Treat all basic events for the input conditions. (COSMOS-FP)

3. Feature of COSMOS

COSMOS_GUI

Equipment Status
(User Inputs)

Schedule Making /COSMOS-FP
PCS Division /COSMO-SD
(COSMOS AUTO.EXECUTE)

User Interface for Maintenance
Schedule Setting CDF
For Each POS / COSMOS-SD
POS Division /COSMOS-SD
(COSMOS AUTO.EXECUTE)

COSMOS_DB

_____

Sets of Status
of Equipments and
The Quantification results

Maintenance
Schedule File

SPLIT FRACTIONS

Communications
Control

COSMOS QUANTIFICATION
ENGINES and SYSTEMS

FT Re-quantification

Aralia (BDD Method)

ET Re-quantification

ET ENGINE

RISKMAN
(OPENINSIGHT)

PSA MODEL

（Using XML Format ⟷ ）

3.(1) COSMOS-FP （for at-power）

- Assume to use COSMOS-FP for scheduling of at-power on-line maintenance.

- Restore sets of status of equipments and the quantification results to the database. COSMOS-FP utilizes the database for speeding calculation.

- Have a feature of successive execution of systems and ETs corresponding to the on-line maintenance equipments.
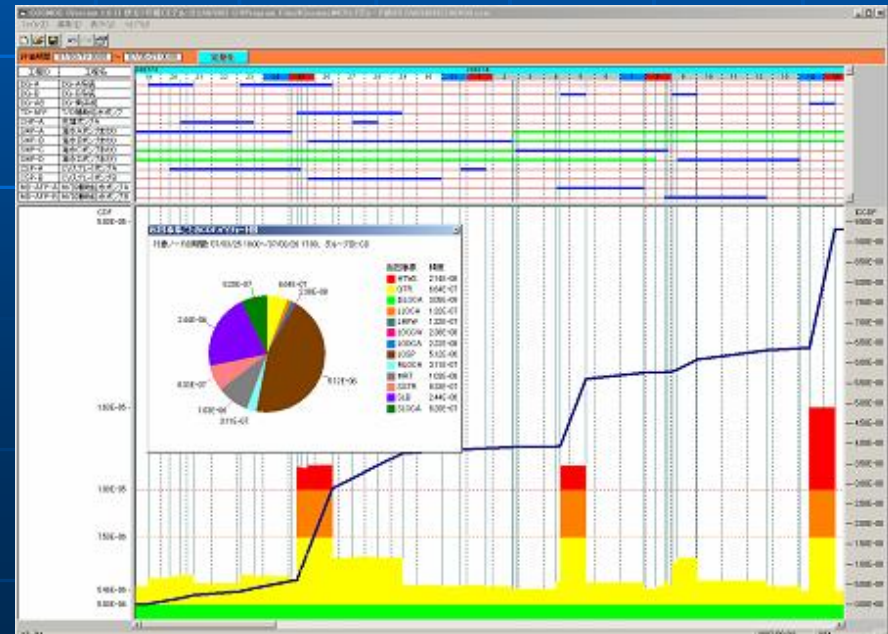
3.(1) COSMOS-FP
For On-line Maintenance Scheduling
and Risk Evaluation (COSMOS_GUI)

· <u>Input Generation</u>

- Gantt Chart Operation

- Inputs referred to Calendar

- Inputs from Formatted file (XML)

- "In-service" or "Standby" or "Out of Service" Switching

· <u>Result Indication</u>

- Time dependent CDF and/or
  ICCDP/Cumulative ICCDP Outputs

- The CDF sequence outputs
  by each time phase

- The core damage frequency outputs
  for every IE by each time phase

3.(1) COSMOS-FP

For Successively Execution of Systems and ETs corresponding to Exact Plant Conditions

1. Set the exact equipments status

   - in-service, standby or out of service of PSA equipments

2. Re-quantify the system failure probabilities based on exact equipments status

   - the failure probability of maintenance equipment as 1.0

   - Based on BDD method using ARALIA

3. Re-quantify Event Trees using updated system failure probabilities

   - We developed quantification Engines and successively quantification system cooperated.

   - COSMOS-FP stored sets of status of equipments and the quantification results (CDFs for each IE and the sequences of CDF) to COSMOS_DB.

3.(2) COSMOS-SD （for shutdown）

- COSMOS-SD is utilized for the risk evaluation during shutdown.

- Equipments are normally maintained each system units. So COSMOS-SD does not re-quantify FTs based on basic events but re-quantify only ETs based on systems.
  This logic is similar to ATORAS.

- COSMOS-SD divides Shutdown into POSs automatically. Each POS is divided depending on RCS water level and the cooling systems (SG or RHR). Moreover they are divided by status of the mitigation systems.

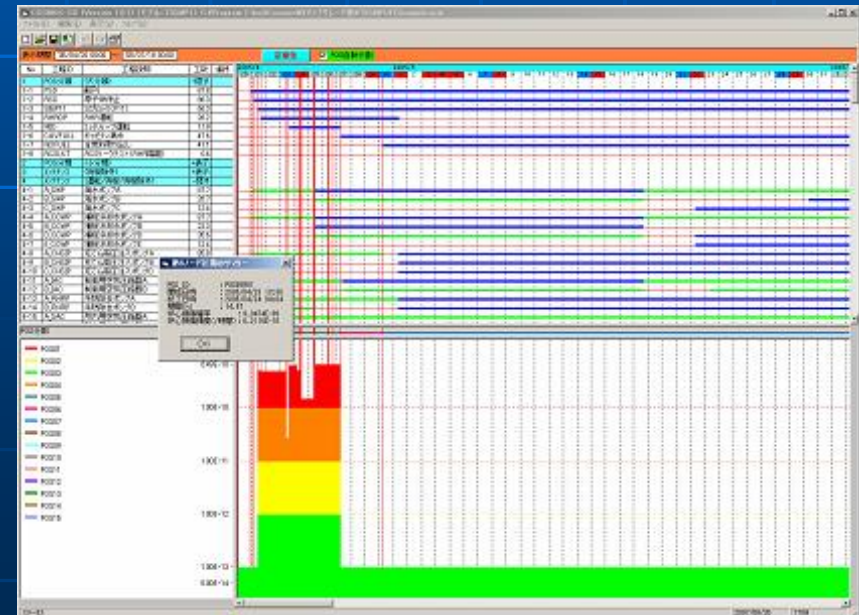# 3.(2) COSMOS-SD

For Shutdown Scheduling and Risk Evaluation (COSMOS_GUI)

- <u>Input Generator</u>
    - Gantt Chart Operation
    - Inputs through Calendar
    - Inputs from Formatted file (XML)
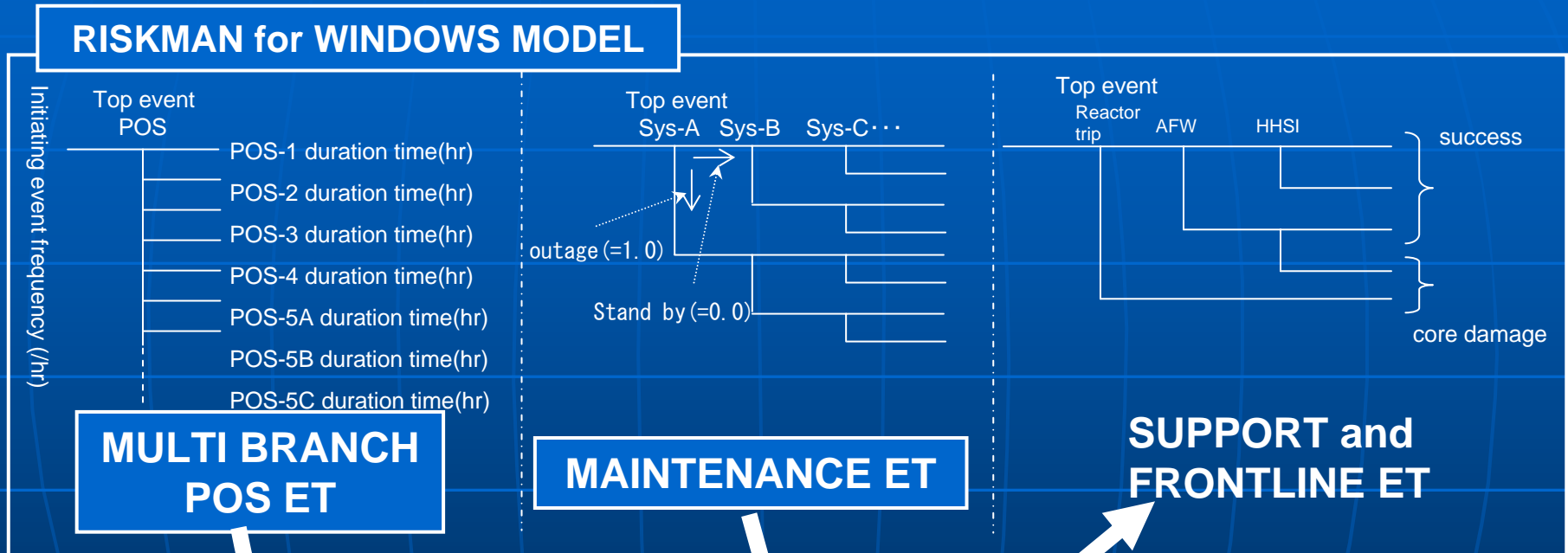   - "In-service" or "Standby" or "Out of service" Switching

- <u>Result indication</u>
    - Time dependent CDF
    - The CDF sequence outputs by each POS
    - The core damage frequency outputs for every IE by each POS

3.(2) COSMOS-SD
For improvement of a shutdown RMW model

RISKMAN for WINDOWS MODEL

Initiating event frequency (/hr)

Top event
POS

POS-1 duration time(hr)
POS-2 duration time(hr)
POS-3 duration time(hr)
POS-4 duration time(hr)
POS-5A duration time(hr)
POS-5B duration time(hr)
POS-5C duration time(hr)

MULTI BRANCH POS ET

Top event
Sys-A Sys-B Sys-C···

outage (=1.0)

Stand by (=0.0)

MAINTENANCE ET

Top event
Reactor
trip   AFW   HHSI

success

core damage

SUPPORT and FRONTLINE ET

• Get all POSs CDF once quantification

• Maintenance System Status for Each POS

4. Further Enhancements

- Quantification Speed-up with Event Tree Engine Changing (Bin-cutoff setting to 0)

- Adding to the Importance Calculation Function

- Calculation Logic of "COSMOS-SD" Based on ETs Re-quantification Shifting to "COSMOS-FP" based on FTs and ETs Re-quantification.

- Linkage Developing to the Maintenance Schedulers (responded to the user request)

5. Conclusions

- We have developed the risk monitoring system COSMOS which has two separated modules "COSMOS-FP" (for at-power) and "COSMOS-SD" (for shutdown) with the aim of each utilizations.

- COSMOS-FP has a feature of successive execution of FTs and ETs.

- COSMOS-SD does not re-quantify FTs based on basic events but re-quantify only ETs considering systems maintenance.

- COSMOS has completely linkage to RMW and the model.
  If you have the RMW model for at-power or shutdown, you can use COSMOS-FP or COSMOS-SD easily (without much effort).

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