Verification and Validation of AMGs

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Overview

- SEOPs and SAMGs validation and verification bases
- Krsko NPP V&V SAMG experience
- C-1 NPP V&V SEOP experience
- References

Verification and Validation Bases

- IAEA NS-G2.2 Operational Limits and Conditions and Operating Procedures for Nuclear Power Plants
  - 9. DEVELOPMENT OF OPERATING PROCEDURES
    - 9.3. The format of procedures may vary from plant to plant, depending on the policies of the operating organization, but **should be developed in accordance with established quality assurance requirements and recommendations**. Appropriate guidance is provided in an IAEA Safety Series publication on quality assurance, and particularly in Safety Guide No. 50-SG-Q13.
    - 9.6 Guidance specific to the plant should be provided in the following areas:
      - e) A verification and approval process that includes validation for the plant in question or for a simulation as relevant as practicable.

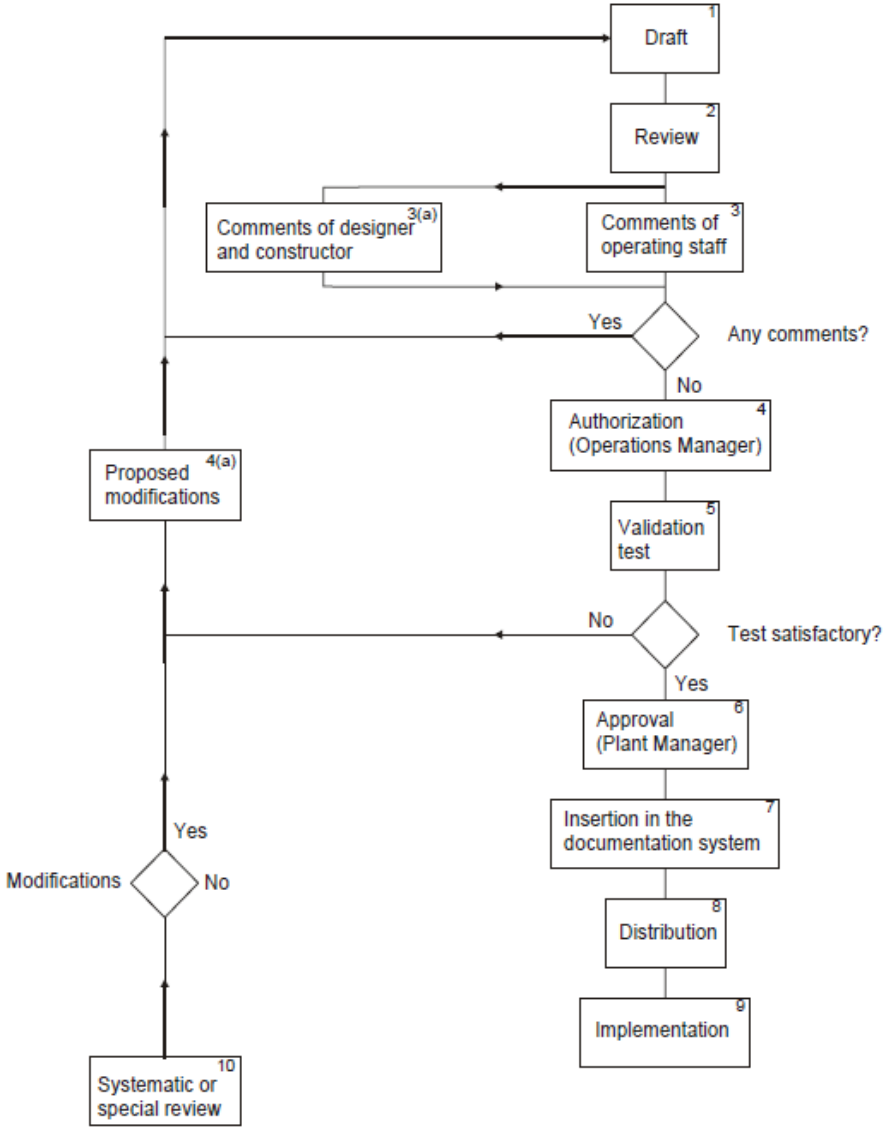
- IAEA NS-G-2.15 Severe Accident Management Programmes for Nuclear Power Plants
  - 3.99. All procedures and guidelines should be verified,
  - 3.100. All procedures and guidelines should be validated.

Verification and Validation Bases

- **IAEA SRS 32 Implementation of Accident Management Programmes in Nuclear Power Plants**
  - Phase 1: Planning and familiarization,
  - Phase 2: Development and validation,
  - Phase 3: Implementation and improvement.

- Plant specific analysis requirements are discussed in the following sections of IAEA SRS 32 in terms of three categories of analysis:
  - Preliminary analysis (see Sections 3.4.3 and 3.4.4) needed for evaluating basic strategies of EOPs and SAMGs,
  - Procedure and guideline development analysis (see Section 4.3) needed for confirmation of strategies and set point calculations,
  - Verification and validation analysis for procedures and guidelines (see Section 4.6.3).

IAEA NS-G-2-2 Development Diagram for EOP



Background Krsko NPP Experience

- Verification was performed based on WOG Generic material and documented in separate report WENX-00-05
- The purpose of the SAMG validation:
  - exercise to test the usage of the Krsko SAMG in conditions as close as possible to real severe accident conditions
- Validation was performed based on WCAP-14213
- Training and Integral Exercise were performed in March 2001 and documented in WENX-00-29;

Objectives of verification

- The purpose of the SAMG verification:
  - review Krsko SAMG package consistencies including the background documents (Strategies and Setpoints)
- Verification determines the various inconsistencies between generic SAMGs and plant specific package:
  - Misunderstand setpoints
  - Missing the setpoints/strategies bases from SA phenomena evaluations in Krsko IPE
  - Missing steps/notes in the procedures
  - Not technically clear diagnostic assumption
  - Typographical errors in designation of System, Structures and Components

Objectives of validation

- Verify the usability of the Krško SAMG in as realistic environment as possible
  - The validation verified the structure, content, clarity and format of the Krško SAMG such that it was useable by both the MCR and the TSC in an acceptable time frame for accident management.

- Ensure that SAMG strategies can be used as planned
  - The validation verified that the strategies included in the SAMG could be used as intended. This included consideration of such items as corrections or enhancements to strategies, capability of local actions, equipment availability, timing considerations, etc.

Objectives of validation

- Ensure that any conflicts or other problems are identified and addressed prior to formal implementation
  - As part of the validation, problem areas needed to be identified and corrected before the final revision of the Krško SAMG is placed in the TSC room and in the control room for use. Areas of concern included, but are not limited to, missing or extra steps in the guidelines, interface with Emergency Operating Procedures (EOP), interface with Emergency Plan (E Plan), cognizance of responsibilities, plant status information availability and communication capabilities.

Objectives of validation

- Provide confidence in the SAMG material to satisfy the plant management and the authorities
  - Prior to place the initial revision of the Krško SAMG in the TSC room and in the control room for use, the Krško plant staff and the authorities needed to be assured that the SAMG would address challenges to the Krško plant during a severe accident situation. They also needed to be assured that usage of such guidance would not exacerbate the plant conditions.

- Provide SAMG hands-on training to the TSC and the control room personnel
  - The validation exercise was also valuable with respect to the training and experience gained by utility personnel in using the SAMG material.

Example for Validation Acceptance Criteria

APOS

EOP - SAMG INTERFACE

- Is the EOP-SAMG transfer point clear and useable?
- Is the timing appropriate?
- Is the responsibility for the EOP-SAMG transition clearly defined?

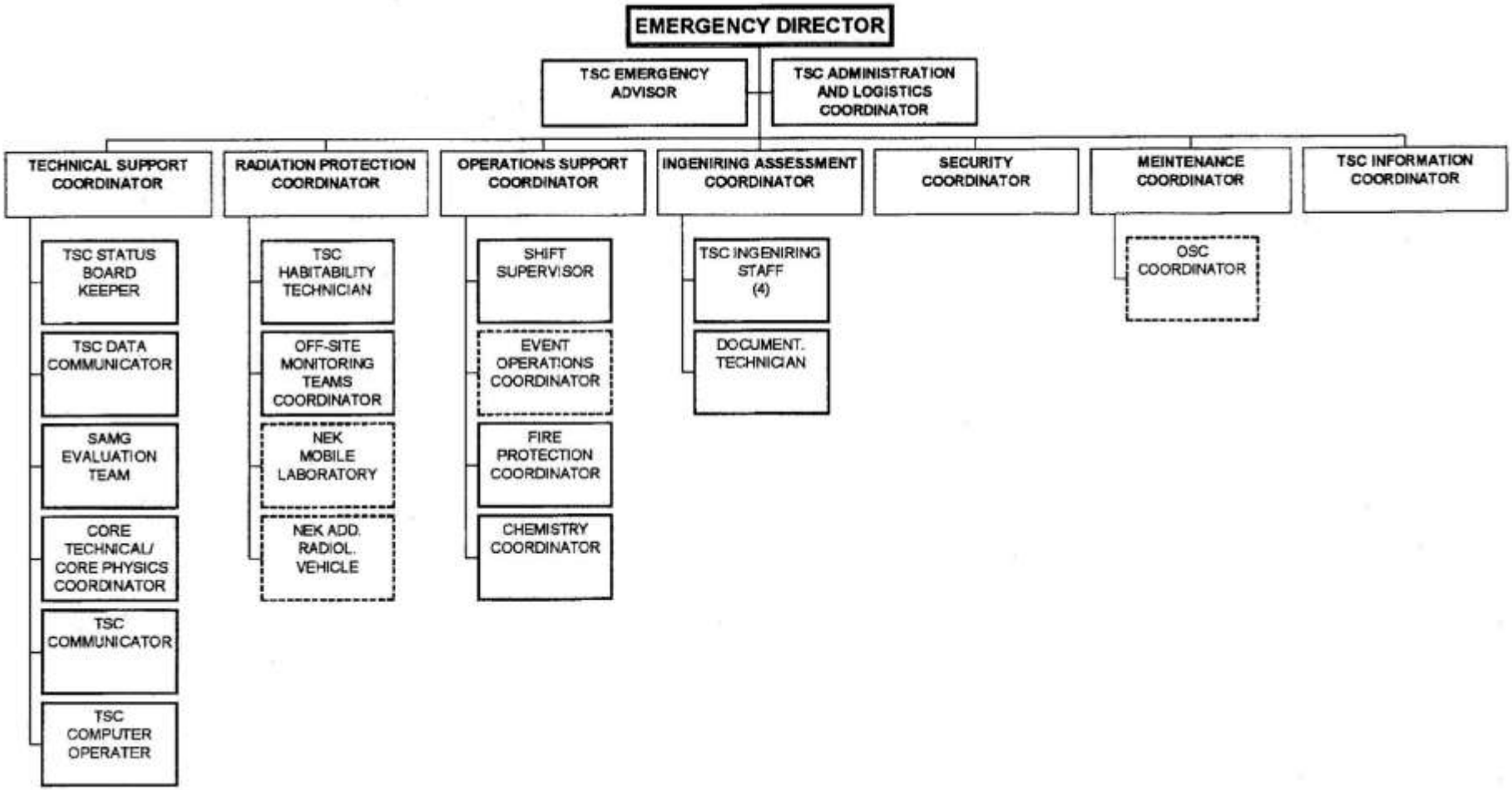
CONTROL ROOM GUIDELINES

- Can the needed plant parameters be obtained?
- Are the decision steps logically ordered?
- Are there extraneous or missing steps?
- Can each of the steps be completed?
- Are the instructions clear and understandable?
- Is the communication between the control room and the TSC emphasized enough?

Validation Time Schedule and Participants

Day	Schedule	Participants
1st	One day overview training course.	All members of the Krsko emergency response team involved in using the SAMG, or interfacing with those using the SAMG.
2nd **3rd** **4th**	Three days training session: • Plant specific course on the SAMG materials and thinking process, • TSC validation exercise • Control room validation exercise.	TSC members (i.e., SAMG evaluation team) <u>For both exercises:</u> TSC members (i.e., SAMG evaluation team) or control room people, as required by the exercise. Krško controllers and additional observers as required.
5th	One day integrated validation exercise.	All Krsko emergency organization. Krško controllers and additional observers as required.

TSC Organizational Scheme



Severe Accident Scenarios

- A joint Westinghouse – Krsko team finalized the scenarios during a preparation session in Krsko. These scenarios were run on simulator (driven by MAAP code / version 4.04) before being used for the validation session in Krsko

- TSC Exercises:
  - Station Blackout – Loss of AC Power – Failure of Diesel Start
  - Station Blackout – Loss of AC Power – Failure of Diesel Start – Cavity Flooding Line Plugged

- MCR Exercise:
  - LOCA – Failure of Safety Injection

- Integrated Exercises:
  - Total Loss of Feedwater – Failure of PORV Opening – Failure of Containment Spray
  - LOCA – Failure of Containment Integrity

Modeling and simulation history

- Recognized as an important area after TMI
- Industry initiative - IPE triggered development of MAAP (3B) - integrated code
- Regulator initiative (MELCOR, RELAP-SCADAP) - integrated based on already existed codes (phenomena based - hydrogen,…)
- Benchmarking - against test, experiments - reduce uncertainty but still large
- Users to be aware of large uncertainty

Modeling, simulation capability in NEK

- MAAP 3B used in IPE (NEK performed majority of the required analyses)
- NEK member of MAAP users group - always latest code available to users - MAAP 4.04 (used in the past for living PSA applications as well as for emergency drills)
- MAAP 4 integrated into plat specific full scope simulator - KFSS
  - **Normal, Abnormal, Emergency as well as Severe accidents including core melt, reactor vessel failure, MCCI, Containment failure and RM response in ENV in REAL time.**
  - **Simulation response on all possible actions required by SOP, GOP, AOP, EOP as well as SAMG**
  - **All the data available in TSC (via SPIS)**

SA simulation approach on KFSS

- One configuration with possibility to switch to SA simulation,
- All the simulator functions available (Freeze, backtrack, store,..)
- If SA to be simulated SIM RCS, Core and CNT models are frozen and MAAP models for RCS, core and CNT become “active”
- All the interfaces with other system resolved and are active in real time

SA modeling/simulation Conclusions

- Users should be aware of large modeling uncertainty at different applications
- Available tools should be used since this is the best we have
- In case of Krsko NPP - Severe accidents simulation on FS simulator verified (interfaces, real time response,..), decision to use this capability to enhance training from the area of SA management - emergency drills
  - **Already used in SAMG and EOP validation**
  - **Already used in and will be used for future emergency drills**
    - **Savings in scenario preparations (time - money)**
    - **Realism (real time response)**
    - **Progression of the accident depends on actions (when and what) performed by MCR, TSC**

Severe Accident Scenarios - SAG / SCG Covered

Exercise	SAG / SCG Covered
Control Room Exercise	SACRG-1
TSC Exercise	SAG-1, SAG-2, SAG-3, SAG-4, SAG-6, SAG-7, SAG-8, SCG-3, SAEG-1
Integrated Exercise #1	SAG-1, SAG-2, SAG-3, SAG-4, SAG-6, SAG-8, SCG-2, SAEG-1
Integrated Exercise #2	SAG-1, SAG-3, SAG-4, SAG-5, SAG-6, SAG-8, SCG-1, SAEG-1

MCR Exercise – examples of WEE observer comments

- The Krsko operators had very few problems using the SACRG-1 in spite of non-familiarity.

- A small miss-understanding of weather the recombines needed to be started or stopped as per SACRG-1 was rapidly corrected. It was due to confusion with the EOP action to start the recombines in FR-C.1.

- Hesitation to read the SACRG-1 steps and regarding the TSC availability can be corrected by an adequate SAMG training for the control room crews.

- The fact that the SACRG-1 is a guideline and not a procedure was clearly understood. Discussion in the control room to know weather one of the two operating charging pumps should be stopped as these pumps were only providing seal water injection tended to show it.

TSC Exercise – examples of WEE observer comments

- The efficiency of the general TSC organization, especially regarding the TSC notification of availability. At the beginning of the accident all TSC members were checked present at the time of their arrival, which led to the declaration of the TSC availability by the emergency director when all were present. This information was immediately transmitted to the control room by the OSC coordinator.

- The communication between the TSC and the CR, and the access to plant information from the TSC seemed adequate. It was emphasized that during the accident scenario the failure of the telephone line between the OSC coordinator and the control room was not simulated. Same thing for the SPDS plant information display. Recommendation is given to test such equipment failures in some future validation or training exercises.

TSC Exercise – examples of WEE observer comments

- Recommendation was given to develop an extended training for the TSC SAMG evaluation team on both the SAMG materials and the SAMG philosophy. Additional exercises including the use of the SAMG guidelines were required.

- Recommendation was given to the TSC SAMG evaluation team to have a pre-prepared status board with a summary of all the main information regarding the use of the SAMG. This board should help focusing on the SAMG usage and should avoid major mistakes like the non-performance of a given applicable guideline.

Conclusions / Lessons learned

- SAMG validation exercises by fully covering the SAMG package but also the whole emergency organization actions met the requirement of both the Krško organization and the Slovenian authorities.

- For all participants, including the Westinghouse observers, the validation goals (training regarding SAMGa and validation) were reached.

- The two exercises were executed with complete emergency organisation. The general feeling regarding the results obtained during this validation week was positive.

Conclusions / Lessons learned

- Although this SAMG validation week was the first of the kind worldwide on a full scope simulator, the exercises conducted permitted to test an important part of the Krško SAMG materials.

- WEE observers and Krsko players comments/responses/feedbacks were documented/discussed in details in validation report WENX-00-29. Comments were related to the following aspects:
  - SAMG material technical aspects (e.g. usage of non-adequate abbreviations, typographical error, missing some steps or positive/negative aspects discussion, etc.)
  - SAMG usage (e.g. the use of the diagnostic tools in the SAMG, the separation of the tasks within the TSC SAMG evaluation team, and the rules of usage of the SAMG, etc.)
  - TSC Spatial Organization (e.g. spatial organization did not facilitate the communication within the TSC SAMG team, and could even get worse if the number of TSC SAMG evaluators would increase by one or two persons)
  - Training (e.g. additional training for the TSC SAMG evaluation team, etc.)

Conclusions / Lessons learned

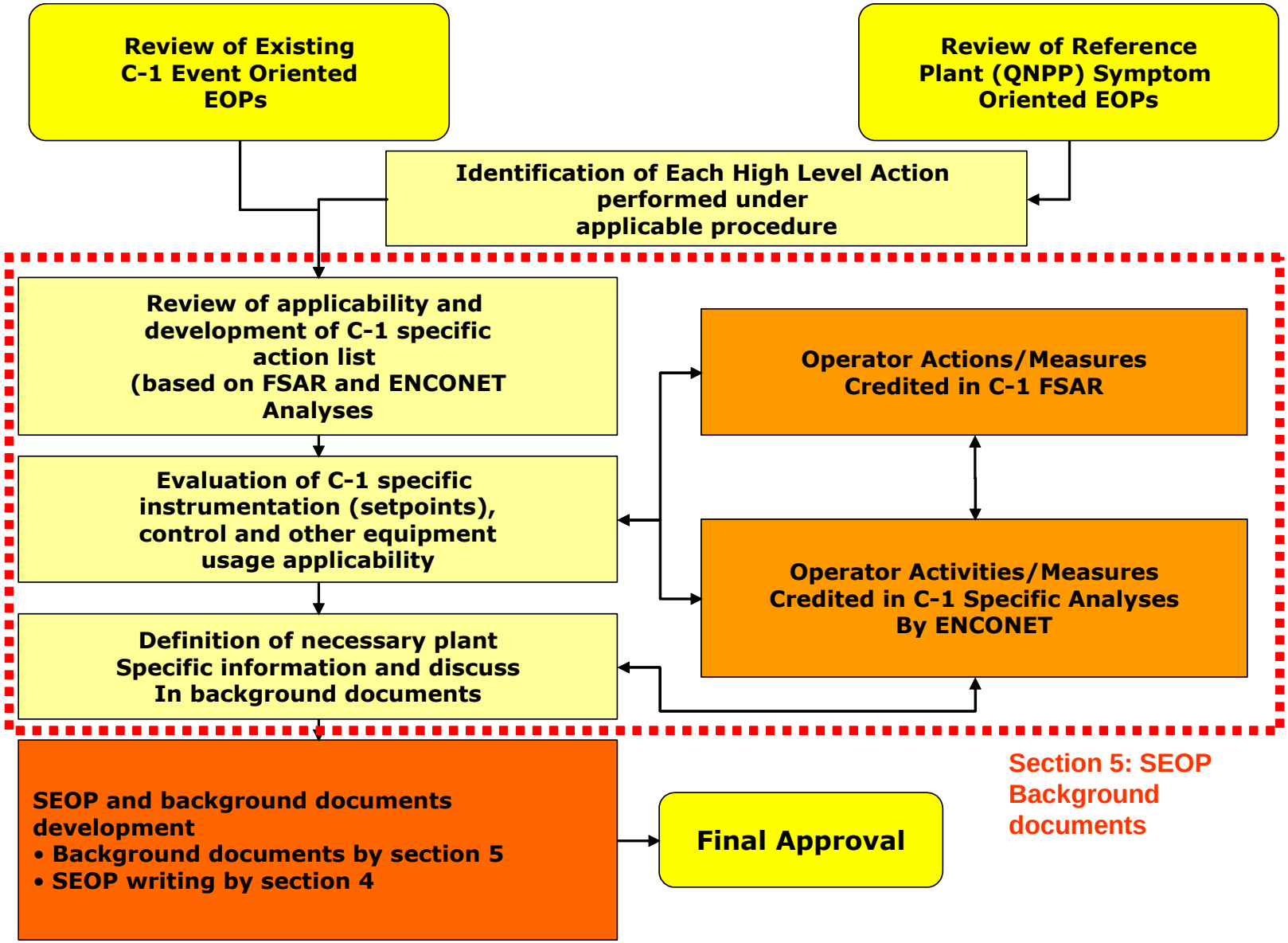
- The flexibility of the simulator to model all SAMG scenarios, and to modify the equipment and system availability at any time, permitted to respond in real time to the TSC SAMG team requirement. It has also permitted to keep a close watch on the scenario development.

- All comments/feedbacks from WENX-00-29 were resolved in revisions 1 (in 2001) of Krsko SAMGs (e.g: development of the separated procedure EIP-17.028 “SAMG Evaluation and Decision Making Responsibilities” with details on how to verify the proposed strategy implementation based on immediate feedback of the actions taken by the control room are. Technical improvement of the SAMG package. Improvement of training program for MCR and TSC team members. Etc.)

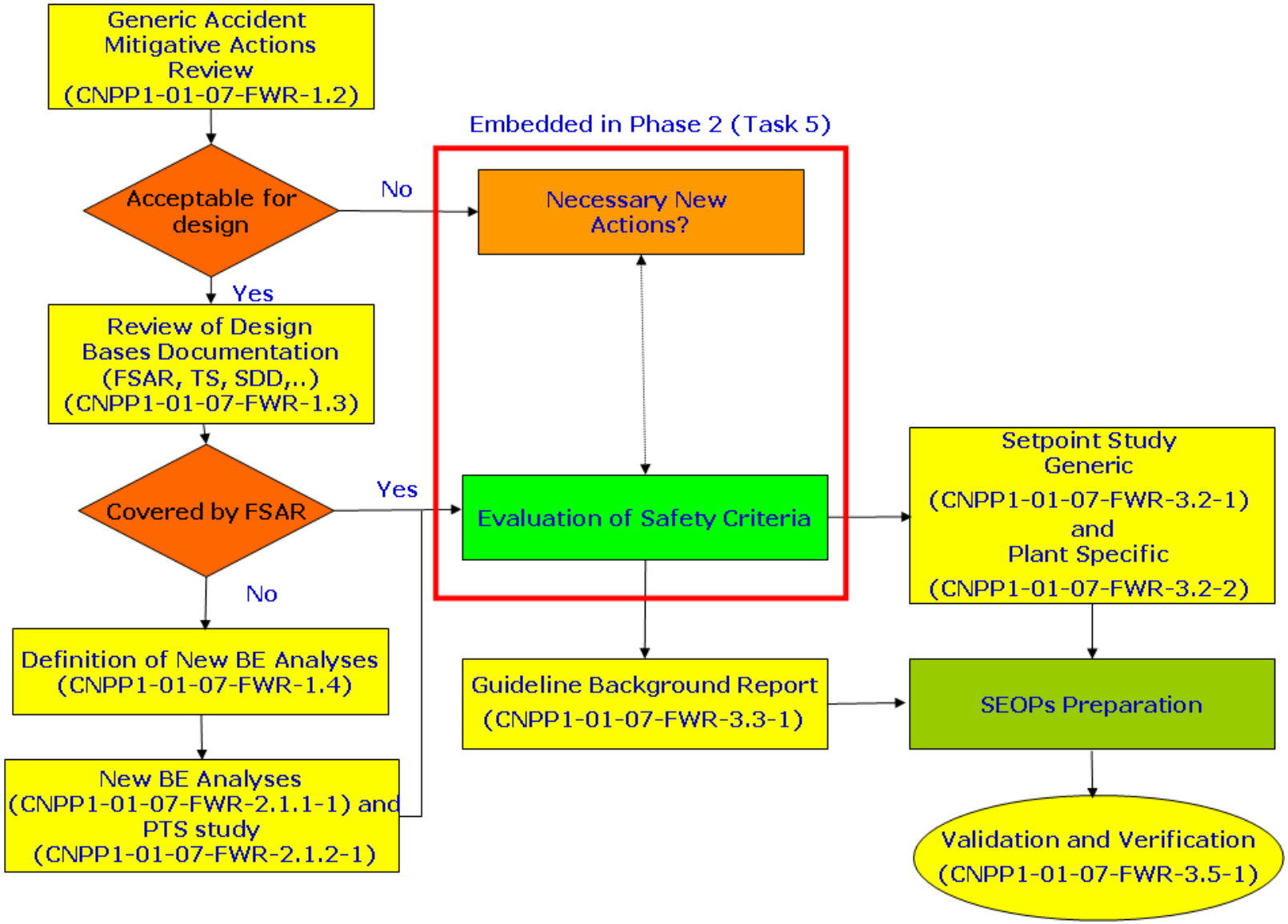
Current Status

- Krsko SAMG package was improved several times since 2001 (taking into account other TSC exercises (once per year) , IAEA RAMP review report, WOG generic materials revision 1 and 1st PSR performed in 2004) as need in the following revision 2, 3, 4,5 and, current, revision 6.

C-1 NPP SEOP Development Overview



C1 NPP SEOP V&V



C-1 NPP Procedures transition

List of scenarios prepared for SEOP validation with list of procedures used in scenarios

Main Feed Line Break (MFLB) – 1/2 HPSI train operational
E-0 > F-0 >E-2 > E-1 > ES-1.1

Loss of Coolant Accident 2 (LOCA 2)
E-0 > F-0 > E-1 > FR-P1 > FR-C2

Loss of Coolant Accident (LOCA) – Inadequate Core Cooling (ICC)
E-0 > F-0 > FR-H.1 > FR-C.1

Loss of Heat Sink (LOHS)
E-0 > ES-0.1 > F-0 > FR-H.1

Main Steam Line Break (MSLB)
E-0 > F-0 > E-2 > E-1 > ES-1.1

ATWS Loss of Feed Water (LOFW)
E-0 > FR-S.1 > F-0 > ES-1.1

Steam Generator Tube Rupture (SGTR)
E-0 > F-0 > E-3

Loss of All AC Power (LOAC)
E-0 > F-0 > ECA-0.0 >ECA-0.2 > E-1 > ES-1.1

Loss of Coolant Accident (LOCA)
E-0 > F-0 > E-1 > FR-P.1 > ES-1.2

C-1 NPP Validation Schedule: 1st week rev. 1

Time	1st WEEK						
			Day 1 (Wed) - 7 Nov	Day 2 (Thu) - 8 Nov	Day 3 (Fri) - 9 Nov	Day 4 (Sat) - 10 Nov	Day 5 (Sun) - 11 Nov
9:00-9.30				V&V: Scenario 1: MFLB	V&V: Scenario 2: LOCA 12	V&V: Scenario 4: LOCA ICC	V&V: Scenario 5: LOHS
9.30-10:30			Status of SEOP Development Project				
10:30-11:00							
11:00-12:30			Validation and Verification Introduction, Organisational Matters				
12:30-14:00			Lunch	Lunch	Lunch	Lunch	Lunch
14:00-15:30			V&V: Scenario 1: MFLB	V&V: Scenario 1: MFLB		V&V: Scenario 4: LOCA ICC	V&V: Scenario 5: LOHS
15:30-16:00			Break	Break		Break	Break
16:00-17:00			V&V: Scenario 1: MFLB	V&V: Scenario 2: LOCA 12	Free	V&V: Scenario 4: LOCA ICC	V&V: Scenario 5: LOHS
17:00-17:30			Discussion	Discussion		Discussion	Discussion

C-1 NPP Validation Schedule: 2nd week

Time	2nd WEEK						
	Day 1 (Mon) 12 Nov	Day 2(Tue) 13 Nov	Day 3 (Wed) 14 Nov	Day 4 (Thu) 15 Nov	Day 5 (Fri) 16 Nov	Day 6 (Sat) 17 Nov	Day 7 (Sun) 18 Nov
9:00-9.30	V&V: Scenario 8: MSLB	V&V: Scenario 9: ATWS	V&V: Scenario 6: SGTR	V&V: Scenario 7: LOAC	V&V: Scenario 3: LOCA 2	Discussion	Report Preparation
9.30-10:30							
10:30-11:00							
11:00-12:30							
12:30-14:00	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch
14:00-15:30	V&V: Scenario 8: MSLB	V&V: Scenario 9: ATWS	V&V: Scenario 6: SGTR	V&V: Scenario 7: LOAC	V&V: Scenario 3: LOCA 2	Discussion	Report Preparation
15:30-16:00	Break	Break	Break	Break	Break	Break	Break
16:00-17:00	V&V: Scenario 8: MSLB	V&V: Scenario 9: ATWS	V&V: Scenario 6: SGTR	V&V: Scenario 7: LOAC	V&V: Scenario 3: LOCA 2	Report Preparation	Presentation of performed work
17:00-17:30	Discussion	Discussion	Discussion	Discussion	Discussion		

C-1 NPP Validation Team?

Task 10: Verification and Validation Report

Availability of plant staff is based on the assumption that maintenance and continued validation of the procedures shall be linked to the training and re-training of the C-1 operator shifts:

- Team 1 - Trainers/Validation Team (3 persons with SRO license, preferably one former Shift Supervisor form C-1, Simulator Personnel, Analysis Engineer)
- Team 2 - Main Control Room Team (as per TS) from C-2

It is assumed that both teams are well acquainted with the submitted frozen versions of the EOP's. Understanding of the background document (CNPP1-01-07-FWR-3. 3-1-2011-0 "SEOP Technical Guidelines") is essential for the Team 1 - Trainers/validation team, especially for all the procedures addressed in the submitted scenarios.

C-1 NPP Validation Observed remarks

- C-2 simulator is proper tool for SEOP exercises – all major phenomena of all assumed accidents were clearly observed. Still some improvements or additional model validation is needed and for this purpose the already existing RELAP runs could be used
- Simulator personnel are ready to prepare and perform similar exercises in the future

C-1 NPP Validation Observed remarks

- Three way communications in Main Control Room was very good.
  - Operators must be trained to perform steps following Shift Supervisor instructions and orders. They are not allowed to perform the steps in advance without notifying shift supervisor (rules of usage), unless instructed by procedure (immediate actions steps at the beginning of E-0, for instance).
- STAR (Stop Think Act Review) principle need to be improved
  - After each action on Main Control Board, operator must check all associated indications that action is successfully completed. It is not enough to turn the switch of the pump off, indications as current, fluid flow and pressure must be checked as well.

C-1 NPP Validation Observed remarks

- Reponses of MCR C-2 staff were excellent taking into account that it was their first contact with these procedures and such typo of scenario and exercises:
  - Training on the background of procedure steps is welcome but background materials shall not be presented in MCRs
  - MCR should have basic background knowledge about setpoint study development but not use it during training or work in MCR
  - Accidents phenomena are known to the MCR staff but it, together with assumed plant responses, still need to be repeated before every exercise

C-1 NPP Validation Observed remarks

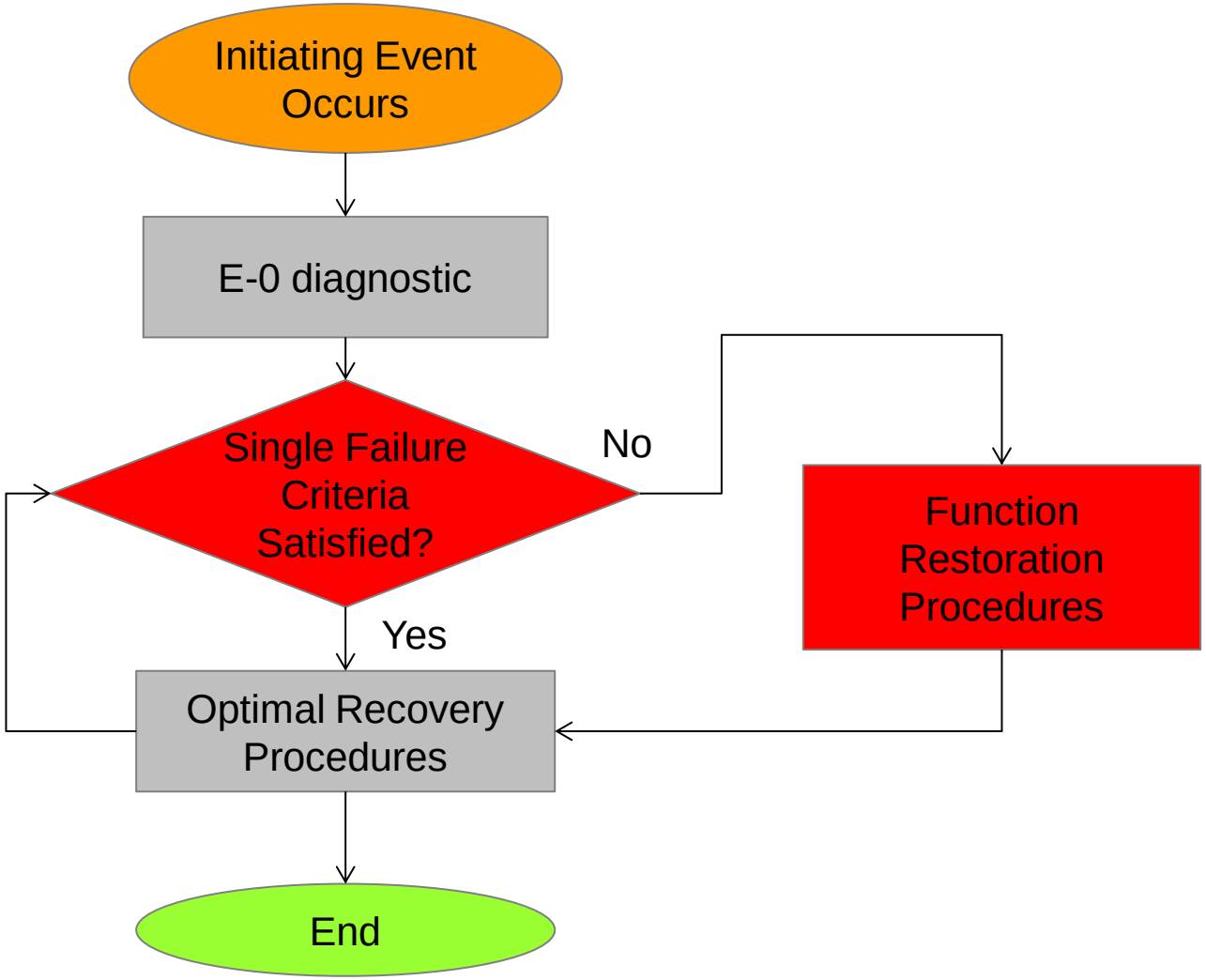
- Verification process is live and on-going process and it need to be high priority for plant. Co-operation of MCR staff from the both plant is necessary:
  - Typo-errors
  - IF some setpoints are not in accordance with Setpount Study
  - IF some steps with same operator actions from different procedures do not use the same or harmonized wording
  - IF list of lineups should be improved
  - IF detail instructions for local operator are missing
  - Engineering Guideline for TSC. On severeal places in SEOP, MCR staff requires opinion from TSC

- Order of procedures and associated folder – controlled copies shall be always organized in recommended order

C-1 NPP Validation Lessons Learned

- Importance of operator training and retraining on such exercises
- Importance of quality of background materials and studies (around 200 different scenarios which can be used also for validation of simulator)
  - Further scenarios can be arranged with use of information from reports and analyses delivered to C-1.
- Well structured – Prevention of multiple failures
  - It was evidenced that even if error (overcooling) was made in execution of E-0 -> E-3 (optimal recovery) procedures (max.cooldown of RCS with open SG PORV in non-faulted SG) the diagnostic of CSFST and usage of F-P.1 (function restoration procedure) will transit plant properly to proper safe and stable state

C-1 NPP Validation Lessons Learned



C-1 NPP Recommendation

- Validation of one scenario without Plant Information System and Displays is recommended
  - Non qualified?
  - Non-interupted power supply?

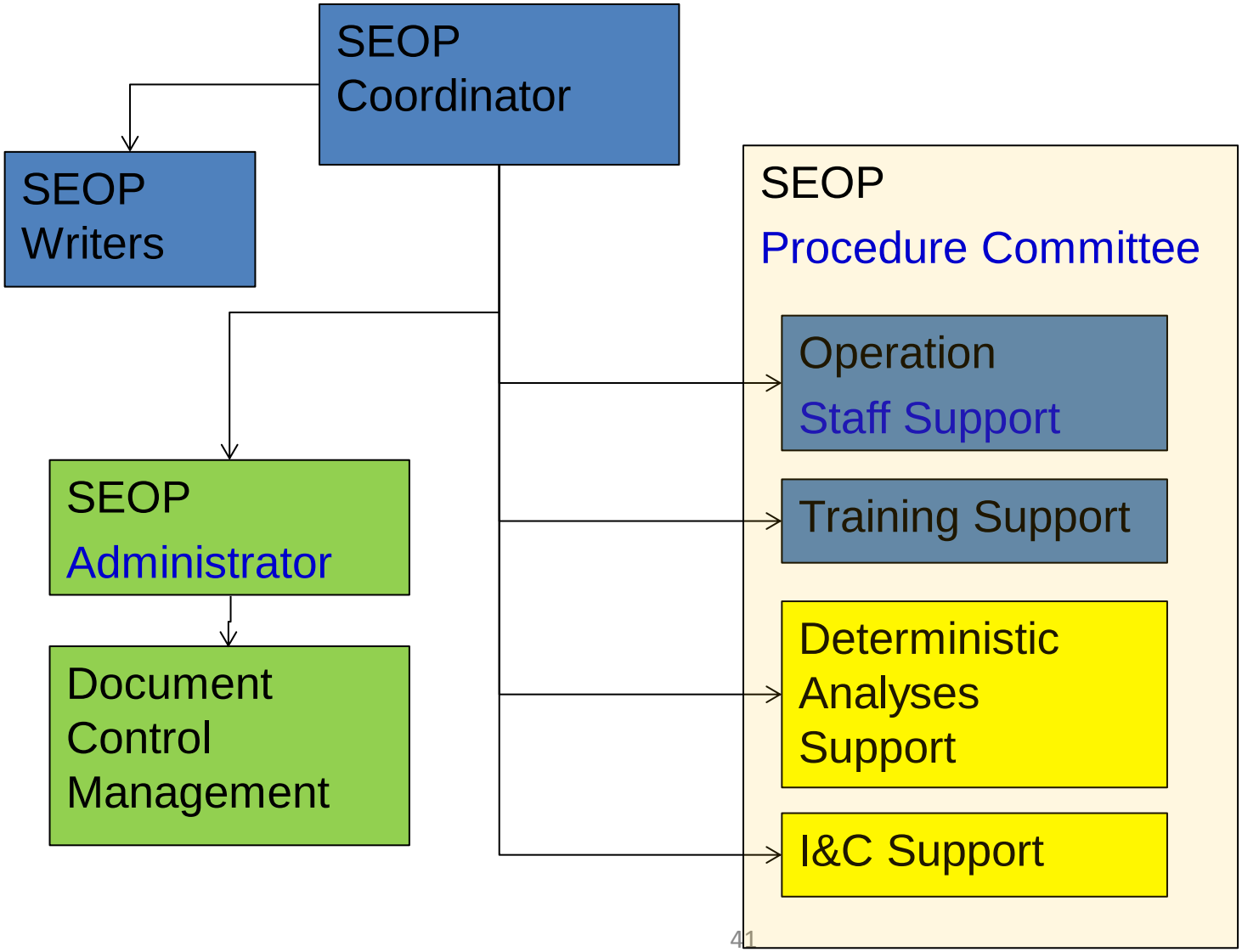
- Organisation of an SEOP Maintenance and Improvement Team is reccomended

- A formal plant program for ongoing evaluation and revision of SEOPs is recommended to ensure that changes in plant design, technical specifications, technical guidelines, writers guide, other plant procedures, or the control room are reflected in the SEOPs.

C-1 NPP Recommendation

- A formal plant program for ongoing evaluation and revision of SEOPs is recommended to ensure that changes in plant design, technical specifications, technical guidelines, writers guide, other plant procedures, or the control room are reflected in the SEOPs.

Example for SEOP Maintenance and Improvement Team



Typical Implementation Plan after SEOP development and V&V Process

Activity	Duration (month)
Writing of the Plant Specific Rule of Usage	0.5
Procedure Verification and Correction (simultaneously with background documents)	2.0
Frozen version administration	0.5
Training of 5 MCR Shifts	5.0
Potentially small changes after training	0.5
Total	**8.5**

References

[1] "NPP Krško Severe Accident Management Guidelines Implementation"; paper presented at the international conference "Nuclear Option in Countries with Small and Medium Electricity Grids 2002"; Dubrovnik, Croatia, June 17-20,2002., I. Basic, J. Spiler, B. Krajnc, T. Bilic-Zabric (NEK);

[1.1] Krško SAMG Review Report, WENX-00-05, Westinghouse Electric Corporation, February 2000;

[1.2] Krško SAMG Validation Report, WENX-00-25, Westinghouse Electric Corporation, December 2001;

[2] "NPP Krško Severe Accident Management Guidelines Review And Validation"; paper presented at the International Topical Meeting on Probabilistic Safety Assessment "Risk Informed decision making at nuclear facilities" Detroit, USA , 6-10 October 2002., I. Basic, J. Spiler, B. Krajnc, (NEK);

Questions?
Comments?

Thanks for your attention!