Republic of South Africa: Eskom's Koeberg Nuclear Power Plant Operating Experience on the Integration of Periodic Safety Review and Safety Aspects of Long-Term Operation (LTO) to produce a safety case for LTO

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Short Biograph

Koeberg Nuclear Power Plant Senior Manager : Koeberg NPP path to demonstrate safe LTO: Synergy between SALTO and PSR Activities to Support Development of LTO safety Case

ESKOM, South Africa

- Bravance works within the Generation Division at Eskom in the Nuclear Operating Unit (NOU), focussed on long-term operation of the NPP. Within Nuclear Engineering her role is mainly concerned with safety assessments and analyses, plant life cycle management, and maintaining of design basis documentation (such as the safety analysis report), and long-term planning for sustainable operations.
- Before the current role, Bravance has been in various technical and managerial positions within the NOU, including systems engineering , work management, and plant engineering.
- She is a professionally registered engineer with Engineering Council of South Africa.
- Bravance has over 19 years of nuclear power plant design and operations experience.

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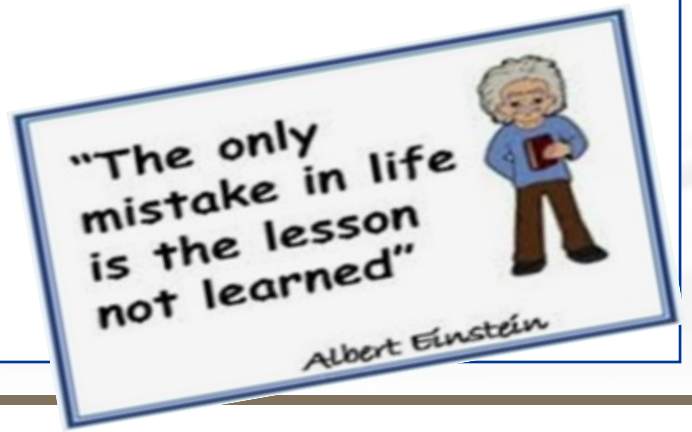
Purpose of the presentation

Aim: share the South African operating experience relating to the integration of SALTO and PSR activities in preparation for LTO and providing the safety case for LTO

The overview will cover the generic lessons learned on the following:

- Interactions with regulatory authority
- LTO programme and Organizational structure
- LTO assessments Integration: PSR, SALTO and Site Characterization in Support of Safety Case.
- Recommendations.



Regulatory Framework: Interactions with the Regulatory Authorities

South African LTO regulatory requirement are in line with IAEA safety standards for LTO

Long-Term Operation Context

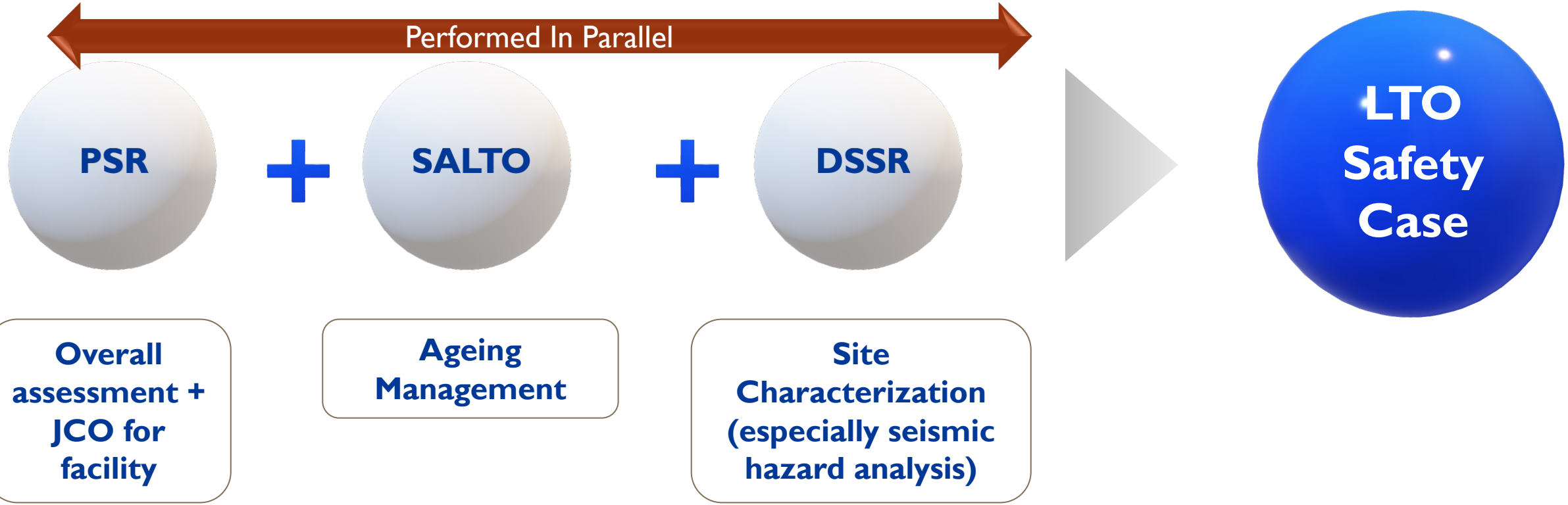
- Plant design life of 40 years (assumed in the safety analysis report).
- Initial nuclear installation license (NIL-001) had no expiry date
- In 2019 NIL-001 was varied to include a license expiry date of 21 July 2024 for both units.
- In 2019 ageing management and periodic safety review (PSR) interim Regulatory guidance documents were issued and
- In 2021 the legislation for LTO of NPP, R.266, was promulgated.
- Eskom intends to continue to operate beyond the 40-year license (i,e., LTO is operation beyond originally intended lifespan or current license expiry date).

Approval authority National Nuclear Regulator (NNR) Regulatory requirements

- Submit an applications no later than 42 prior to end of license. **(requirement met).**
- Submit a safety case no later than 24 months prior to end of license which meets the following criteria. **(requirement met with commitments to be performed during the NNR review period).**
  - ✓ Demonstrate **compliance** with relevant **regulatory safety criteria and requirements.**
  - ✓ Base the application on the results of a safety analysis, **with consideration of the ageing of SSCs**.
  - ✓ Provide an **overall assessment of the safety of the nuclear installation and justification for continued safe operation** (periodic safety review (PSR) for LTO).
  - ✓ Demonstrate **availability of financial and human resources** for LTO.
  - ✓ Include the **necessary safety improvements** in the application, including refurbishment, provision of additional SSCs, and additional safety analyses and engineering justifications, to ensure the licensing basis remains valid during the LTO period.
- Safety case should be informed by LTO safety assessments (LTO assessments define the scope of the LTO programme). **(requirement met)**
- NNR review of the LTO safety case not less than 24 months. **(NNR review in progress)**

LTO Safety Case

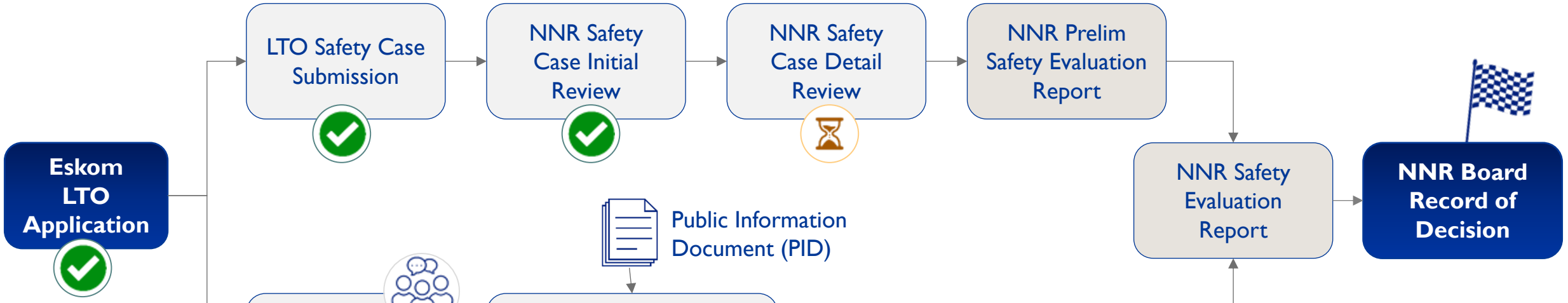
Main inputs assessments (completed)



- DSSR: Duynefontyn site safety report
- PSR: Periodic safety review
- JCO: Justification for continued operation
- SALTO: Safety Aspects of Long-Term Operations

Regulatory Approval Process

Lesson learnt: There must be robust engagements between the operator and the Regulator to ensure all the requirements to support the process are agreed upon in advance and that these do not pose a risk to the facility



- Issue of the safety case to the public
- 230 reference documents had to be issued
- Considering the requirements of local laws and IAEA guidance documents relating to security of nuclear facilities

- Multiple public engagement sessions due to outstanding information relating to actions committed in the safety case to be completed prior to LTO
- Three (3) sessions in total with final participation meeting underway

Source: https://www.nnr.co.za

Completed | In Progress | Completed/In Progress Steps | Remaining Steps

Generic lessons learned: Regulatory Framework

Salient Points

- As an operator, **assumptions were made** on what the Regulator would require to approve the LTO license application.
- KNPP assumed that **the SAR update was the only requirement for license approval** due to NIL-001 with no expiry date.
- **Limited engagements on key issues pertaining to the requirements for the approval** of the extension between the operator and the regulator.
- The issuing of the new regulatory LTO related guidance documentation **increased the scope of activities to be performed in preparation for LTO,** thus resulting in **time and resources constraints** for the LTO assessments.
- LTO assessments scope was enormously more than what was initially anticipated, resulting in the **assessment actions required prior to LTO being documented in the safety case appendix**.
- The **validity of the safety case depended on the completion of these assessment actions** (i.e., claims and arguments made in the safety case were contingent on completing the ongoing activities, as the required evidence of the claims).
- Outstanding submissions to the Regulator resulted **in multiple public engagement sessions** as actions were completed and information made available to the Regulator.

LTO Programme: Organizational Structure, Resourcing and Licensing Interfaces

LTO Roadmap

Extensive LTO scope

2010

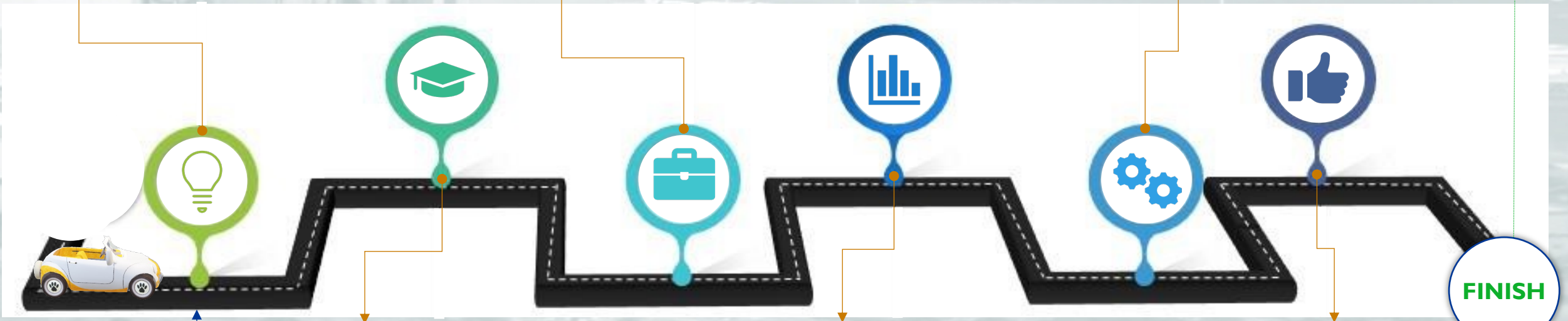
- Plant Life Extension (PLEX) **Business Case Approved**
- Mainly major plant modifications

2019

- **NNR Changes**:
  - NIL Variation 19 (License Expiry Date – 21 Jul '24)
  - LTO Guidance Documents issued
- IAEA **SALTO Pre-Mission II**

2022

- **LTO Safety Case submission** to NNR
- Commencement of NNR Safety Case Review



START

- IAEA **SALTO Pre-Mission I**
- Progress PLEX Modifications

2015

- LTO Programme (**Safety Case Inputs**):
  - Comprehensive Periodic Safety Review for LTO
  - SALTO Ageing Management Assessment
  - Duynefontein Site Safety Report
- Final **SALTO Mission**

2019 – 2022

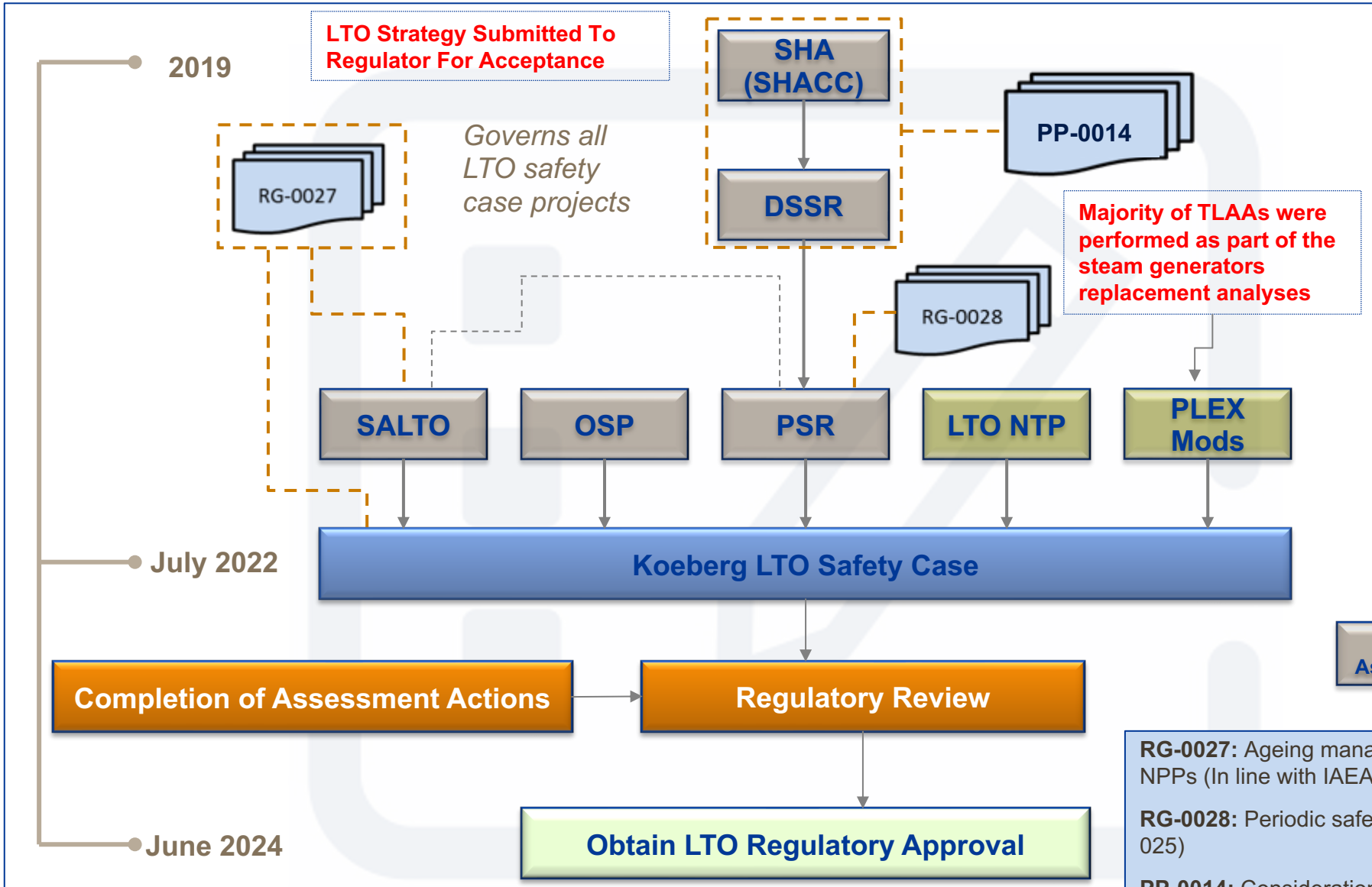
- NIL Extension Approval **(Pending)**

2024

FINISH

Koeberg licensed to operate until 2044/2045

KNPP Comprehensive LTO Programme



Project Description

SHA – Seismic Hazard Analysis Studies

DSSR – Duynefontyn Site Safety Report

SALTO – Safe Aspects for Long Term Operation

OSP – Other Safety-related Programmes

PSR – Periodic Safety Review

LTO NTP – Nuclear Technical Plan

PLEX – Plant Life Extension Modifications (SGR, RFWT, etc.)

Safety Assessments

Limiting Plant Features

RG-0027: Ageing management and long-term operations of NPPs (In line with IAEA SSG-48)

RG-0028: Periodic safety review of NPPs (Inline IAEA SSG-025)

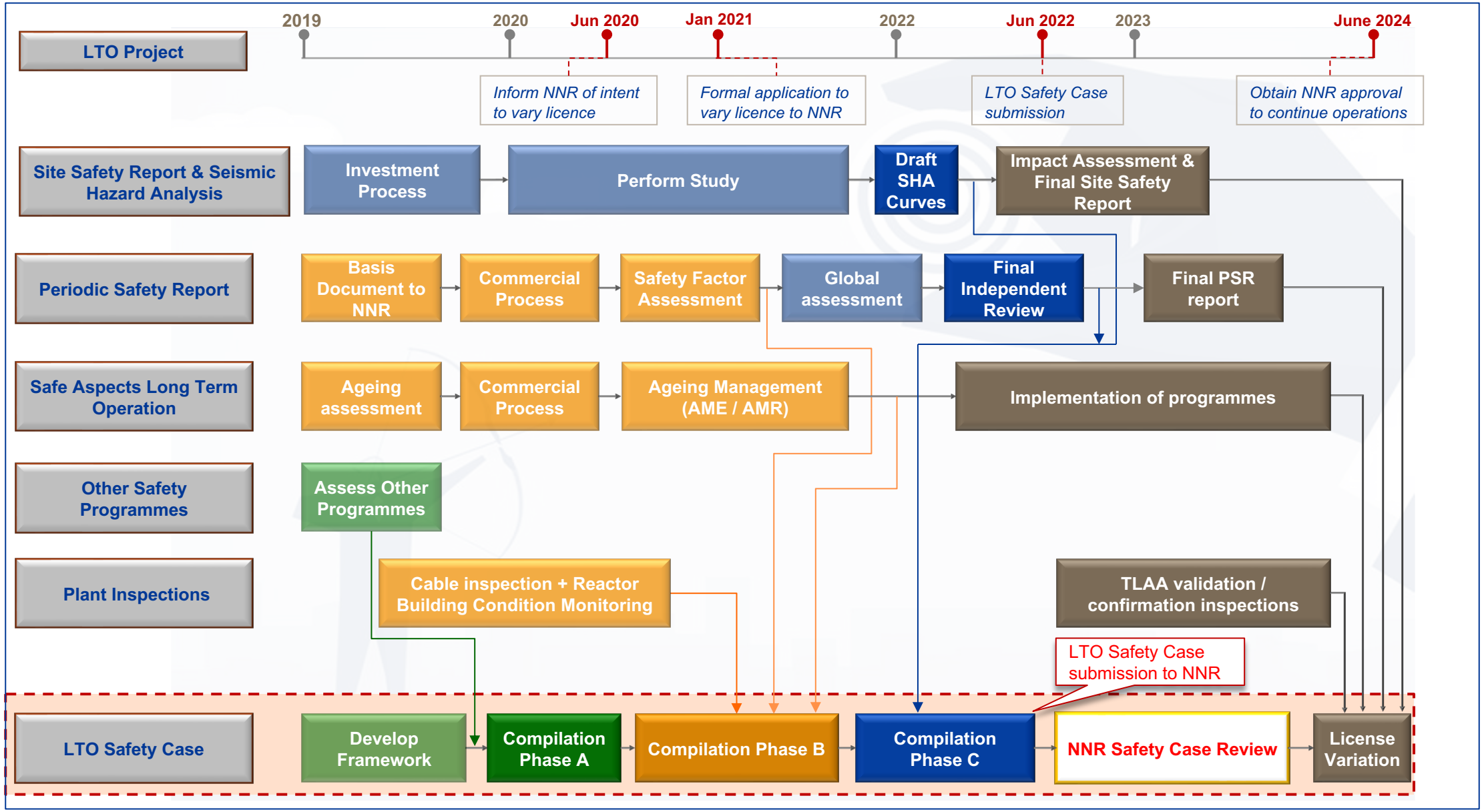
PP-0014: Considerations for external events for nuclear installations

Generic lessons learned: Licensing Interface and Quality assurance

Salient Points

- Due to the scope and timing challenges risking not meeting the timelines for the approval of the license, **innovative ways were employed to minimize the risk and ensure that the safety case is submitted timeously**.
- **Claim, Approach, Evidence (CAE) approach** utilized.
- **Develop the structure and content of the safety case** and obtain Regulatory approval.
- The safety case makes safety **claims and arguments based on the concluded LTO assessments and the assessments documentation is utilized as evidence**. Committed to completing the actions during the Regulatory review phase.
- Determine **critical milestones for each of the assessments to facilitate phased compilation of the safety case**.
- **Determine the documentation deliverables** (evidence) for the assessments milestones (e.g., interim ageing assessment report identifying all the gaps after the AMR/E) to support the CAE approach.
- Multiple NNR-Eskom engagements in line with licensing strategies, and therefore **complex managements of the communication to ensure the quality of the deliverables.** By March 2024 all submissions to the Regulatory were made except for two EAF sentinel locations related to TLAA 106 requirements
- Dedicated **personnel to integrate and manage the licensing communications** to ensure that there is **no conflict and that all communications supports the safety case objectives.**
- **Quarterly meetings (including ad-hoc technical meeting when necessary)** were held with the regulatory authority to **ensure continuous alignment, aid the understanding of expectations regarding submission and fast track the resolution of issues, if any**.

LTO Programme Integration



Global assessment and suitability for continued operations

Global Assessment Objective

- The objective of the PSR global assessment is to arrive at a judgement of the Koeberg Operating Unit's suitability for continued operation on the basis of a balanced view of the findings from reviews of the separate safety factors

(RG-0028 §6.4.1)

Suitability for Continued Operations

1. Consolidation of outcomes of Safety Factors' reports conclusions discussing performance since the last PSR
2. Outcomes of the Interface Analysis utilising the IAEA SF-1 Fundamental Safety Principles
3. Outcomes of a Safety Analysis based on Defence in Depth (5 Levels)
4. Outcomes of a Safety Analysis based on Fundamental Safety Functions
5. Safety status of the plant with and without the implementation of safety improvements supported by a risk assessment
6. Supporting arguments for LTO activities; together with safety improvements (Integrated Implementation Plan) related to the Plant and Organisation.

Case of suitability for continued operations

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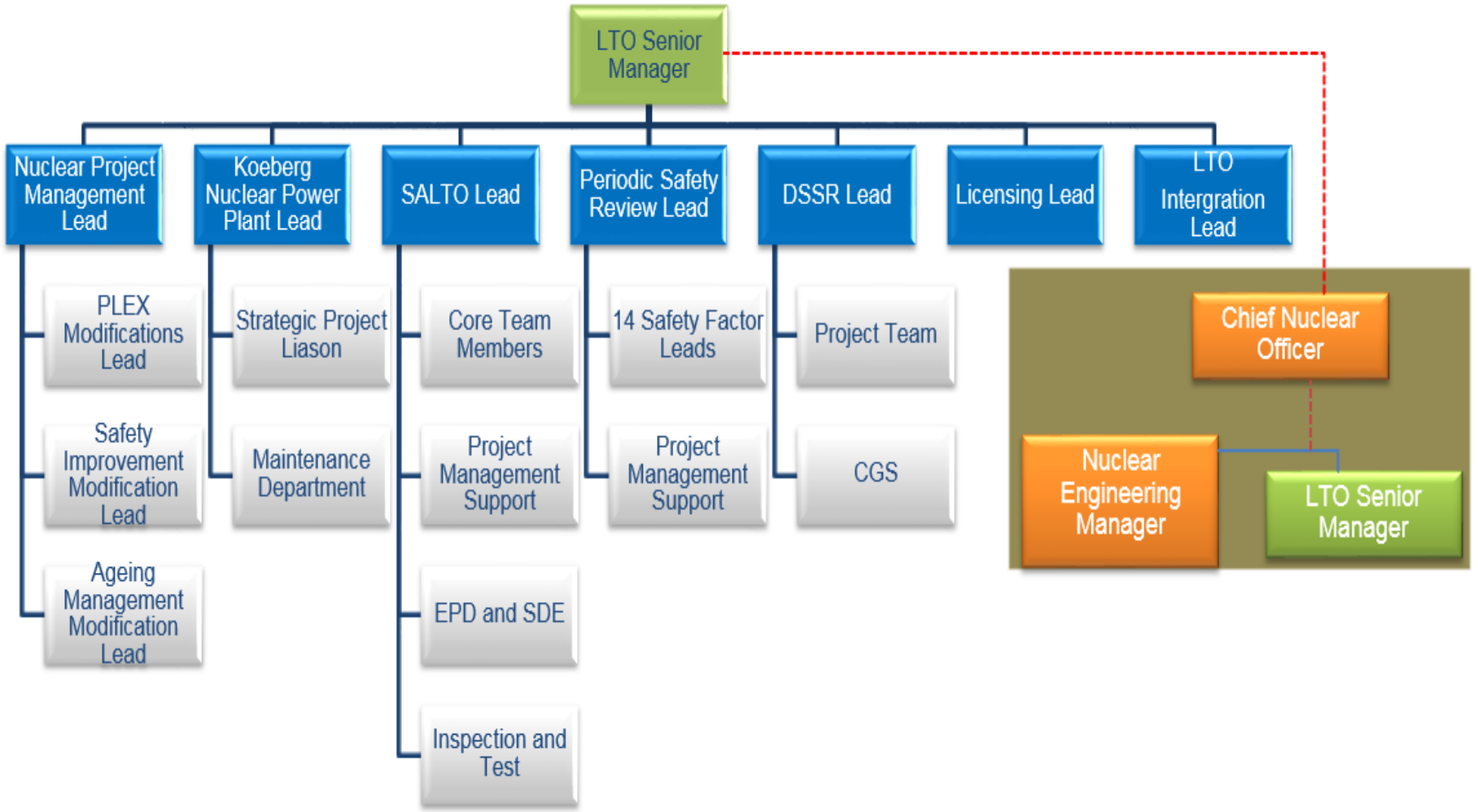
High-level Organogram for the LTO Programme



LTO Programme Resourcing

Resources Plan for LTO

Item No.	Project Name	Eskom Full Time	Eskom Part Time	Eskom Reviewers	Supplemental Workers	Outsources services	Comments
1.	SALTO						
1.1	Assessment Phase						
1.1.1	AMR/E	5		10		√	
1.1.2	TLAAs screening	5	6	10		√	
1.1.3	Project Management	1			7	√	
1.1.4	Proejct QA				1		Framatome / Lesedi Consortium
1.2	Execution Phase						Framatome
1.2.1	TLAAs	5	4	3		√	TUV Nord
1.2.2	New AMP developments	1	5	9		√	
1.2.3	Existing AMP Updates	1	4	9		√	
1.2.4	Project Management	1			5		
1.2.5	Proejct QA				1		
2.	PSR						
2.1	Safety Factor 1	1	1	4		√	Jacobs UK
2.2	Safety Factor 2	3		4	7		
2.3	Safety Factor 3	1	2	2	3		
2.4	Safety Factor 4	1		2	3		
2.5	Safety Factor 5	1		2		√	Tratebel Energie
2.6	Safety Factor 6	1	10	2	2		
2.7	Safety Factor 7	2		3	4		
2.8	Safety Factor 8	3		2	3		
2.9	Safety Factor 9	1		2	2		
2.10	Safety Factor 10	1	3	3	3		
2.11	Safety Factor 11	1	1	2	4		
2.12	Safety Factor 12	0	1	2	5		
2.13	Safety Factor 13	0	1	1	2		
2.14	Safety Factor 14	1	1	1	2		
2.15	Project Management	1			4		
2.16	PSR Technical Lead	1					
2.17	Global Assessment	12		5	2	7	
3.	Other Safety-Related Programmes						
3.1	Nuclear Security	1		2			
3.2	Water Chemistry	1		1			
3.3	Other License Binding Programmes	1	1	1			
4.	DSSR						
4.1	Site Specific Characterization	7		3		√	
4.2	SSHACC Studies	3				√	Council for Geoscience
4.3	Contract Management	1	1		1		
5.	EQ Components Replacements						
5.1	Electrical Maitenance Services	3				√	Koebec
5.2	Instrumentation Maintenance Services	6					
6.	Plant Inspections						
6.1	Instrumentation Maintenance Services	12				√	Koebec
6.2	Electrical Maitenance Services	6			10	√	Koebec
6.3	Inspection and Test for Civil Scope	5		5			D-Tech
7.	Modifications						
7.1	I&c Penetrations	2	12	2	10	√	
7.2	Pressuriser Heaters Replacement	2	14	3	11	√	
7.3	Induced Cathodic Protection Installation	1	3	5	6	√	
7.4	RCP Narrow Range RTDs Replacement	2	11	2	9	√	
7.5	Hardened Water Supply Tanks	10	12		3	√	
7.6	Hardened Water Connections	10	12		3	√	
8.	Commercial Support						
8.1	Commercial Support	2					
9.	Finance						
9.1	Management Accounting Support	2					
	Total	127	110	99	118		454

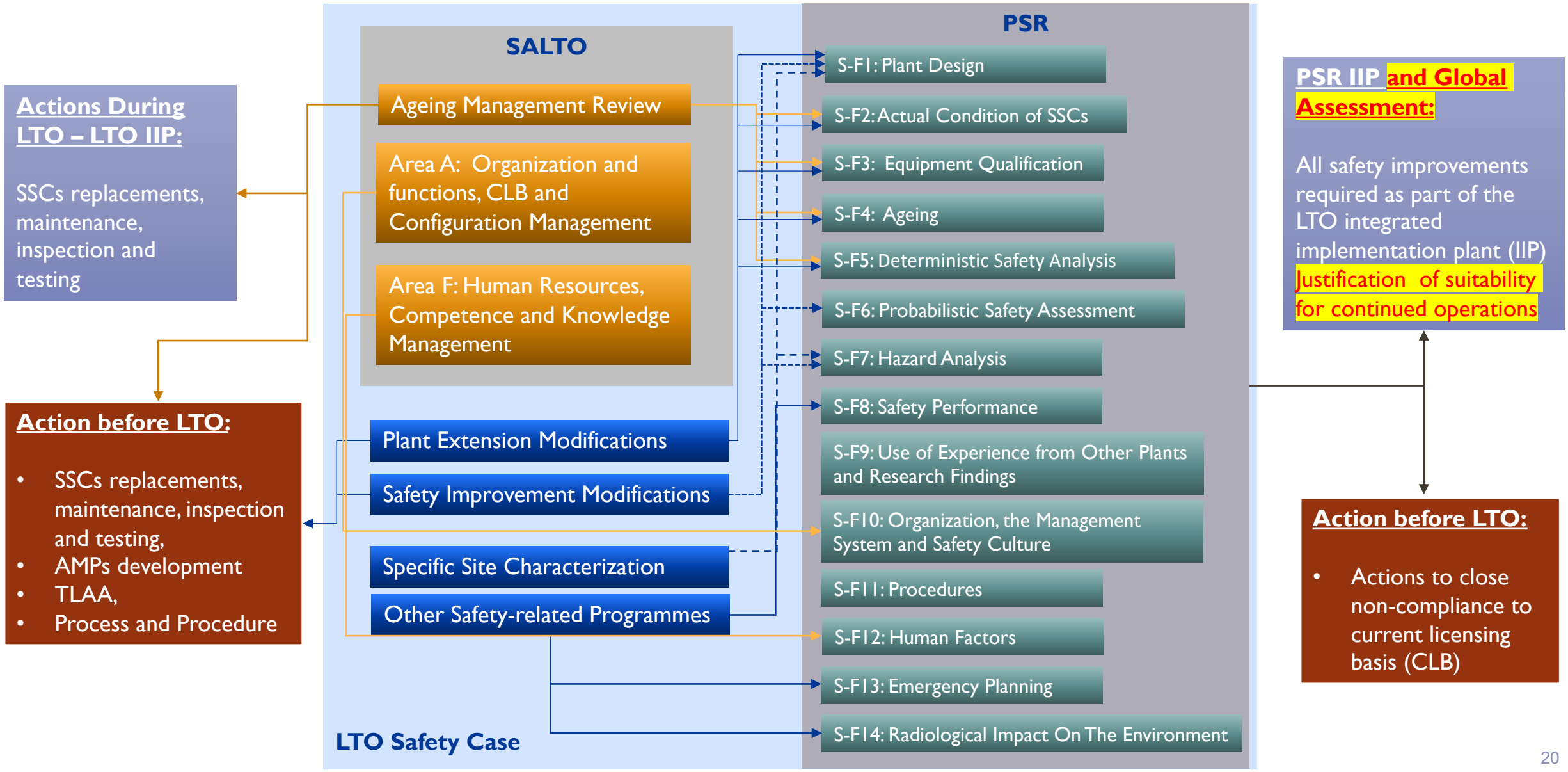
Generic lessons learned: Structure, Resources, Skills and Expertise

Salient Points

- The LTO structure was **based on the current Eskom's NOU business mandate** which reduced **the risks and challenges involved in creating new LTO organization.**
- The above strategy ensured continuity since it is **based on currently established mandates with established quality management systems** and not short-term mandate associated with short-term projects.
- The number of Eskom's resources were complemented with **supplemental workers as and when required,** which ensured effective use of resources (human and financial).
- However, **local skills and expertise were not sufficient to undertake such a programme**, resulting in dependence on international support.
- **Extensive on the job training from the IAEA and technical support organizations (TSOs), supplemented with technical IAEA support missions** to ensure that the Eskom and supplemental personnel are equipped to perform the tasks.
- The limited expertise were demonstrated by the number of reworks activities in specific areas ,e.g., in PSR some safety factors such as EP, deterministic safety analysis and safety performance, had to be reworked. Additionally, some of the TLAAs reviews resulted in further work that could have been prevented should the reviews had been rigorous.
- TSOs skills and expertise in some instances were questionable.

LTO Assessments: PSR, SALTO and Site Characterization Activities Integration

Parallel PSR and SALTO Scopes Interdependencies



Generic lessons: PSR, SALTO and Site Characterization

PSR

Fast Tracked ~ Completed in < 2.5 years

Rework was required in some areas due to different levels of review details in the various safety factors. Early cross reviews from different safety factors will assist with this issue.

Inconsistency in how documents were stored was time consuming and created a lot of confusion.

Ensure that **document controllers receive all relevant training and access authorizations for different document databases prior to the start of a project**.

Mobilise **technical resources in advance and integrate them to your teams so that they can learn the organization's culture.**

To minimise rework, **ensure that technical individuals form part of the panel interviewing the contractors.**

SALTO

(>200 000 SSCs)

TLAA 201- **Application of the IEEE standard for the cable revalidation resulted in unnecessary additional work**

During the revalidation, the team **matched the requirements of the IEEE Trial standard used in design of NPP to the latest standard**

Used **multiple methods of revalidating the TLAA 201 selected without proper justification** (IEEE dual logo standard)

Cables TLAA **lack of information during the revalidation** resulting in unnecessary limitation on the cable life

Information provided to TSOs was at times incorrect or lacking resulting in incorrect results (TLAA 301 had to be revalidated twice)

Lots of one-time inspections especially for the civil structures – **resource intensive during outages and affecting outage duration at time**

Site Characterization

SSHAC Studies

2 years were required to perform the seismic monitoring and conclude the studies. Late start of the study **affecting the PSR and safety case development**

Developed an **interim solution for the seismic hazard utilizing the expedited seismic evaluation process** to ensure that **plant robustness could be performed** for the safety case

Demonstrate that the ESEP results envelopes the SSHAC results (0.5pga versus 0.36 pga which was above the 0.3 pga design basis) for the validity of the safety case

Impact analysis of the 0.36 pga was negotiated with the Regulatory authority to be done during the LTO period

However, the rest of the hazard analysis were not addressed **because a strategy was not developed to deal with the outcomes of the site characterization**.

Generic lessons learned: Integration of activities

Salient Points

The generic areas of improvement identified during the PSR project include:

- Ensure **consistency of format of the contents of the final documents** produced for the various assessments. For example, assessment or review, findings and gaps.
- Ensure a **thorough technical review** before acceptance of TSOs final submissions to ensure soundness of technical argument to prevent reworks which are costly.
- Multiple projects required **strong monitoring and integration function** to avoid conflicts and meet the objective of the programme.

Recommendations

Recommendations

- Commence the LTO assessments early enough (at least 6-10 years prior to end of license term) considering the plant shutdown's requirements to perform the actions stemming out of the assessments.
- Assessments to be done in series to avoid the complexities of integrating the activities during the LTO assessments.
- If a safety case is a requirement, commence LTO assessments and preparation actions prior to the development of the safety case to ensure that a comprehensive complete safety case can be submitted to the authorities
- Ensure that there is clear understanding of the IGALL requirements, for example, TLAA acceptance criteria, usage of TLAAs and related AMPs
- Ensure that both technical staff and technical support organizations are sufficiently skilled to perform the engineering work (i.e., analysis and assessments) to prevent reworks which are resource consuming
- Reconciliation and use of the original design standards and latest standards should be clearly established prior to undertaking the analyses and be sufficiently justified
- Provide all documentation to ensure that the regulatory authority has sufficient time to review and provide a decision timely manner to prevent impact of late decision on the production plan

NB: Although not recommended, KNPP was able to complete all requirements for extension of unit 's license within 4.5 years

Engagement

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