Engineering Systems Systematically

Romuald Duperrier

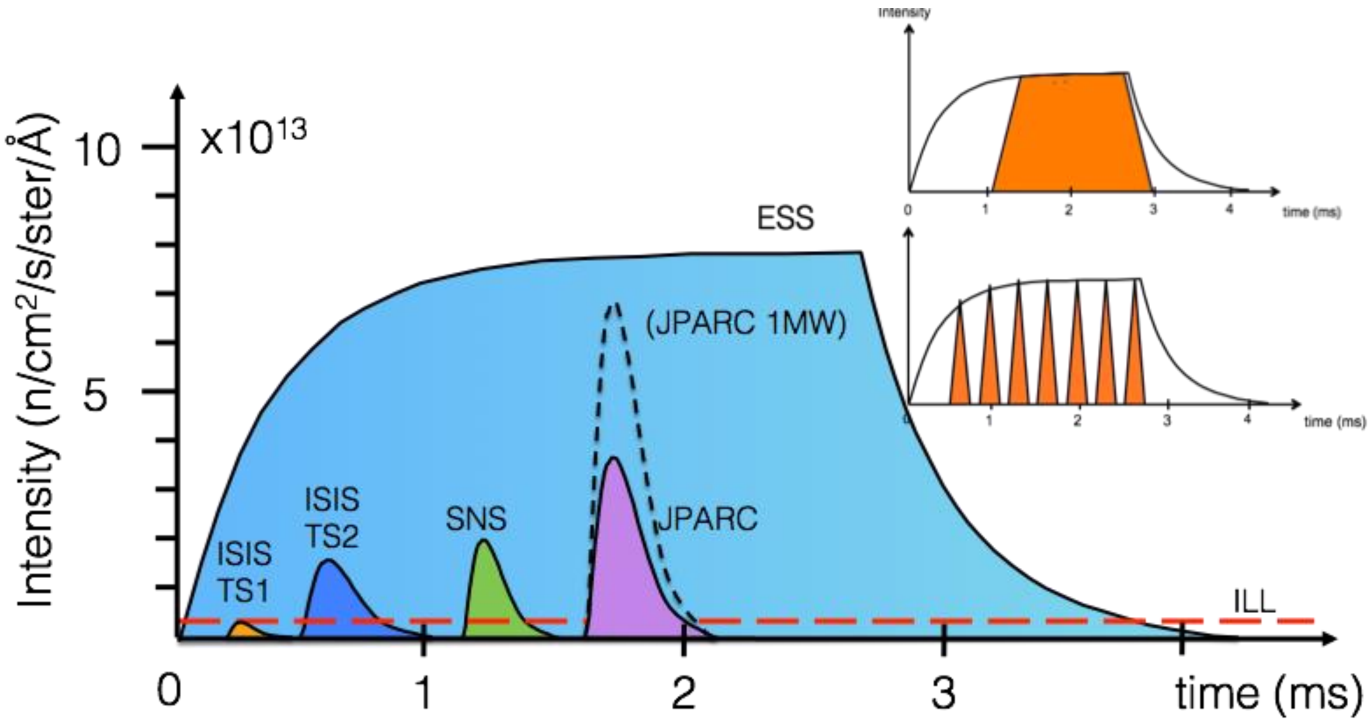
ESS Systems Engineering Manager

Sommaire

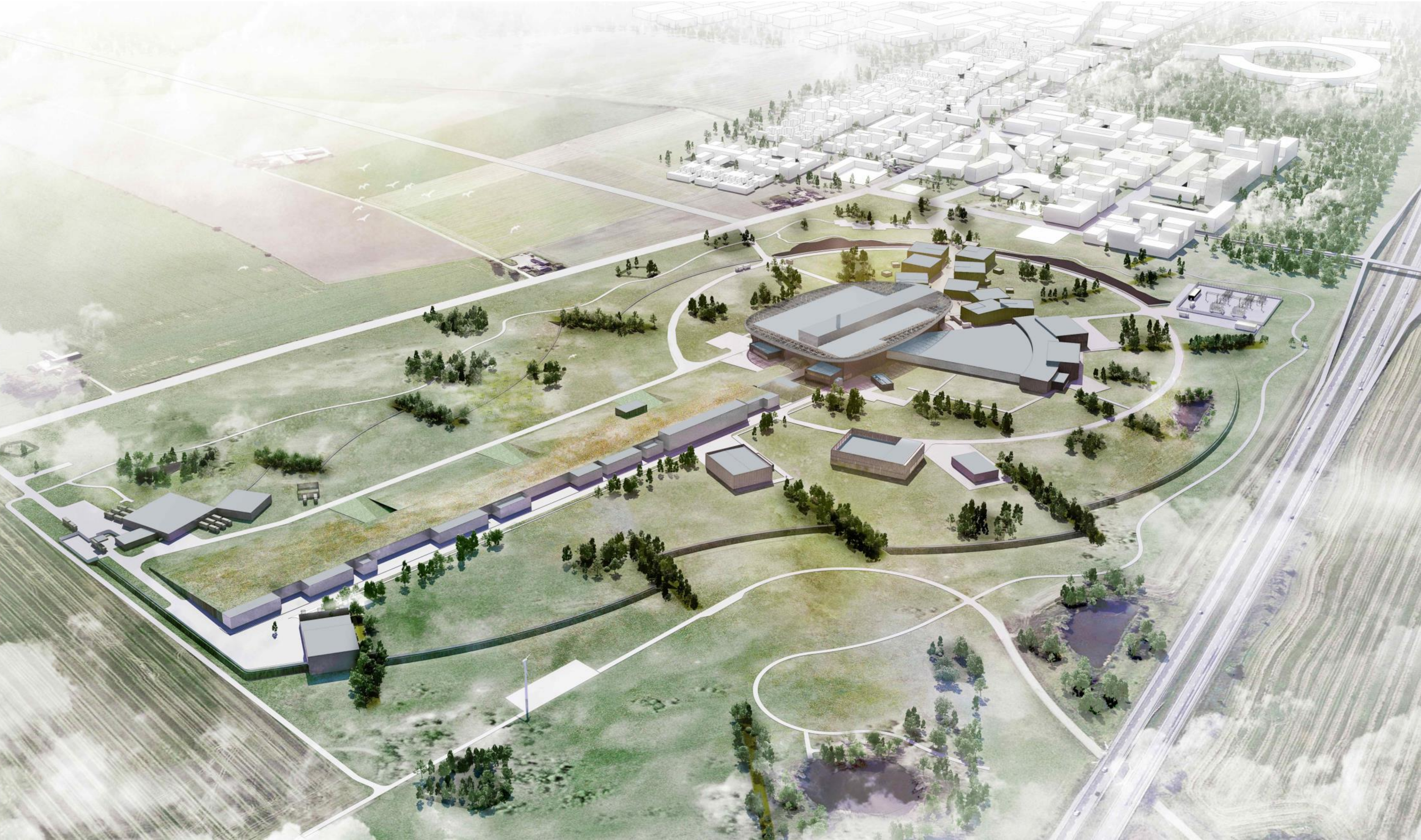
- Le défi technologique
- Des jalons ambitieux
- ESS: un partenariat de 17 pays européens
- Un site vierge (de tout)
- Déploiement du système qualité
- Rôle de l’Ingénierie des Systèmes
- Les méthodes, les outils, le contenu
- Le status quo (résultats et REx)

ESS

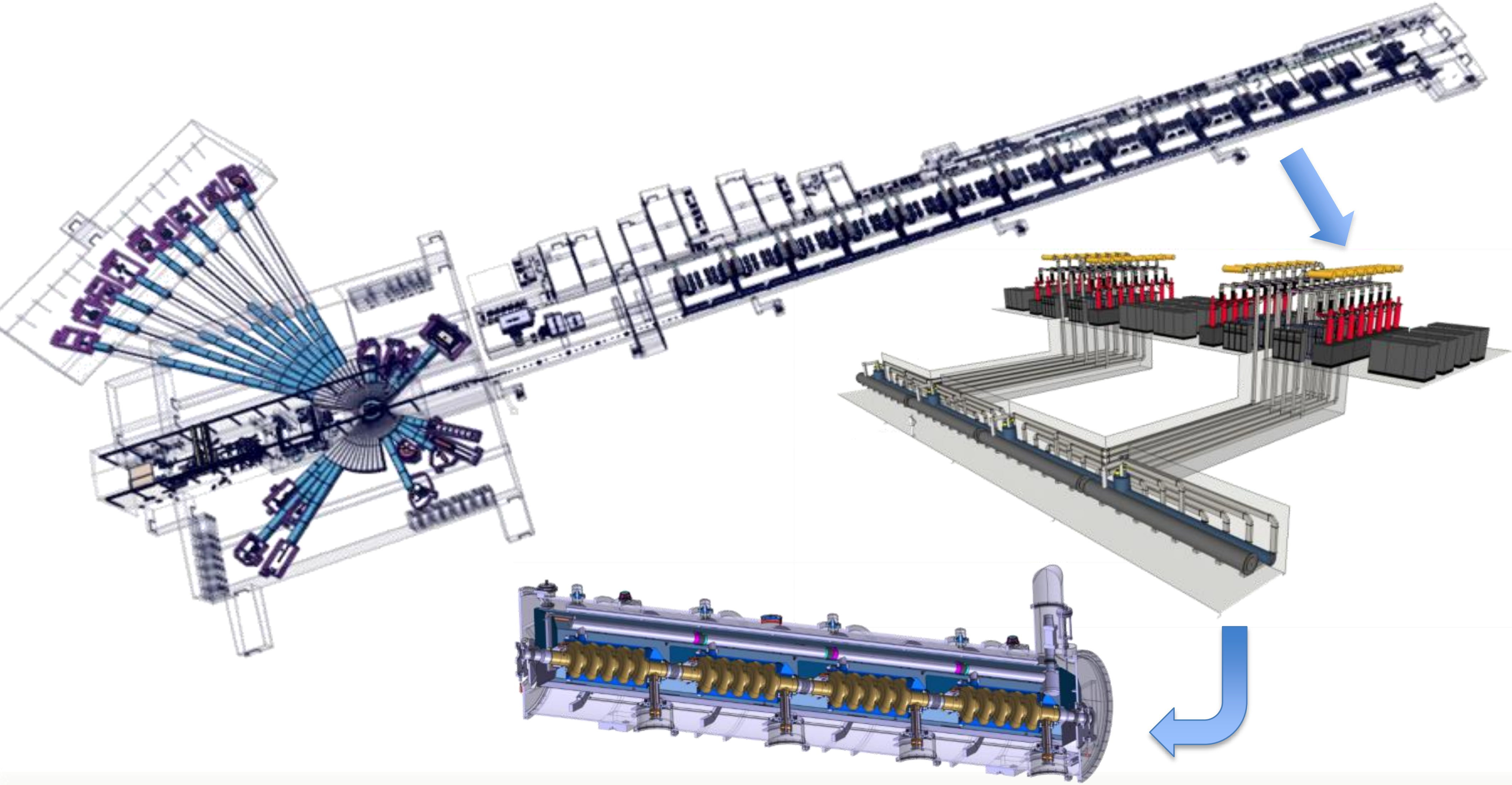
“A partnership of 17 European nations committed to the goal of collectively building and operating the world’s leading user facility for research using neutrons by the second quarter of the 21st century.”



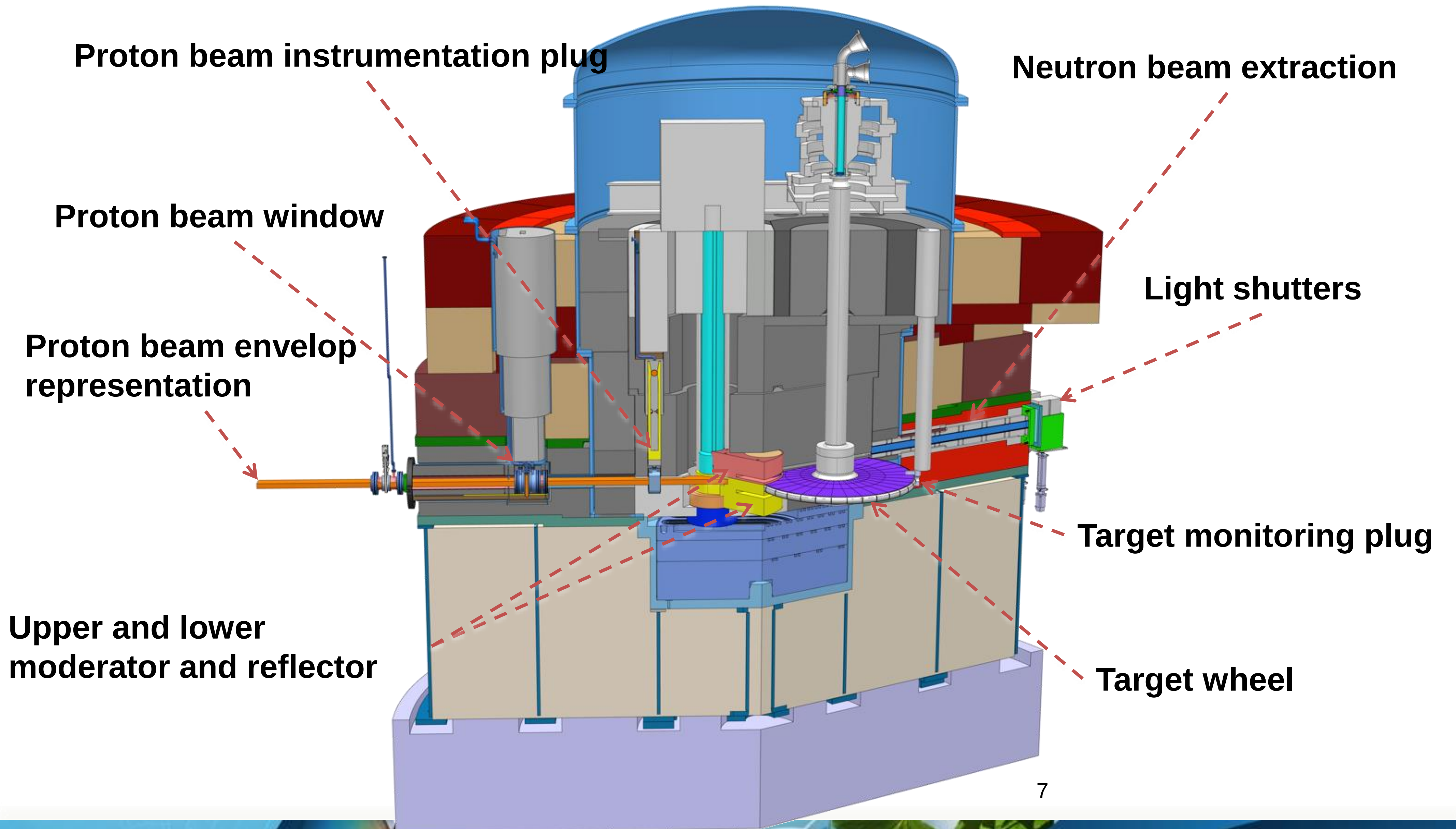
ESS facility looking towards Lund University



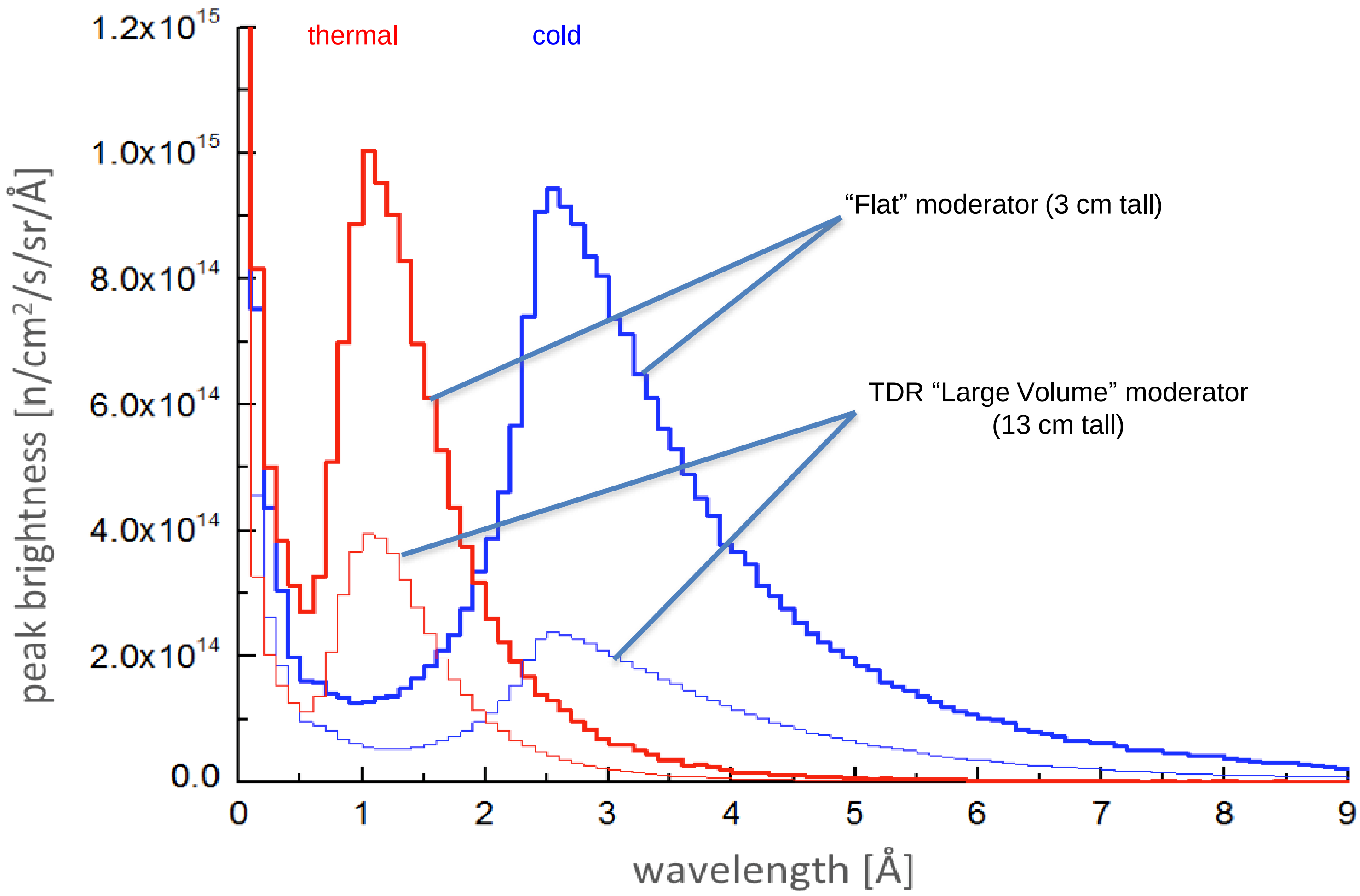
ESS modèle 3D



Target Station



Progress on High Performance Moderators



Science Drivers for the Reference Instrument Suite

- Multi-Purpose Imaging
- General-Purpose SANS
- Broadband SANS
- Surface Scattering
- Horizontal Reflectometer
- Vertical Reflectometer
- Thermal Powder Diffractometer
- Bispectral Power Diffractometer
- Pulsed Monochromatic Powder Diffractometer
- Materials Science Diffractometer
- Extreme Conditions Instrument
- Single-Crystal Magnetism Diffractometer
- Macromolecular Diffractometer
- Cold Chopper Spectrometer
- Bispectral Chopper Spectrometer
- Thermal Chopper Spectrometer
- Cold Crystal-Analyser Spectrometer
- Vibrational Spectroscopy
- Backscattering Spectrometer
- High-Resolution Spin-Echo
- Wide-Angle Spin-Echo
- Fundamental & Particle Physics

- life sciences
- soft condensed matter
- chemistry of materials
- energy research
- magnetism & superconductivity
- engineering & geo-sciences
- archeology & heritage conservation
- fundamental & particle physics

Accelerator radiation related facts and figures

Annual Airborne release (stack) :

H3	8.8E+6 Bq
Be7	1.0E+7 Bq
C11	2.6E+12 Bq
N13	2.7E+12 Bq

- 0.7 m thickness concrete wall
- 5 m of earth

Not accessible to public

Dose rate < 10 µSv/h on top of the earth berm (controlled radiation area blue)

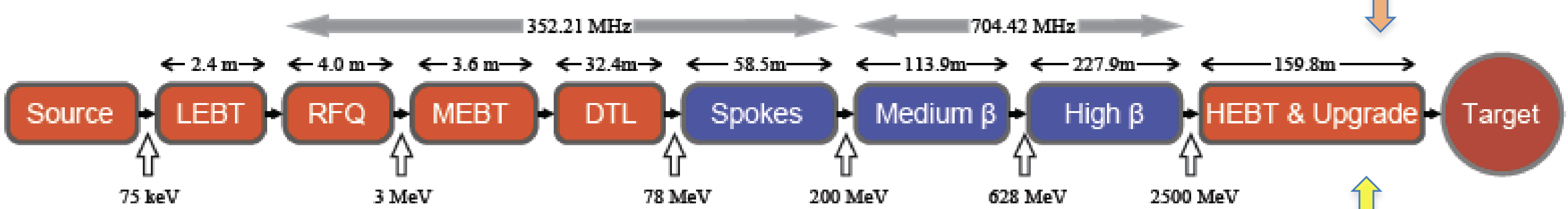
Without HVAC controlled radiation area yellow

Air activity inside tunnel for 50 days campaign : < 10^6 Bq/m^3

Main Rn	$T_{1/2}$	A (Bq/m³)	DAC (Bq/m3)	level
^{7}Be	53 d	5.10^5	1.6 10^5	3 DAC
HTO	12 y	4.10^4	3 10^5	0,1 DAC

Prompt radiation inside tunnel

5.7 Gy/h (in 1h you receive more than lethal dose*)



Residual radiation inside tunnel

1 hour after 50 days campaign shut down :
- 200 µSv/h 1 m
- 300 mSv/h contact

- Lethal dose LD : 4 - 5 Gy
(50% people receiving this dose will die)

the annual limit for workers (equivalent dose to hands) is exceeded in 2 hours

A2T area not taken into account

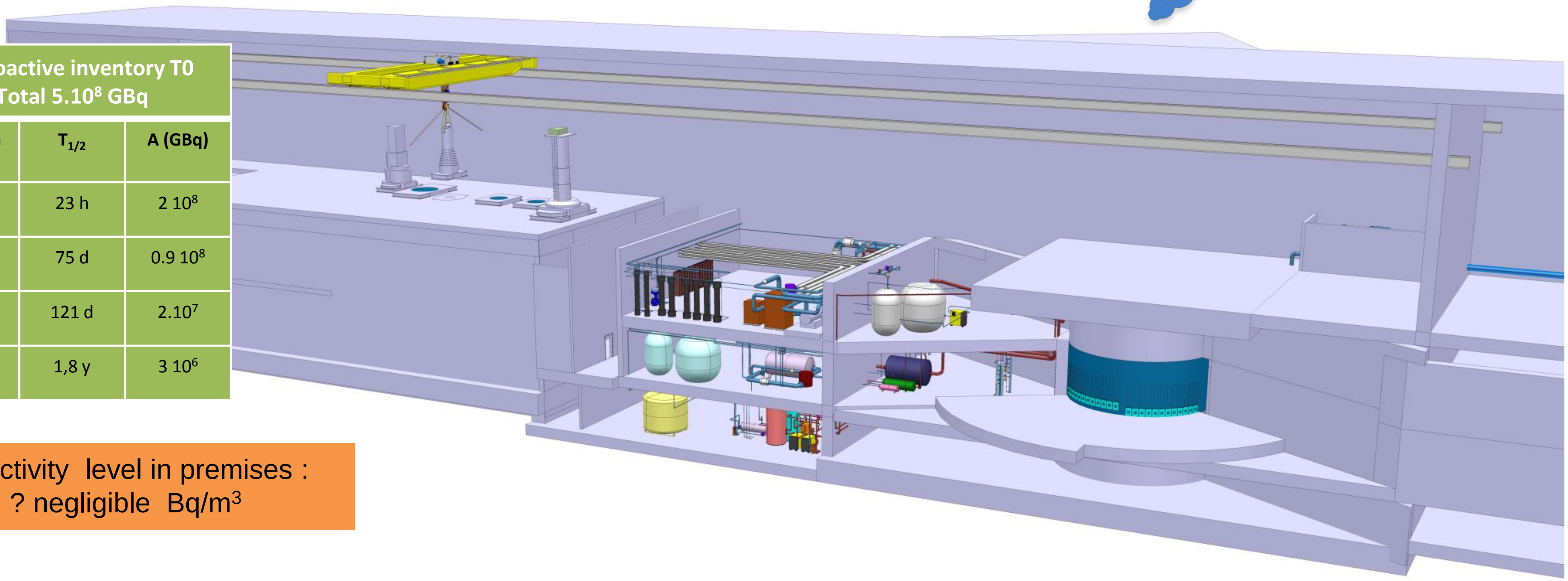
6 month after 50 days campaign shutdown :
- 8 µSv/h 1 m
- 15 mSv/h contact

Target station radiation related facts and figures

Total Radioactive inventory : 5.10^8 GBq
Very similar to research reactor inventory
(in terms of activity level but nuclides are different)

Annual Airborne release (stack) :
Leak from He loop
H3 4.16E+8 Bq + 5.0E+12 Bq * (target dismantling)
I125 1.87E+8 Bq

Radioactive inventory T0 Total 5.10^8 GBq		
main Rn	$T_{1/2}$	A (GBq)
^{187}W	23 h	$2\ 10^8$
^{185}W	75 d	$0.9\ 10^8$
^{181}W	121 d	2.10^7
^{179}Ta	1,8 y	$3\ 10^6$



Air activity level in premises :
? negligible Bq/m^3

Normal cooling circuit water release in public sewer :
1 TBq H3/year (3 mg tritium) (more than Swedish BWR annual H3 release in sea)

- At least 2 times higher than Swedish nuclear power plant tritium annual gas release

Residual radiation level ?

Prompt radiation level "analytical estimation"(with 4 m steel + 2 m concrete for target shielding) :
•0.2 µSv/h in high bay floor
•1.2E-04µSv/h at 100 m

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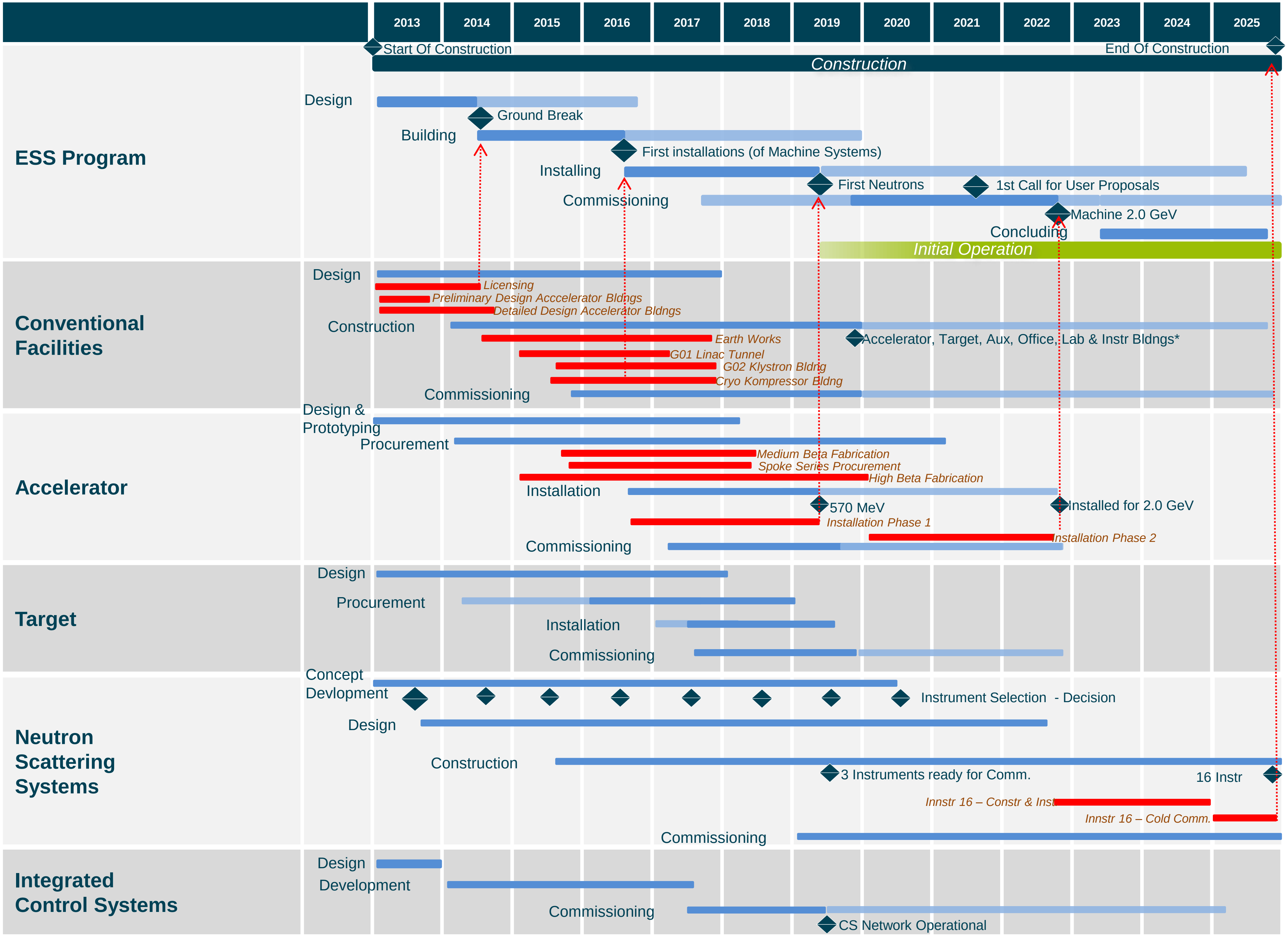
Safety Objectives

ESS Safety Objectives			Current	New proposal
Operating conditions Initiative event likelihood	Workers limit (effective dose)	Public limit (effective dose)	Public limit	
Normal operation - H1	10 mSv/year	50 µSv/year	0,1 mSv	0,1 mSv
Incidents - H2 *$F > 10^{-2}$* *Ex : loss of external power, loss of moderator/target cooling*	20 mSv/event	500 µSv/occurrence	1 mSv ÷ 5	0,1 mSv
Unexpected events - H3 *$10^{-4} < F < 10^{-2}$* *Ex : pipe breaks*	50 mSv/event	5 mSv/occurrence	10 mSv ÷ 5	1 mSv
Design Basis Accident – H4	50 mSv/event	20 mSv/occurrence	100 mSv	20 mSv
Highly improbable events – H5 *$10^{-7} < F < 10^{-6}$*	NEW		none	100 mSv

Collective dose : 1 man Sv/year

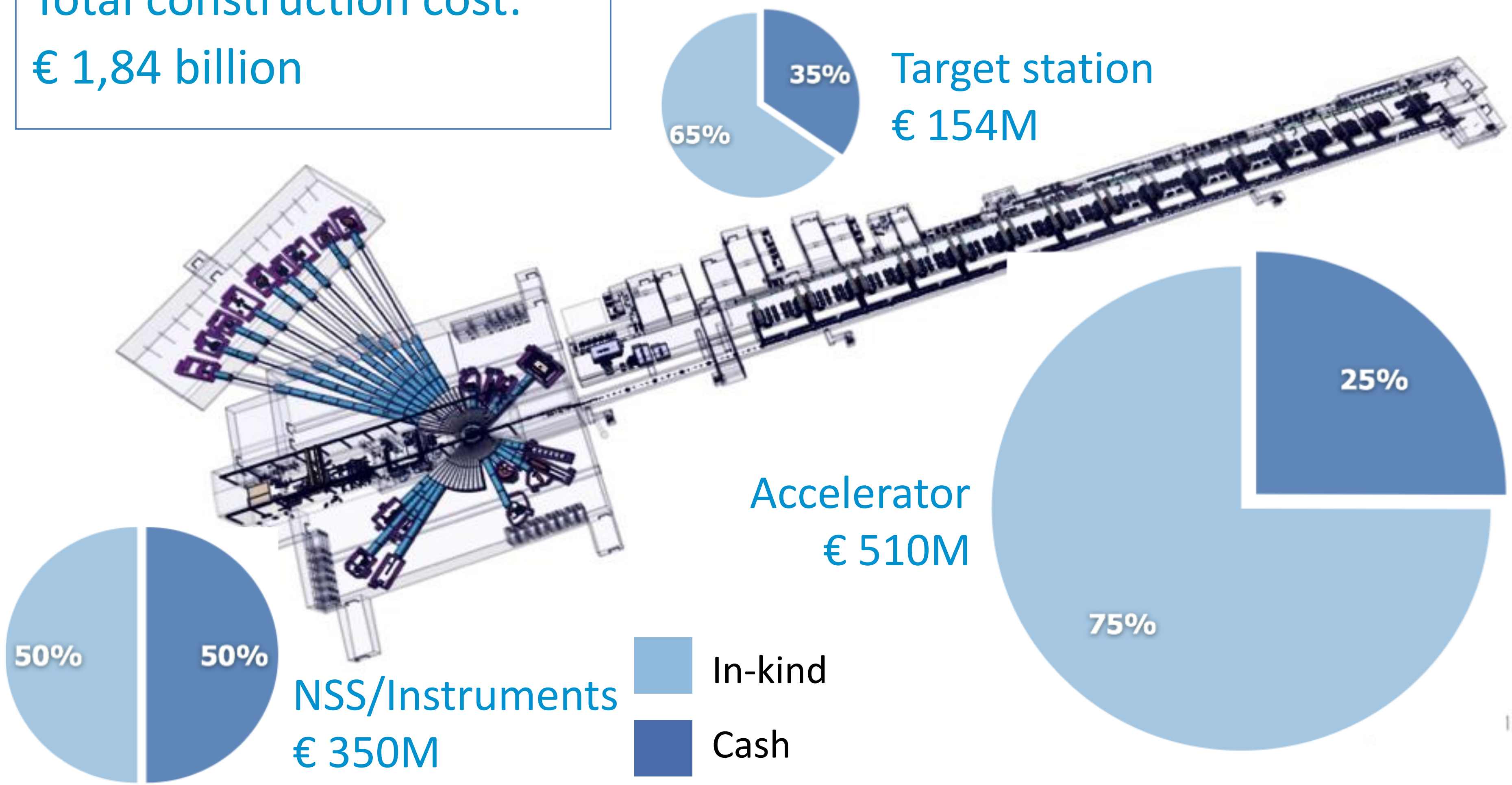
Top-Level ESS Project Schedule



Un partenariat de 17 pays

Total construction cost:

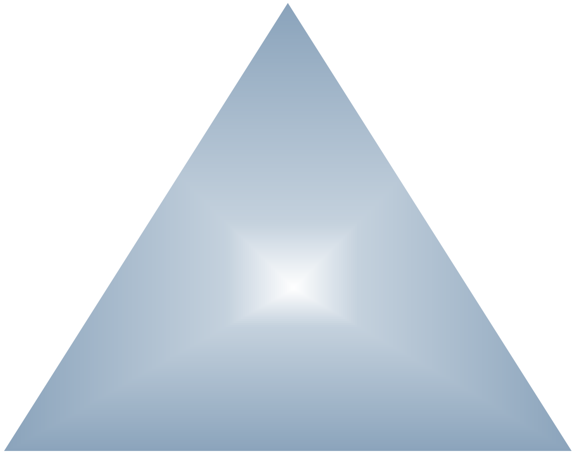
€ 1,84 billion



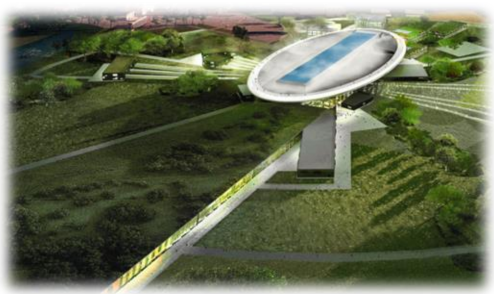
Potential In-kind identified is ~36%. Working to increase potential above 40%.


ESS
E22
MAX IV
Utmarksvägen
Odarslövsvägen
äladen
Sony Ericsson
Norra Ringen

Organisations (*qui*)



Produits (quoi et *pourquoi*)

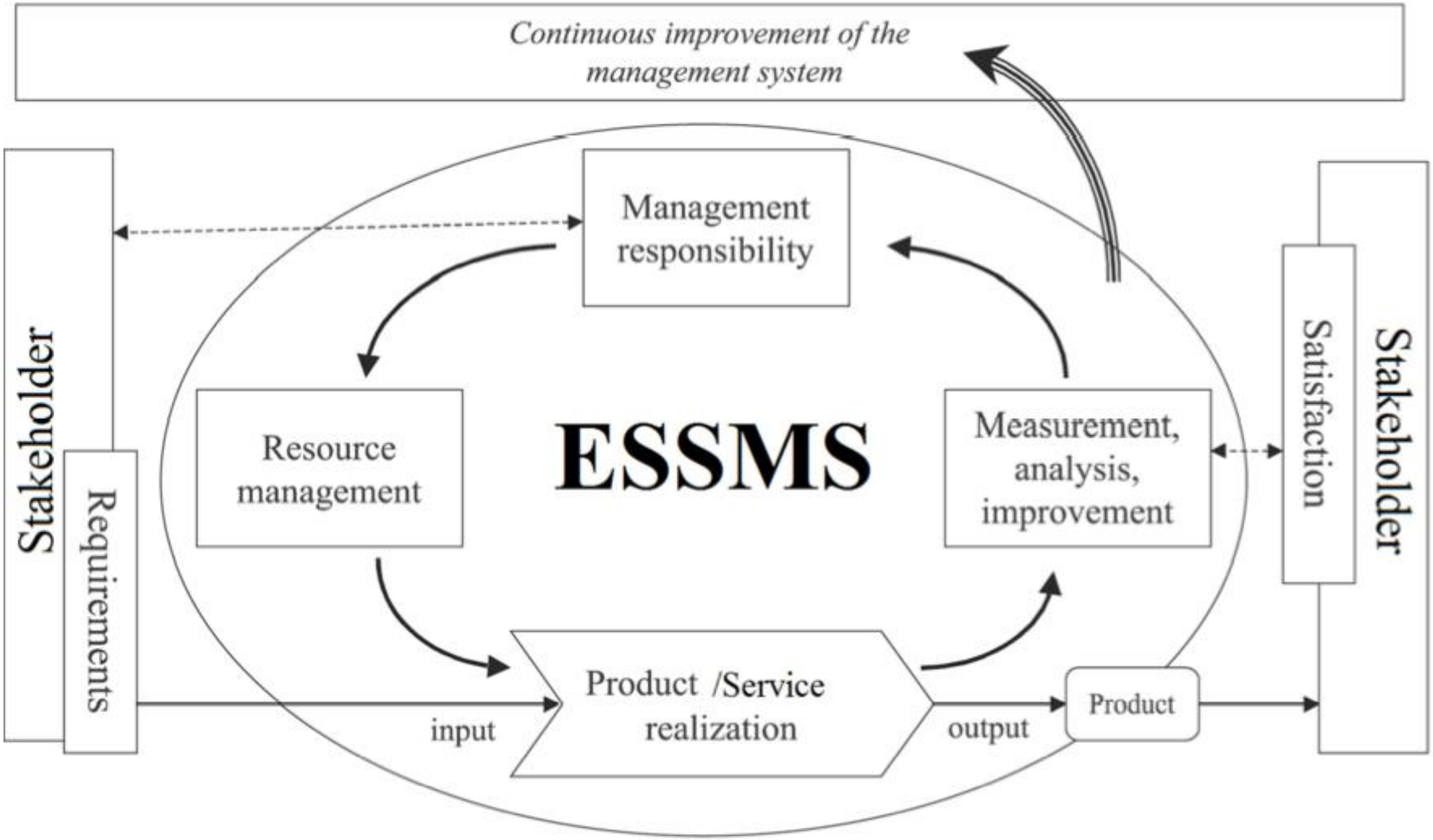


Comment

Specify → Design → Implement → Test …

… Integrate → Handover → Operate Maintain → Disposal

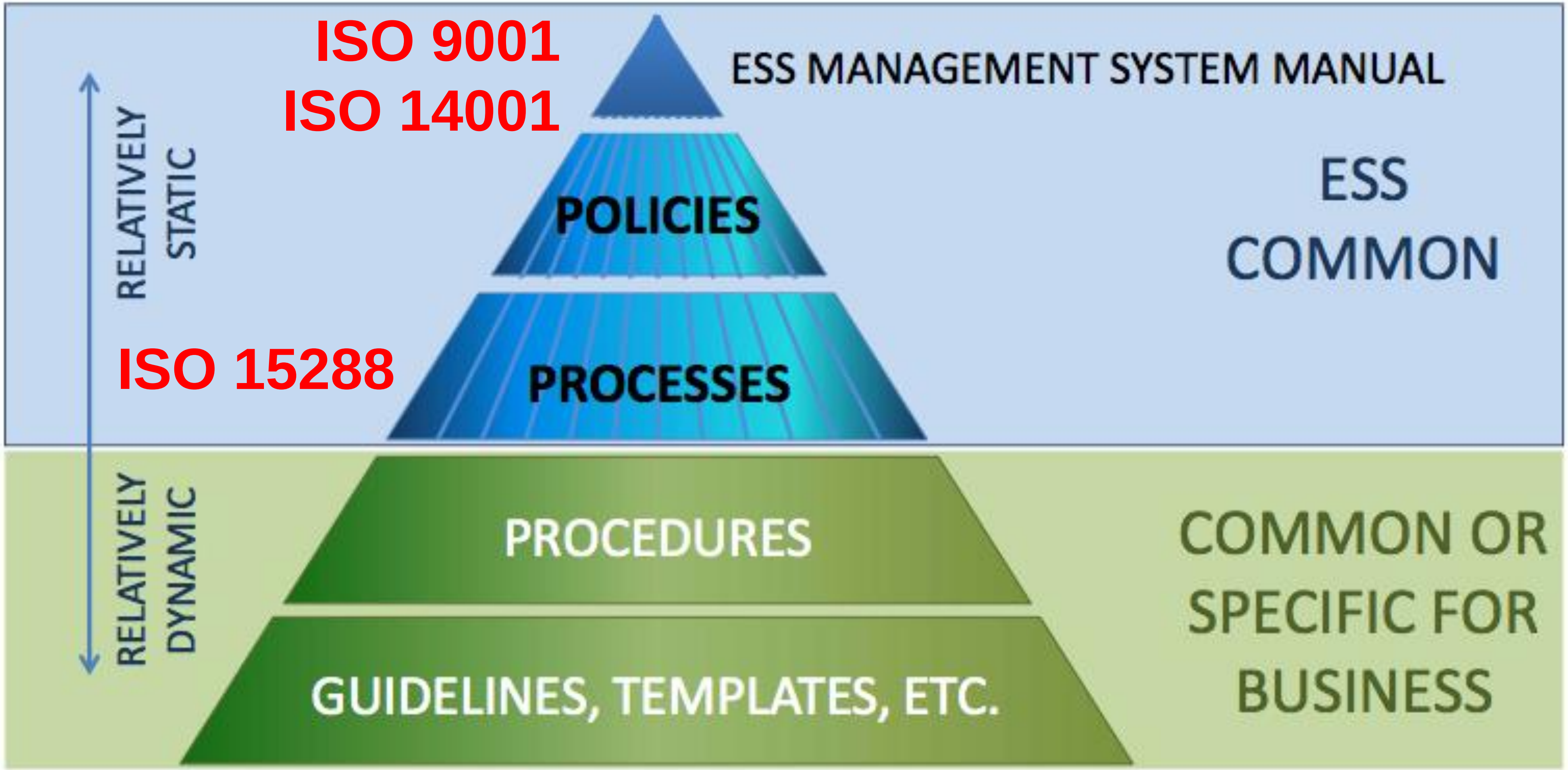
From needs to satisfaction



Need for a Systematic approach

- The construction of the ESS includes a huge number of:
  - products (most of them are not challenging),
  - activities (most of them are simple),
  - roles (all are important).
  - and thus a huge number of interfaces.
- Most of the activities are common sense, but the **quantity creates the complexity**.
- The inherent risk with such complexity can be significantly reduced by a documented systematic approach (ISO 15288).
- Traceability from requirements to verification is a must for the whole facility life cycle management.

Standards mapping



ESS policies

- Human Resources and Personnel
- Quality Assurance
- Communication
- Code of conduct
- Occupational Safety Health Environment
- Information Technology
- Procurement (legal)
- System life cycle management

Processus ISO 15288

Organizational project enabling processes

- Project portfolio management
  Mikael Jakobsson
- Infrastructure management
  Vacant
- Life cycle model management
  Romuald Duperrier
- Human Resource Management
  Anne Säfström Lanner
- Quality management
  Ola Ejnarsson

Agreement processes

- Aquisition
  Meredith Shirey
- Supply
  Meredith Shirey

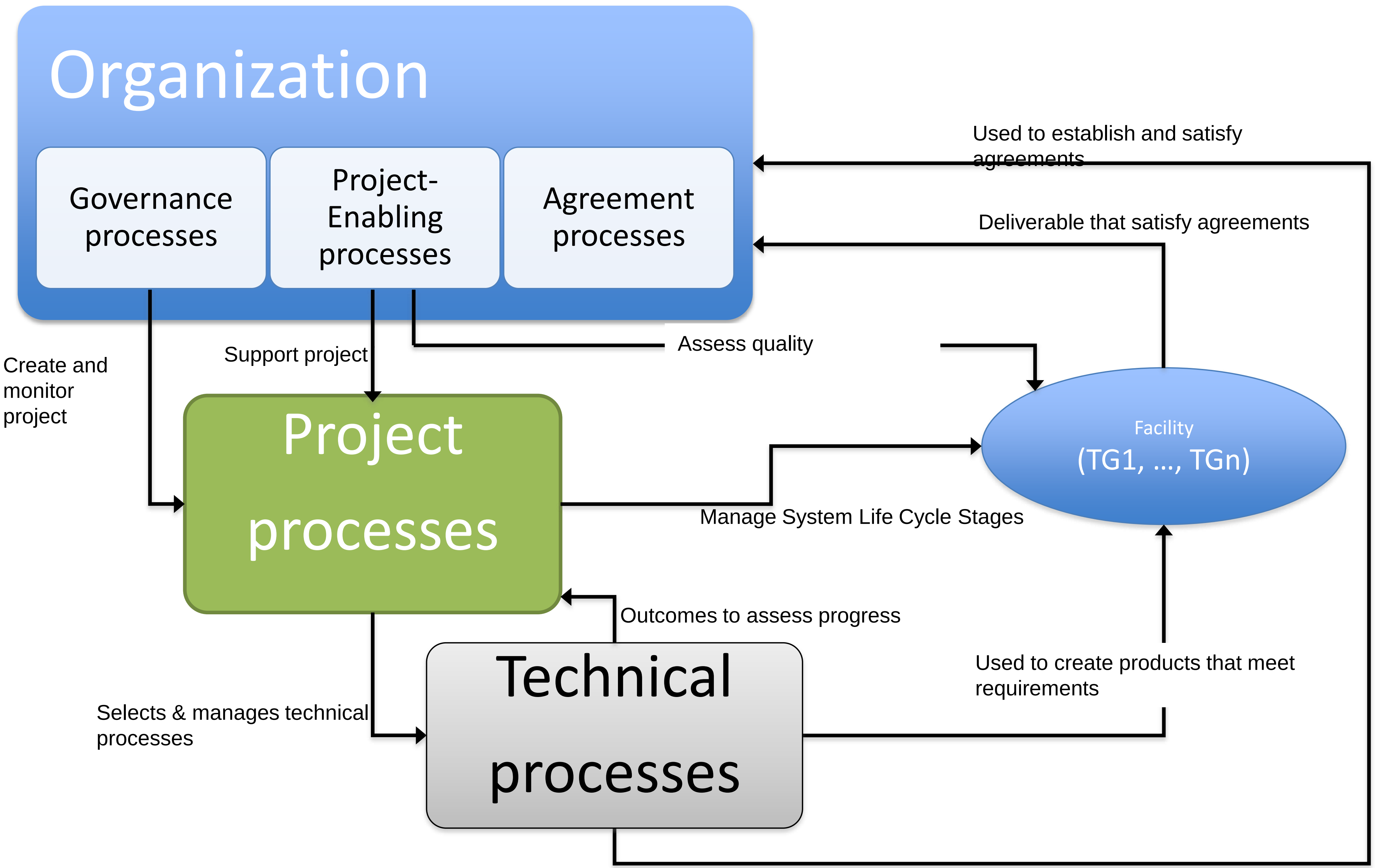
Project processes

- Project planning
  Mikael Jakobsson
- Project assessment and control
  Mikael Jakobsson
- Decision Management
  Therese Welander
- Risk Management
  Joel Wollberg
- Configuration Management
  Vacant
- Information Management
  Vacant
- Measurement
  Vacant

Technical processes

- Stakeholder Requirement Definition
  Romuald Duperrier
- Requirement Analysis
  Romuald Duperrier
- Architectural Design
  Romuald Duperrier
- Implementation
  Romuald Duperrier
- Integration
  Romuald Duperrier
- Verification
  Romuald Duperrier
- Transition
  Romuald Duperrier
- Validation
  Romuald Duperrier
- Operation
  Romuald Duperrier
- Maintenance
  Romuald Duperrier
- Disposal
  Romuald Duperrier

Processes map
[H. Lawson]

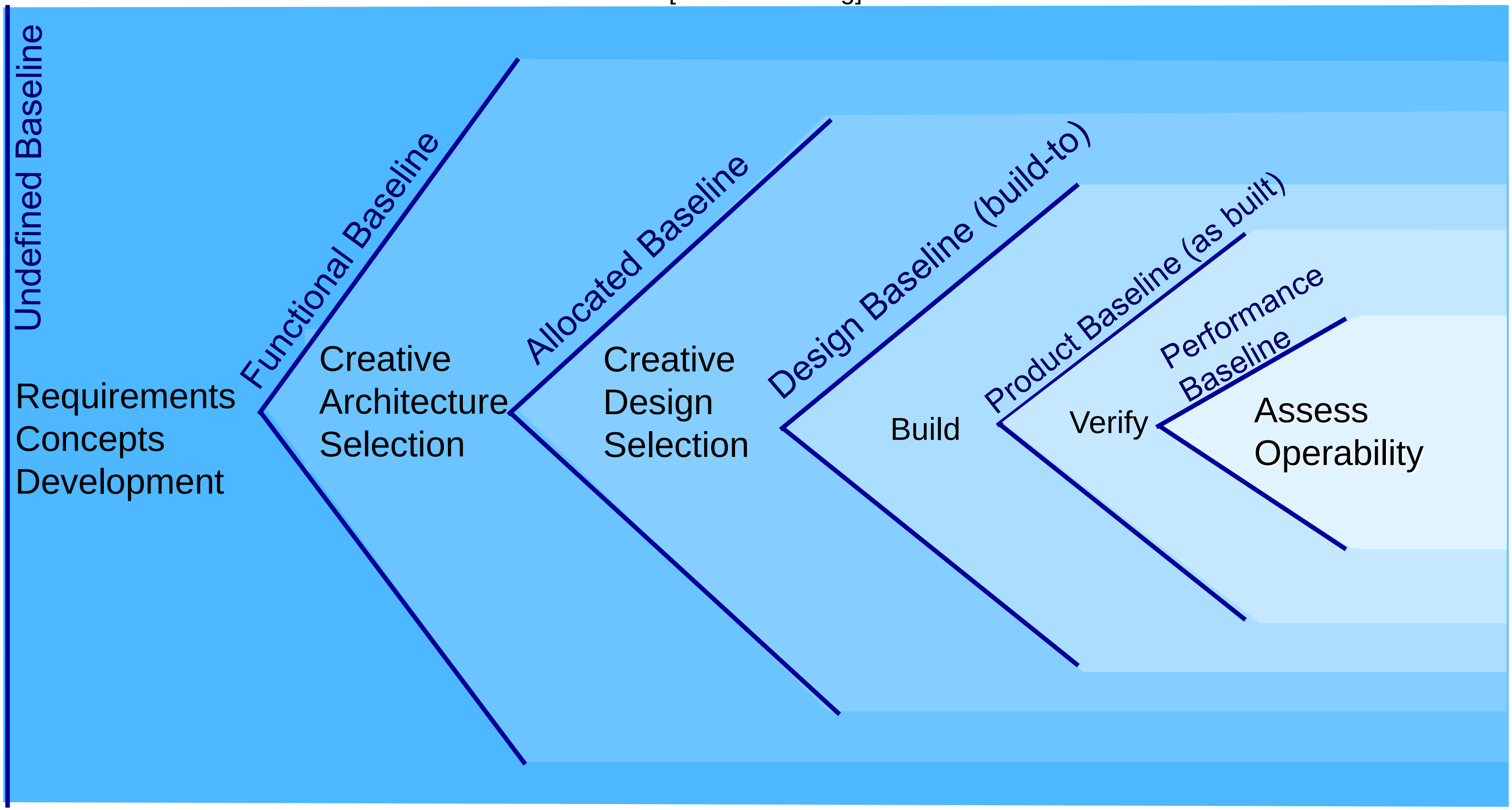


Management plans
What, when, who

- Programme Management Plan, ESS-1122
- Quality Management Plan, ESS-18636
- Construction Phase Management Plan, ESS-14361
- Systems Engineering Management Plan, ESS-2908
- Configuration Management Plan, ESS-3688
- Interface Management Plan, ESS-2917
- Risk Management Plan, ESS-4460

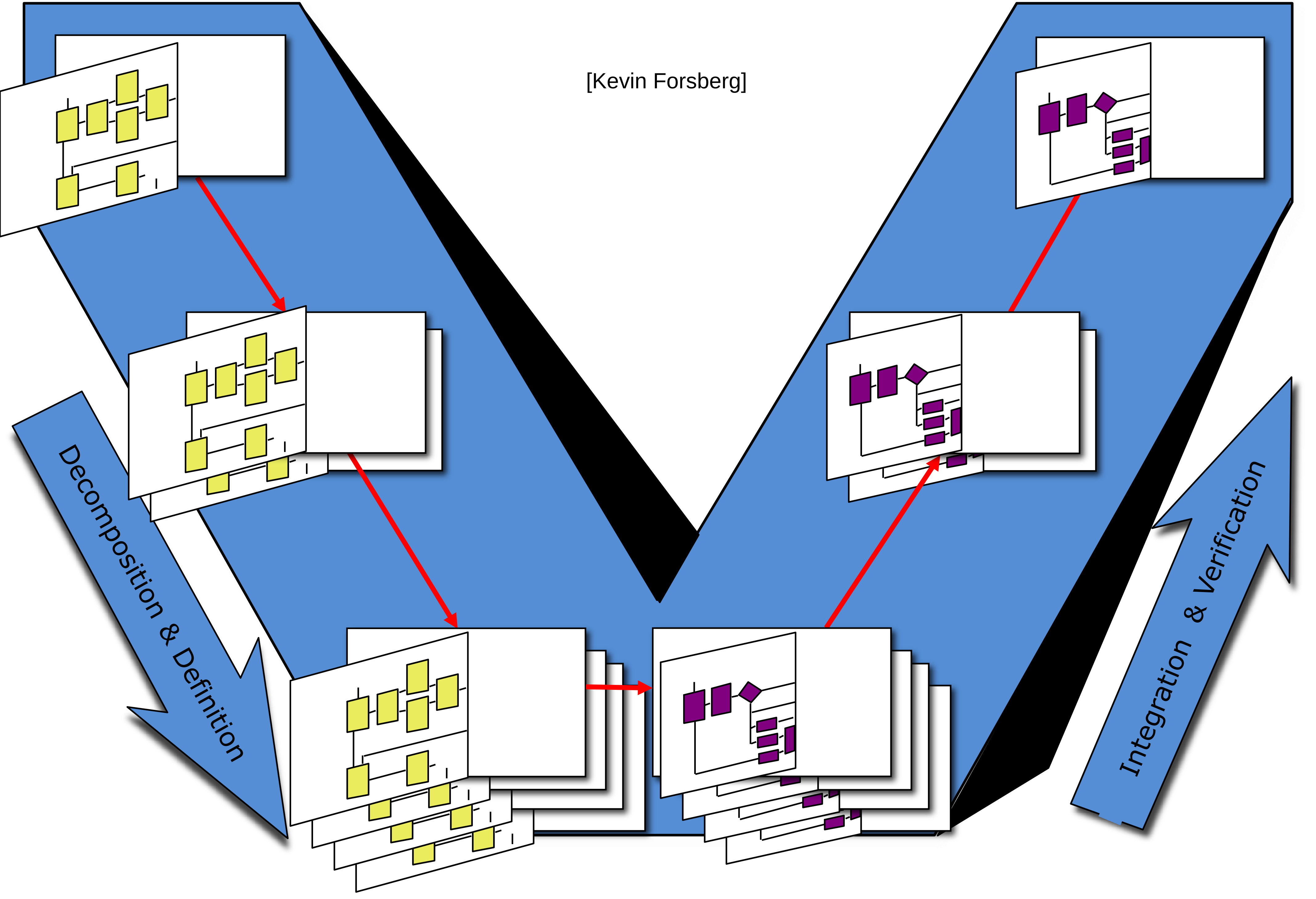
Technical baselines as an integral configuration management concept

[Kevin Forsberg]



Dual Vee

[Kevin Forsberg]

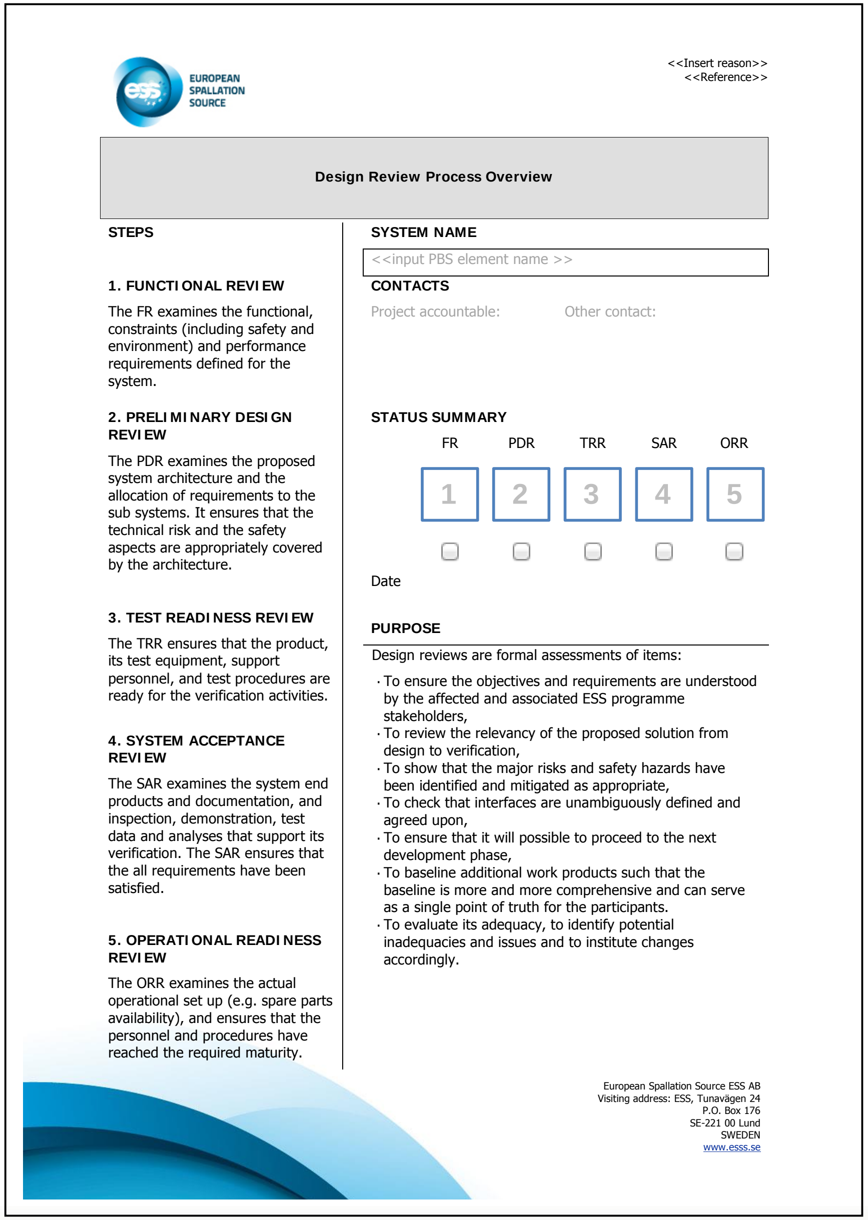


Deliverables for design reviews

Review	Deliverables	Level of interest
FR	System Requirement Document Concepts of Operation	System
PDR	System Architecture Specification Interface Control Documents System Verification Plan System Integration Plan System Validation Plan	System
CDR	System Requirement Document System Design Descriptions (drawings, P&ID, etc) Interface Control Documents System Integration Plan System Operation and Maintenance Manual System Verification Plan	Element
TRR	System Verification Plan System Validation Plan	System / Element
SAR	System Verification Report	System / Element
ORR	ESS Validation Report Training programme reports	System / Element

Supporting documents

- Design Review Standard Operating Procedure [ESS-8910]
- Design Review Overview Templates and Checklist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<<Reference>>

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Design Review Process Overview

STEPS

1. FUNCTIONAL REVIEW

The FR examines the functional, constraints (including safety and environment) and performance requirements defined for the system.

2. PRELIMINARY DESIGN REVIEW

The PDR examines the proposed system architecture and the allocation of requirements to the sub systems. It ensures that the technical risk and the safety aspects are appropriately covered by the architecture.

3. TEST READINESS REVIEW

The TRR ensures that the product, its test equipment, support personnel, and test procedures are ready for the verification activities.

4. SYSTEM ACCEPTANCE REVIEW

The SAR examines the system end products and documentation, and inspection, demonstration, test data and analyses that support its verification. The SAR ensures that the all requirements have been satisfied.

5. OPERATIONAL READINESS REVIEW

The ORR examines the actual operational set up (e.g. spare parts availability), and ensures that the personnel and procedures have reached the required maturity.

SYSTEM NAME

<<input PBS element name >>

CONTACTS

Project accountable: Other contact:

STATUS SUMMARY

FR	PDR	TRR	SAR	ORR
1	2	3	4	5

Date

PURPOSE

Design reviews are formal assessments of items:

- To ensure the objectives and requirements are understood by the affected and associated ESS programme stakeholders,
- To review the relevancy of the proposed solution from design to verification,
- To show that the major risks and safety hazards have been identified and mitigated as appropriate,
- To check that interfaces are unambiguously defined and agreed upon,
- To ensure that it will possible to proceed to the next development phase,
- To baseline additional work products such that the baseline is more and more comprehensive and can serve as a single point of truth for the participants.
- To evaluate its adequacy, to identify potential inadequacies and issues and to institute changes accordingly.

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SE process at ESS
(facility level)

Capture stakeholder's needs
Identify context

Initiate Functional Baseline

Facility Functional Review

Initiate Allocated Baseline

Facility Preliminary Design Review

Implement facility systems

Verify and integrate facility systems

Facility Test Readiness Review

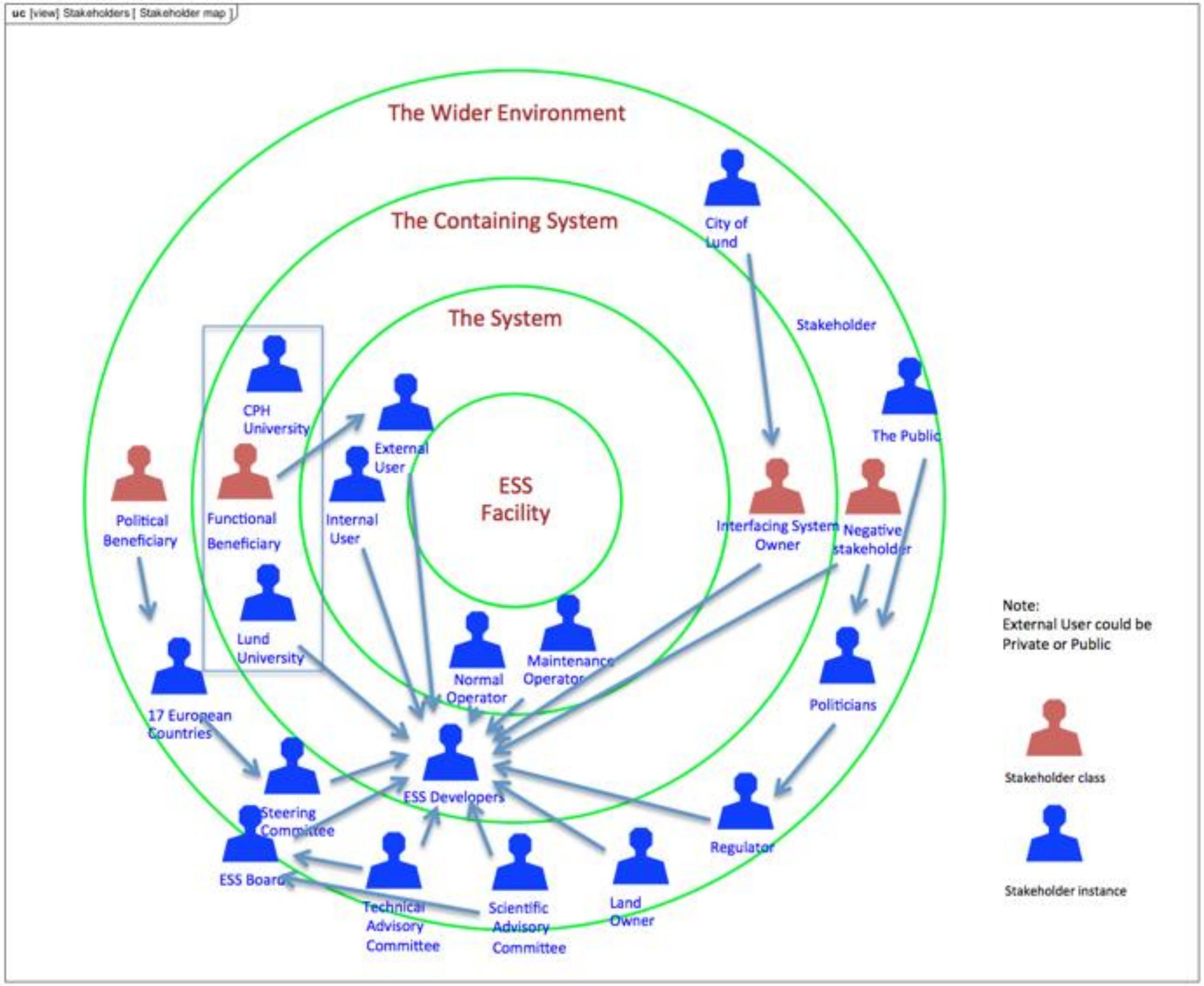
Verify ESS

Facility Acceptance Review

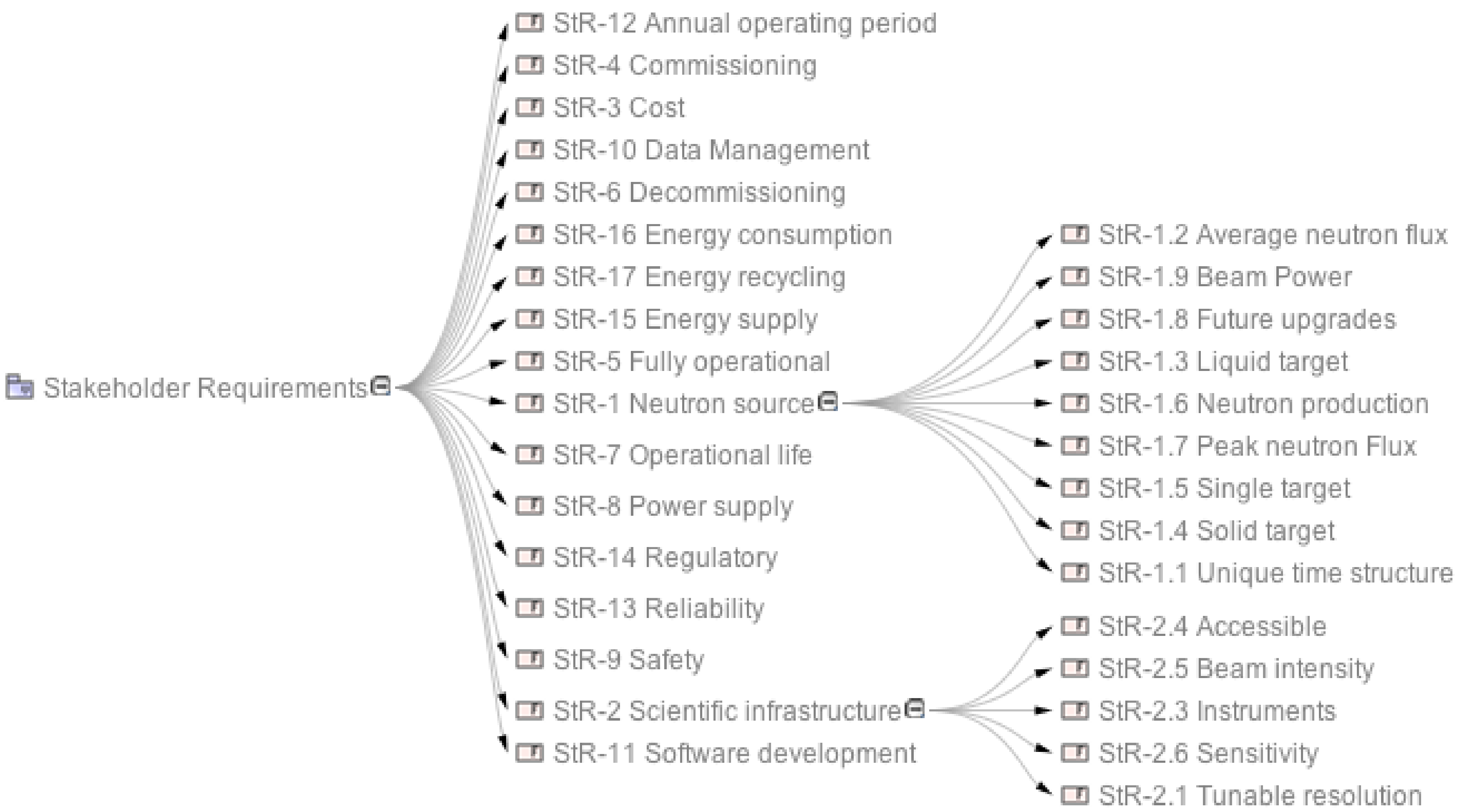
Validate ESS

Operation Readiness Review

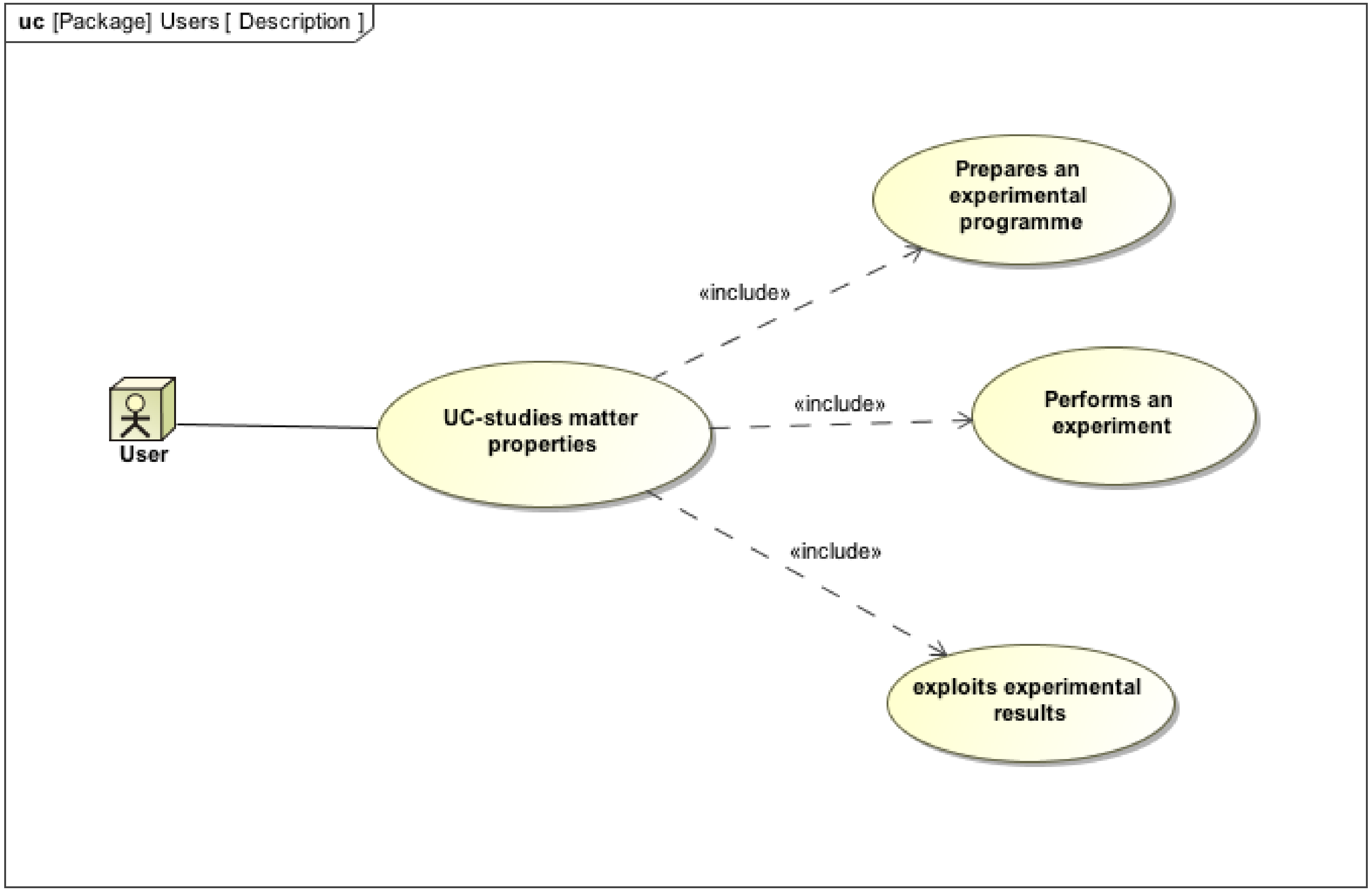
First results of the approach: Stakeholder map



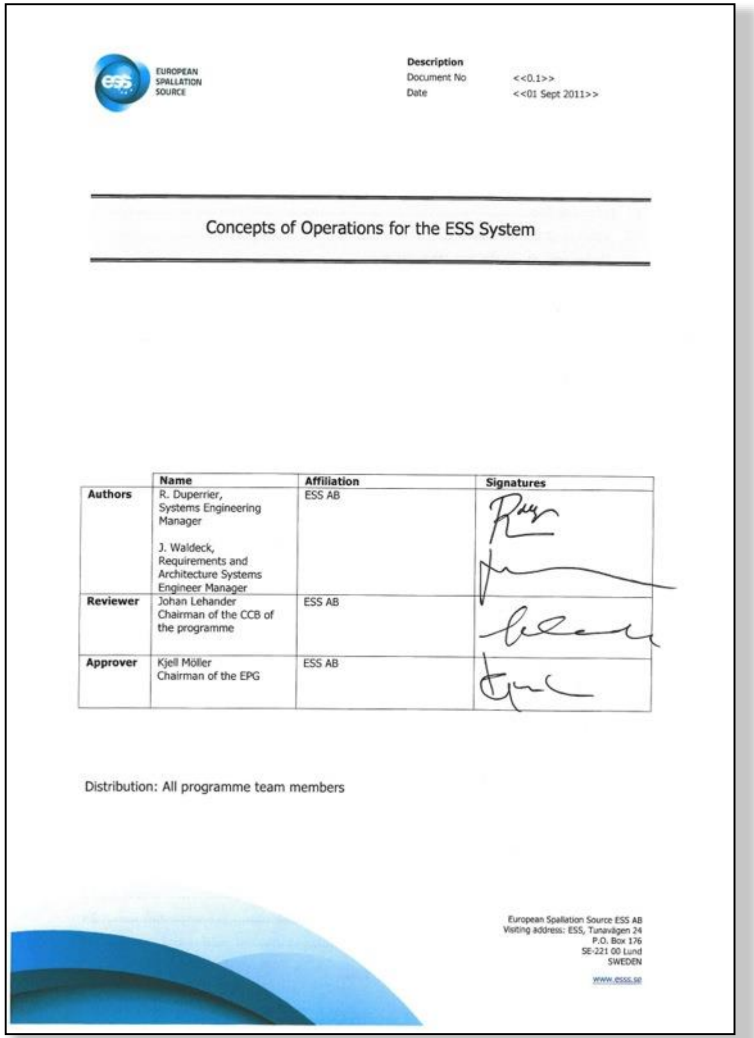
First results of the approach: Stakeholder’s requirements



First results of the approach: use case NS user



Technical Baseline item at ESS level



EUROPEAN SPALLATION SOURCE

Description
Document No <<0.1>>
Date <<01 Sept 2011>>

Concepts of Operations for the ESS System

	Name	Affiliation	Signatures
Authors	R. Duperrier, Systems Engineering Manager J. Waldeck, Requirements and Architecture Systems Engineer Manager	ESS AB	
Reviewer	Johan Lehander Chairman of the CCB of the programme	ESS AB	
Approver	Kjell Möller Chairman of the EPG	ESS AB	

Distribution: All programme team members

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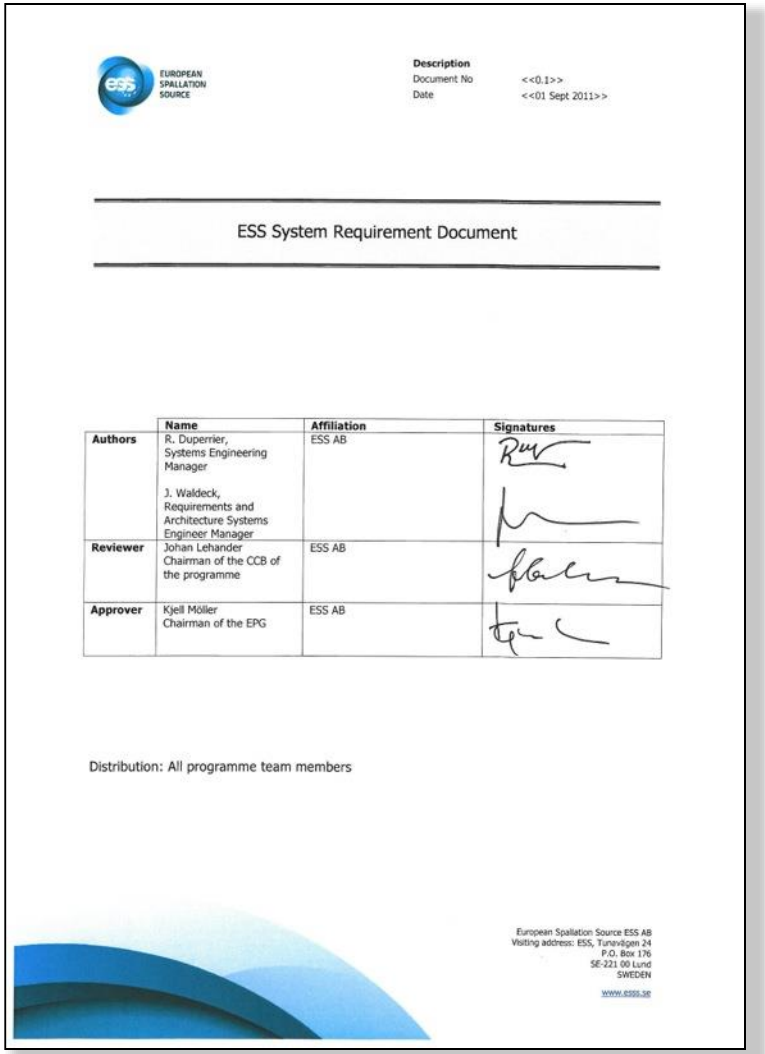
[ESS-0003640]



EUROPEAN SPALLATION SOURCE

Description
Document No <<0.1>>
Date <<01 Sept 2011>>

ESS System Requirement Document

	Name	Affiliation	Signatures
Authors	R. Duperrier, Systems Engineering Manager J. Waldeck, Requirements and Architecture Systems Engineer Manager	ESS AB	
Reviewer	Johan Lehander Chairman of the CCB of the programme	ESS AB	
Approver	Kjell Möller Chairman of the EPG	ESS AB	

Distribution: All programme team members

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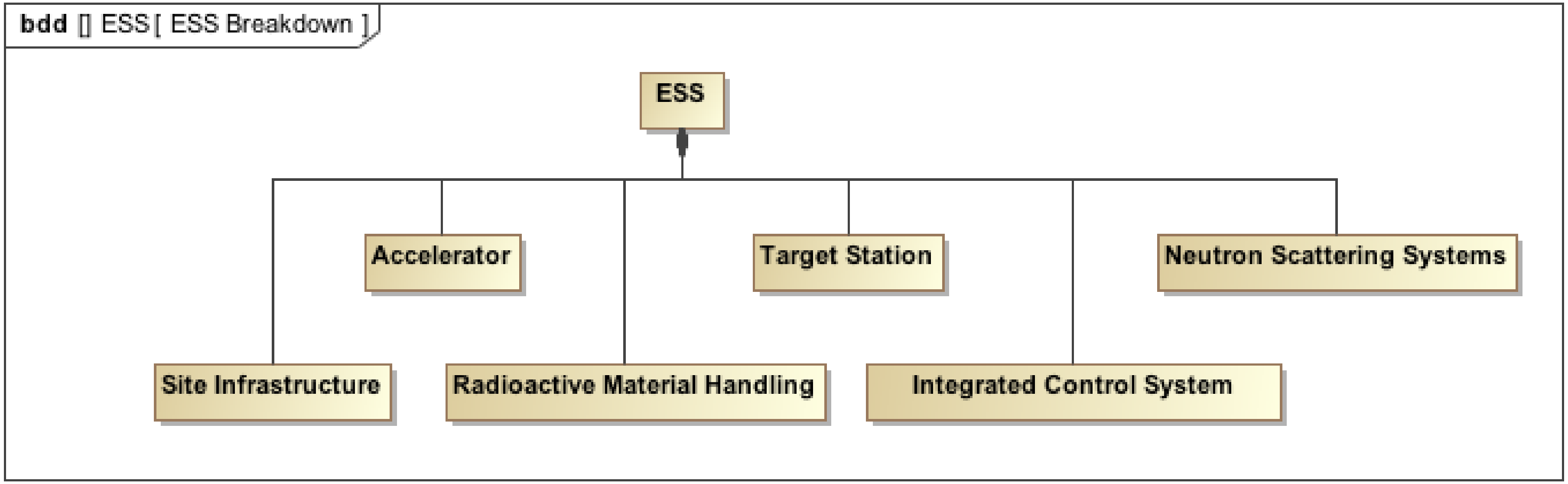
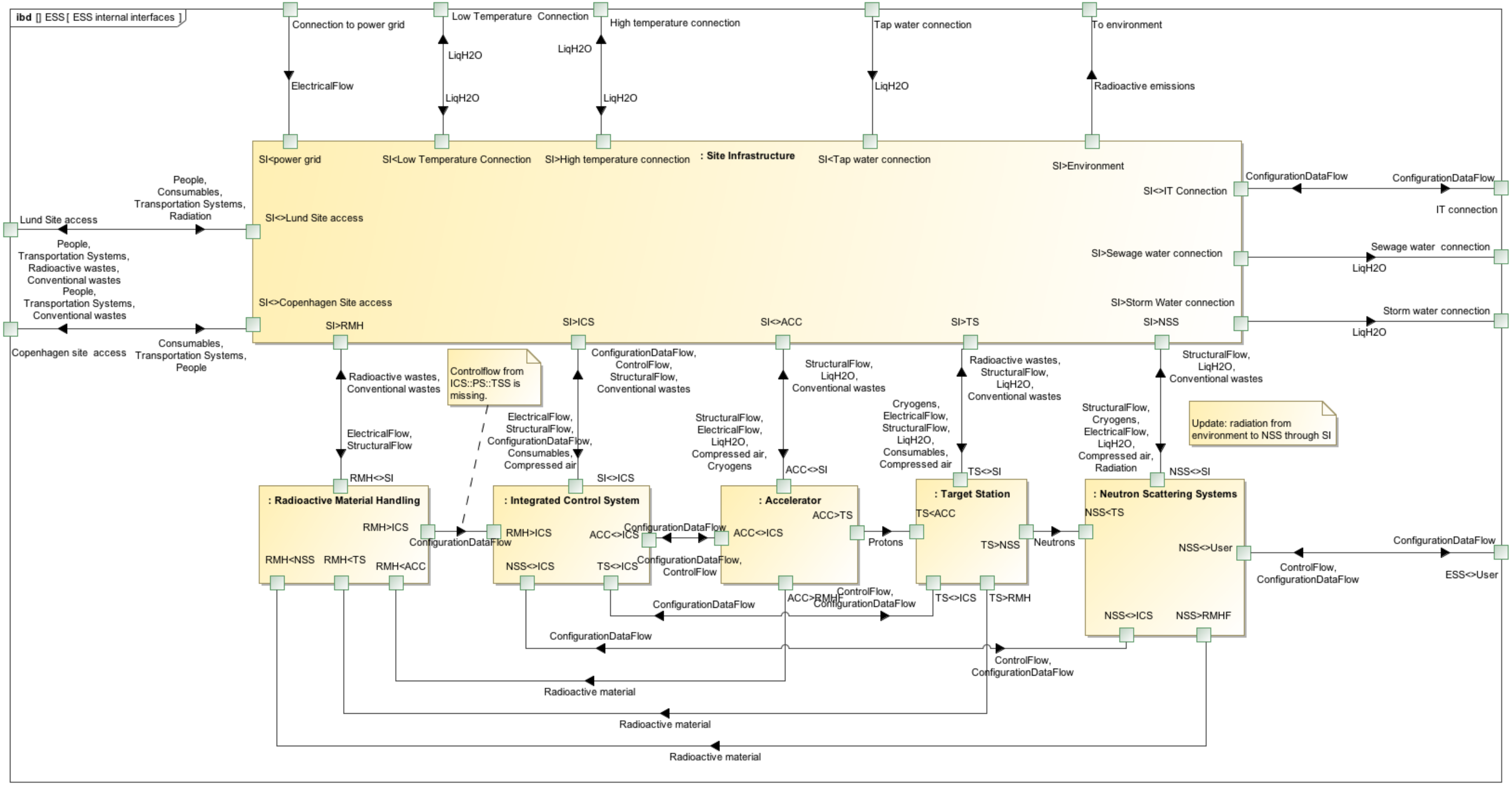
[ESS-0003641]

Architecture



[ESS-5699]

ESS white box view



- Reduce the number of interfaces between the constituting elements,
- Specialize the elements,
- Separate service-functions and ESS specific functions

Interface management

ACC					
ESS-0005734	TS				
	ESS-0005748	NSS			
ESS-0005732	ESS-0005738	ESS-0005735	ICS		
ESS-0005733	ESS-0005745	ESS-0005743	ESS-0005737	SI	
ESS-0005741	ESS-0005742	ESS-0005739	ESS-0005736	ESS-0005744	RMH

Interface Control Documents for ESS subsystems

Interface requirements are developed in pairs from interface description

IR for ACC

The accelerator components shall be enclosed in space slots in G01 according to ICD ESS-0005733, chapter 3.1.3.

ICD ACC-SI

Section 3.1.1

Drawings

A02-40---1-G—090---

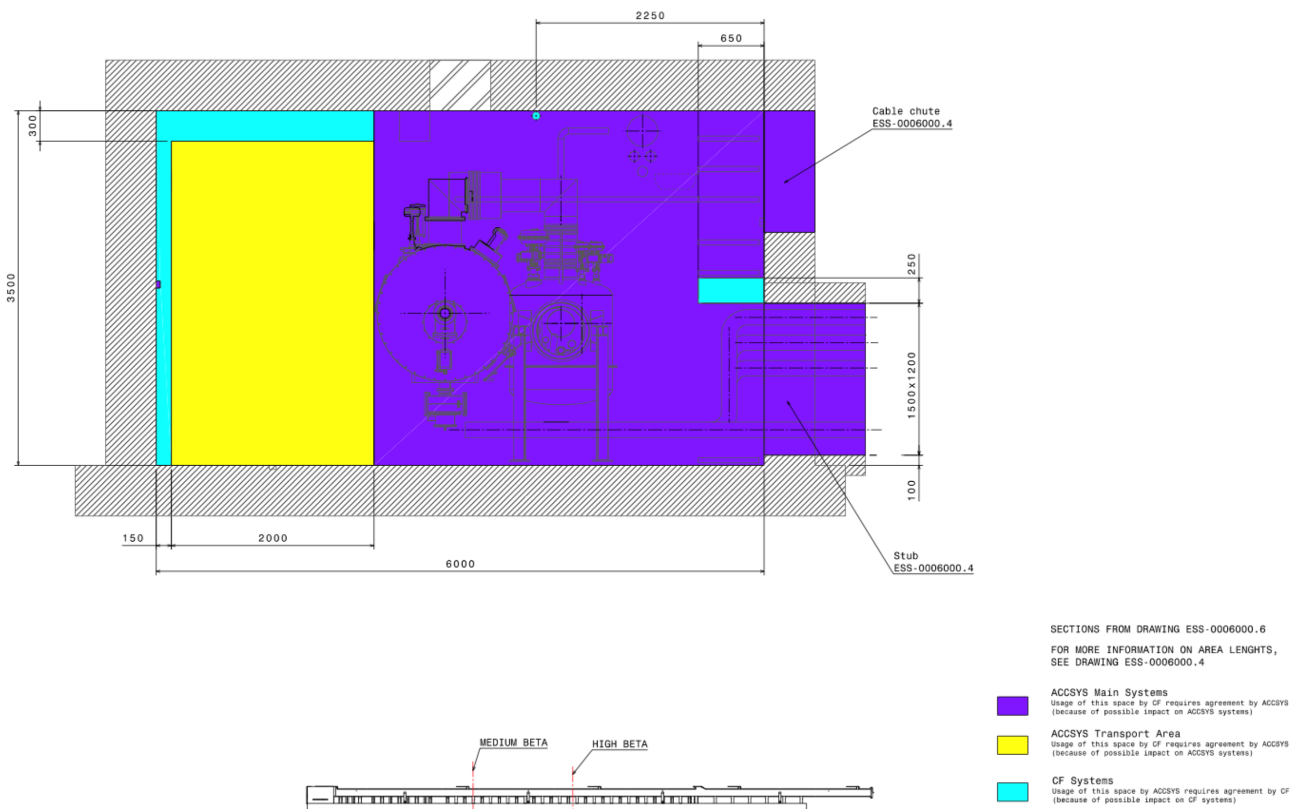
A02-40---1-G—090---100

A02-40---1-G—090---200

etc

IR for SI

The G01 shall contain the accelerator components in space slots as defined in the ICD ESS-0005733 section 3.1.3.



SE process at ESS
(facility level)

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Facility Functional Review

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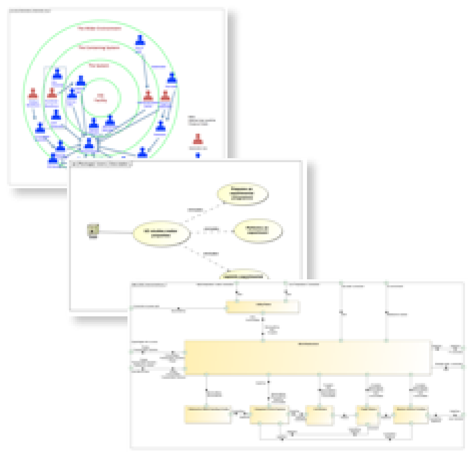


SE process at ESS
(lower levels)

Refine functional baseline

System Functional Review

Refine allocated baseline

System Preliminary Design Review

Implement subsystems

OR

Engineer subsystems

Implement facility systems

Verify and integrate sub systems

SE process at ESS
(lower levels)

Design systems

Critical Design Review

Specify manufacturing

Build or subcontract manufacturing

Verify manufacturing

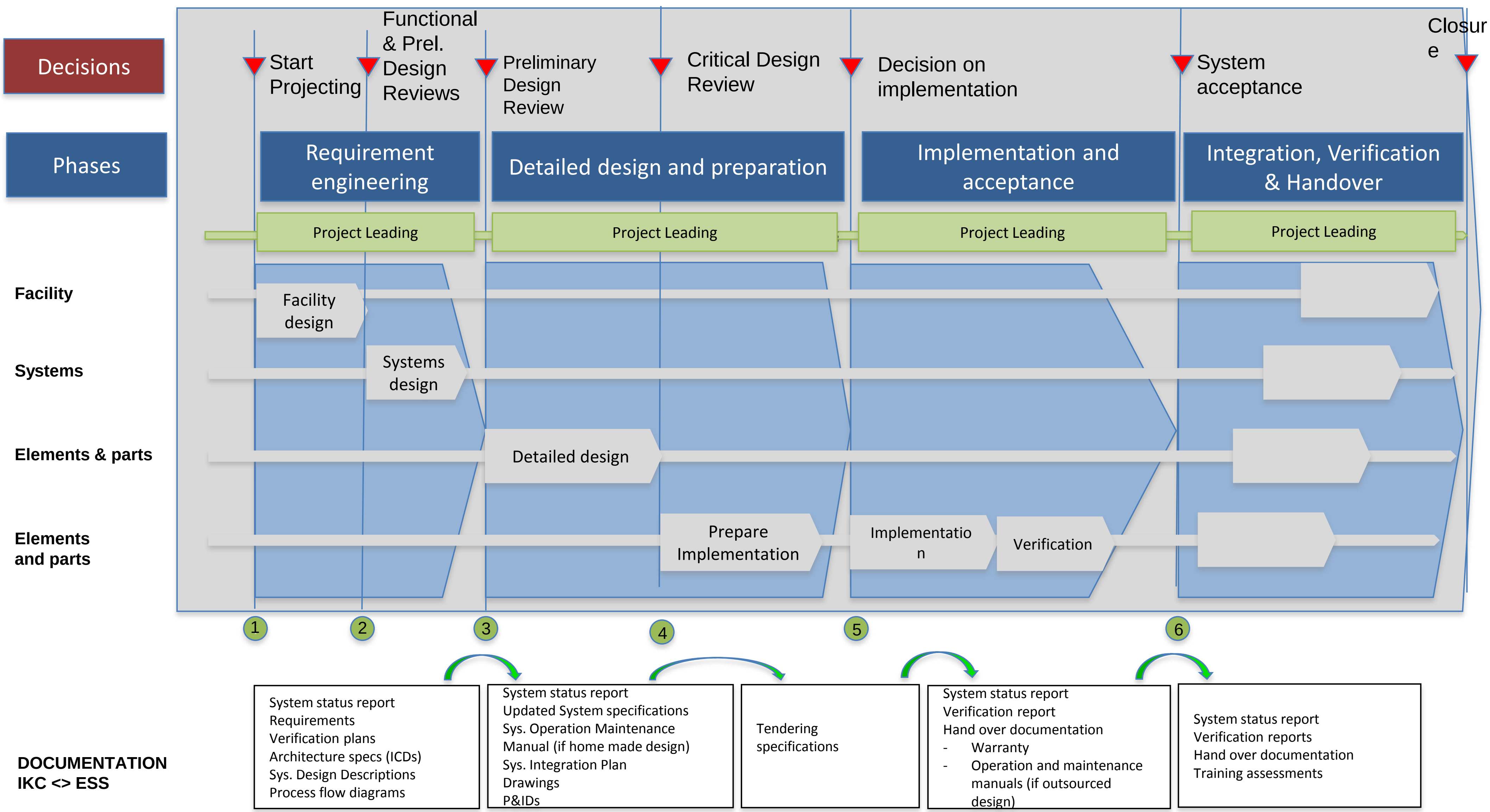
OR

Specify procurement

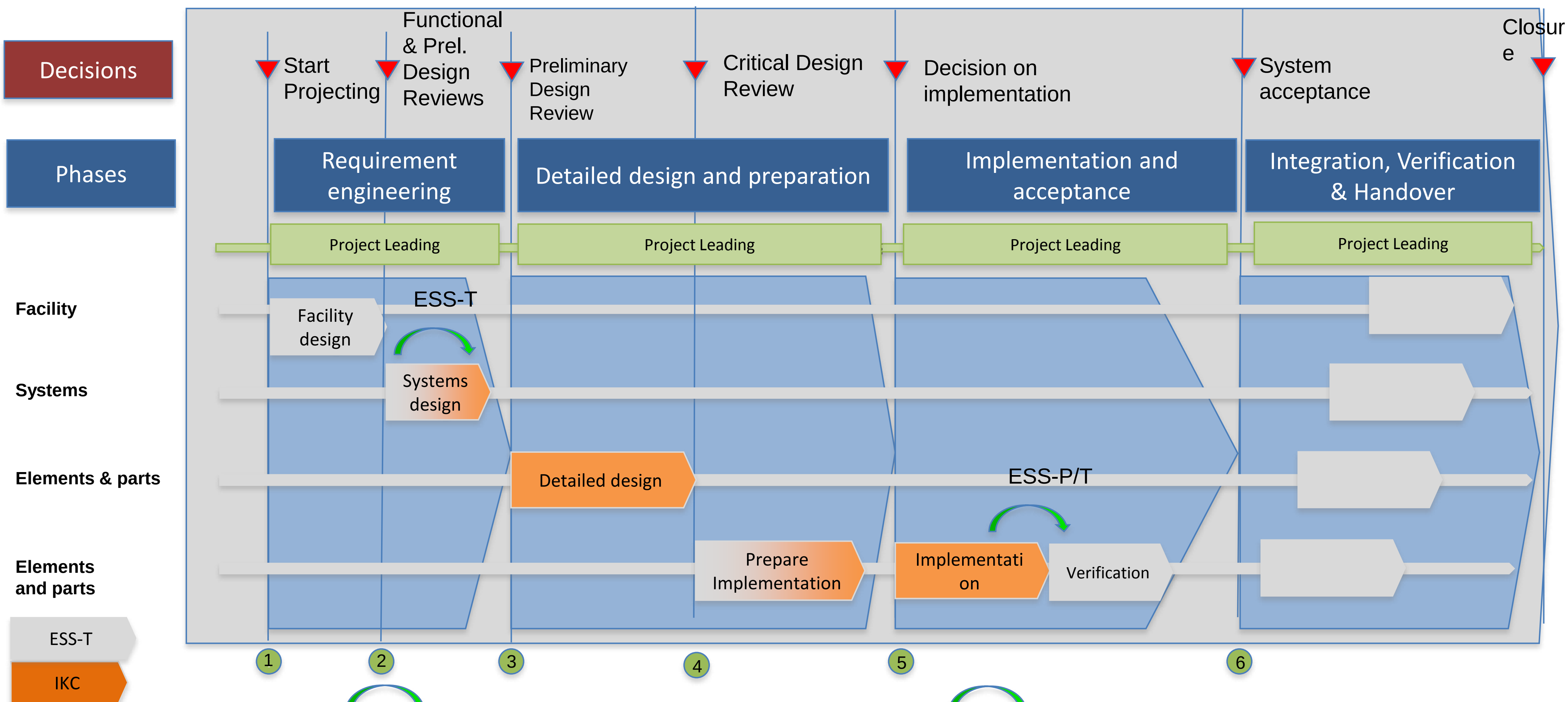
Procure

Engineer subsystems

Generic Technical Project



Technical project-A
IKC performs detailed design and manufacturing in implementation phase



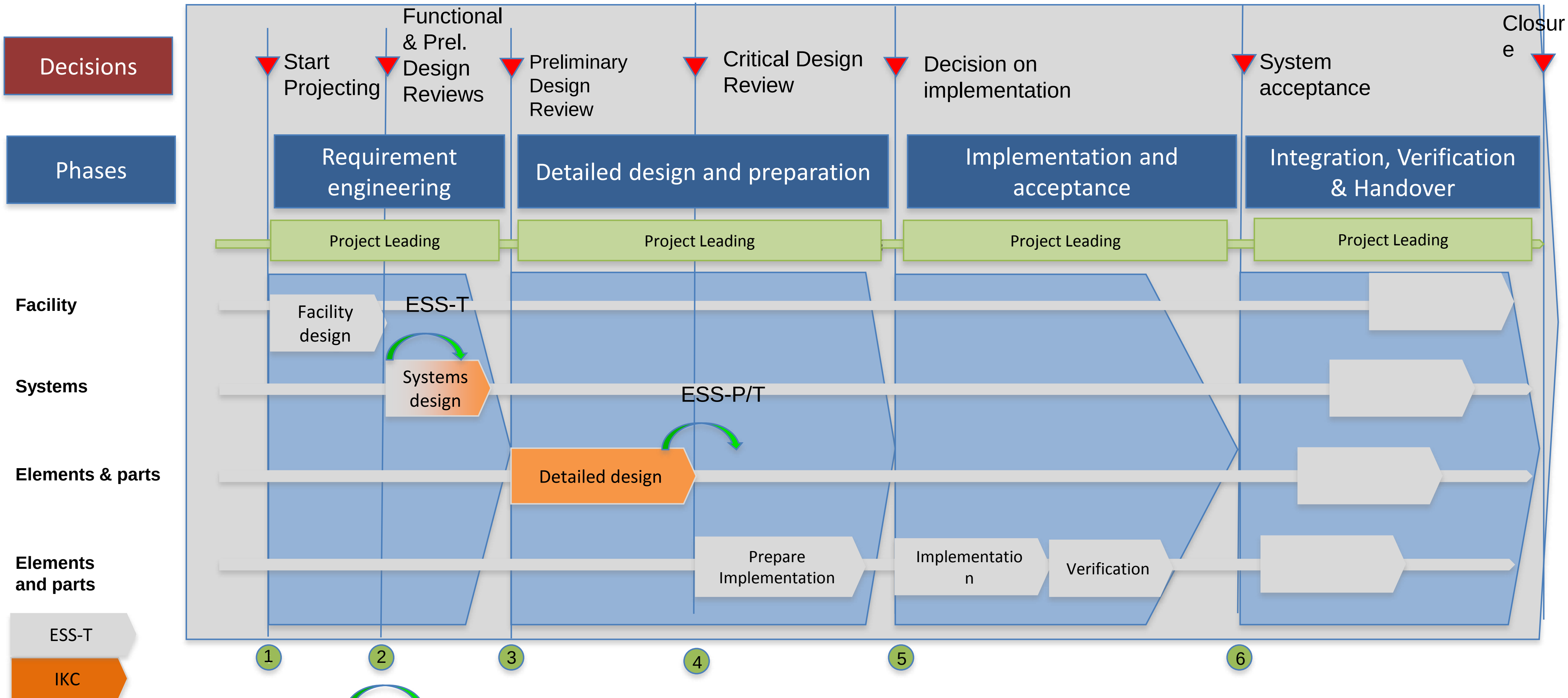
ESS-T: ESS Technical
ESS-P: ESS Procurement

DOCUMENTATION
IKC <> ESS

System status report
Requirements
Verification plans
Architecture specs (ICDs)
Sys. Design Descriptions
Process flow diagrams

System status report
Verification report
Hand over documentation
- Warranty
- Operation and maintenance manuals (if outsourced design)

Technical project-B
IKC performs detailed design
ESS takes over for procurement



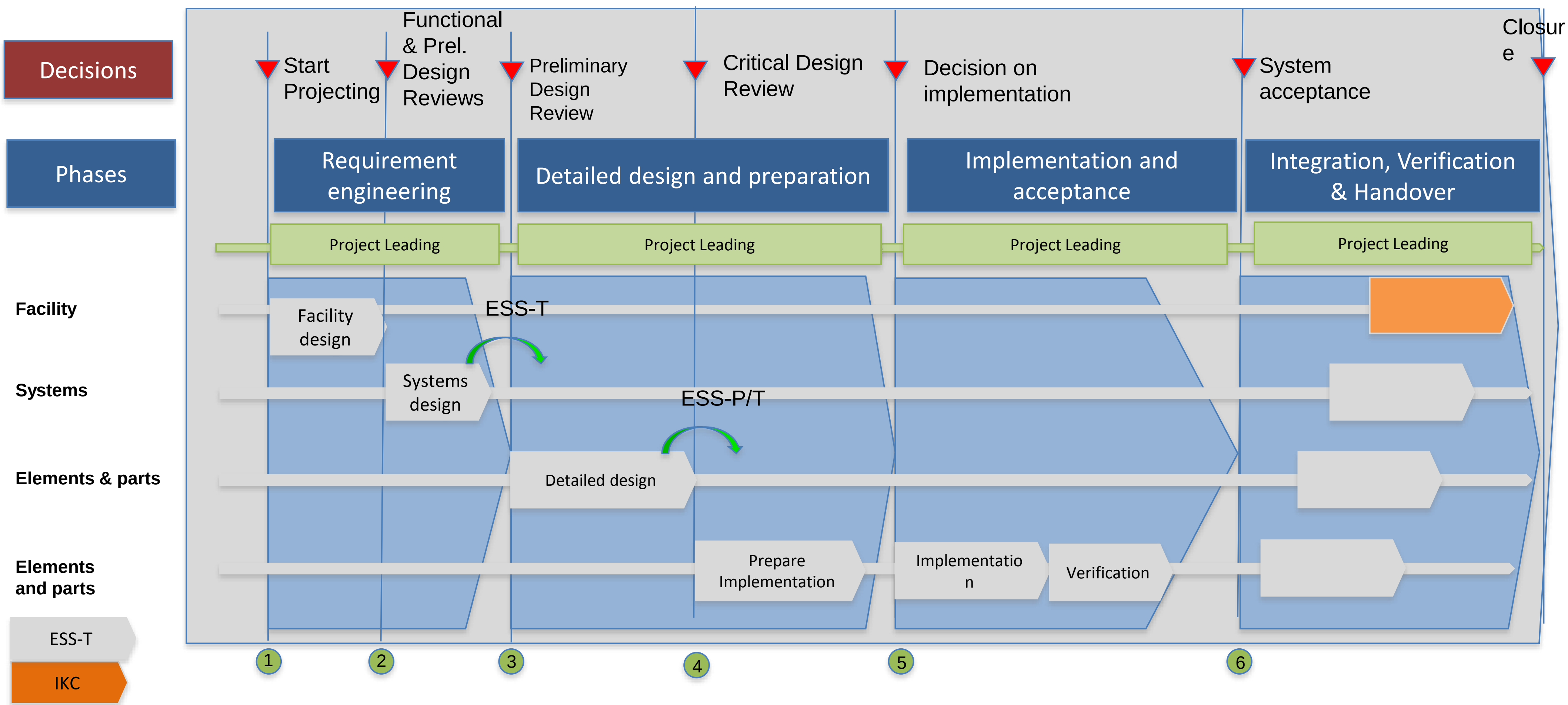
ESS-T: ESS Technical
ESS-P: ESS Procurement

DOCUMENTATION
IKC <> ESS

System status reports
Requirements
Verification plans
Architecture specs (ICDs)
Sys. Design Descriptions
Process flow diagrams

System status reports
Updated System specifications
Sys. Operation Maintenance Manual
Sys. Integration Plan
Drawings
P&IDs

Technical project-C
IKC performs a service activity for supporting commissioning and/or operation



ESS-T: ESS Technical
ESS-P: ESS Procurement

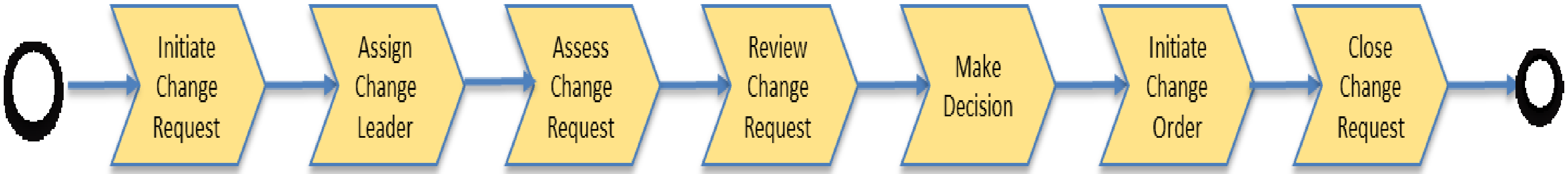
DOCUMENTATION
IKC <> ESS

Scope of Work template

- This document aims at describing the Scope of Work required to complete an IK product contribution to the ESS programme.
- It is a formal document and is agreed upon by all parties involved.
- It is an annex of an IKC agreement.
- The SoW contains an appropriate level of detail so all parties clearly understand what work is required, the duration of the work involved, what the deliverables are, and what is acceptable.

Table of contents

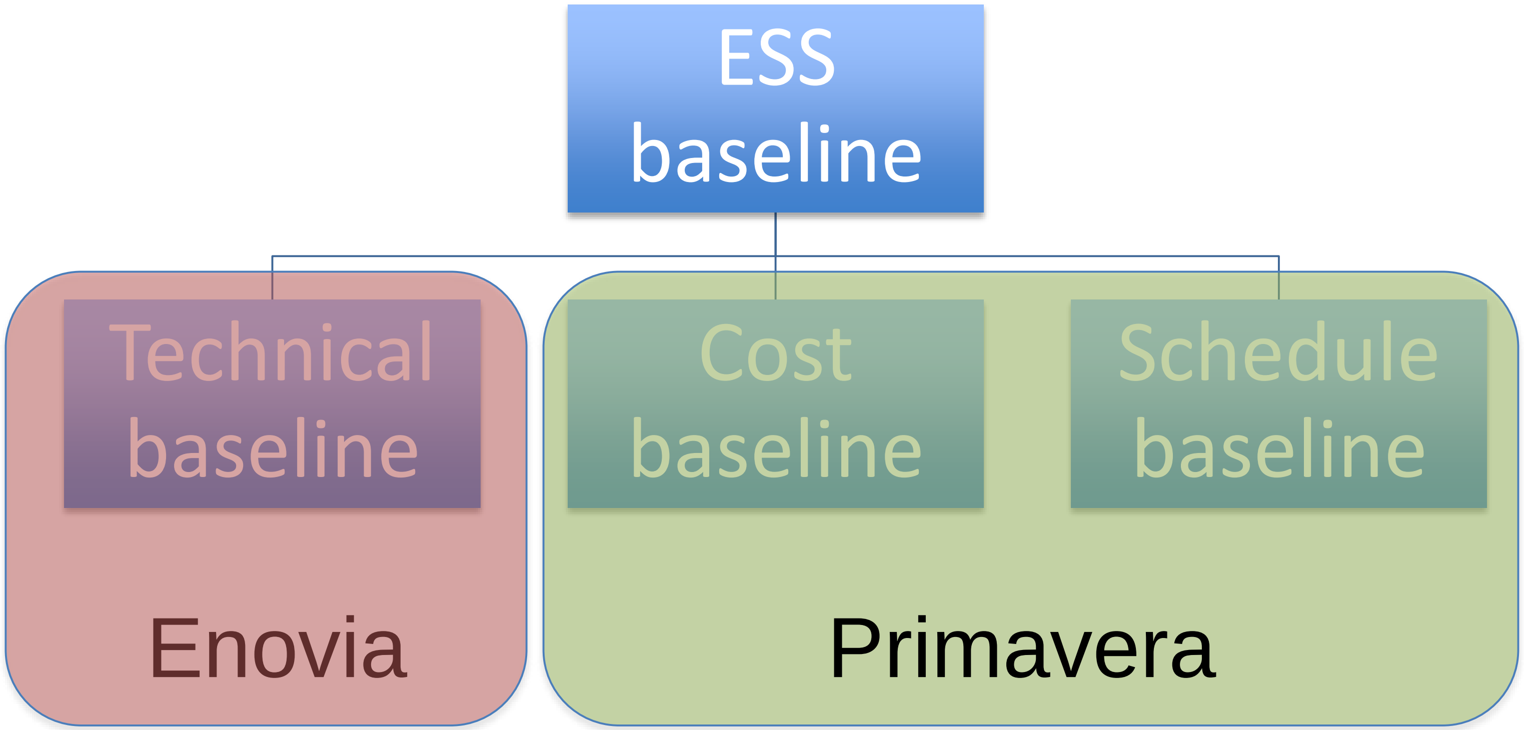
Change Control Procedure



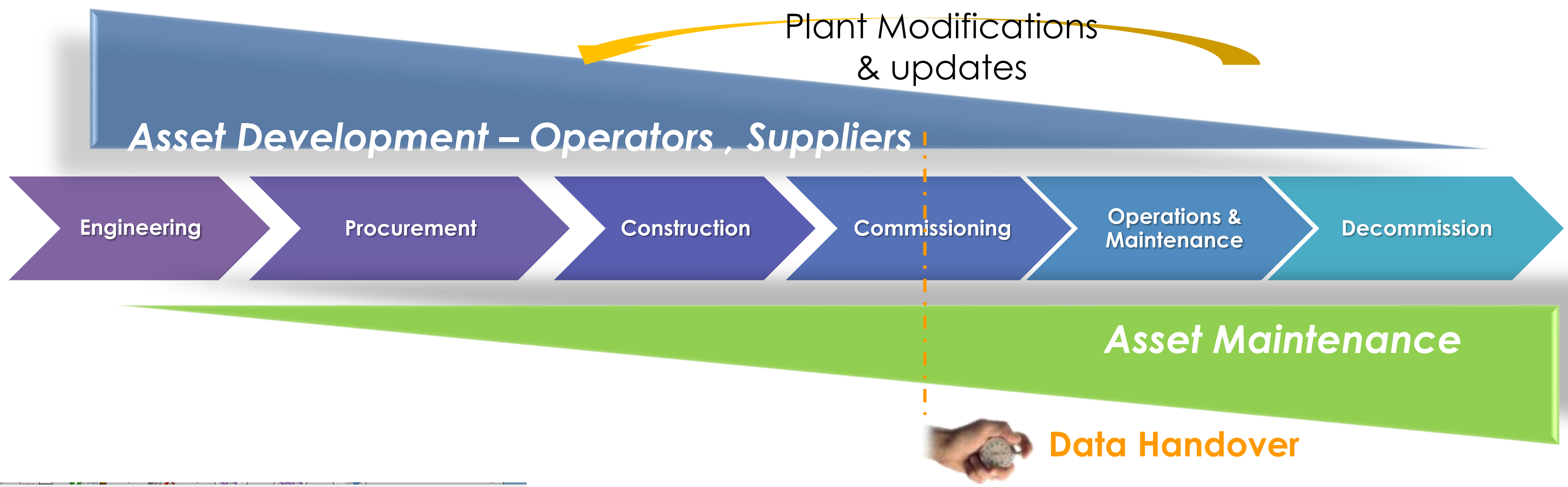
Change levels and authorities

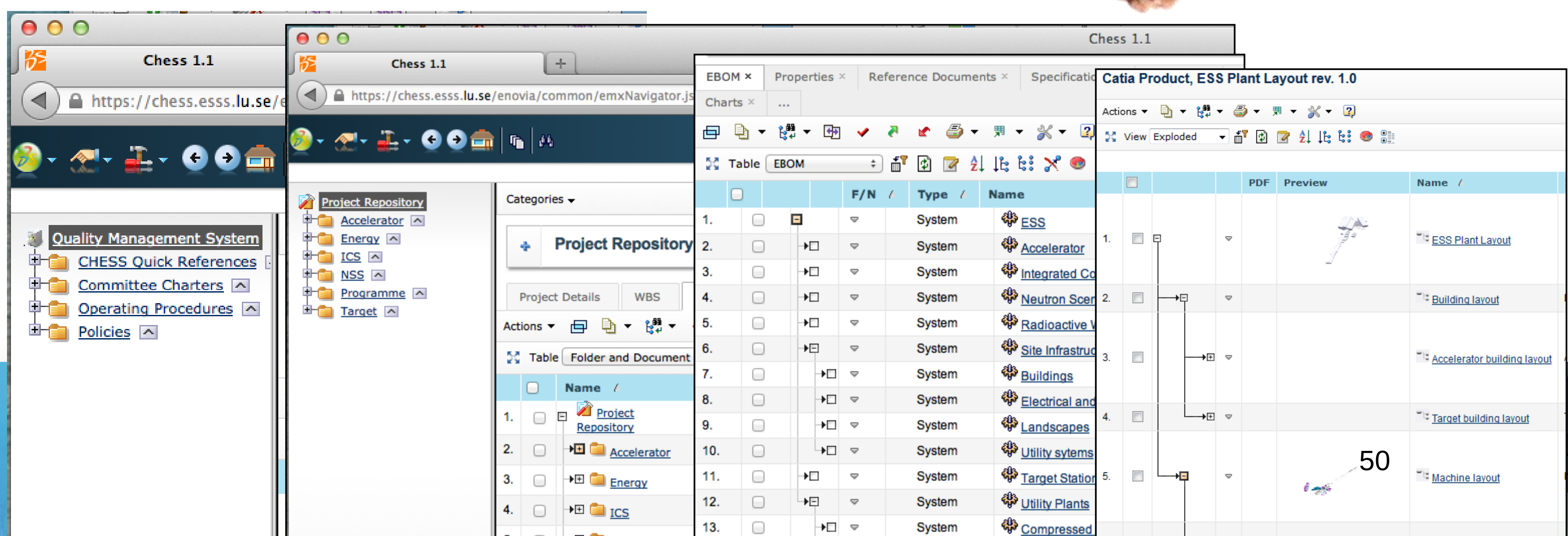
Level (L) of change related to the Approving entity	Technical Baseline	Schedule Baseline	Cost Baseline
Level A **ESS AB Board /STC**	Changes that impact the technical goals stated in the Programme Plan.	Changes that impact the programme phase tollgates as stated in the Programme Plan.	Changes that impact the cost of the construction, operation or decommissioning as stated in the Programme Plan.
Level B **CEO**	Changes that impact the configuration items (L1) including changes to ICDs between PBS L2 systems.	Changes that impact the construction phase L1 milestones or change to L2 milestone ≥3 months.	Changes that impact the contingencies or the total cost of the ESS construction phase cost.
Level C **Project Manager**	Changes that impact the configuration items for PBS L2 systems.	Changes that impact the construction phase L2 milestones <3 months or change to L3 milestone ≥1 month	Changes cost and risk neutral to the Programme and the Project.
Level D **WP Manager**	Changes that impact the configuration items PBS L3	Changes that impact the construction phase L3 milestones <1 month	Changes cost and risk neutral for the WP.
Level E **Manager of the originating organisation**	Minor changes to correct clerical errors or to add clarification to configuration items.		

Configuration Baselines

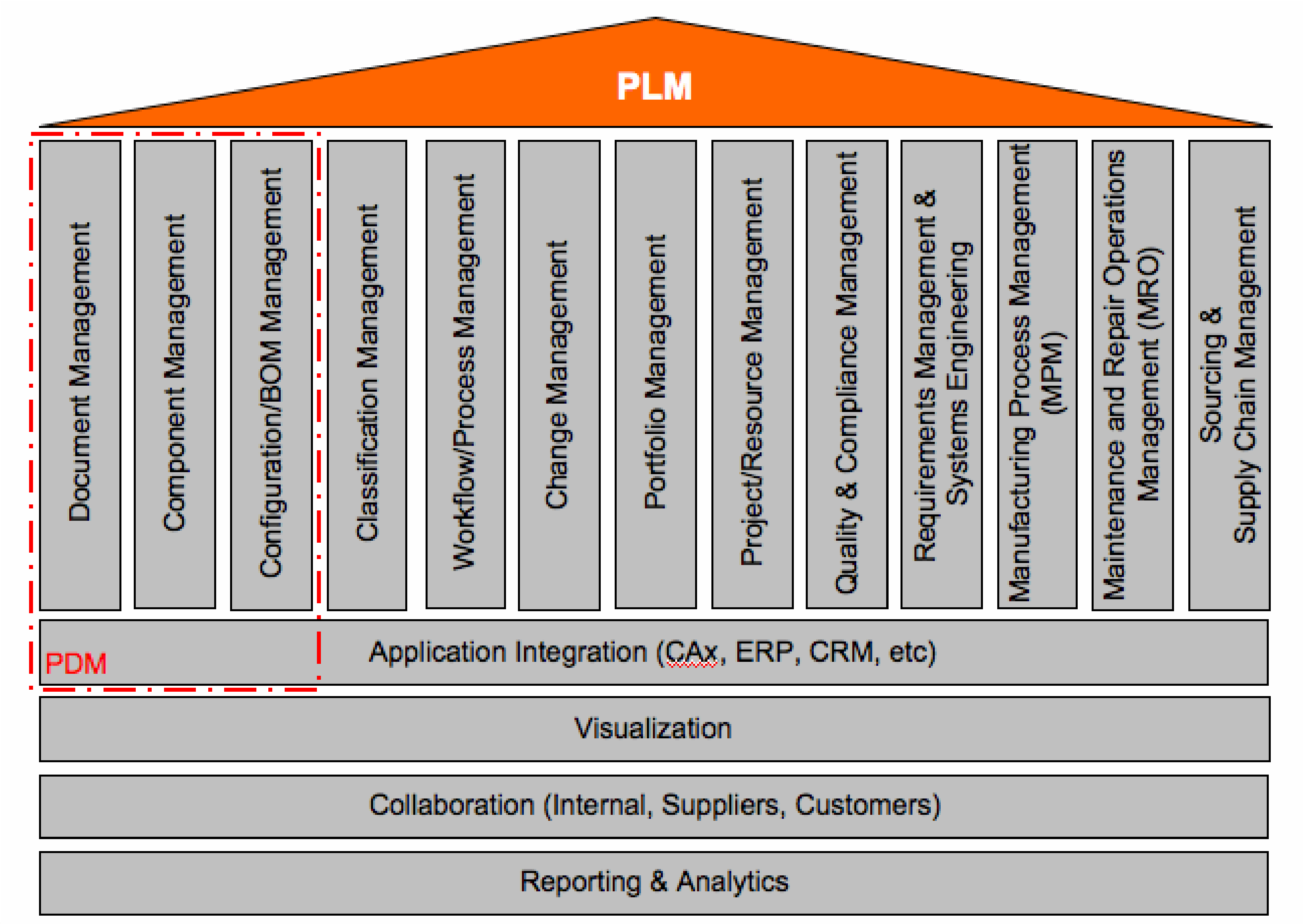


Life cycle management





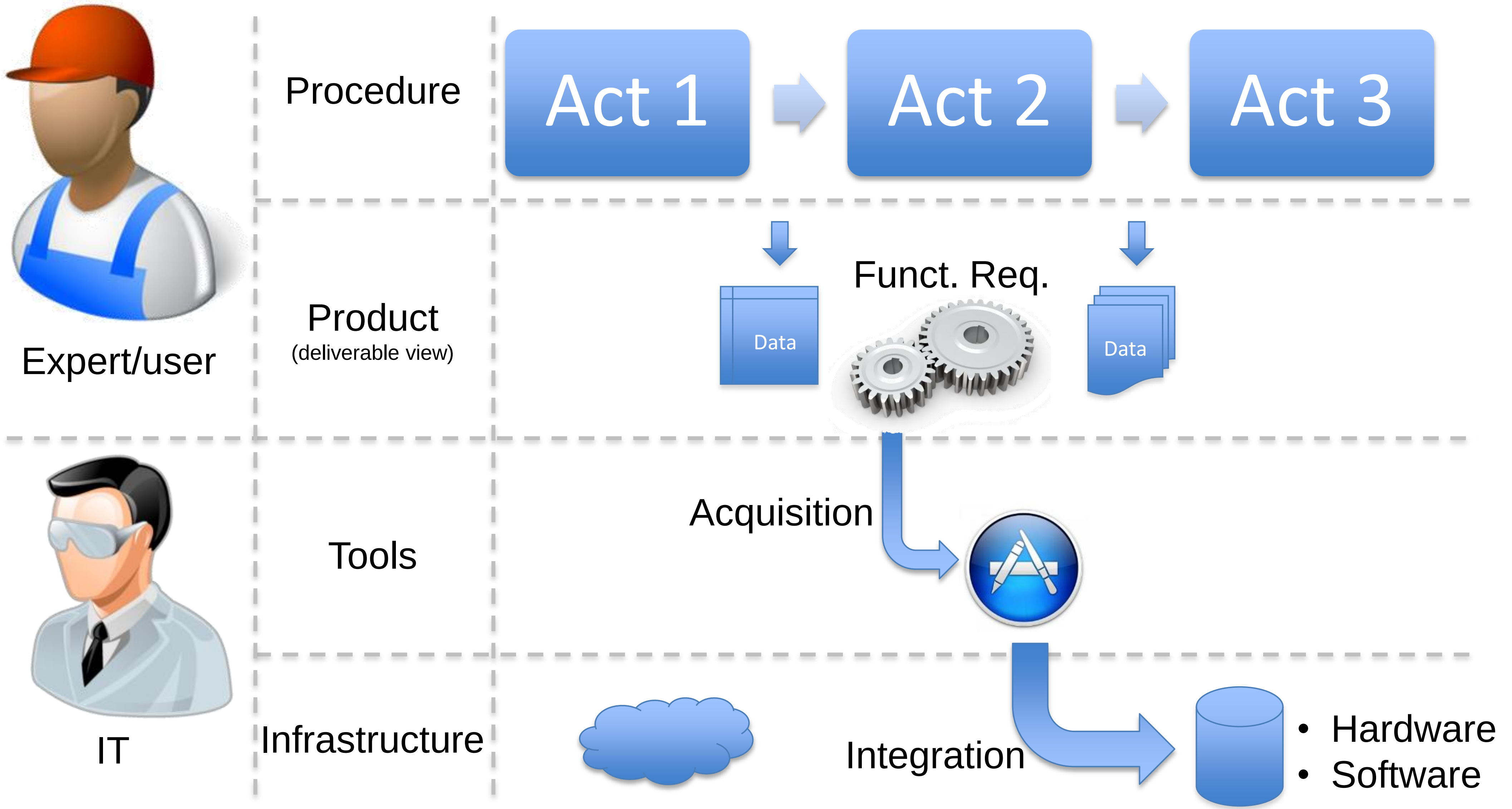
Product Life Cycle Management



Les sirènes du PLM

- **Attention aux idées fausses:**
  - Je peux déployer mon PLM en une semaine
  - Je prends systématiquement la solution de mon éditeur CAO
  - Le PLM va être adopté par tous
  - Je m’occupe du PLM et je verrais après les liens avec mon ERP
- **Quelques pièges:**
  - Sous-évaluation des coûts et pas de réelles comparaisons des solutions
  - Ce n’est pas un problème de qualité de la solution mais l’adéquation au CONTEXTE de l’organisme utilisateur
  - Laisser les fonctionnels ou les informaticiens choisir
  - Vouloir tout déployer en une fois (Faire des lots)

From procedure definition to an implemented support solution



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M. Marazzi, Chair

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ASSOCIATE DIRECTOR FOR OPERATIONS, ES&H and QA	**P. Carlsson**
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Technical Director
Roland Garoby
Johan Lehander (dep.)

ESS Cross Functional

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Romuald Duperrier

Integration and Design Support Division
Peter Rådahl

Accelerator Division
Mats Lindroos

ICS Division
Garry Trahern

Target Division
John Haines

SE division

SE Head
R. Duperrier

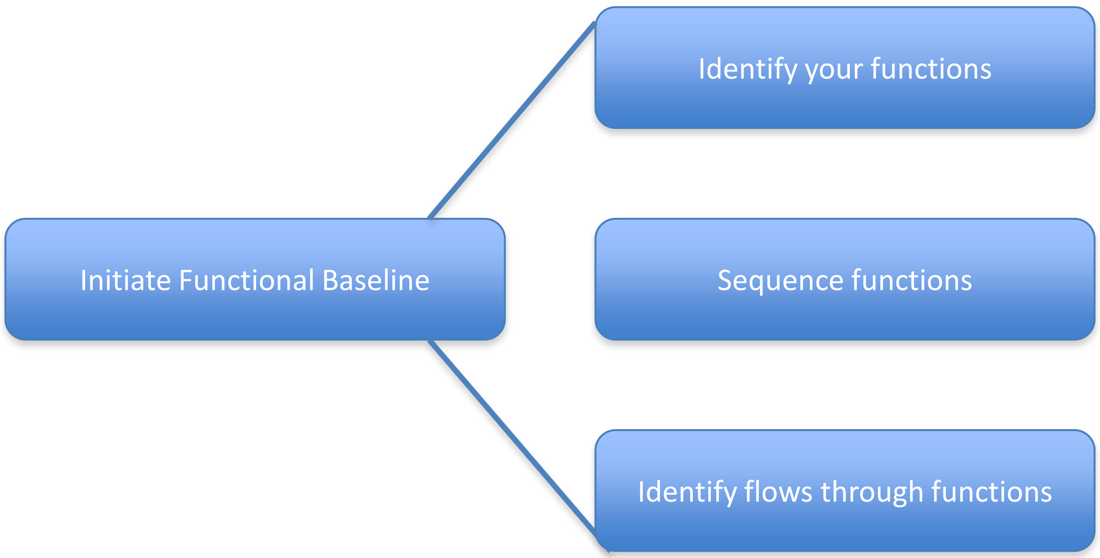
Requirements & Architecture engineering
-
J. Waldeck (GL),
F. Hermodsson,
Requirement engineer (vac.),
S. Wright (C)

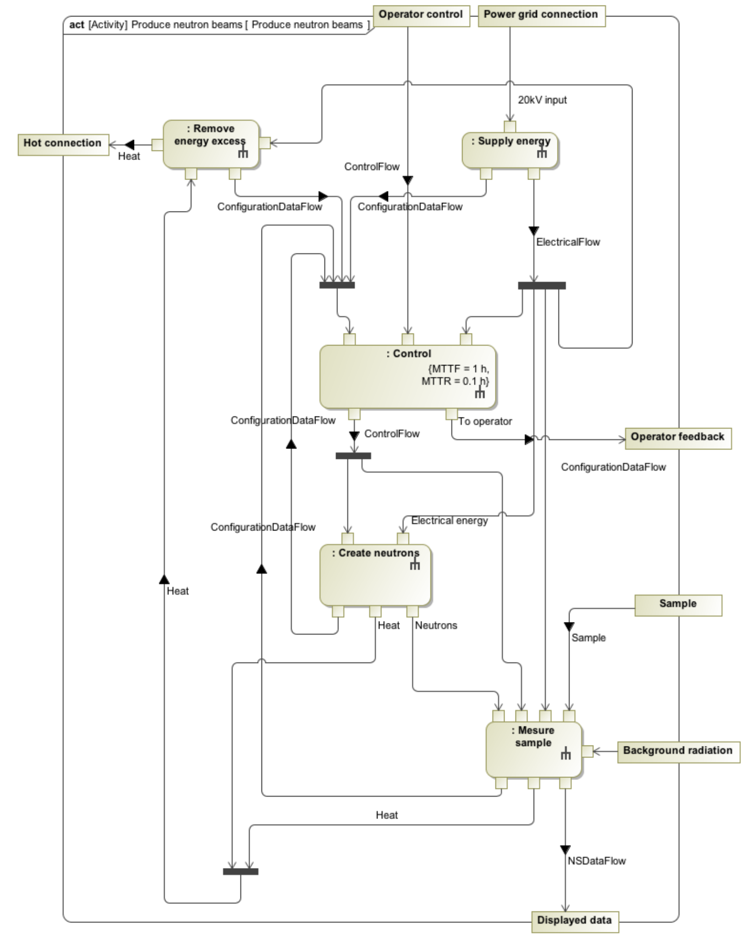
IVV Planning and reporting
-
Planner (vac.)

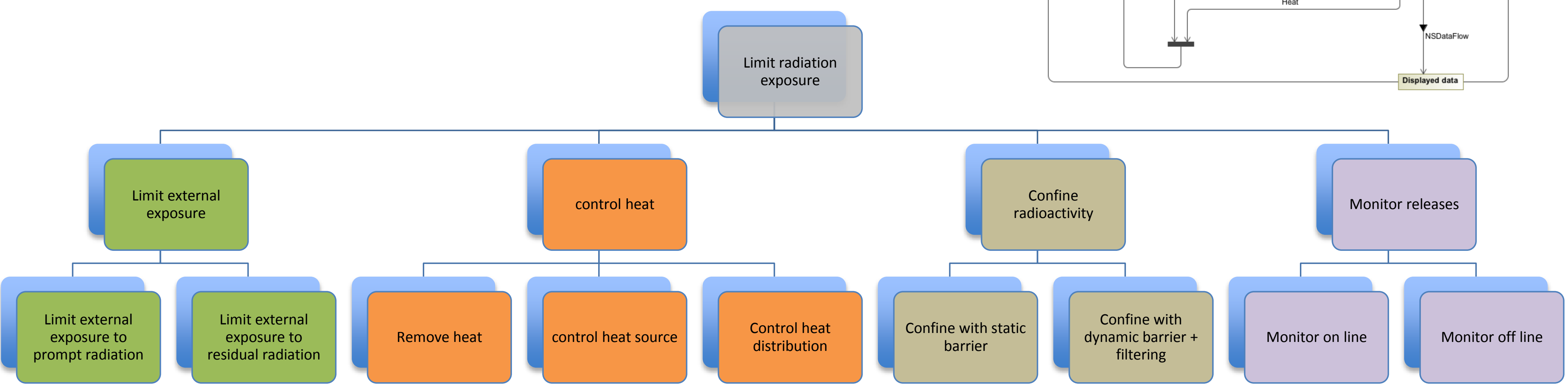
Safety engineering
-
F. Javier (GL),
Nuclear Safety eng. (vac.)
Conv. Safety eng. (vac.)

Logistics engineering
-
Group leader (vac)

Architecture fonctionnelle







SIC classification procedure

SSC required to perform safety function:		SSC classification		SSC failure from normal operation that lead to consequences of:
SF C1	----------------->	**SIC 1**	<-----------------	**An accident not considered a design basis accident**
SF C2	----------------->	**SIC 2**	<---------------	**Medium severity**
SF C3	----------------->	**SIC 3**	<---------------	**Low severity**

Severity scale

<u>High severity</u> :

- lead directly to a release of radioactive material that exceeds the limits for design basis accidents accepted by the regulatory body; or
- Cause the values of key physical parameters to challenge or exceed acceptance criteria for design basis accidents

<u>Medium severity</u> :

- lead to a <u>release of radioactive material below the limits for design basis accident</u>s accepted by the regulatory body but <u>higher than those established for anticipated operational occurrences</u>; or
- Cause the values of <u>key physical parameters</u> to <u>exceed the design limits for anticipated operational occurrences</u>, but <u>remain within the design limits specified design basis accidents</u>

<u>low severity</u> :

- lead to an <u>off-site release of radioactive material not exceeding the releases authorized for normal facility operation, but could lead to doses to workers above the authorized limits</u>

Status quo

- Main achievements:
  - Foundations for the quality system required by licensing authorities.
  - Awareness for a need to define requirements,
  - Awareness for integrating safety and risk in the design,
  - Policies; processes and plans are defined.
  - Design reviews.
  - Functions as a basis for classifying safety systems
- To be improved:
  - Turn awareness into day to day practices,
  - Understanding of the relationship between the documentation and the work on a day to day basis.
  - Integration of RAMS in the design process.
  - Interface descriptions
  - Risk management

Summary

- Most of the processes are common sense, but their **quantity creates the complexity**, their **lack** of definition and how they relate all together is a **major risk of cost and/or schedule overruns**.
- The ESS SE process establishes a robust and systematic approach for developing the facility.
- It is tailored to the ESS context and integrates safety and technical risk as a core design activity while enabling the traceability required by licensing authorities.