Regulatory Approach to Radiation Protection in new NPPs in Finland

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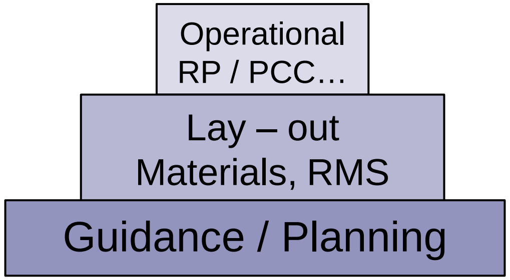
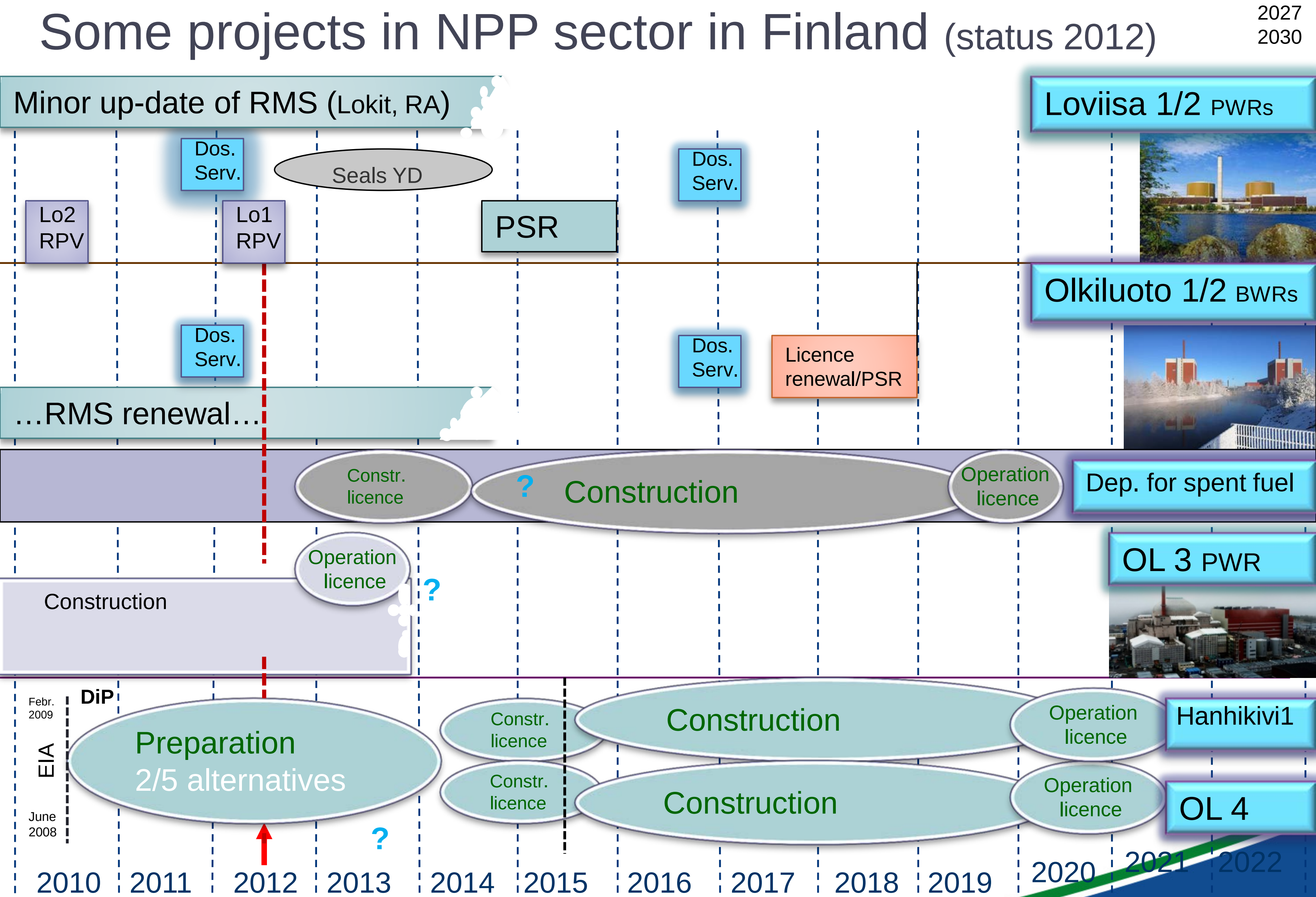
Radiation and Nuclear Safety Authority (STUK)

Content

- General information
- Regulatory background
- Sources, lay-out...
- System specific review
- Primary system material specification
- Dose estimation
- Future aspects



Some projects in NPP sector in Finland (status 2012)



Olkiluoto NPP (TVO)

- 2 operating units – ASEA BWRs
- OL3 (EPR) under construction
- **OL4 (TBD)**
  - ABWR, Toshiba Westinghouse
  - APWR, Mitsubishi Heavy Industry
  - AP1400, KHNP
  - EPR, Areva
  - ESBWR, GE Hitachi


Source: TVO


Source: TVO

FENNOVOIMA

Hankikivi 1 (TBD) Pyhäjoki

- ABWR, Toshiba Westinghouse
- EPR, Areva

Loviisa NPP (Fortum)

- 2 operating units - VVERs


Source: Fortum

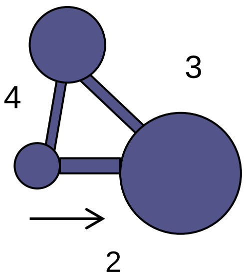
Guides in Radiation Protection

Guidance / Planning

YVL 7.1	Limitation of public exposure in the environment of and limitation of radioactive releases from a NPP (in Finnish)	22 Mar 2006
YVL 7.2	Assessment of radiation doses to the population in the environment of a NPP	23 Jan 1997
YVL 7.3	Calculation of the dispersion of radioactive releases from a NPP	23 Jan 1997
YVL 7.4	NPP emergency preparedness	9 Jan 2002
YVL 7.5	Meteorological measurements of a NPP	28 May 2003
YVL 7.6	Monitoring of discharges of radioactive substances from a NPP (in Finnish)	22 Mar 2006
YVL 7.7	Radiation monitoring in the environment of a NPP (in Finnish)	22 Mar 2006
YVL 7.8	Environmental radiation safety reports of a NPP (in Finnish)	22 Mar 2006
YVL 7.9	Radiation protection of workers at nuclear facilities	21 Jan 2002
YVL 7.10	Monitoring of occupational exposure at nuclear facilities	29 Jan 2002
YVL 7.11	Radiation monitoring systems and equipment of a NPP	13 Jul 2004
YVL 7.18	Radiation safety aspects in the design of a NPP	26 Sep 2003

- **Lay –out -> ALARA**

Improvements in layout and design relevant to radiation protection



1 generation

2 generation

- separation of hot leg from cold leg

- thermal insulation in cassette form

pre-Konvoi

- residual heat removal pumps separated from valves

- increase of inspection platforms in the auxiliary building

- elimination of welds to be inspected (e.g. SG cone, pressurizer)

Konvoi N4

EPR

- tanks/vessels usually set separately (e.g. liquid waste, coolant)
- Considerable reduction of welds (RCL, SG)
- shielded safety injection pump & pipe ducts
- fuel pool and residual heat removal pumps, accessibility after accidents
- separate access paths of many levels (avoidance of ladders)
-widened transport and construction routes

-2-room containment (EPR)

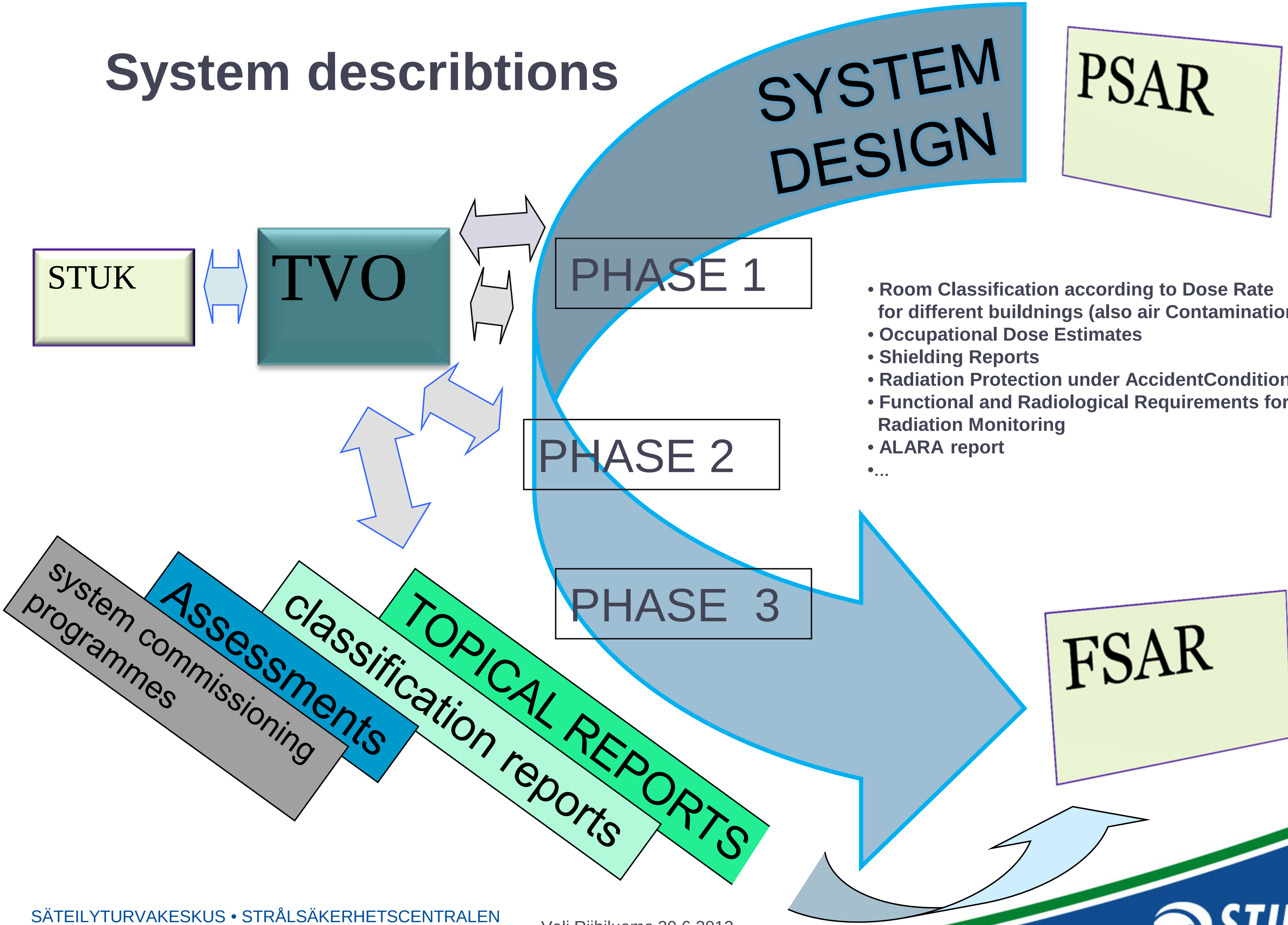
-access-building layout changes (OL3)

- machines for changing filters & decontamination systems (gradually improved)

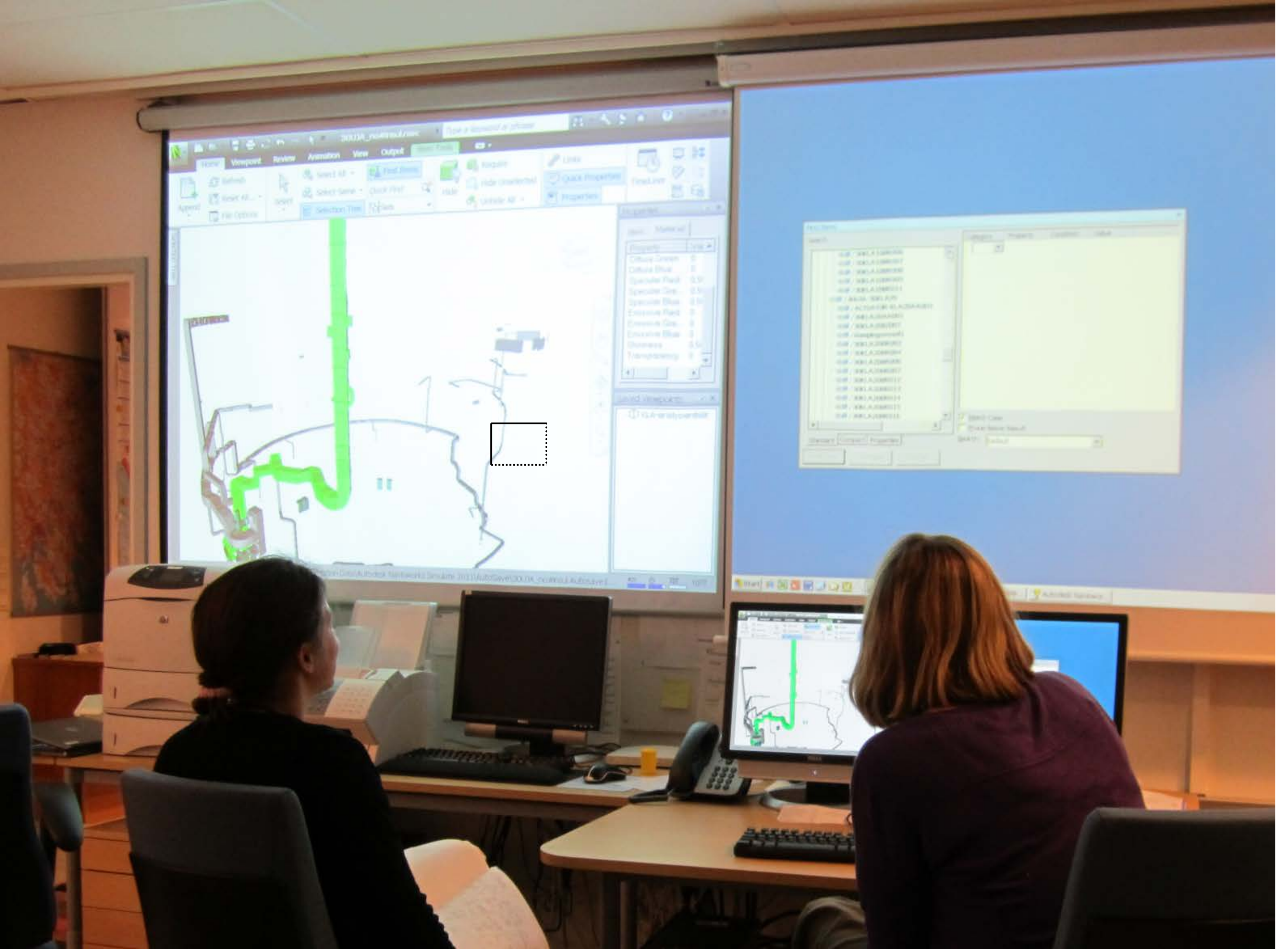
- **Detailed design**

Process -> ALARA

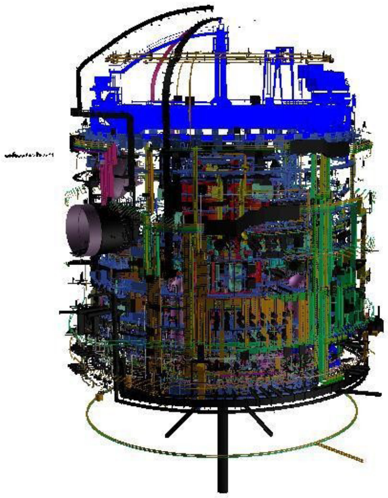
System describtions



- Room Classification according to Dose Rate for different buildnings (also air Contamination)
- Occupational Dose Estimates
- Shielding Reports
- Radiation Protection under AccidentConditions
- Functional and Radiological Requirements for Radiation Monitoring
- ALARA report
- …



Autodesk Navisworks Review v.2010 SP1



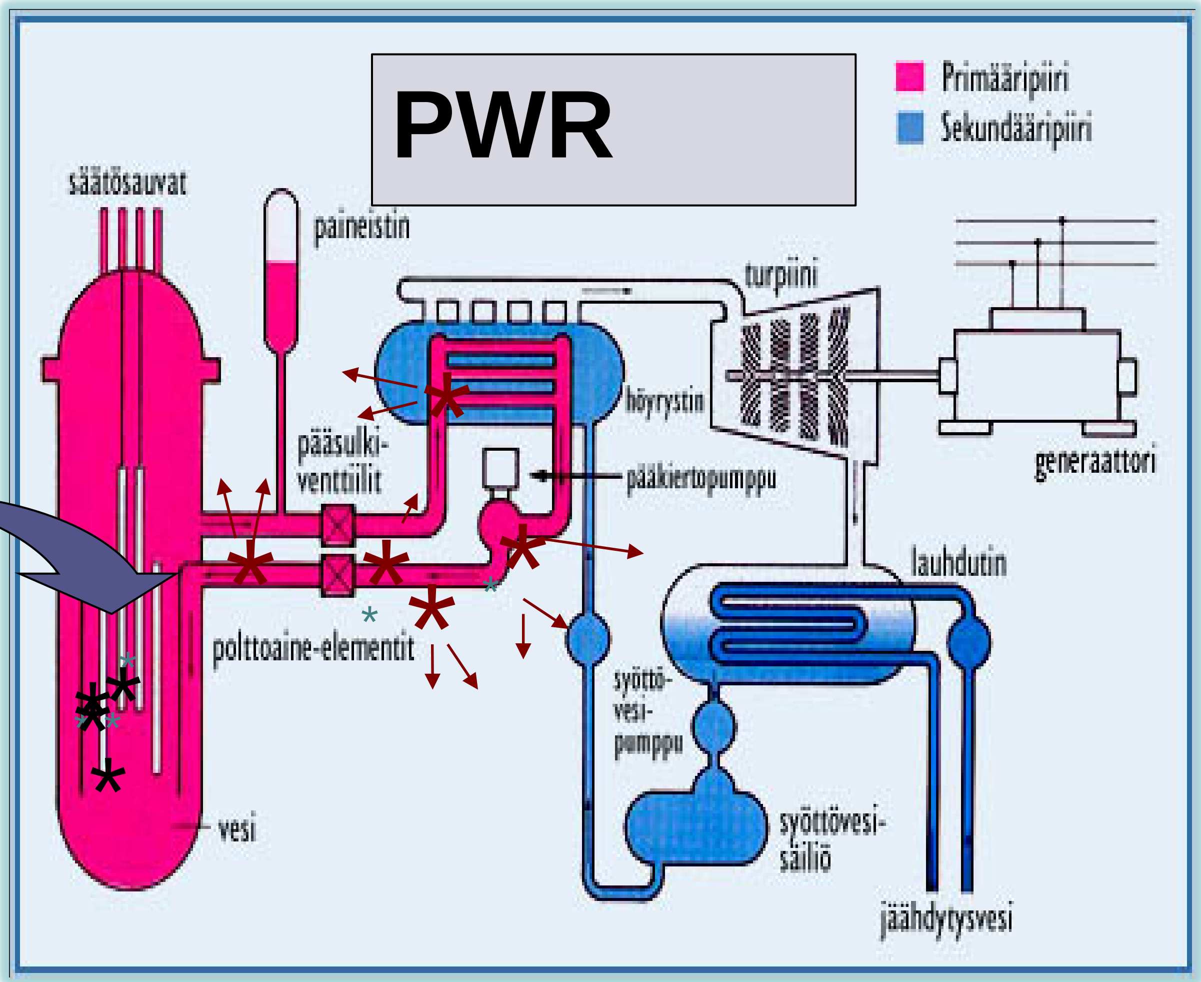
location of components, piping systems, ducts, cable routings, cubicles, switchgears, instrumentation, civil structures

- Physical separation aspects
- Internal hazards analysis
- Radiation protection requirements

Lay – out
Materials
Guidance / Planning

- **Materials -> ALARA**

- ~~Ni-58 + n -> Co-58 + p~~
- ~~Cr-50 + n -> Cr-51 + γ~~
- ~~Fe-54 + n -> Mn-54 + p~~
- ~~Fe-58 + n -> Fe-59 + γ~~
- ~~Co-59 + n -> Co-60 + γ~~



- ~~Zn-64 + n -> Zn-65 + γ~~
- ~~Ag-109 + n -> Ag-110m + γ~~

Material selection, SG tubes

- SG tubing material in OL3 was selected **Alloy 690TT** (**nickel base, 58% Ni**)
  - better corrosion resistance (general C & Stress C Cracking) compared to Alloy 600 & 800

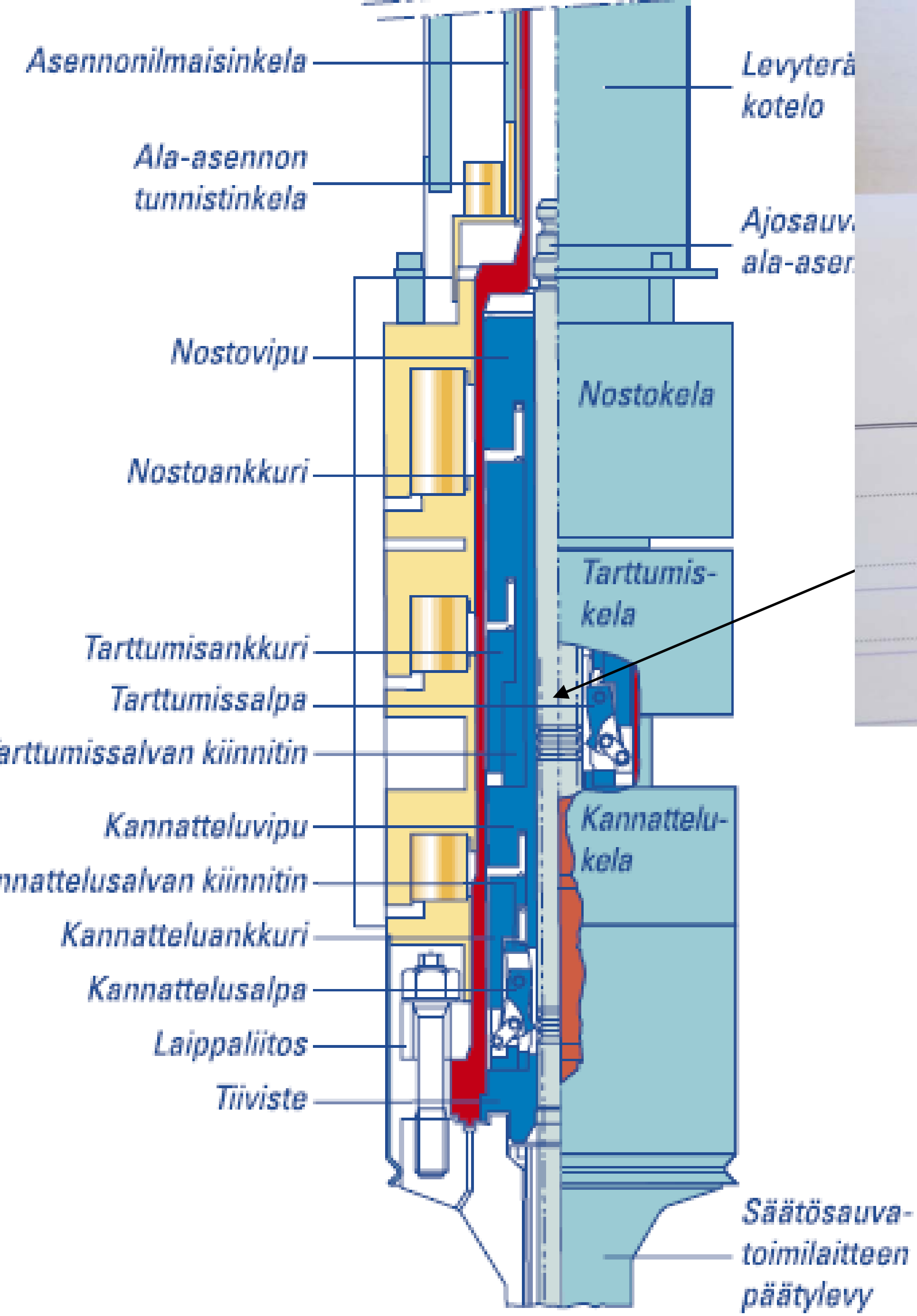
- The cobalt content of construction materials in contact with primary coolant for EPR OL3 was specified as below:
  - Stainless Steels or Ni-Cr-Fe alloys (other than tube bundle) **Co ≤ 0.06 %**
  - Tube bundle (averaged over all castings) **Co ≤ 0.015 %**

Co-operation between RP and material experts

Material selection, Co, hard-facing

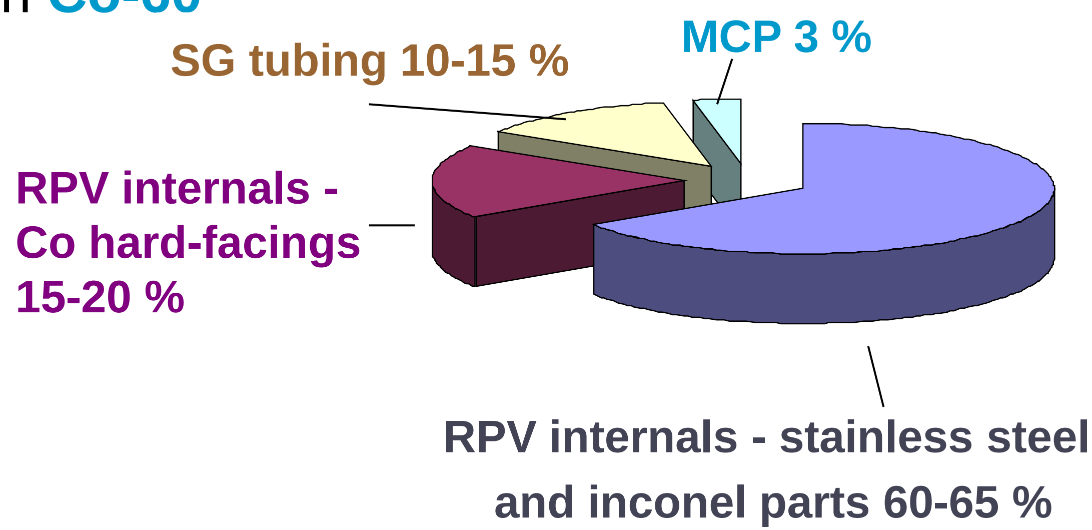
Stellite minimisation vs. increase of potential technical risk

	EPR (OL3)	Konvoi	P'4 (1300 MW)
CRDM	2.3 m^2	1.6 m^2	1.8 m^2
MCP	1.42 m^2	0	2.5 m^2
RPV + internals	0.45 m^2	0.03 m^2	0.56 m^2
auxiliary systems and valves	0	1.0 m^2	2.3 m^2
Total amount	**4.2 m^2**	**2.6 m^2**	**7.2 m^2**


Asennonilmaisinkela
Ala-asennon
tunnistinkela
Nostovipu
Nostoankkuri
Tarttumisankkuri
Tarttumissalpa
Kannatteluvipu
Kannatteluankkuri
Kannattelusalpa
Laippaliitos
Tiiviste
Nostokela
Tarttumis-
kela
Kannattelu-
kela
kotelo
Säätösauva-
toimilaitteen
päätylevy

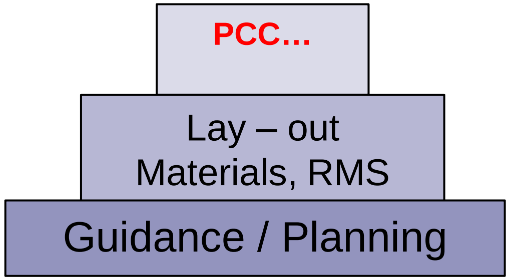
Material -> dose contribution

- Main contributors in **Co-60 source term:**



- Main contributors in **Co-58** source term:
  - SG tubing 80 %
  - Fuel assemblies (inconel parts) 7 %

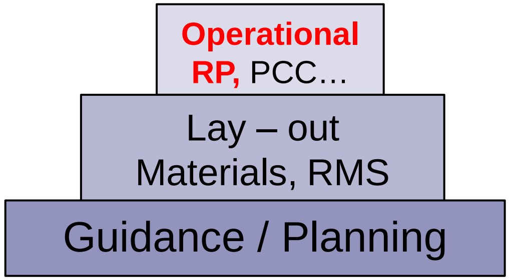
PCC -> ALARA



The primary coolant chemistry has to base on an optimized conditioning and on the limitation of impurities in order:

- To minimize coolant corrosion product (CP) formation
- To optimize CP migration and re-deposition
- To limit the **corrosion rate of fuel cladding material** (thermal effect and chemistry effects)
- To **avoid oxygen formation** by radiolysis (by hydrogen addition)
- To prevent localized corrosion (SCC/pitting) by limiting impurities (chlorides, fluorides, sulphates)

Co-operation between RP and chemistry experts



Operational RP -> ALARA

- Instructions (integration of practices)
- Dosimetry
- Operational material/equipment in RP (Integration of functions with old units)
- Measurements (RMS-system) instructions/tests/maintenance
- Outage planning/work permits (short, well planned outages to minimize dose)
- New personnel (Timing of recruiting/hiring new personnel due to delay)
- Training (timing is a challenge)

ALARA-planning - taken in consideration in all use of NPP

RMS -> ALARA

Lay – out
Materials, **RMS**
Guidance / Planning

- RP of persons
  - Area monitoring
  - Personnel monitoring
- Control of activity flow
  - Start of reactor protection measures
  - Process Monitoring
- RP of the environment and population
  - Stack monitoring of radioactive releases
  - Monitoring of liquid releases
  - Monitoring of the environment

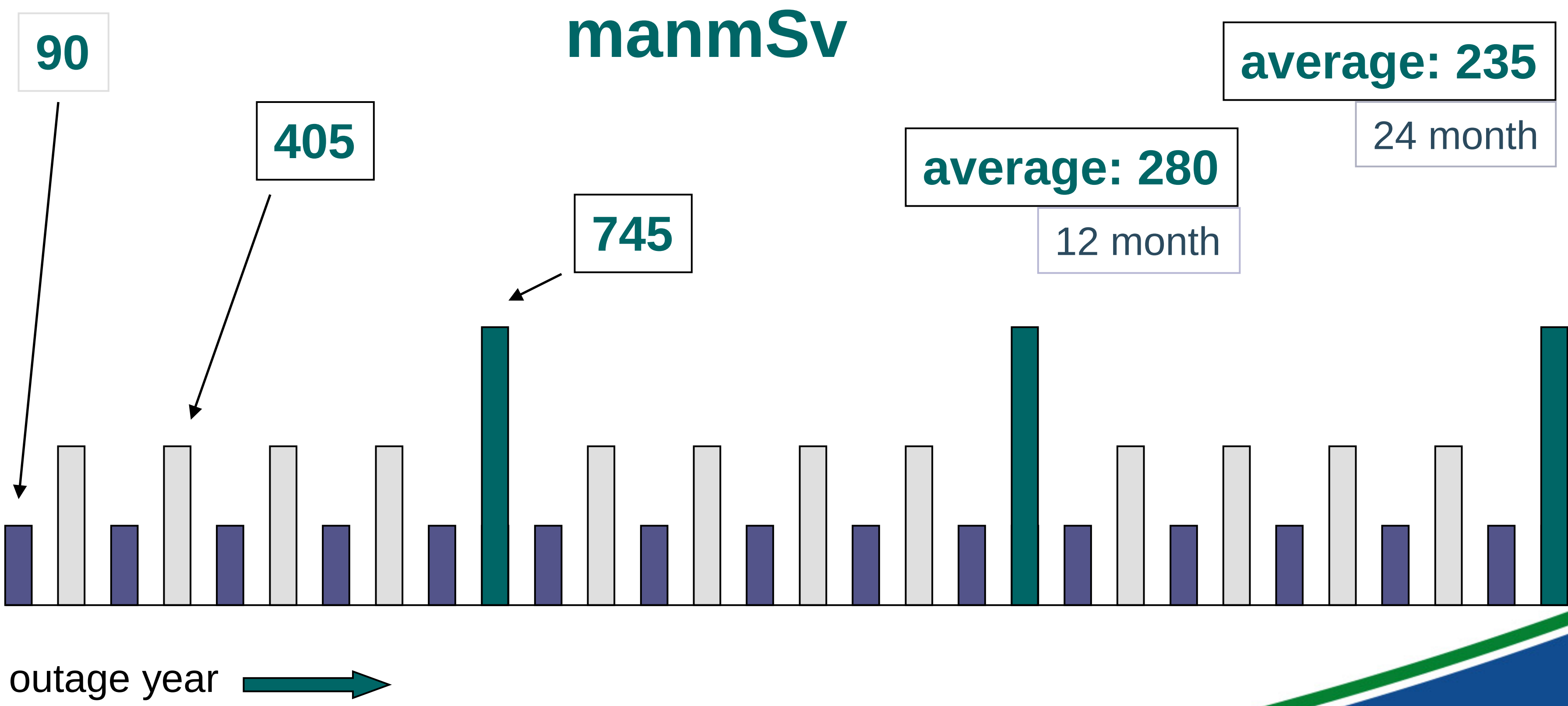
MCR
CRCS

Technical support
I&C
Offsite support

- **In future**

Doses for 12-months outage sequence

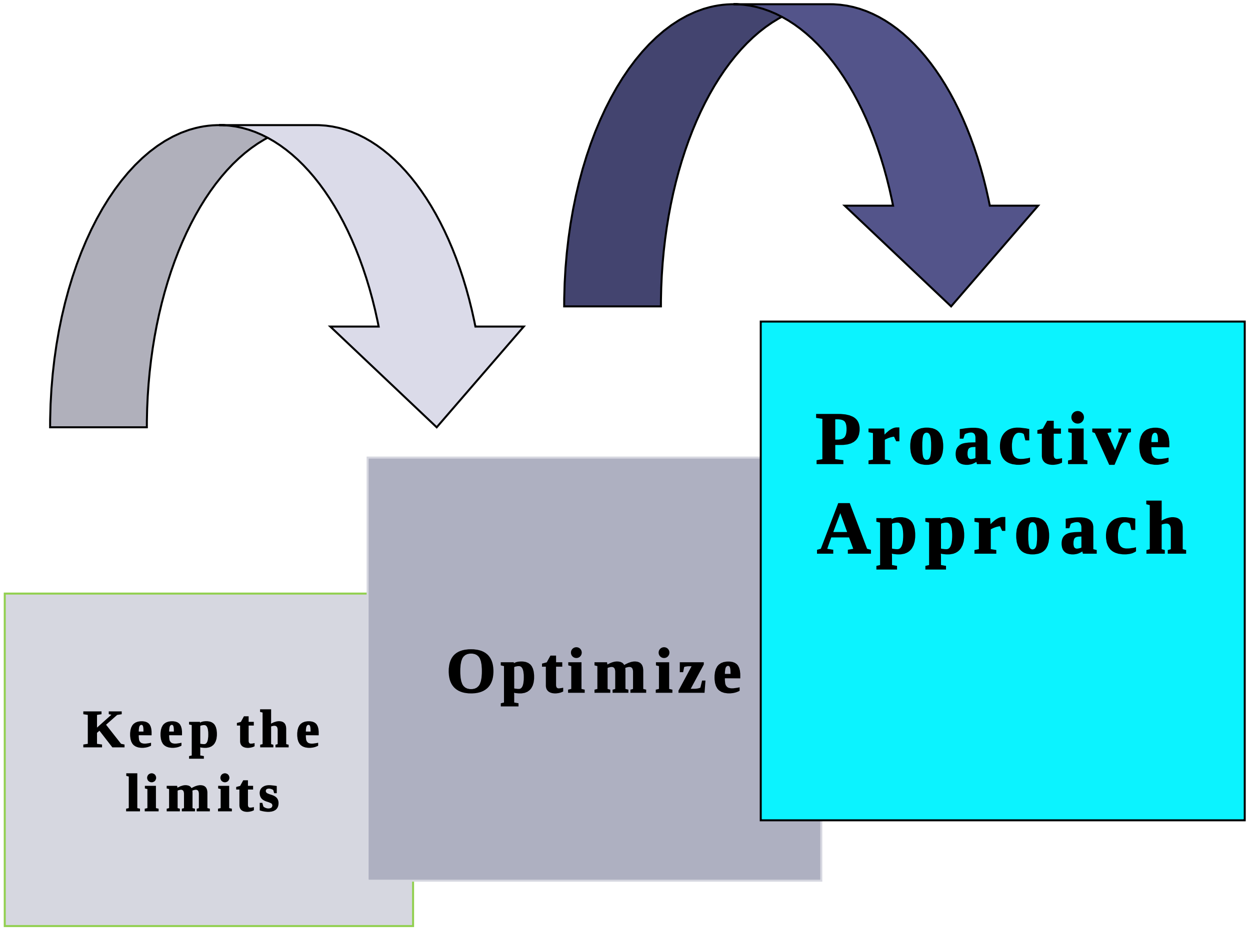
- Design criterion for an annual personnel collective dose:
  < 0.5 manSv / 1 GWe averaged over the plant life
  < 0.8 manSv / year for OL3 (1600 MWe)
- EUR document requirement for EPR:
  target for annual collective effective dose averaged over the plant life is 0.5 manSv / year
- OL3 PSAR: 0.425 manSv/year (12 months cycle)

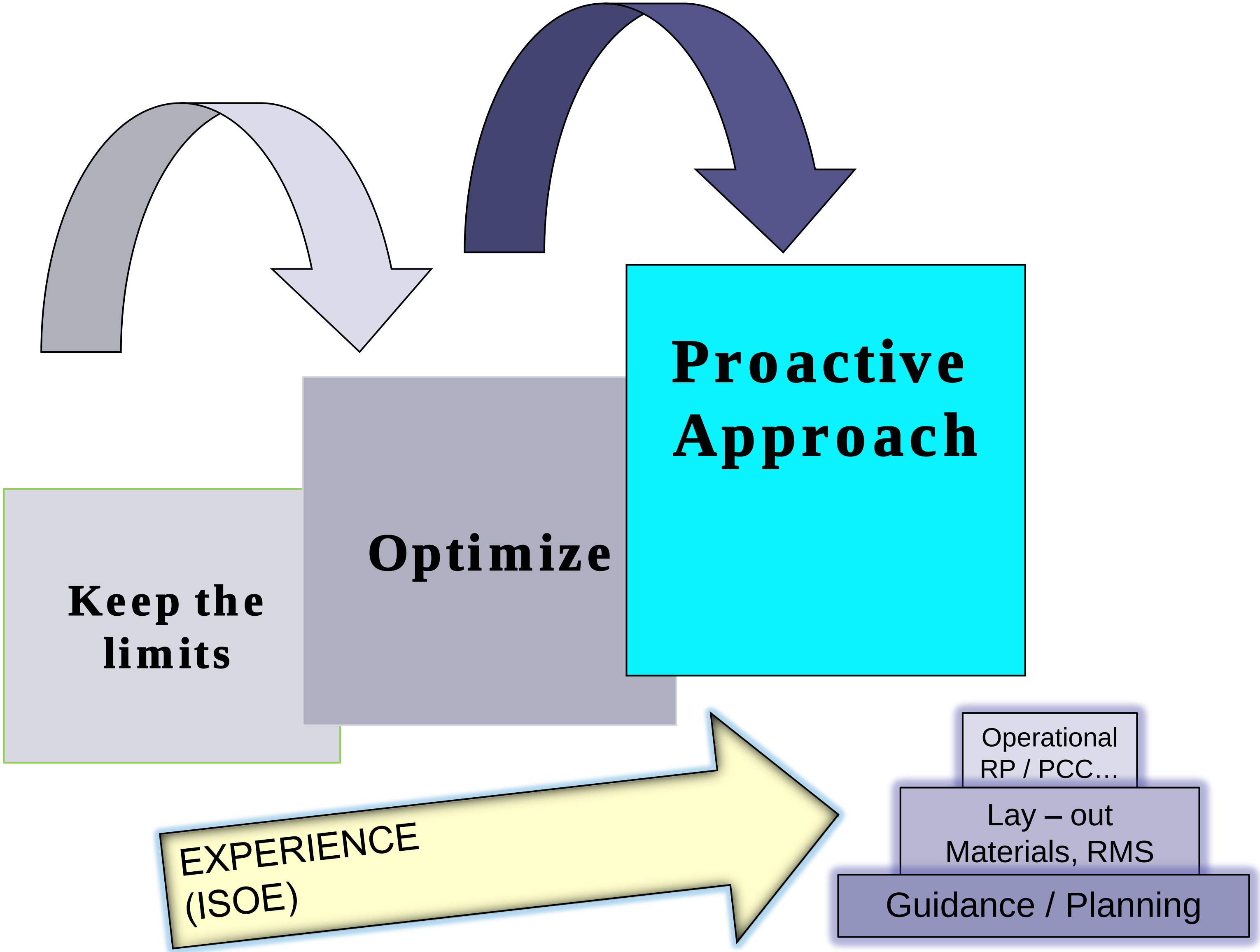


List of the future YVL guides

A Safety management of a nuclear facility	B Plant and system design	C Radiation safety of a nuclear facility and environment	D Nuclear materials and waste	E Structures and equipment of a nuclear facility
A.1 Regulatory control of the safe use of nuclear energy	B.1 Design of the safety systems of a nuclear facility	***C.1 Structural radiation safety and radiation monitoring of a nuclear facility***	D.1 Regulatory control of nuclear non-proliferation	E.1 Inspection, testing and certifying organisations
A.2 Siting of a nuclear facility	B.2 Classification of systems, structures and equipment of a nuclear facility	**C.2 Radiation protection and dose control of the personnel of a nuclear facility**	D.2 Transport of nuclear materials and waste	E.2´Manufacture and use of nuclear fuel
A.3 Management systems of a nuclear facility	B.3 Safety assessment a NPP	**C.3 Control and measuring of radioactive releases to the environmental of a nuclear facility**	D.3 Handling and storage of nuclear fuel	E.3 Pressure vessels and pipings of a nuclear facility
A.4 Organisation and personnel of a nuclear facility	B.4 Nuclear fuel and reactor	**C.4 Radiological control of the environment of a nuclear facility**	D.4 Handling of low- and intermediate-level waste and decommissioning of a nuclear facility	E.4 Verification of strength of pressure equipment of a nuclear facility
A.5 Construction of a NPP	B.5 Reactor coolant circuit of a NPP	**C.5 Emergency preparedness arrangements of a NPP**	D.5 Final disposal of nuclear waste	E.5 In-service inspections of pressure equipment of a nuclear facility
A.6 Operation and accident management of a NPP	B.6 Containment of a NPP		D.6 Production of uranium and torium	E.6 Buildings and structures of a nuclear facility
A.7 Risk management of a NPP	B.7 Preparing for the internal and external threats to a nuclear facility			E.7 Electrical and I&C equipment of a nuclear facility
A.8 Ageing management of a nuclear facility	B.8 Fire protection of a nuclear facility			E.8 Valve units of a nuclear facility
A.9 Reporting on the operation of a nuclear facility				E.9 Pump units of a nuclear facility
A.10 Operating experience feedback of a nuclear facility				E.10 Emergency power supply of a nuclear facility
A.11 Security arrangements of a nuclear facility				E.11 Hoisting and transfer equipment of a nuclear facility

Collected definitions of YVL-guides: a part of the regulations, but a separate document.

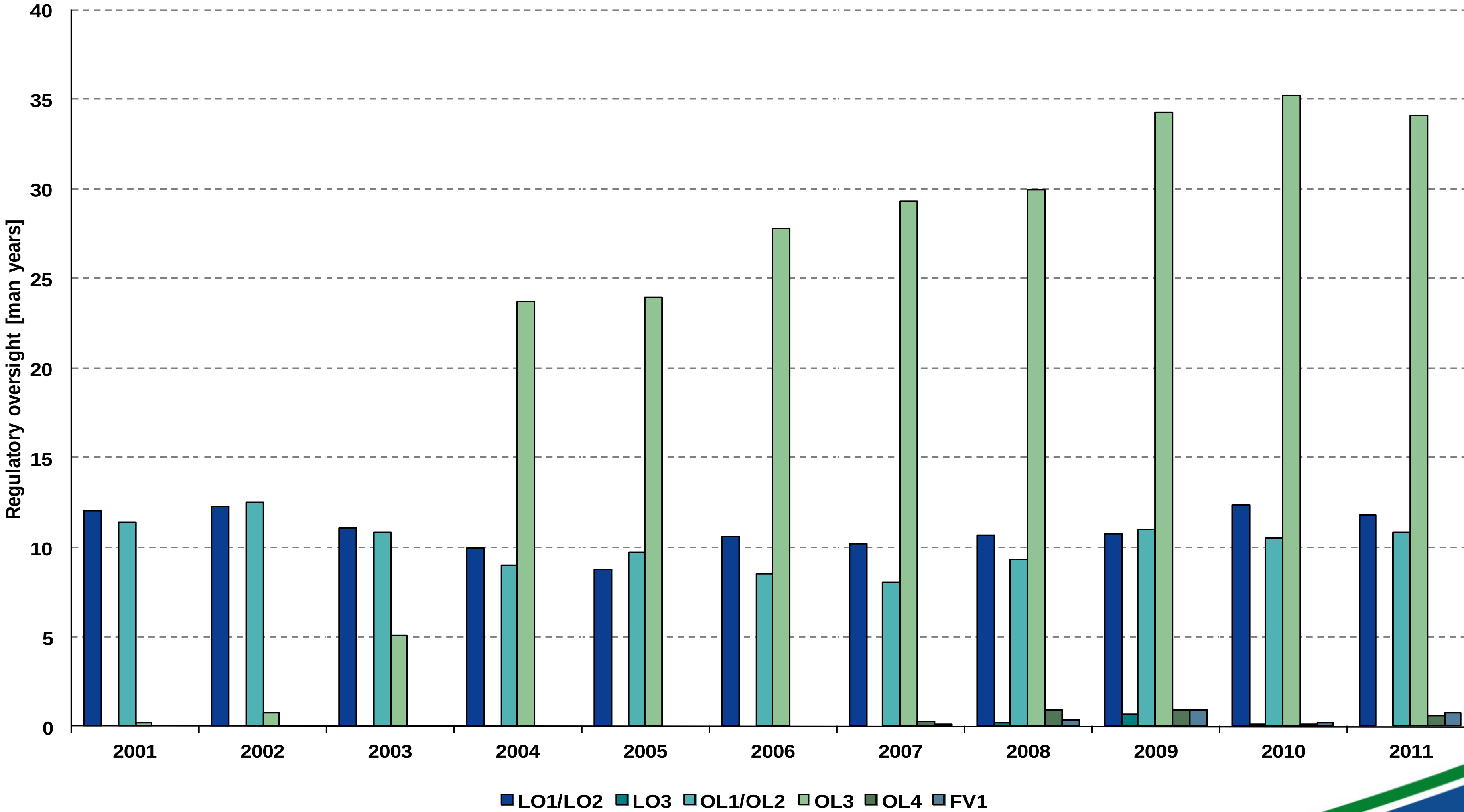

Keep the limits
Optimize
Proactive Approach


Proactive Approach
Optimize
Keep the limits
EXPERIENCE
(ISOE)
Operational
RP / PCC…
Lay – out
Materials, RMS
Guidance / Planning

- Thank you
- Děkuji

- EXTRAS

Regulatory Oversight (man-years/NPP)



Source: Kaisa Koskinen

Applying operating licence

Section 36
When applying for an operating licence, the applicant shall provide the Radiation and Nuclear Safety Authority (STUK) with the following:

1) the FSAR
2) a PRA
3) a classification document,
4) a QM programme for the operation of the nuclear facility;
5) the Technical Specifications
6) a summary programme for periodic inspections;
7) plans for the arrangements for security and emergencies;
8) a description on how to arrange the safeguards that are necessary to prevent the proliferation of nuclear weapons;
9) administrative rules for the nuclear facility;
10) a programme for radiation monitoring in the environment of the nuclear facility;
11) a description of how safety requirements are met; and
12) a programme for the management of ageing.

Collective dose estimation

- **RB, shutdown** **245 manmSv**

reactor work	22 %
SG, PZR	23 %
logistics (cleaning, supplies, scaffolding, insulation, reactor pool decontamination)	23 %
I&C, ventilation and filtration systems	6 %
pumps and valves	15 %
management, operations team, health physics	10 %
NDE, hydraulic tests	1 %

- **RB, power operation** **30 manmSv**

  e.g. tests on polar crane, maintenance of HVAC systems, maintenance of the internal filtration system

- **other buildings** **150 manmSv**

  e.g. CVCS, SIS, coolant storage system, fuel pool activities; based on Konvoi experience

-> total (12 months cycle) 425 manmSv

Licensing steps in Finland