



Atoms for the Future 2014

Commissioning of Nuclear Power Plants The AREVA approach

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Commissioning of NPPS

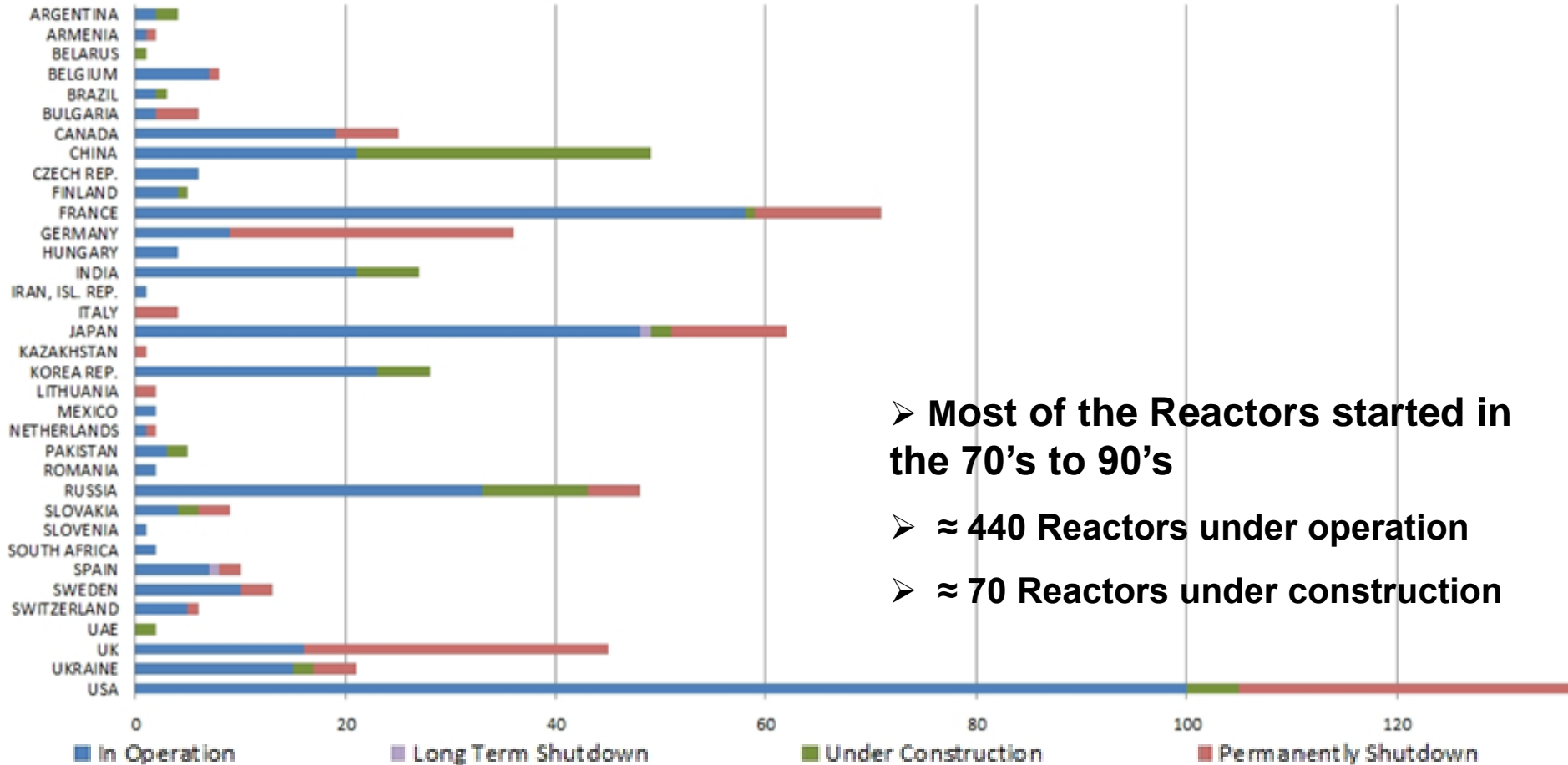


Agenda

- **Commissioning in Project process**
- **Overview of Commissioning Phases and Tests**
- **General Commissioning organization / Interfaces**
- **Commissioning skills**

Introduction

Number of Power Reactors by Country and Status



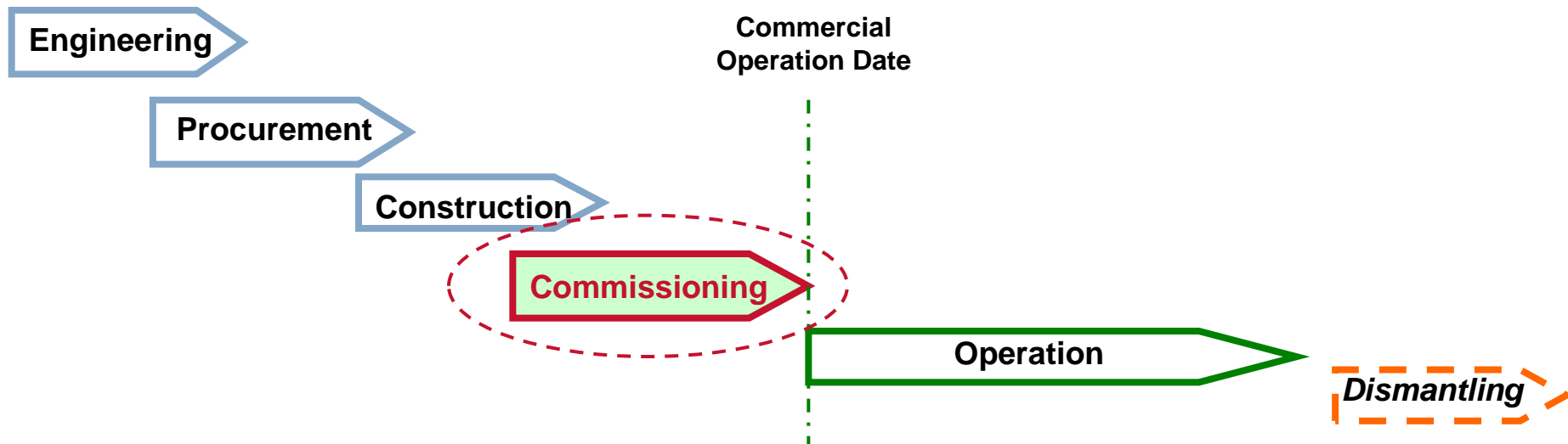
- Most of the Reactors started in the 70's to 90's
- ≈ 440 Reactors under operation
- ≈ 70 Reactors under construction

Power reactors by status worldwide (as June 2014 ref: IAEA PRIS)

Commissioning in Project Process

What is commissioning? Why is it such a special field of expertise?

- ▶ The commissioning, starting at the end of construction with tests and initial operation of components and systems, is the last phase of the project where all the preceding phases are verified & validated.

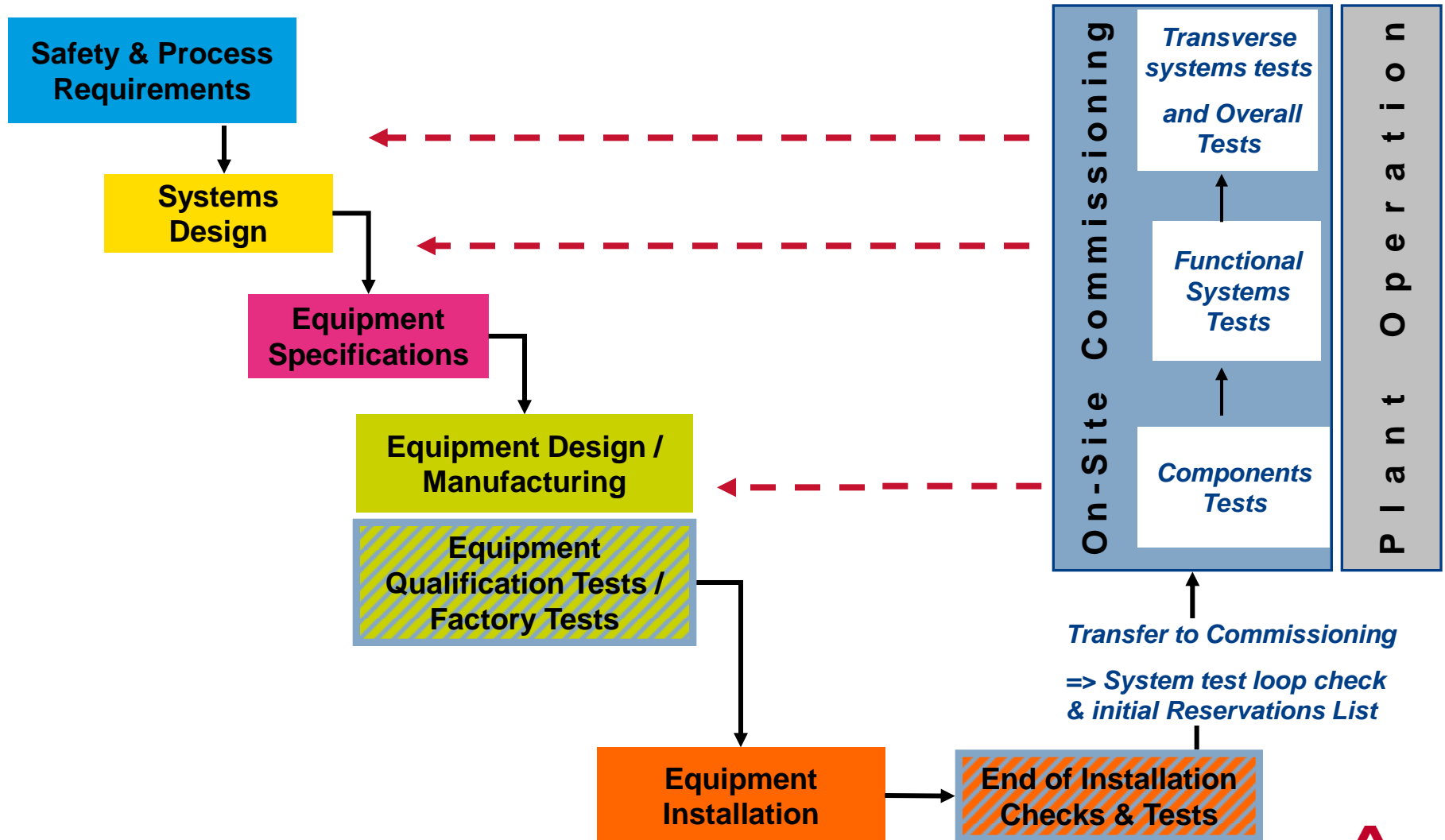


- ▶ Commissioning is on the critical path of a project and is considered a crucial phase of the project.

Introduction

- ▶ **The commissioning approach of AREVA (organization, methods, principles, sequencing, criteria, completeness, documentation, ...) is based on and in line with:**
 - ◆ **improved principles and methods applied and recognized by Utilities and Authorities in different countries.**
 - ◆ **the results and lesson learned of more than 40 years of experience in Nuclear Plants construction and commissioning through the startup and testing of around 100 nuclear power station units in France, Belgium, Germany, South Africa, Korea, China, Brazil,...**
 - ◆ **the principles developed and applied now for commissioning of EPR™ Plants in Finland, France and China,**
 - ◆ **the experience feedback analysis and recommendations from AIEA (such as new Safety guide SSG 28 for commissioning which replaced NS-G-2.9) and other international sources recommendations (such as EPRI, US Regulatory guides).**

Commissioning in Project Process



Commissioning in Project Process



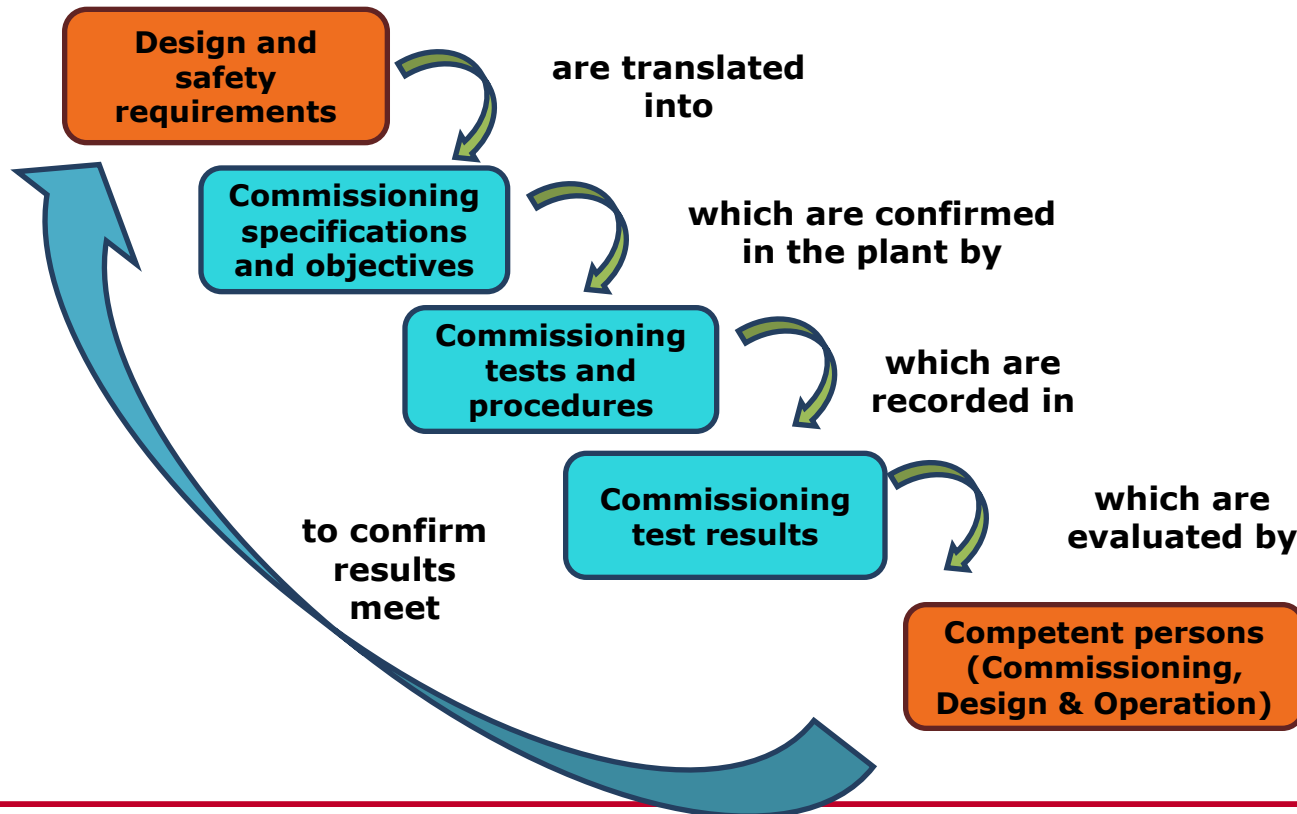
What are its objectives?

- ▶ The objectives of commissioning are to verify the fulfilment of Process and safety requirements and compliance of components and systems to Design intent.
- ▶ They shall cover:
 - ◆ Initial startup and operation of components and systems
 - ◆ Checking and demonstration of systems and plant correct operation in all practicable design configurations including:
 - Verification of components and systems compliance with design intent and requirements
 - Verification of safety and operational requirements fulfillment
 - ◆ Demonstration of Plant Operability and capability
 - ◆ Demonstration of contractual performances fulfillment
 - ◆ Familiarization of Operating staff with plant operation
 - ◆ Contribution to the validation of Operating and Periodic Test procedures

Commissioning in Project Process

What are the requirements for its performance?

- ▶ Commissioning has to be organized and performed in the frame of proven, mastered and standardized principles and methods, continuously integrating experience feedback and optimization analysis results.
- ▶ Commissioning Process:



Commissioning in Project Process

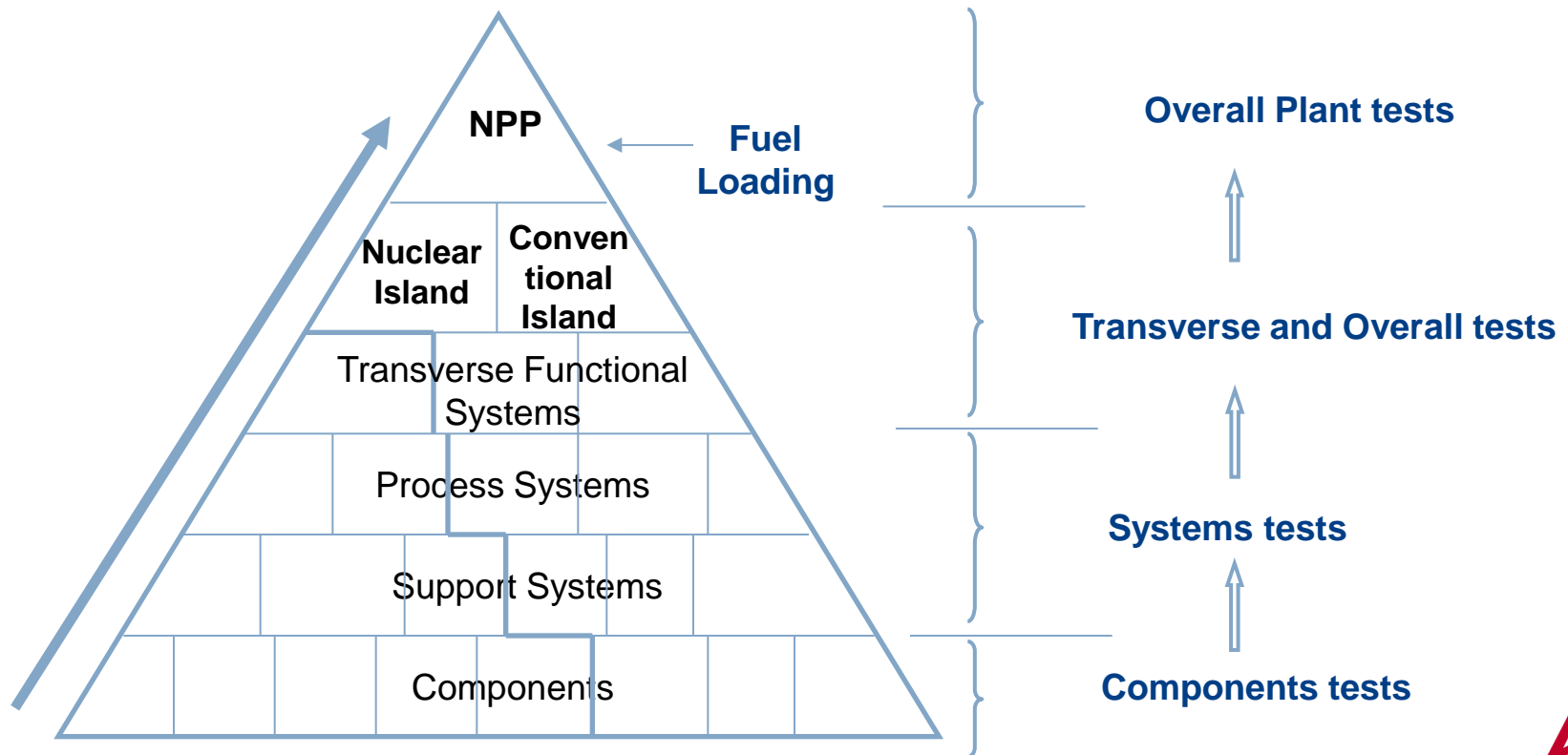
What are the requirements for its definition?

Main principles and requirements for the commissioning program development can be summarized as follows:

- ▶ **Completeness** = Program should cover
 - ◆ All systems and functions
 - ◆ All systems and plant operating modes - normal and as possible abnormal operating situations
- ▶ **Progressiveness** =
 - ◆ Commissioning by steps
 - ◆ Allowing safe fallback states in case of troubles
- ▶ **Respect of Operating limits and specifications**
- ▶ **Limitation of Equipment and plant loading situations during commissioning**
- ▶ **Respect of environment**
 - ◆ Limitation of wastes
- ▶ **Anticipation**
 - ◆ Detection of problems the earlier possible
 - ◆ Risk analysis – Mitigation measures
- ▶ **Optimization** = consideration of checks and tests performed
 - ◆ In Factory
 - ◆ On Test benches, platform
 - ◆ During and at the end of construction / installation

Overview of Commissioning Phases & Tests

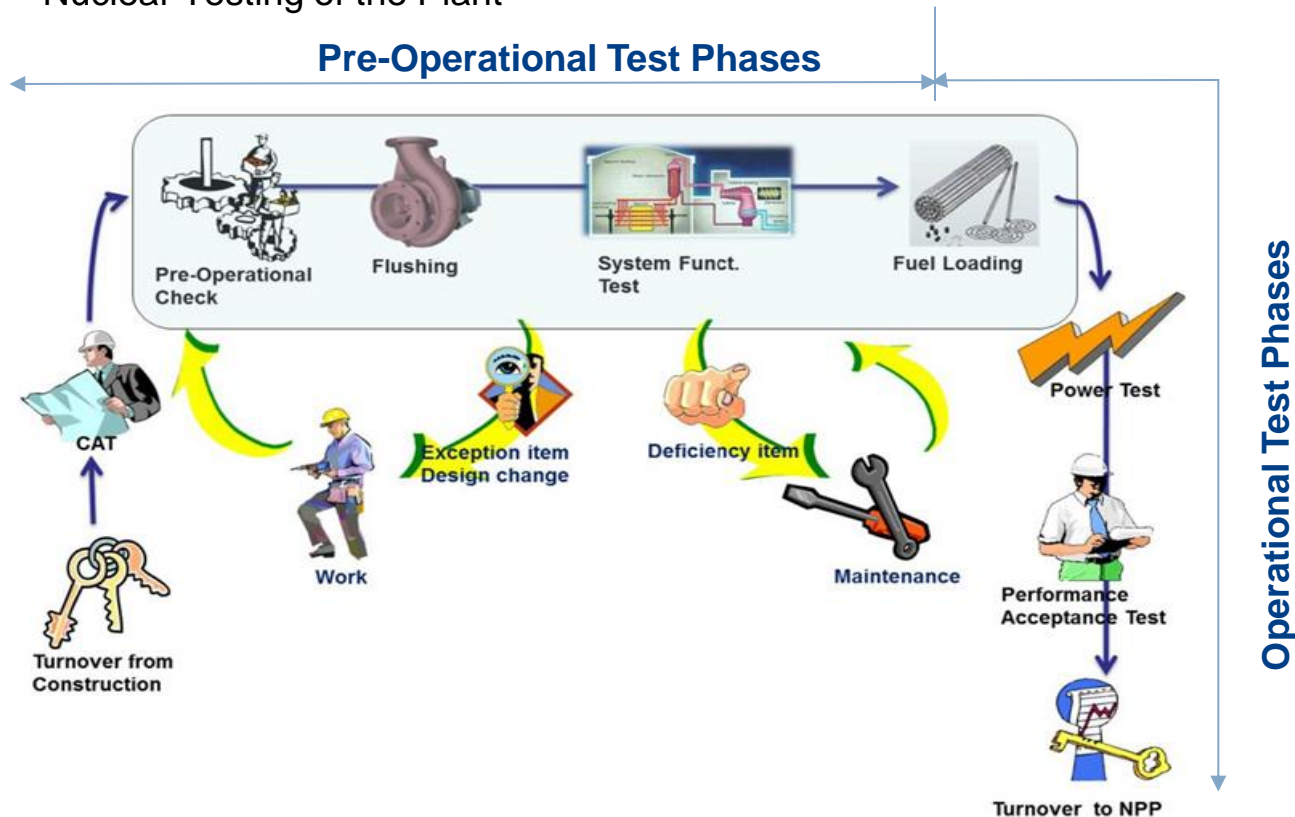
- ▶ The commissioning is performed according to a commissioning plan ensuring that succession of tests is such that plant safety is never dependent on the performances or availability of structures, systems or equipment that have not yet been tested.



Overview of Commissioning Phases & Tests

► Commissioning Activities range from erection to Commercial Operation Date and include two test categories:

- Pre-operational Tests (before fuel loading), corresponding to Non-Nuclear Testing of the Plant
- Operational Tests – Called Commissioning Tests (after Fuel Loading), corresponding to Nuclear Testing of the Plant



Overview of Commissioning Phases & Tests

Main Commissioning Phases:

► PRE-OPERATIONNAL TESTS

◆ PHASE A: Pre-Operational Systems Tests

- System Transfer Process (Erection/Commissioning)
- Component Commissioning (Tests of individual components)
- System Commissioning Tests
- Nuclear Circuit Cleaning (NCC) and Cleaning of TI circuit

◆ PHASE B: Pre-Operational Overall systems Tests

- Cold Functional Tests (CFT) including Pressure Testing of Primary Circuit
- Hot Functional Tests Phase I (HFT) Pre-Core

► OPERATIONAL TESTS

◆ PHASE C: First Core Loading and Hot Functional Tests II (Post-Core)

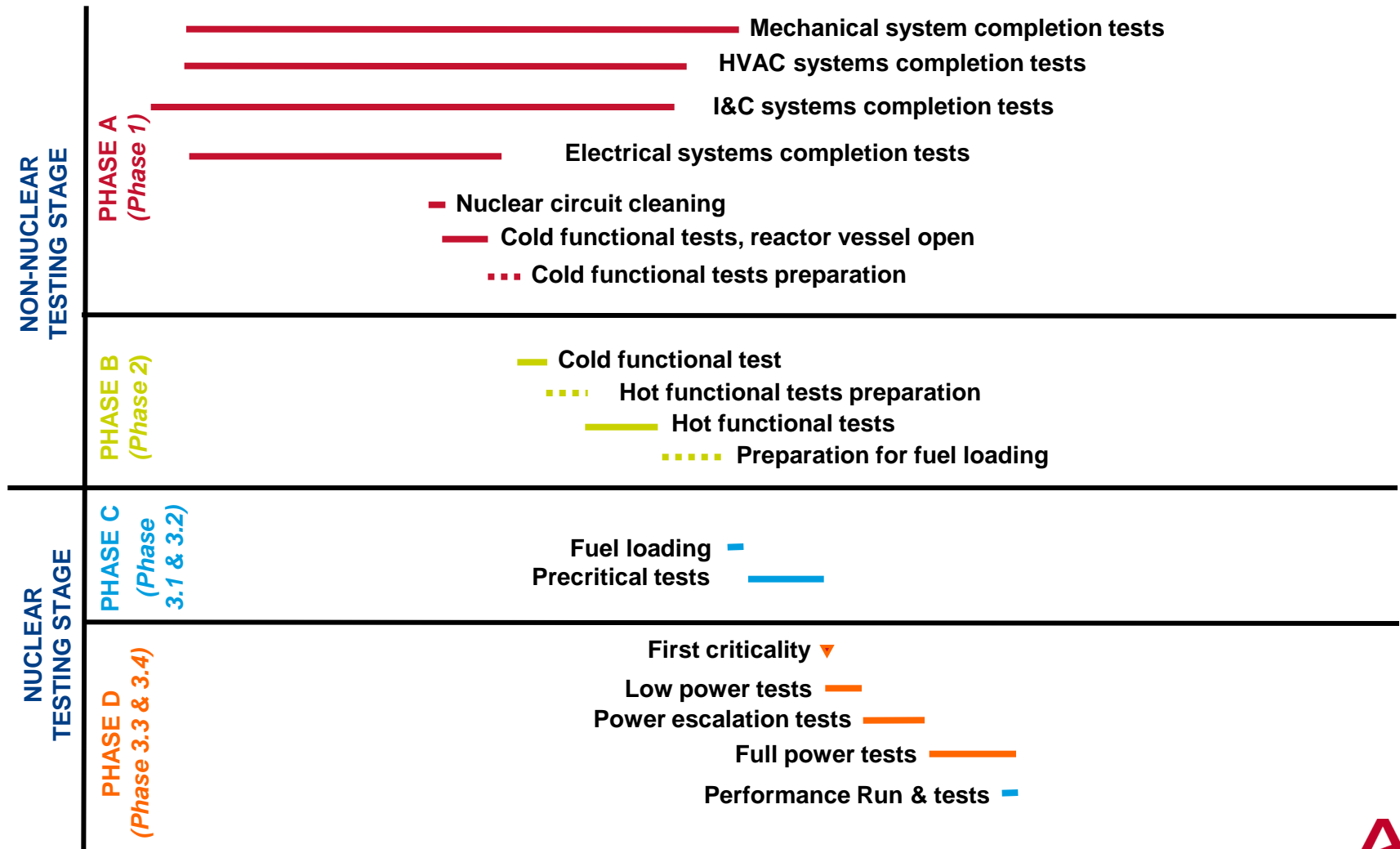
- First Core Loading (FLG)
- Hot Functional Tests Phase II Post-Core (Pre-critical Tests)

◆ PHASE D: First Criticality and Power Escalation

- First Criticality and Zero-power Tests
- Turbine-Generator Set Tests and First Connection to the Grid
- Power Escalation (Typically 30%, 50%, 80%, 100%)
- Performance Test (at the Rated Thermal Output)

Overview of Commissioning Phases & Tests

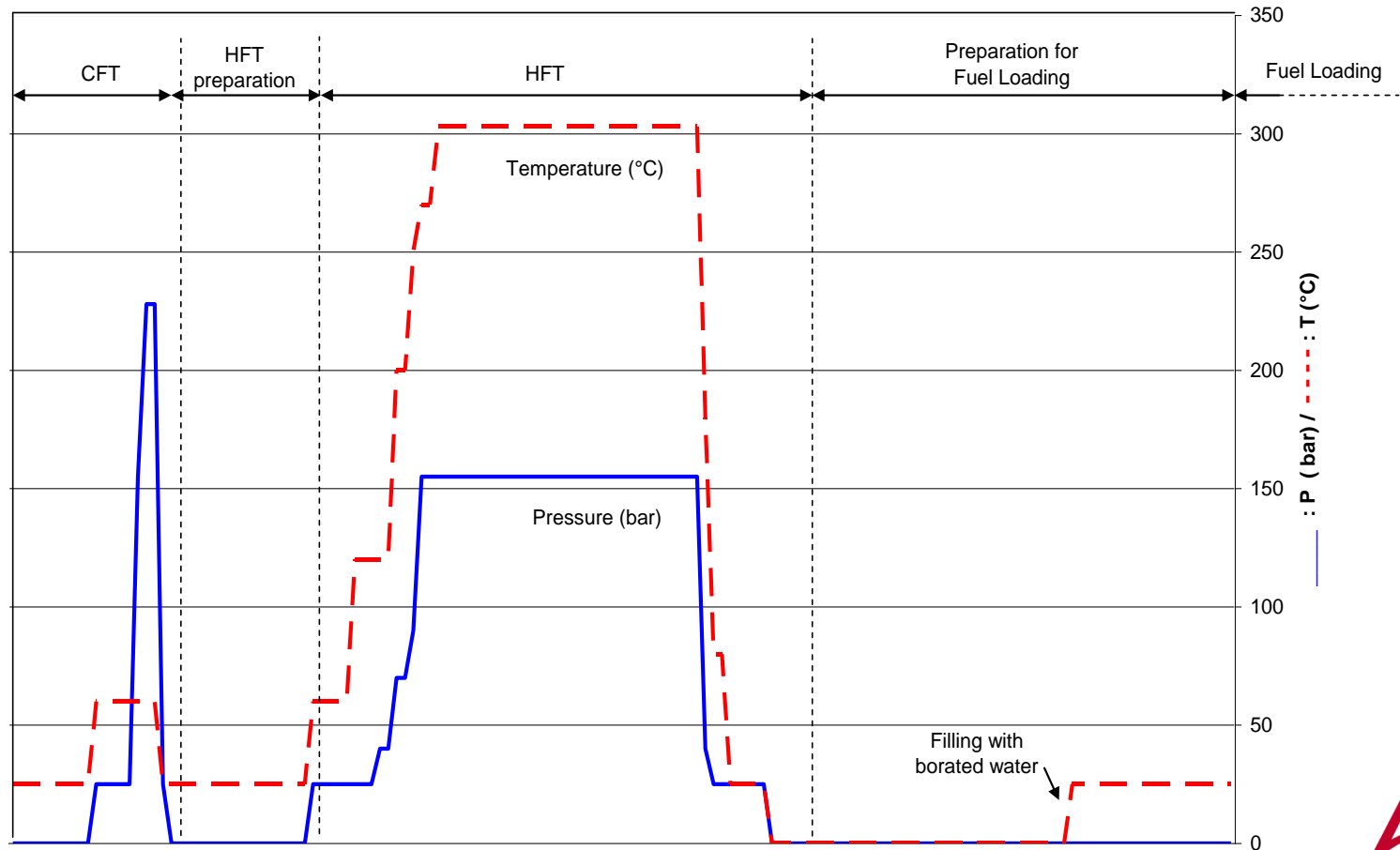
Commissioning phases overview (Typical sequence)



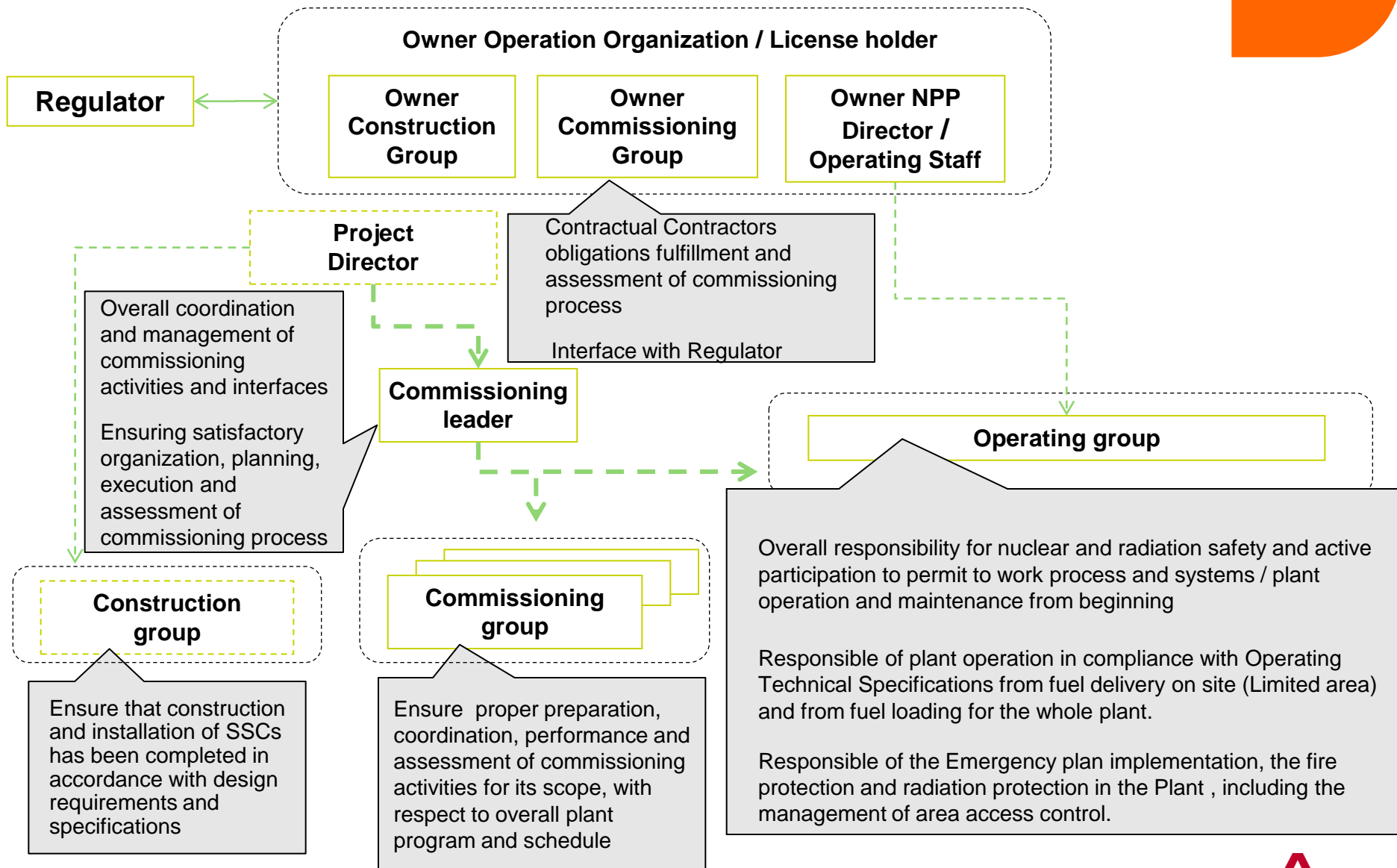
Overview of Commissioning Phases & Tests

► PRE-OPERATIONNAL TESTS – Overall Tests Phase

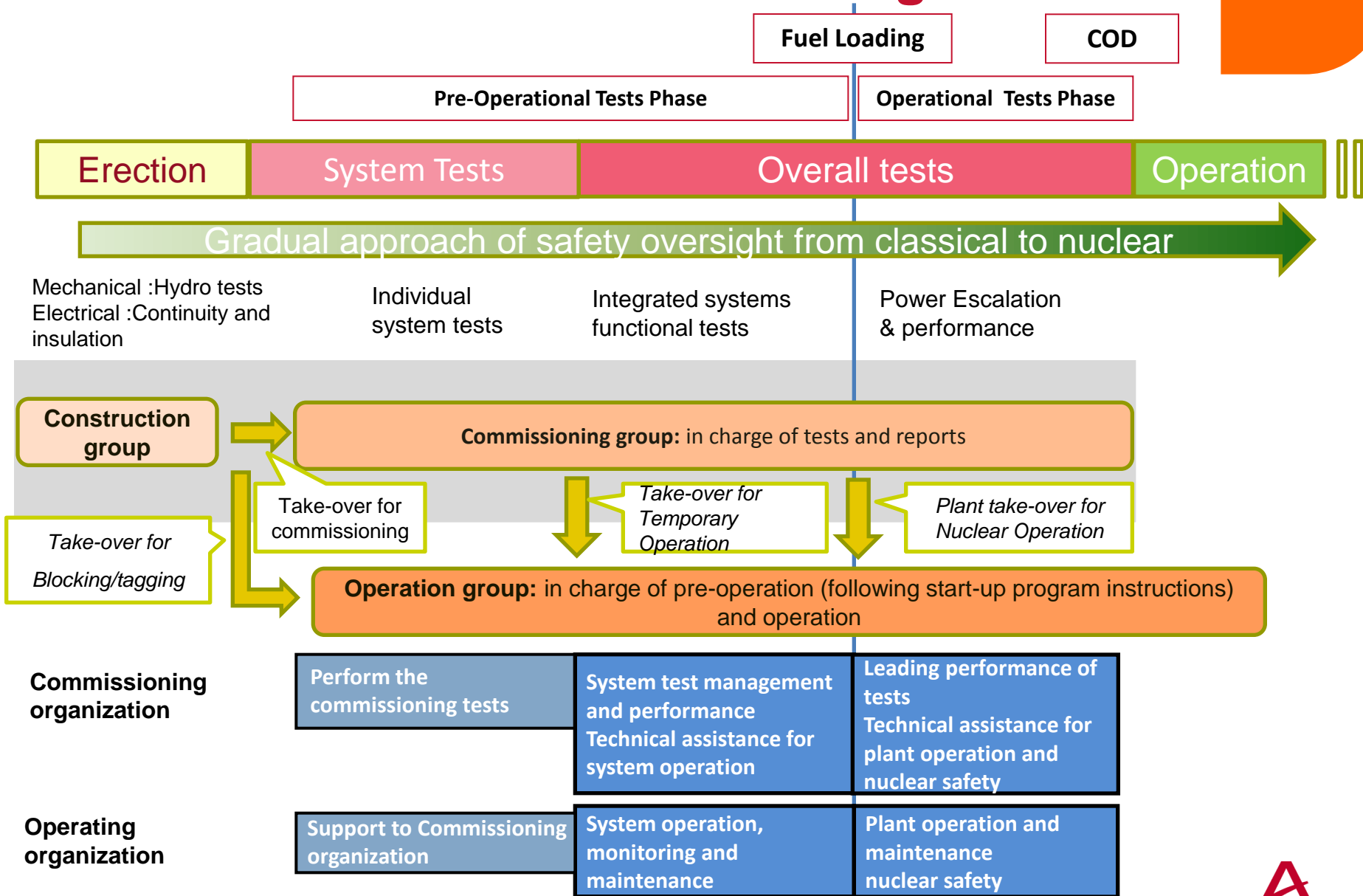
- ◆ Cold Functional Tests (CFT) including Pressure Testing of Primary Circuit .
- ◆ HFT Phase I Preparation
- ◆ Hot Functional Tests Phase I (HFT) Pre-Core
- ◆ Preparation for Fuel Loading)



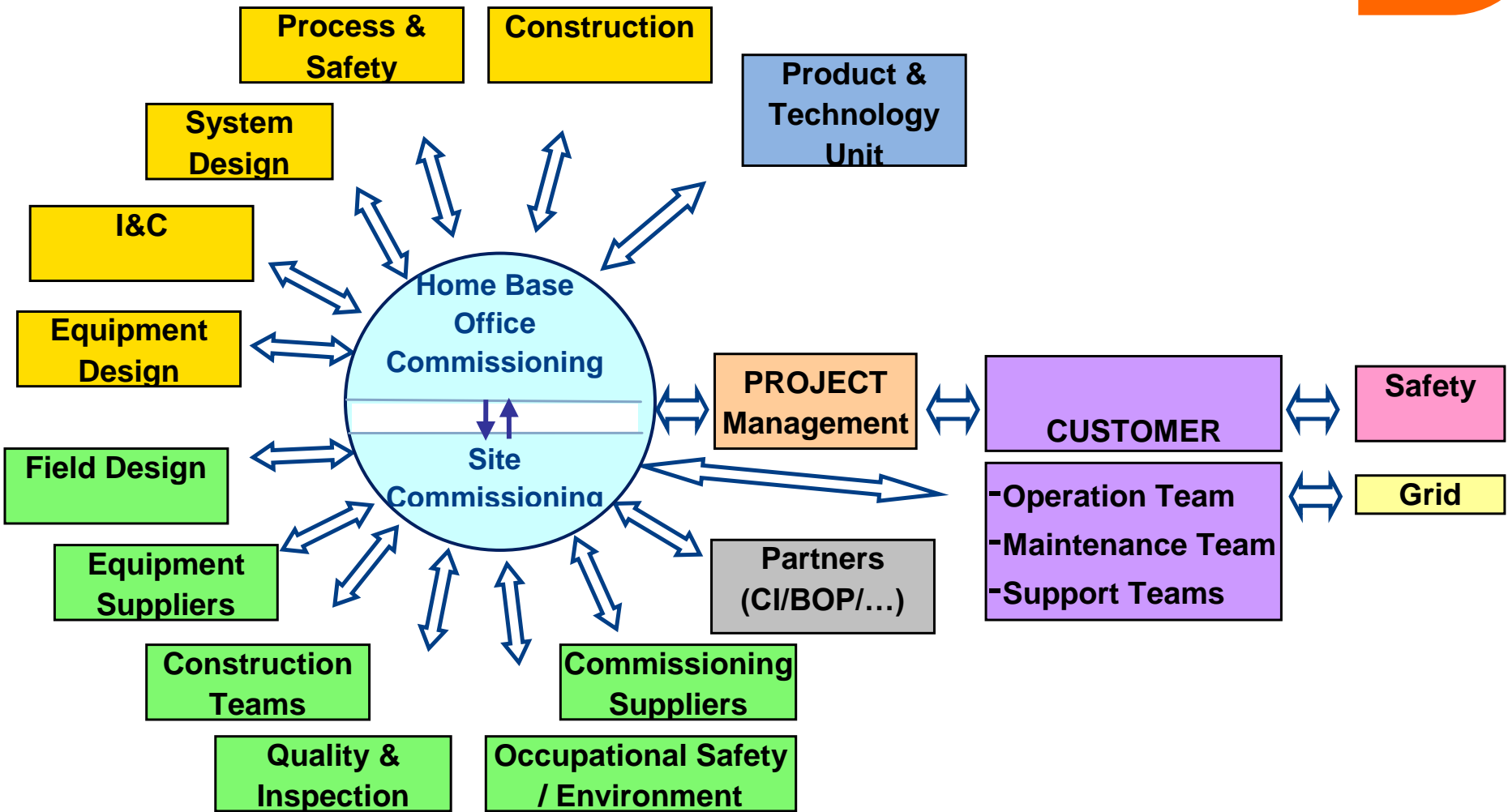
Main generic organization / responsibilities



Commissioning Interfaces



Commissioning Interfaces – Site & Head Office



Commissioning skills

- ▶ **Commissioning requires qualified, experimented and operational resources**
 - ◆ **With a strong Safety culture**
 - ◆ **With a Team spirit**
 - ◆ **With strong reactivity in case of problems or particular requests from Customers or Safety Authority.**

- ▶ **Commissioning can not be learned only at school.**
 - ◆ **Commissioning requires a great variety of skills in all main project fields: mechanics, instrumentation & control, electricity, chemistry, process, safety, neutronics,**
 - ◆ **but most of all with the global practical approach of the systems functioning and plant operation.**

Commissioning skills

- ▶ **A Commissioning engineer should have a global and practical view covering activities that can only be mastered by working on the project construction site, such as :**
 - ◆ **Technical activities: Follow-up of construction, Commissioning preparation and implementation in compliance with specific site conditions, Commissioning Lessons learned, ...**
 - ◆ **Project activities: operational interfaces and scheduling management, contractual follow-up of suppliers, contractual interfaces with customer and partners**

- ▶ **This explains why it is considered sometimes as a “special profession”, offering a real carrier opportunity for people seeking an operational and challenging job.**

▶ Commissioning = Challenging Phase in a Project

- ◆ Last phase of the Project,
- ◆ On the critical path of the Project,
- ◆ Considered as a crucial phase of the Project

▶ Commissioning Success depends on:

- ◆ Quality, completeness and sequencing of the commissioning programs and methods:
 - with consideration of experience and lessons learned from previous Projects and from benchmark with other nuclear facility projects
 - With early involvement of commissioning in the design phase
 - with respect of internal and external interfaces (from and to commissioning)
- ◆ Availability of qualified, experimented and operational resources, with a Team Spirit and support of young generation by experienced engineers.

▶ Commissioning = Attractive and enhancing job

- ◆ Both theoretical and practical
- ◆ Multidiscipline, both technical and managerial
- ◆ Key experience in an engineer career development



Questions ?

Thanks for your Attention



BACK-UP

General site commissioning organization

- **Main generic Functions vs. relevant commissioning aspects:**
 - **Contractual supervision and follow-up of plant commissioning**
 - **Owner Project Commissioning Group**: Contractual Contractors obligations fulfillment and assessment of commissioning process
 - **Contractor's Site Representative Team**: Handling of deviations to Contractual obligations; Commissioning process and performances assessment
 - **Commissioning organization and implementation:**
 - **Commissioning Leader**: Overall coordination and management of commissioning activities and interfaces; Ensuring satisfactory organization, planning, execution and assessment of commissioning process.
 - **Commissioning Groups**: Organization and implementation of the Commissioning for its scope of supply and services; With respect to overall plant program and schedule
 - **Operating Group**: Overall responsibility for nuclear and radiation safety and active participation to permit to work process and systems / plant operation and maintenance from beginning
 - **Test Leader**: Responsible for a system tests implementation through test permit process
 - **Suppliers in technical assistance**: Participation to the Commissioning for its scope of supply and services, under Commissioning Group coordination and supervision.