



# Integrating industry into early stage plans\*

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\*based on a presentation by R. Brown to FIIF, Brussels, November 2016



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## **The fusion roadmap**

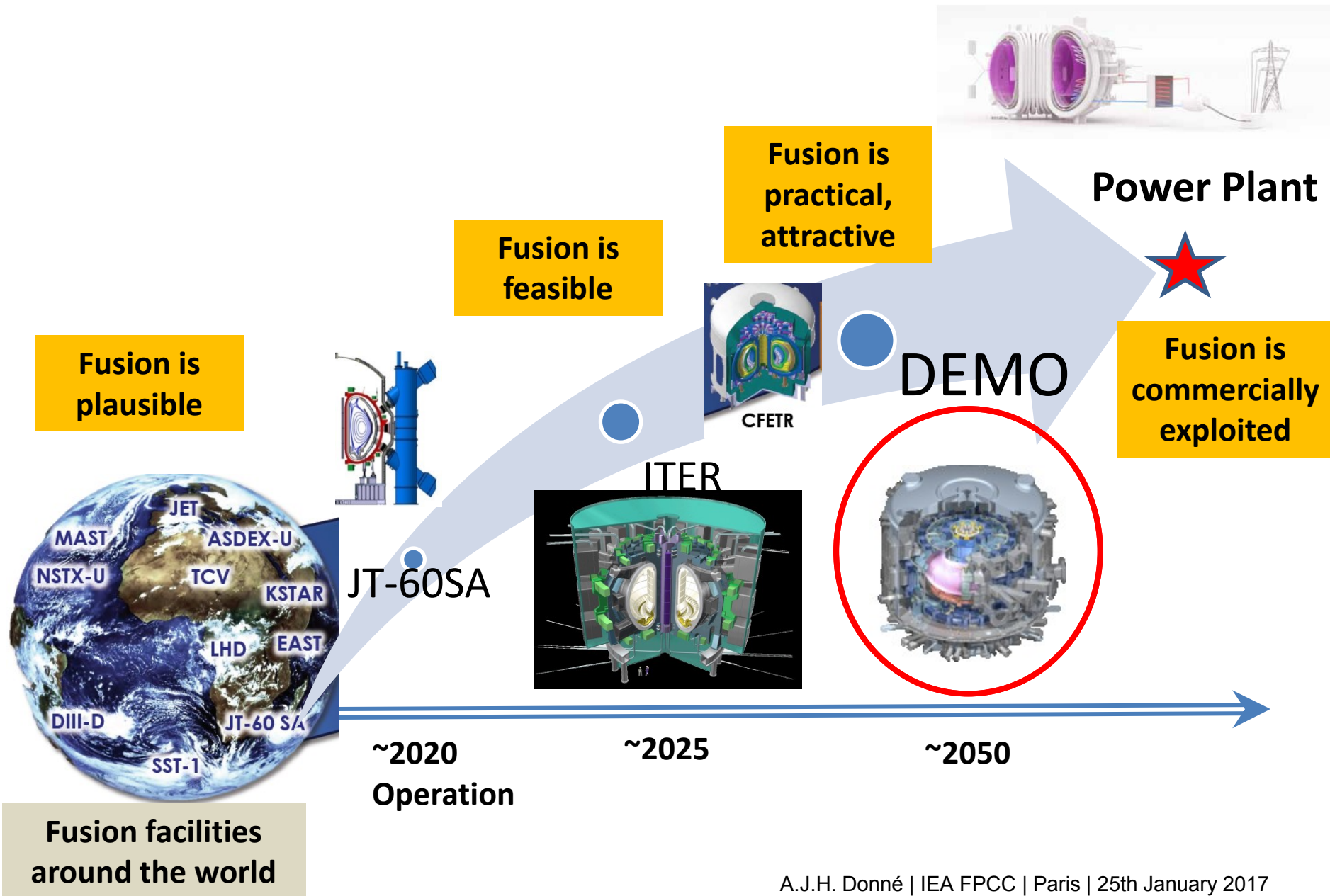
### **Overview of System Engineering in DEMO PPPT**

- ‘Systems Thinking’
- A Systems Engineering view of DEMO.
- The role of a Lead Systems Integrator.
- Systems Engineering and Project Management Functions.

### **Industry Support in System Engineering in PPPT**

- Ongoing Industry Tasks.
- Phased Industry Engagement Strategy.
- Industry professional(s) seconded to the PMU

# Roadmap towards fusion electricity



Work in Progress:  
Roadmap is presently under  
revision

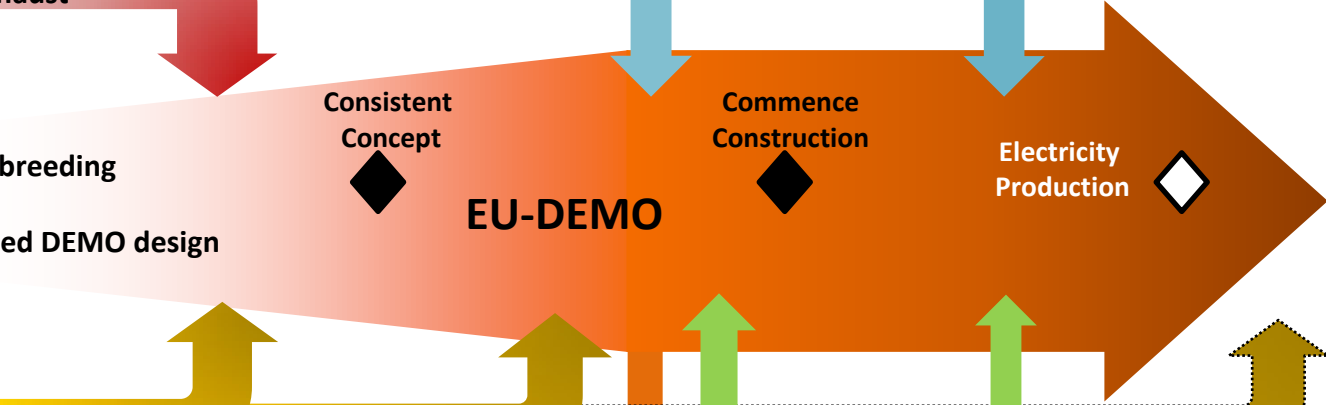
Mission 4-7 – Maximise ITER input to DEMO

Mission 1 – Plasma scenarios  
Mission 2 – Heat exhaust



Mission 1 – Plasma scenarios  
Mission 2 – Heat exhaust

Mission 4 – Tritium breeding  
Mission 5 – Safety  
Mission 6 - Integrated DEMO design



Mission 3 – Materials

DONES

IFMIF

Mission 7 – Lower cost, innovations

Mission 8 – Stellarator



Science & Technology Basis for first FPPs



## Systems Thinking

**Holistically:** Need to think about the whole system and its environment because the system is greater than the sum of the parts

**Structurally:** Need to think about the relationships, dependencies and interactions between components and groups of components

**Abstractly:** Need to think about different representations by changing domain and simplifying to determine underlying patterns, structures and behaviours

**Perceptively:** Need to think about different perspectives and viewpoints to gain different understanding of the same

## Reductionist Thinking

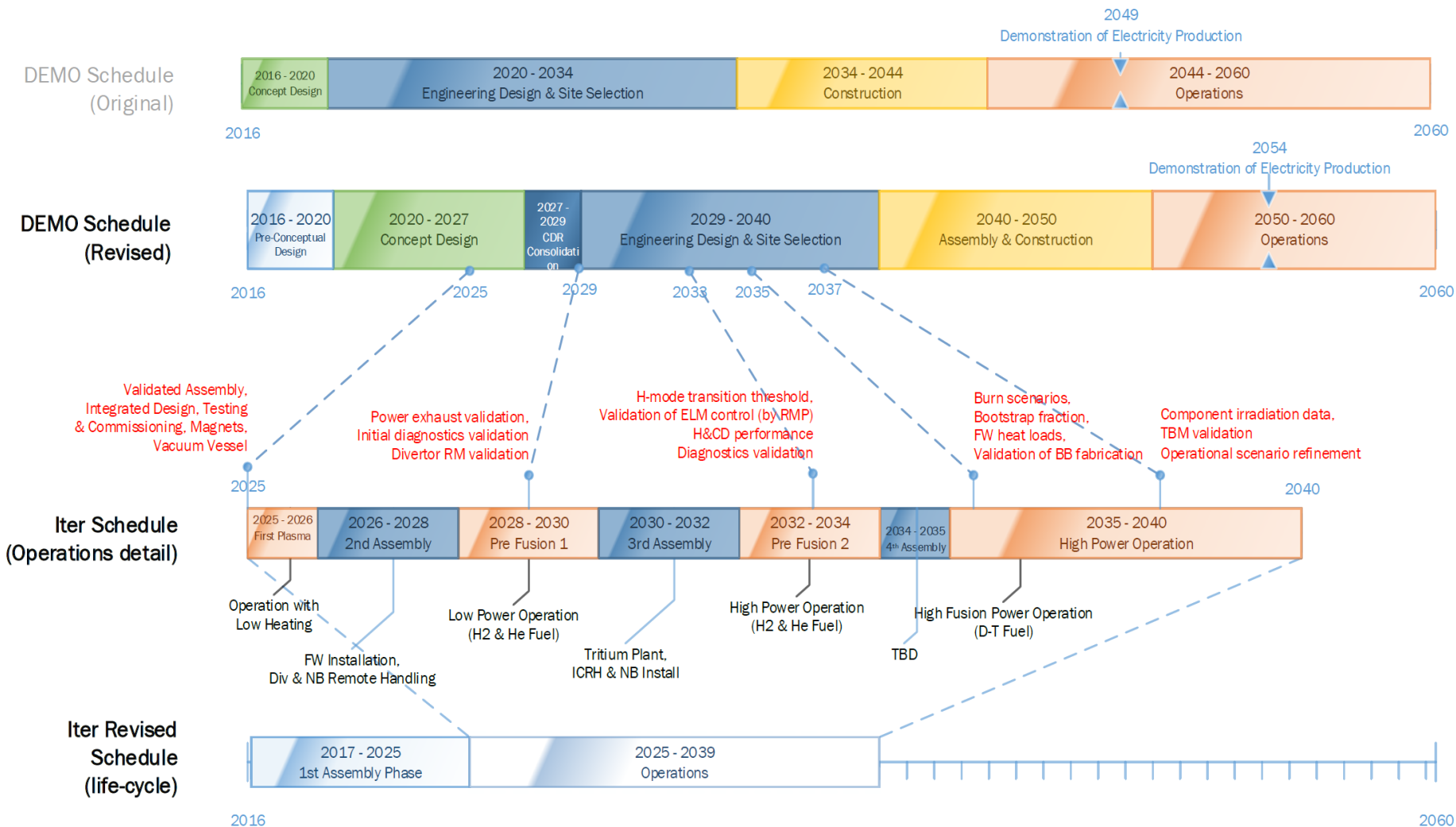
**Focused:** on simple aspects or things  
– the whole will be the sum of the parts

**Deterministically:** cause and effect is linear and each effect has one cause

**Concretely:** Need to bound the situation and break it up into smaller isolated problems

**Mono-view:** Need to define a single view

# Overview of DEMO phasing





## System-of-systems (SoS):

- A set or arrangement of interdependent systems that are related or connected to provide a given capability.
- The loss of any part of the system will degrade performance capabilities of the whole.
- Optimising individual systems does not lead to overall optima.
- Exhibits emergent behaviour not otherwise achievable by the **Constituent Systems**.
- The **complexity of dependencies between systems** increases significantly once we move to their physical embodiments.

Site Services

Waste Mngmt

Mainten

1<sup>st</sup> Confinement

2<sup>nd</sup> Confinement

Cryocontrol

Tritium Breeding\*

Shielding

Power\* Generation



## PPPT Programme Organisational Arrangements

- Geographic distribution and volume of communication channels complicates design coordination and integration.
- The objectives & activities of the Work Packages must be aligned to the needs of the programme.
- This requires strong technical and programme leadership.
- Communications and information exchange must be rationalised.
- Technical and Project Management Process must be unified.
- Overall, it is very difficult for the Programme Management Unit (PMU) to exert centralised monitoring, control and technical coordination functions.





Pre-Conceptual Design 2020 Conceptual Design 2027-2030 Engineering Design

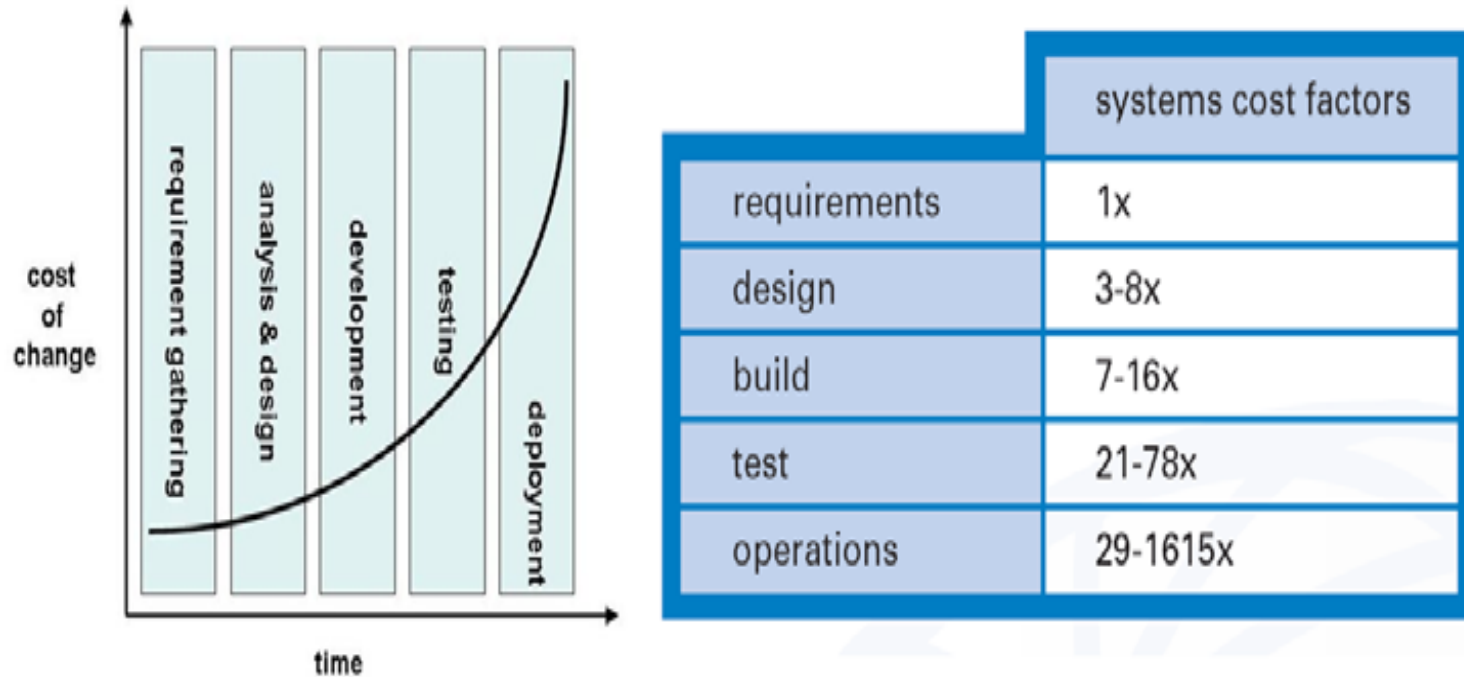
Engineering Programme

Research Programme

## PPPT Programme Schedule

- Multiple variants and sub-variants must be managed.
- Different technology options at different levels of maturity.
- Must align the programme to a Decision Gate Process (DGP).
- How to structure decision making, and ensure rational choices are made?
- How to ensure Research Programme maintains relevance to the Engineering Programme?
- How to ensure traceability in decision making in a long duration programme?

# Costs of change to a system



[Source: INCOSE UK, Z3, Issue 3, March 2009]



- Management of DEMO development is complex and must be well coordinated.
- SoS development require a **Lead Systems Integrator (LSI)** to plan and perform:

## Systems Engineering

Requirements Definition  
System Architecture Development  
Evaluation of Alternatives  
Systems Integration  
Technical Assessment

Technical Planning  
Risk Management  
Configuration Management  
Data Management  
Decision Analysis

## Project Management

Management Planning  
Cost Analysis  
Integrated Assessment  
Schedule Management  
Resource Management  
Documentation Management

*Image Credit: Adapted from NASA Systems Engineering Handbook*

### From a position of strategic oversight the LSI must:

- Determine what requirements are appropriate to maximize the overall capability of the SoS.
- Take a **holistic view** of the SoS and determine where and when to place resources.
- Oversees **technological maturity**, sub-system development and makes decisions regarding trade-offs.
- Provide clear technical and project decision-making authority.

Recommended Reading: [Organisational considerations for Implementing Systems Engineering and Integration in the ARES project office \(NASA\)](#)

# Lead Systems Integrator



The **Systems Engineering** and **Project Management** functions in DEMO PPPT are split between PMU and WPPMI:

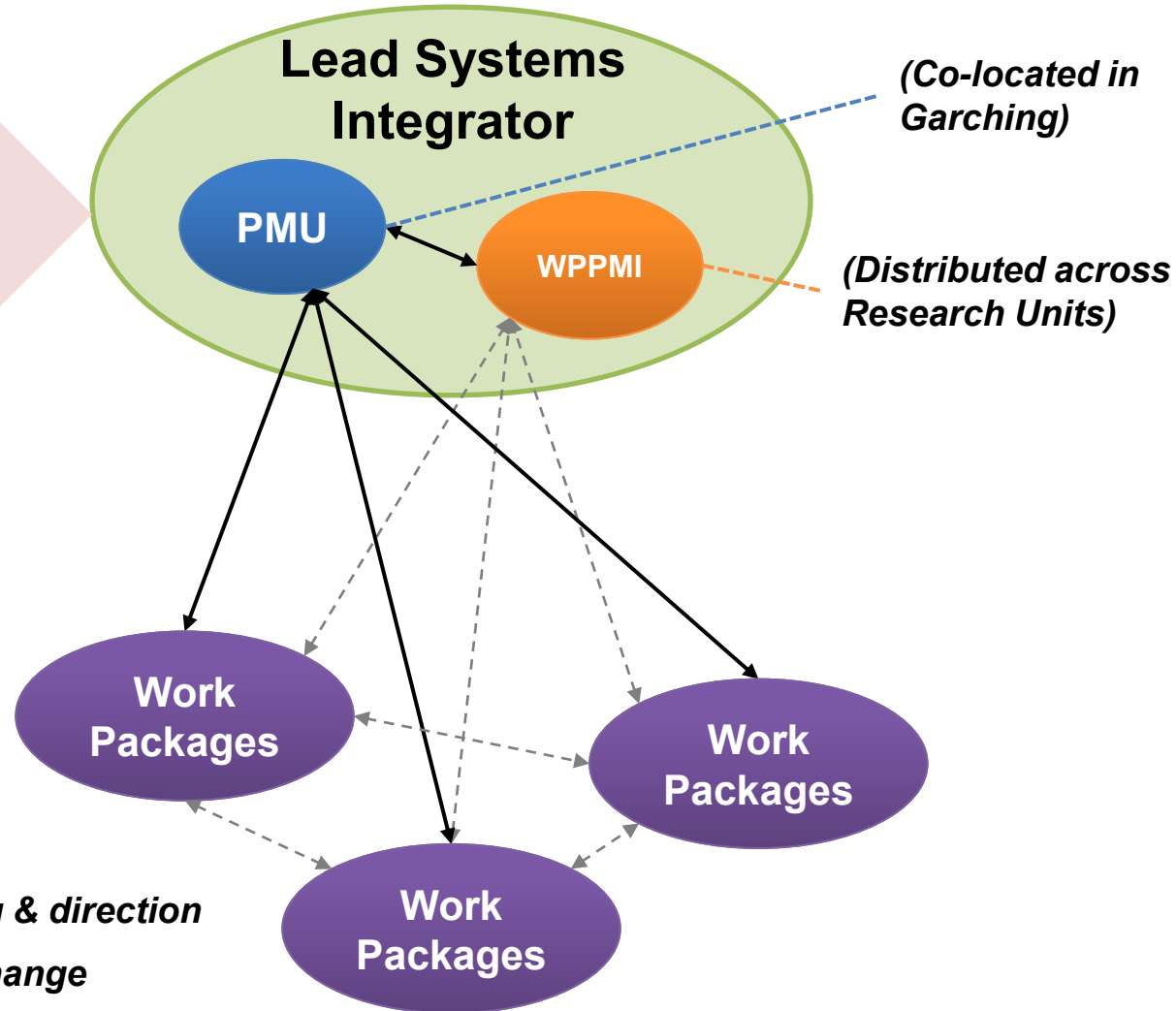
## Standard LSI functions

### Systems Engineering:

- Requirements Analysis
- Systems Architecture Modelling
- Interface Management
- Analysis of Alternatives
- Design Review Criteria
- Configuration Management

### Project Management

- Risk Management
- Cost Analysis
- Management Planning
- Integrated Assessment
- Schedule Management
- Resource Management
- Documentation & Data Management

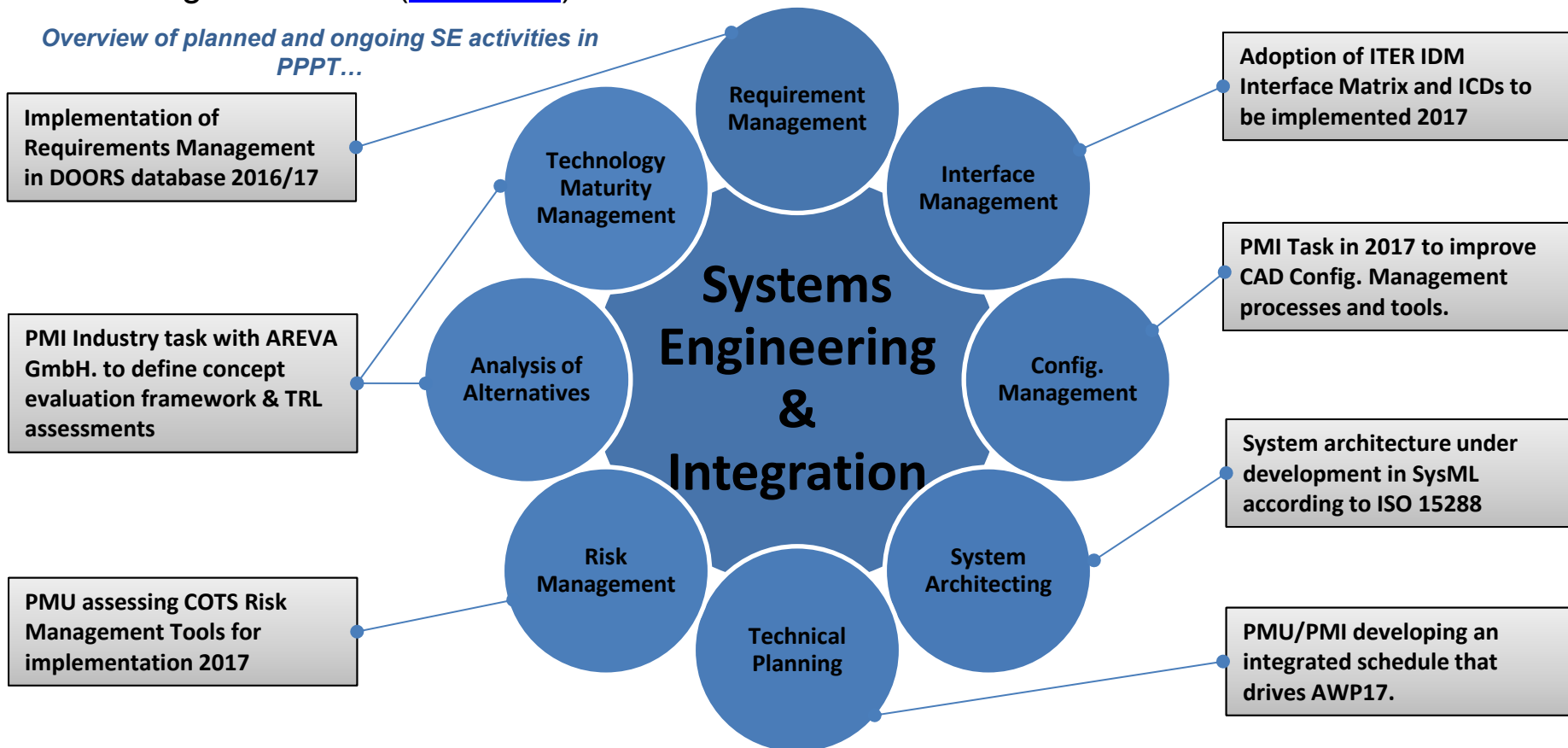


# Management and technical processes



- Implementation and ownership of common **Processes, Methods & Tools (PMTs)**, is an important function of the **Lead Systems Integrator**.
- An overview is provided in the PPPT Technical Management Plan ([2LJUAN](#)) and the PPPT Management Plan ([2MSBRN](#)).

*Overview of planned and ongoing SE activities in PPPT...*

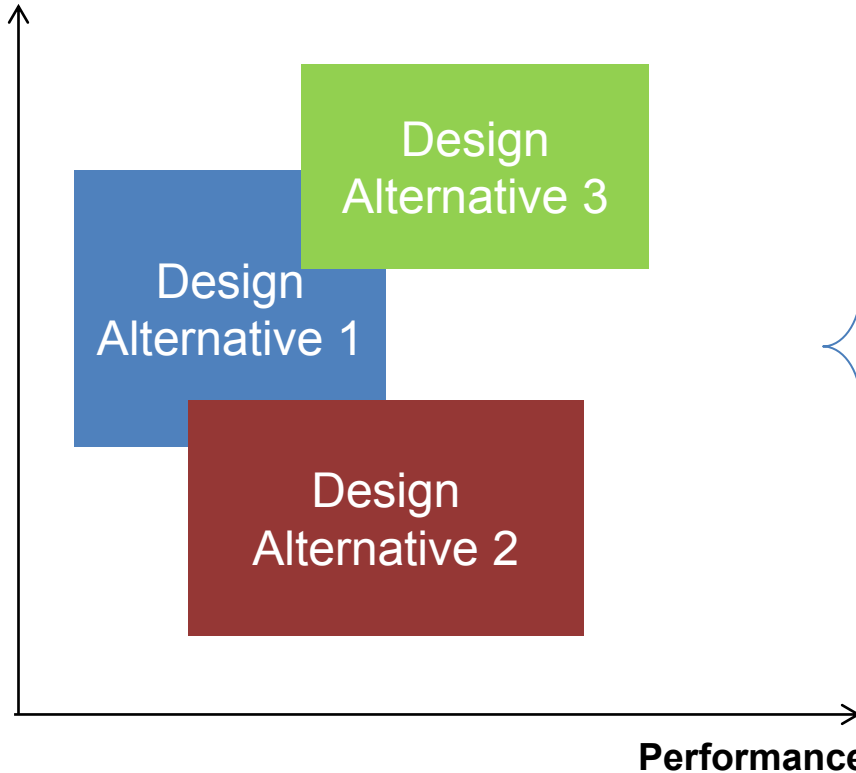


**Strengthening coordination and oversight role of the PMU has been recommended by the EY Management Assessment – and could be enhanced via industry support within the PMU.**

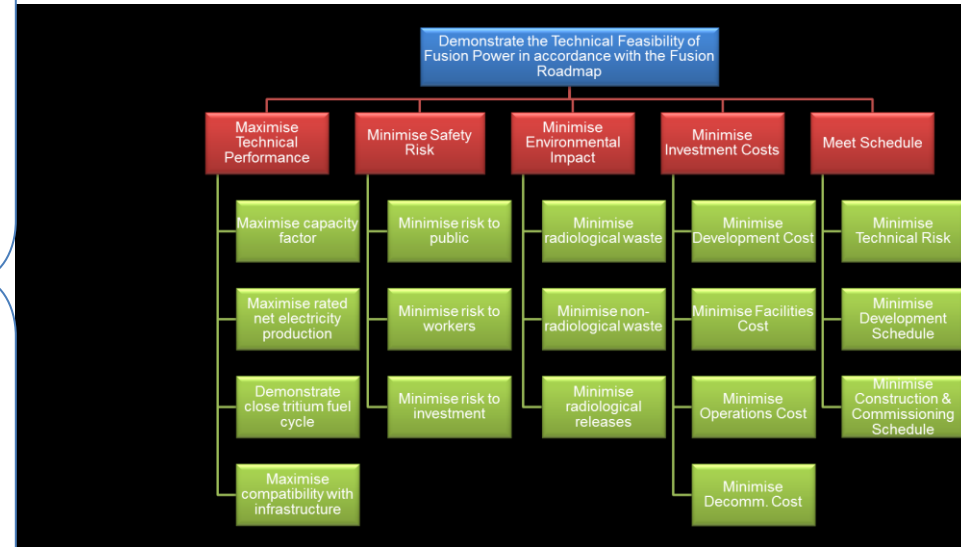
# Analysis of Design Alternatives



Risk/Cost/Schedule



## Stakeholder Objectives Hierarchy



### How to select the 'best' design alternative amongst multiple options:

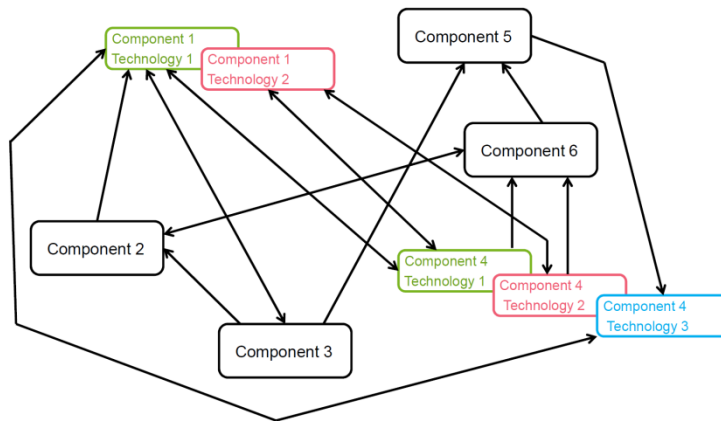
- Design interactions highly complex and inter-linked.
- High uncertainty in performance estimates.
- High design feasibility risks.
- Consideration of cost and schedule constraints.
- Multiple (conflicting) objectives.

# Example of an ongoing industry collaboration

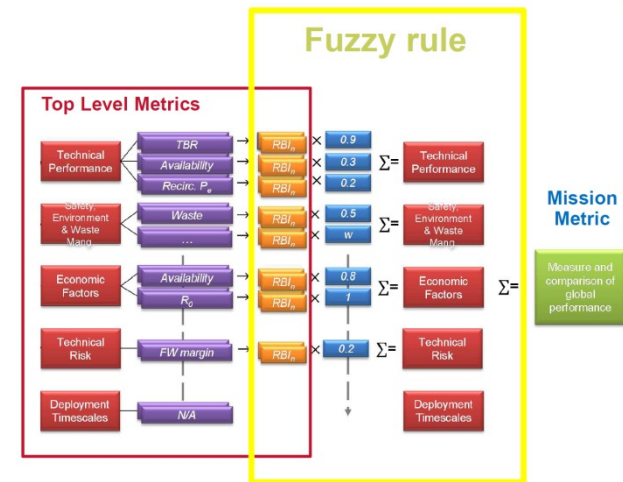


- **SE Process Area;** Analysis of Design Alternatives.
- **Task:** Creation of a Plant Assessment Framework to perform integrated assessment of DEMO design & technology options
- **Task Participants;** Areva GmbH.

Relationship Graph



Fuzzy rule (Example)



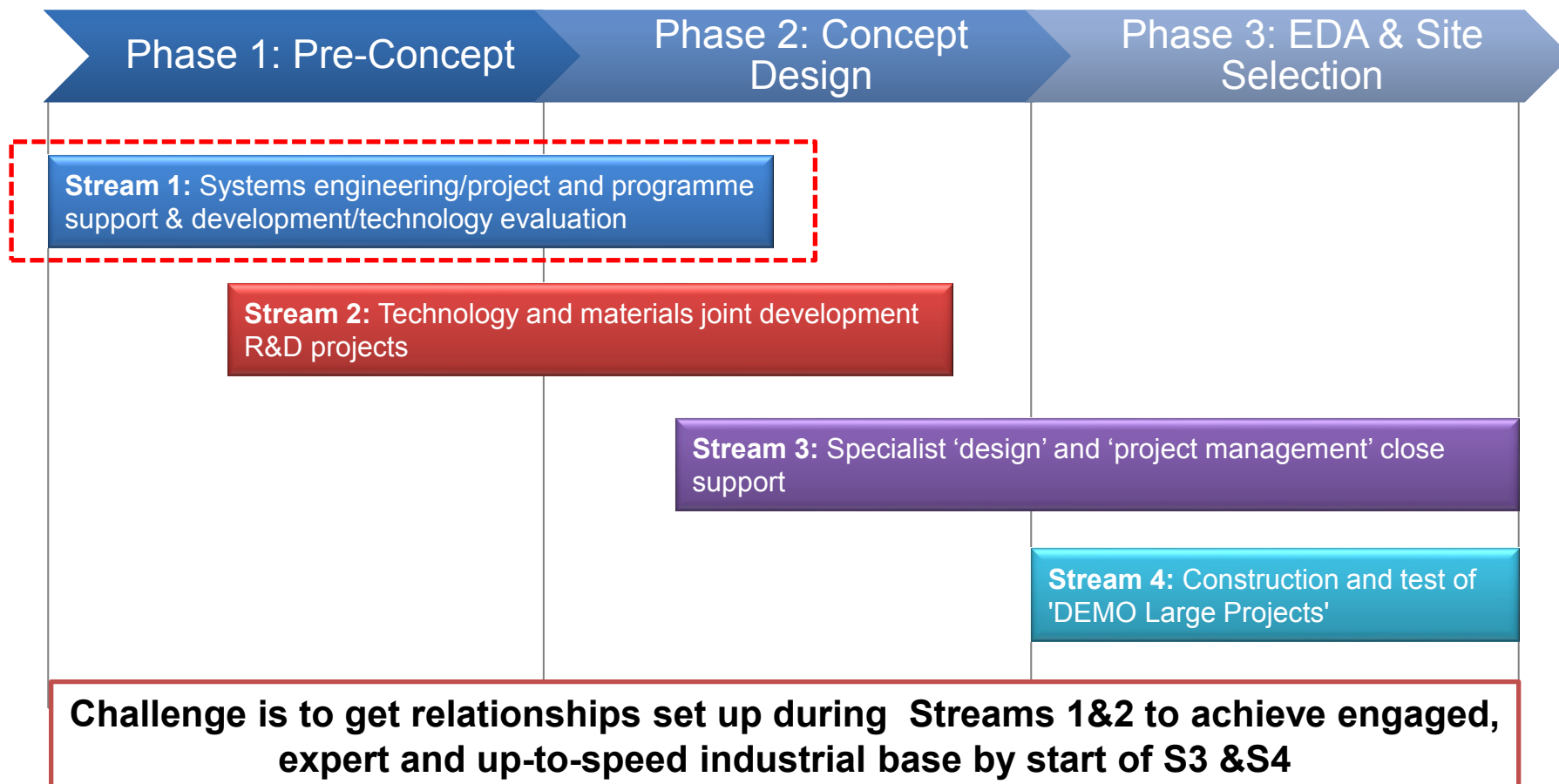
- Provides and opportunity for Industry and EUROfusion to participate in methodology development.
- Industry familiarisation with DEMO technology and plant design.

# Phased Industry Engagement Strategy



**Roadmap Annex 11:** A *streamed-approach* is proposed for the Industrial contribution to the development of DEMO for the period 2016-2030 [1].

Streams would run concurrently with start and end points related to, though not coincident with, DEMO Phase boundaries.



[1]: Presentation of D. Stork to DEMO SHG, "Industry Contributions to DEMO Development", 8<sup>th</sup> March 2016



# Feedback from Management Reviews



Feedback from the Ernst & Young and Mid-term management reviews, have recommended strengthening the role of industry in PPPT **Programme Coordination** and **LSI** activities:

*“EUROfusion should develop instruments to allow industry secondees to the PMU.”  
Ernst & Young Management Review, Recommendation 2.7.1.*

## The Industry Secondee shall...

- Support the PMU in implementing Systems Engineering **Processes, Methods & Tools (PMTs)** across the PPPT programme.
- Ensure that the PPPT is adopting Industry Best Practice and that the programme is orientated towards an ‘industrial approach’ and ‘project culture’.
- Help to develop the relationships within industry in Streams 1 & 2 to lay the industrial base to support the programme in Streams 3 & 4.

**The Call for Interest is launched in January 2017.**

# Scope of Work for Industry Professional in PMU



The following is a possible scope of work for an Industry Professional(s) to be embedded in the PMU (scope currently in review).

## Project Management Support

- Review of current PPPT Project Management processes and delegation model.
- Support and review the integrated schedule development.
- Advise on the alignment of the programme to **Decision Gate Process (DGP)** with suitable pass out criteria.

## Technical Management Support

- Review of current PPPT **Technical Management Framework**
- **Risk Management**; advise on process improvement and utilisation.
- **Interface Management** process development and implementation support.

## Systems Engineering Support

- Review the current **Plant System Architecture**.
- Development of a '**Systems Engineering Roadmap**'.
- Support with Systems Engineering **training and workshops**.

# Conclusions



- Application of Systems Engineering from the outset is mandatory for managing the design development and realisation of DEMO.
- **Systems Engineering** must be aligned with **Project Management** to provide a strong **Lead Systems Integrator (LSI)** capability.
- Industry involvement & support in **programme coordination** and the **LSI functions** should be increased.
- The PMU has launched an industry task (via. a selected Research Unit) for an Industry Professional to be seconded to PMU, Garching.
- This task is launched within the existing EUROfusion consortium industry contract procedure.
- We see this as a first step towards progressive increase of industry involvement in the central coordination of the PPPT programme.

# Appendix Slides





Note:  
Systems and their sub-systems will have a complex relationship in the way that they satisfy a requirements is a simplified

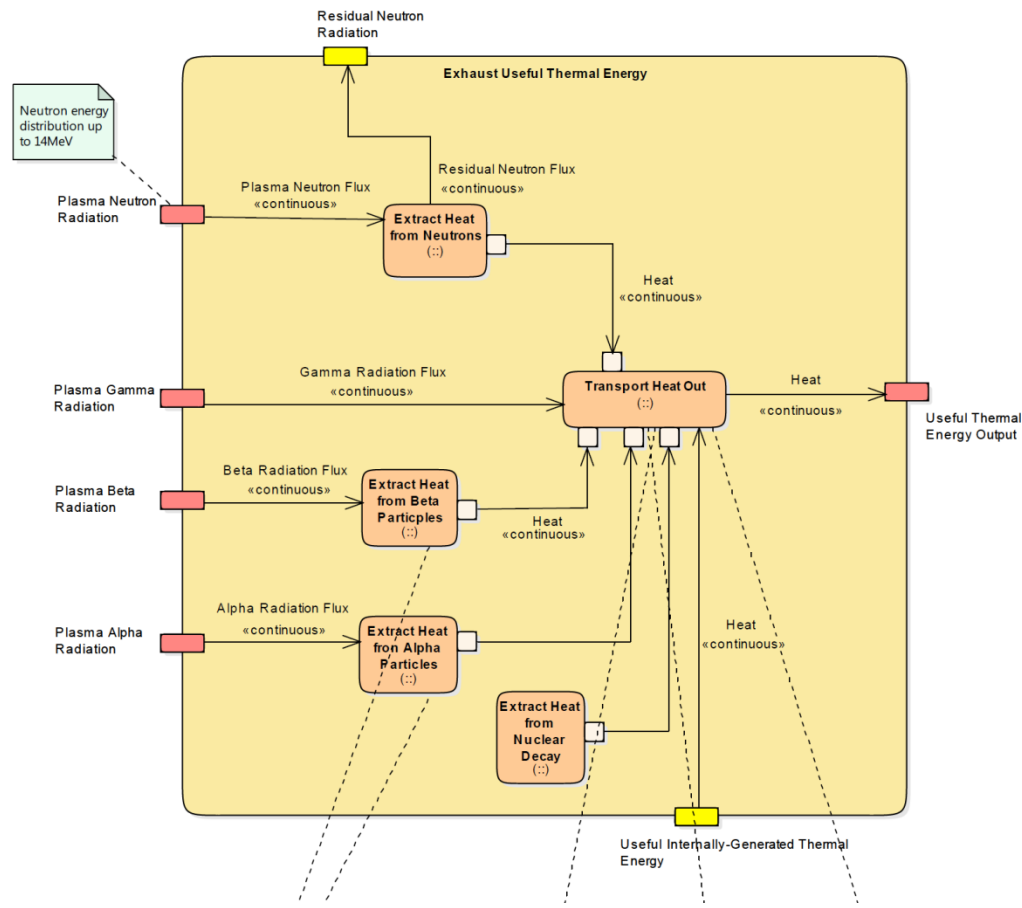
«block»  
DEMO Fusion Power

«requirement»  
Demonstrate the Tokamak

«requirement»  
De-Risk Future

Note:  
From a System Architecture perspective, the "De-Risk Future Powerplant" requirements can

- **Functional Analysis** performed at System level, to break down the functions into sub-functions and derived requirements.
- SysML utilised as a standard modelling language.
- Challenge to maintain logical consistency and traceability between plant and system level.
- Provides a common reference of the current design configuration.



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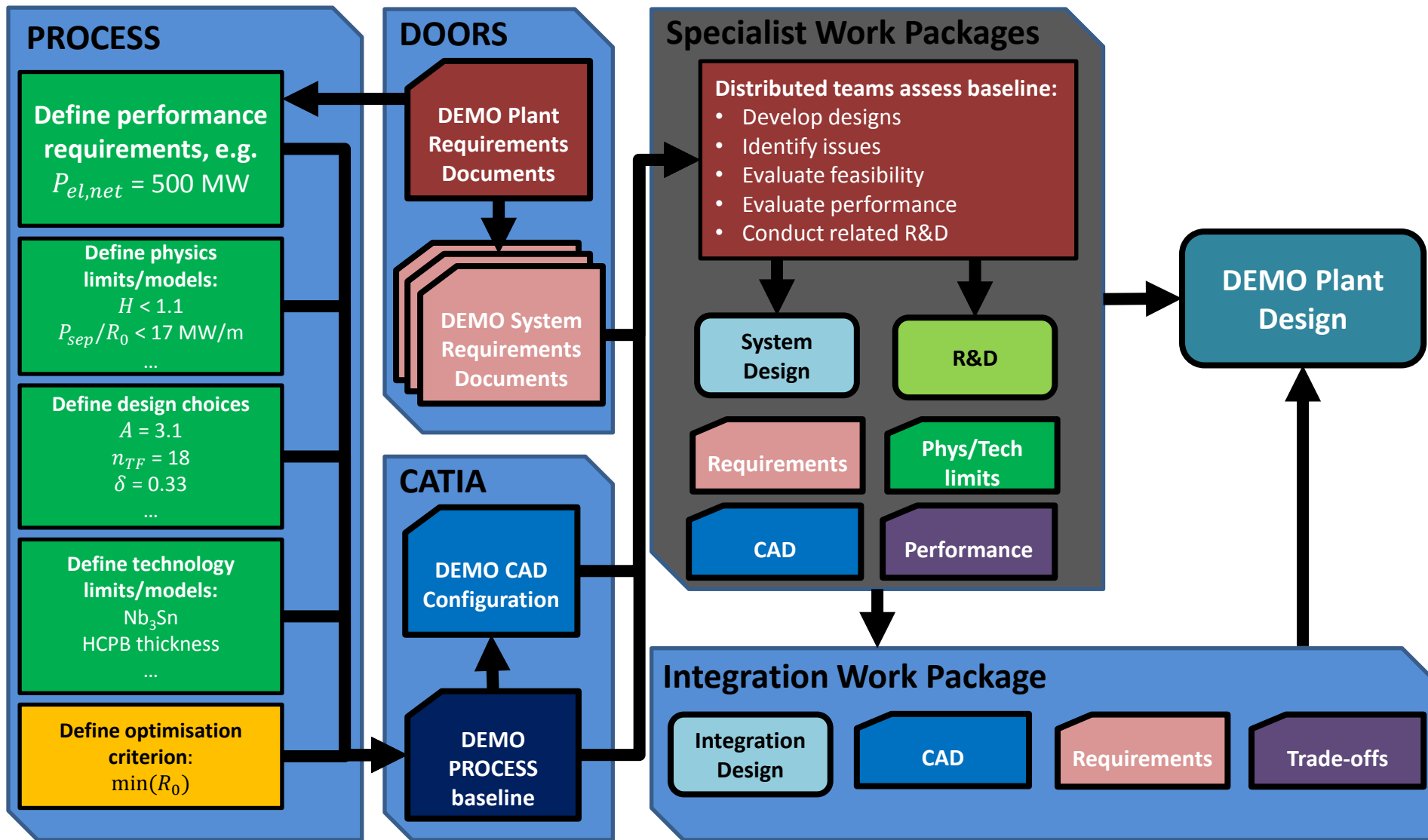
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Each system is allocated requirements and functions, and broken down into further sub-systems until a sub-system design can be “sub-contracted” to a Work Package with a formalised set of requirements (SRD).

# Baseline development process



A stable conceptual basis to perform more detailed engineering/physics assessments



# WP Industry Tasks Contracting Strategy



Summary of current procedure for placing contracts with Industry:

- Tasks for industry involvement are identified in an annual cycle in the WPPMI and distributed WPs.
- A call is raised by the PMU to the beneficiaries (Research Units) who announce their interest to lead an industry task.
- PMU selects the Research Unit 'best suited' to lead the industry task (based on experience, contacts and diplomacy).
- The chosen research launches a formal **national tender** procedure on behalf of PMU/WP.
- Research unit selects the winning tender and administer the contract.
- Cost are reimbursed by PMU to the RU – up to a €150k per PPY ceiling.

**This is currently under review based on recommendations from Ernst & Young**

