A SYSTEM ENGINEERING APPROACH TO SMART PRODUCT EXPLORATION

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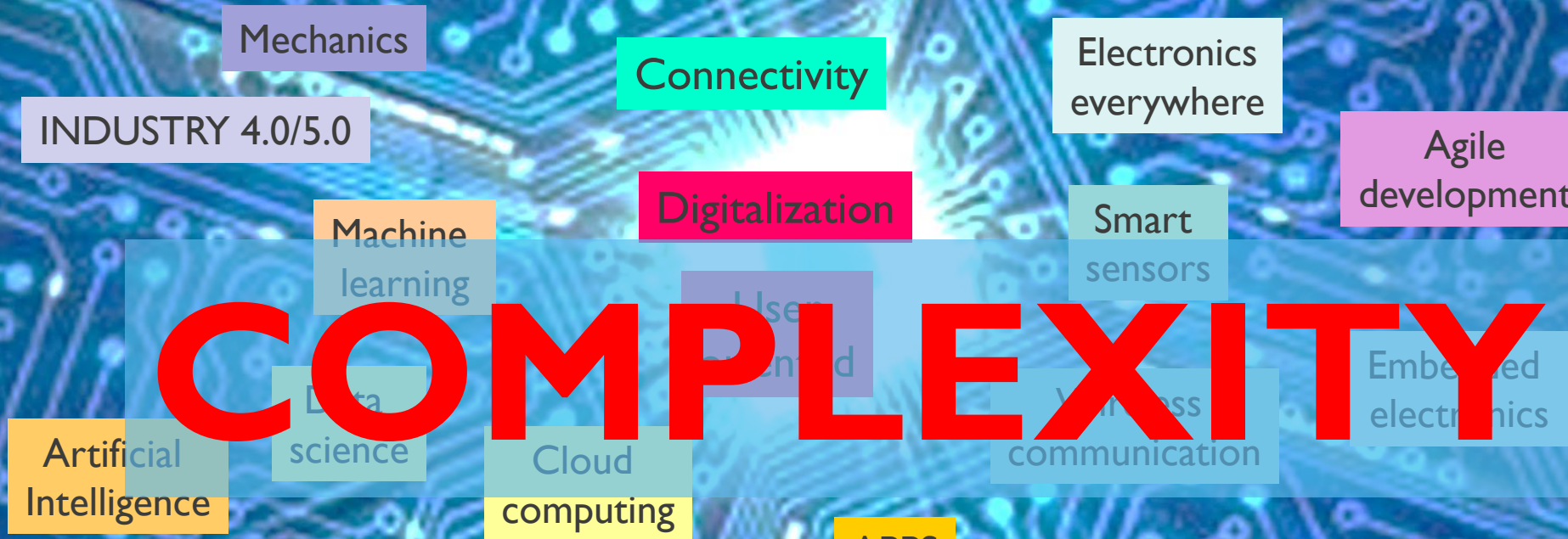
EDM
Electronics Design & Manufacturing

Met steun van:
AGENTSCHAP INNOVEREN & ONDERNEMEN

CONTENT

1. Smart product challenge
2. Life Cycle Stages and Life Cycle Processes per ISO/IEC/IEEE 15288
3. Stage gating New Product Exploration: mastering the Fuzzy Front End
4. Business/Mission exploration and validation
5. Stakeholder needs and solution exploration and validation
6. Conclusion

1. SMART PRODUCT CHALLENGE



1. SMART PRODUCT CHALLENGE

"SMART WORLD" SYSTEM CHARACTERISTICS

@ *Application level:*

Software (AI) using

@ *functional level:*

A high number of (wireless) **interconnected & distributed electronic hardware** modules (sensing, computing, communication, power).

@ *physical level:*

- New electronic devices in all kinds of "environments": wearables, vehicles, machinery, building, infrastructure...
- Also in hard-to-reach and harsh environments.
- Integration of electronics in new environments.

1. SMART PRODUCT CHALLENGE

PRODUCT DEVELOPMENT REQUIREMENTS FOR THE "SMART WORLD"

- Flexible solutions: System adaptable to
  - Different applications
  - Different environments and mission profiles
  - Different volumes, markets (consumer, professional, safety critical)
  - Different product life cycles
  - All this may be variable over time for the same product
- Use of new electronic devices with little use history
- High quality, high reliability, low maintenance.
- Short time-to-market: fast development, scale-up and deployment
- Lowest possible cost

1. SMART PRODUCT CHALLENGE

THREE KEY QUESTIONS

- What do our customers and stakeholders need/want?

  The NEED
- What can we offer to answer that need?

  The SOLUTION
- How can we make some money?

  The BUSINESS

VALIDATION:

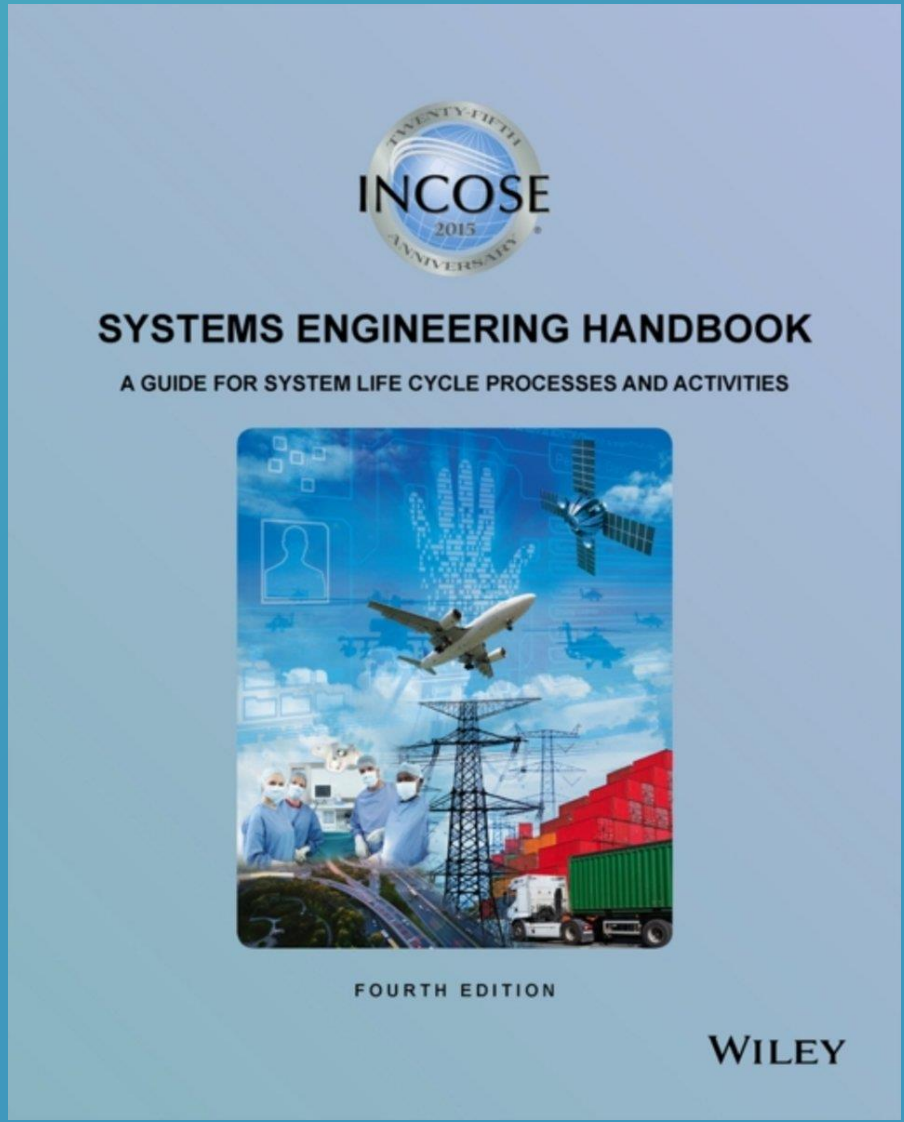
Is the SOLUTION DESIRABLE, FEASIBLE & VIABLE?

1. SMART PRODUCT CHALLENGE

What competences and capabilities do we need?

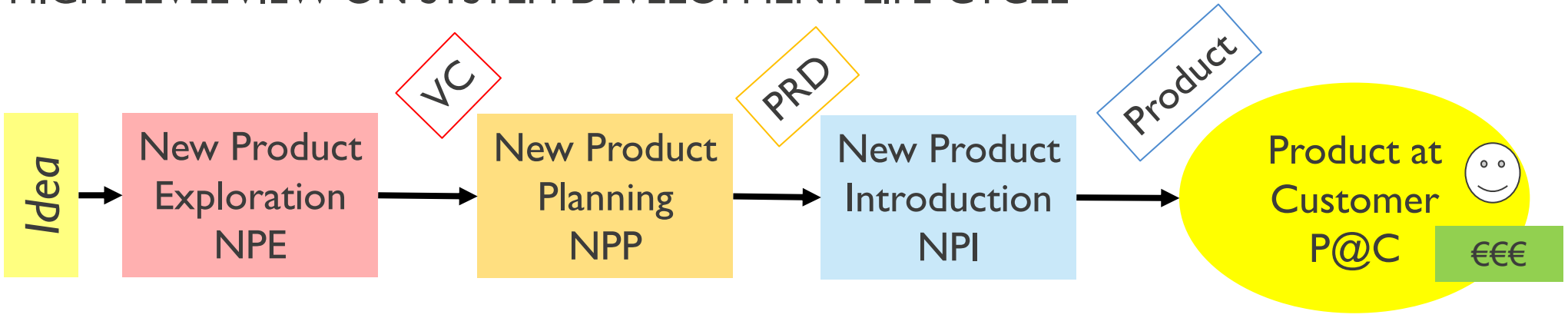
- In-house
- From partners and suppliers

A SYSTEM ENGINEERING APPROACH ISO/IEC/IEEE 24748 & 15288



2. SYSTEM LIFE CYCLE STAGES

HIGH-LEVEL VIEW ON SYSTEM DEVELOPMENT LIFE-CYCLE



NPE - Problem/solution research: user, market, business, technical/industrial feasibility

→ *Validated Concept (VC)*

NPP - Plan the product development, operations and business set-up

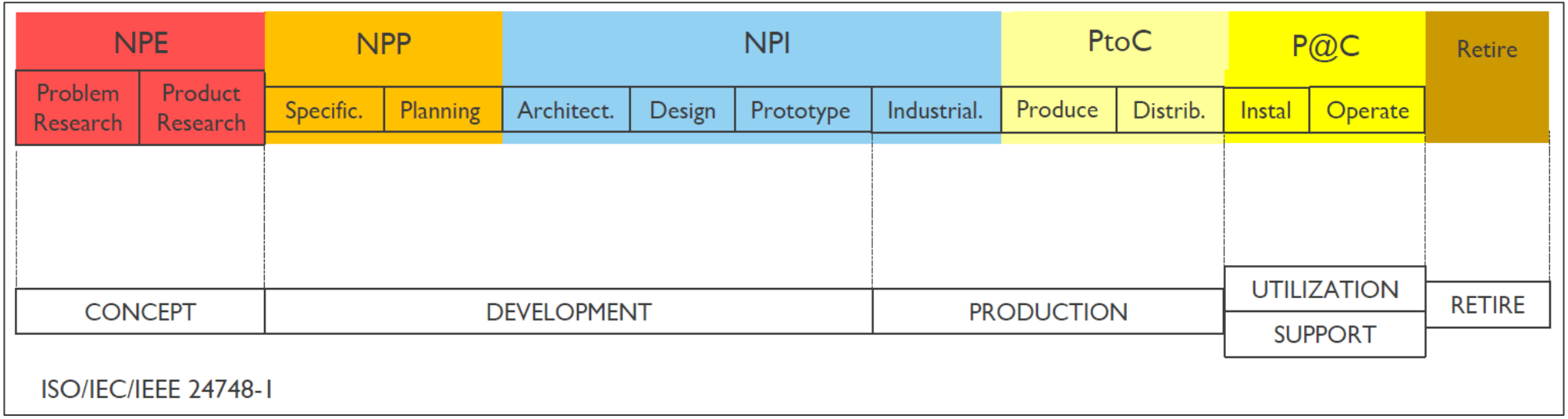
→ *Product Requirements Document (PRD), development, operation and business plans*

NPI - Execution of product development, industrialization, operations and business roll-out

→ *Qualified, documented product delivered to customer.*

2. SYSTEM LIFE CYCLE STAGES

TOTAL VIEW & ALIGNMENT WITH ISO/IEC/IEEE 24748-1

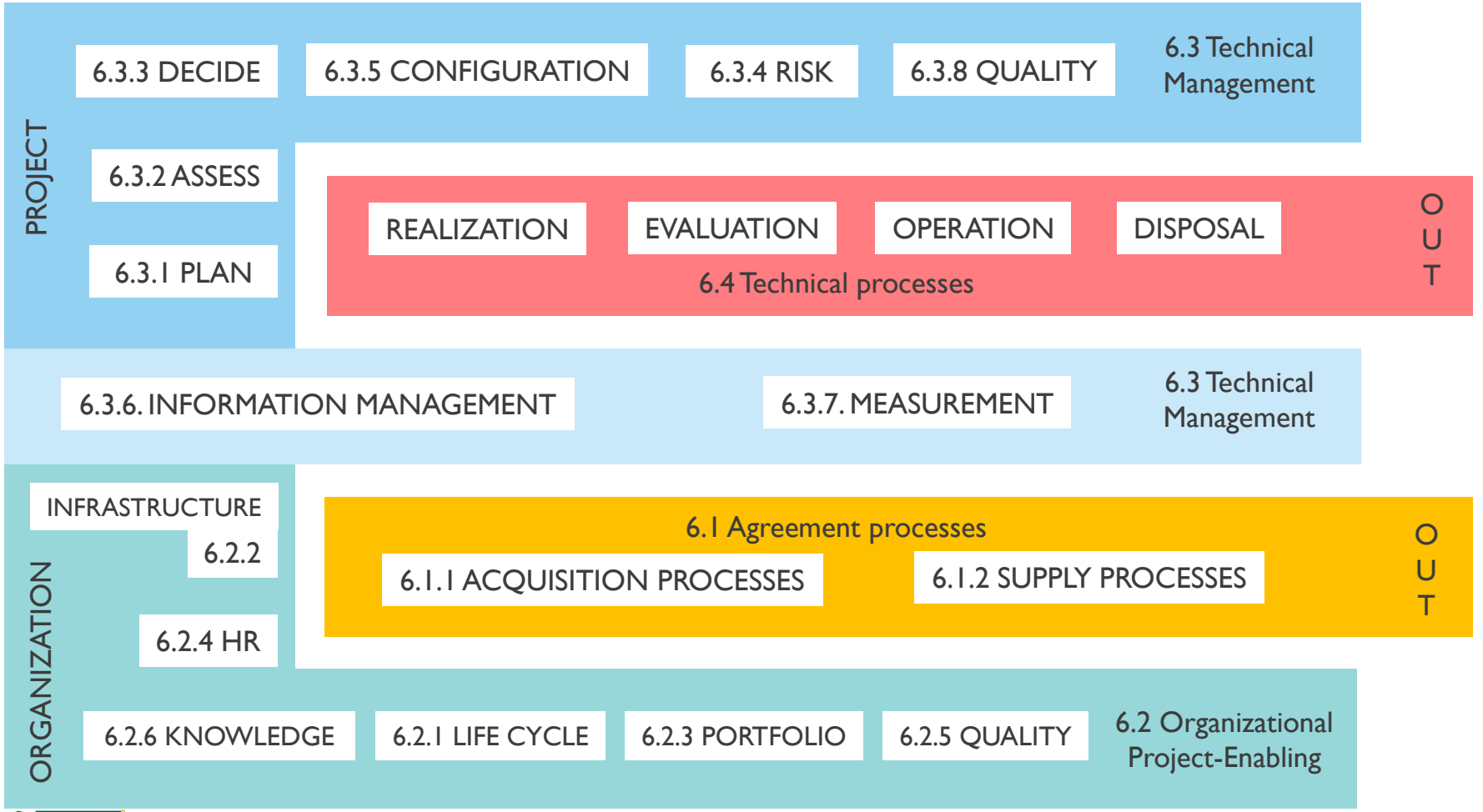


Stage & Phase stage-gates

@ major decision instances

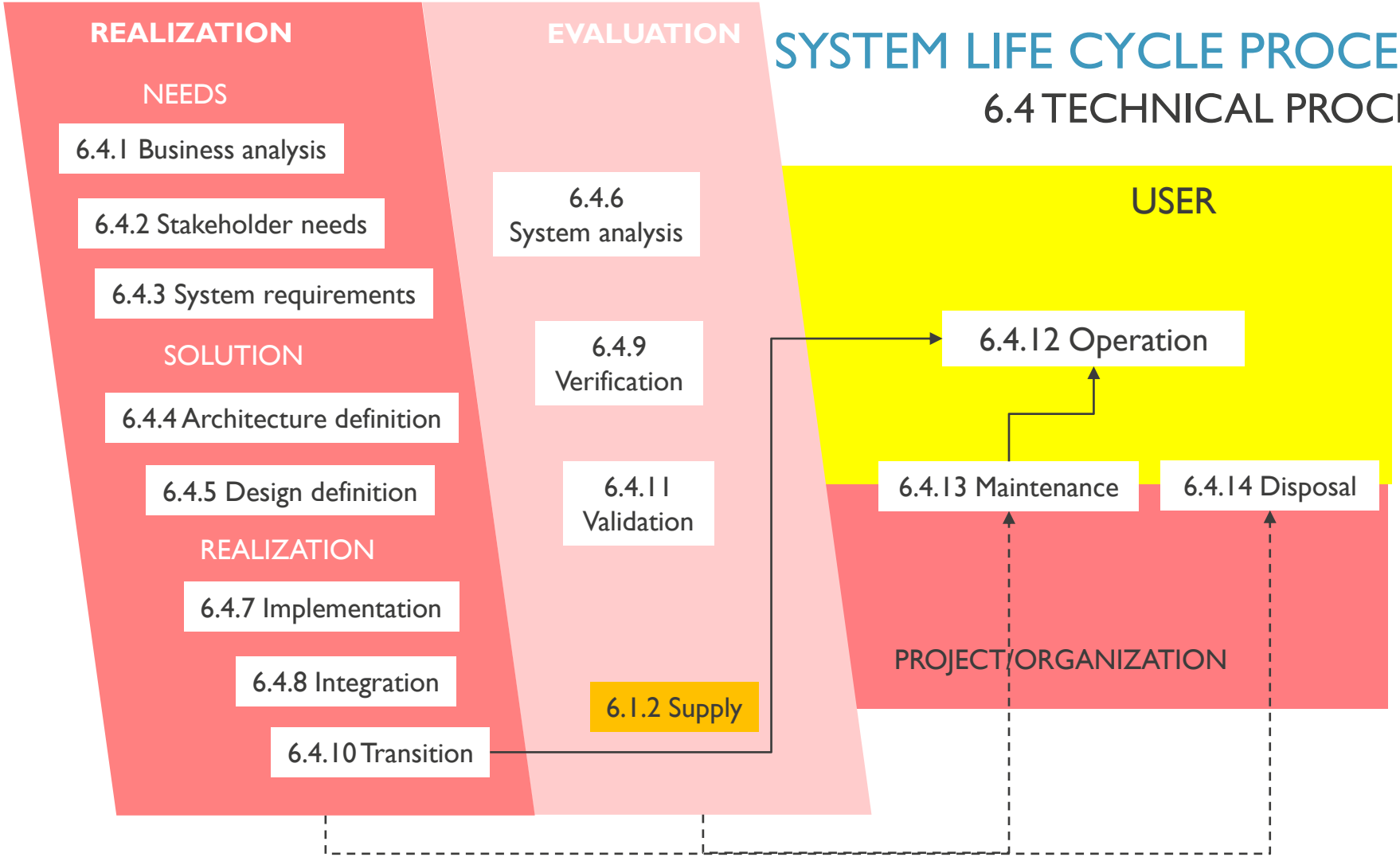
@ responsibility transfer instances

2. SYSTEM LIFE CYCLE PROCESSES



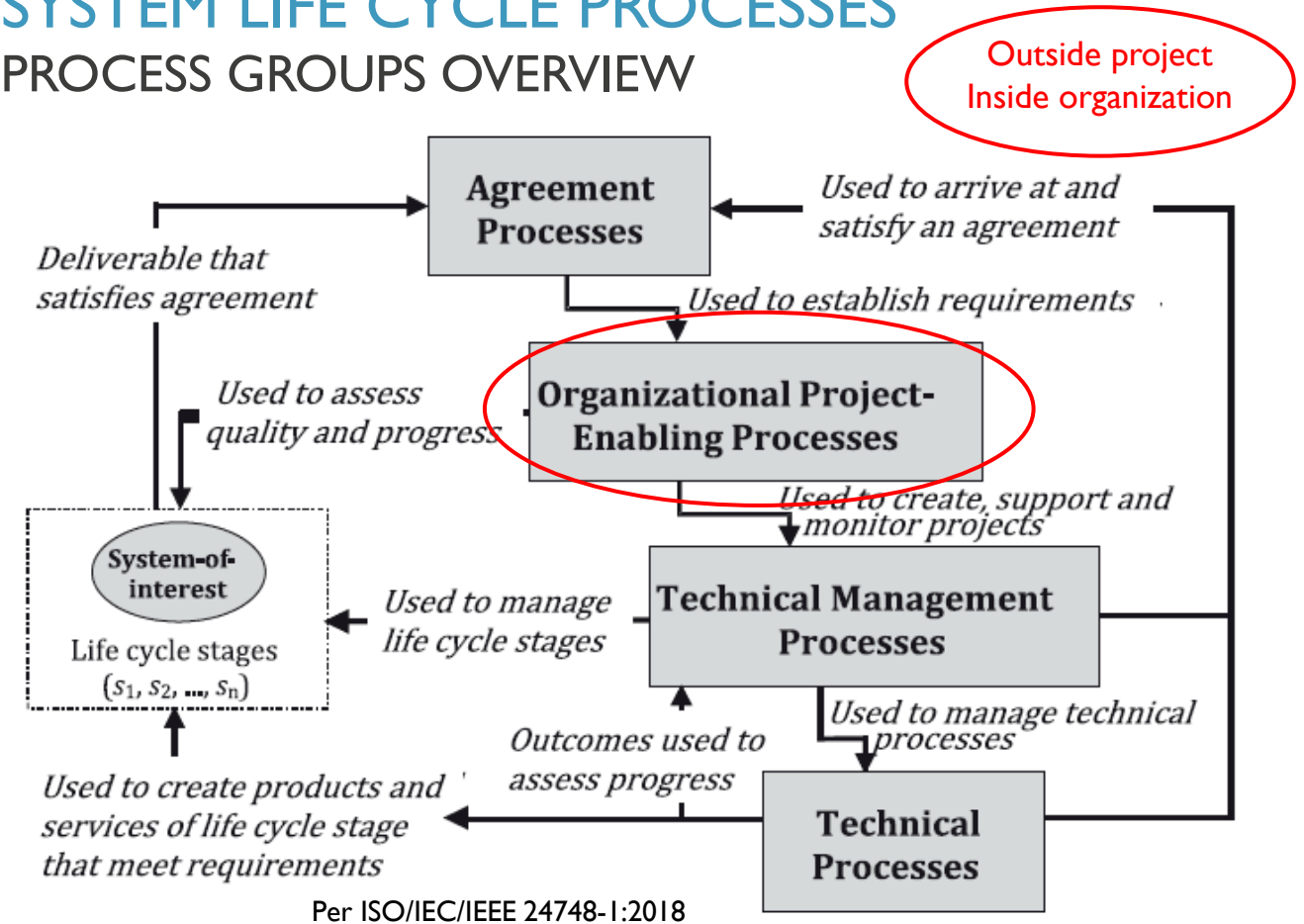
SYSTEM LIFE CYCLE PROCESSES

6.4 TECHNICAL PROCESSES



SYSTEM LIFE CYCLE PROCESSES

PROCESS GROUPS OVERVIEW



Per ISO/IEC/IEEE 24748-1:2018
Per ISO/IEC/IEEE 15288: 2015
Per ISO/IEC/IEEE 12207-1:2017

System Life Cycle Processes

Agreement Processes	Technical Management Processes	Technical Processes
Acquisition Process (Clause 6.1.1)	Project Planning Process (Clause 6.3.1)	Business or Mission Analysis Process (Clause 6.4.1)
Supply Process (Clause 6.1.2)	Project Assessment and Control Process (Clause 6.3.2)	Stakeholder Needs & Requirements Definition Process (Clause 6.4.2)
Organizational Project-Enabling Processes	Decision Management Process (Clause 6.3.3)	System Requirements Definition Process (Clause 6.4.3)
Life Cycle Model Management Process (Clause 6.2.1)	Risk Management Process (Clause 6.3.4)	Architecture Definition Process (Clause 6.4.4)
Infrastructure Management Process (Clause 6.2.2)	Configuration Management Process (Clause 6.3.5)	Design Definition Process (Clause 6.4.5)
Portfolio Management Process (Clause 6.2.3)	Information Management Process (Clause 6.3.6)	System Analysis Process (Clause 6.4.6)
Human Resource Management Process (Clause 6.2.4)	Measurement Process (Clause 6.3.7)	Implementation Process (Clause 6.4.7)
Quality Management Process (Clause 6.2.5)	Quality Assurance Process (Clause 6.3.8)	Integration Process (Clause 6.4.8)
Knowledge Management Process (Clause 6.2.6)		Verification Process (Clause 6.4.9)
		Transition Process (Clause 6.4.10)
		Validation Process (Clause 6.4.11)
		Operation Process (Clause 6.4.12)
		Maintenance Process (Clause 6.4.13)
		Disposal Process (Clause 6.4.14)

2. LIFE CYCLE STAGES & PROCESSES

PLC STAGES VERSUS PLC PROCESSES (ISO/IEC/IEEE 15288: 2015)

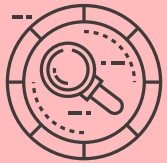
Prepare	
Qualify	
Implement	
Execute	
Monitor	
Improve	
Close	

ELECTRONIC SYSTEMS		Agreement		Technical														
STAGE	Phase			Stakeholder needs	System requirements	Architecture	Design	System analysis	Implementation	Integration	Verification	Transition	Validation	Operation	Maintenance	Disposal
	Technology C															
NPE	Problem Rese															
	Product Rese															
NPP	Product Spec															
	Product Plann															
NPI	Architecture															
	Design															
	Prototype															
	Industrialisation															
PtoC	Production															
	Distribution															
P@C	Installation															
	Product Operation															
Retire	Decommisioning															
	End-of-Life															

Monitor and learn for next generation and next products

3. NEW PRODUCT EXPLORATION

WHAT TO EXPLORE? (and more)



New Product Exploration

User/stakeholder related (desireability):

- User/stakeholder's problem/need vs solution

Product related (technical feasibility)

- Technology readiness, availability, accessibility
- Feasibility of (internal) product life cycle realization and support
- Supply chain readiness and (external) enabling system readiness
- PLC: Risks, scenario's, resources and costs

Business related (viability)

- Company fit
- Market/competition/ecosystem/society/environment fit
- Business/revenue model

Validated Concept

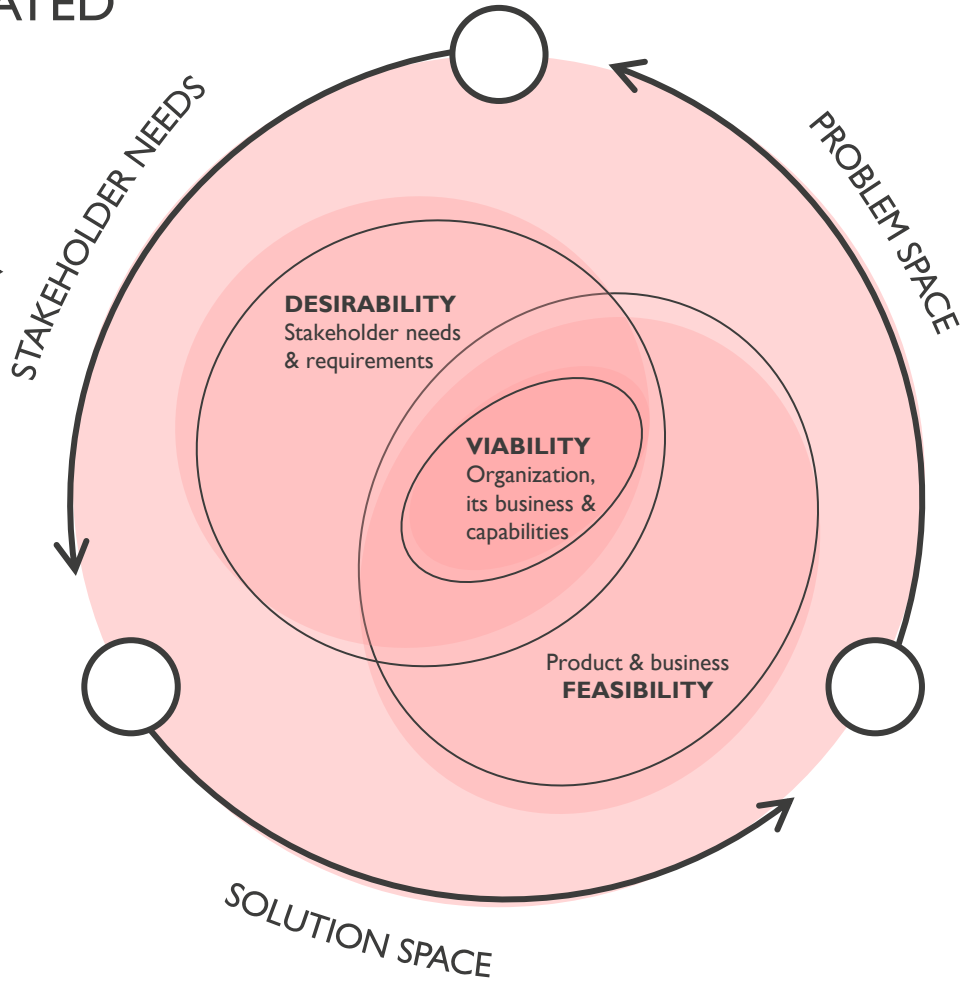
3. NEW PRODUCT EXPLORATION

THE CHALLENGE: EVERYTHING IS INTERRELATED

RESEARCH PLAN

STAGE-GATED PRODUCT RESEARCH

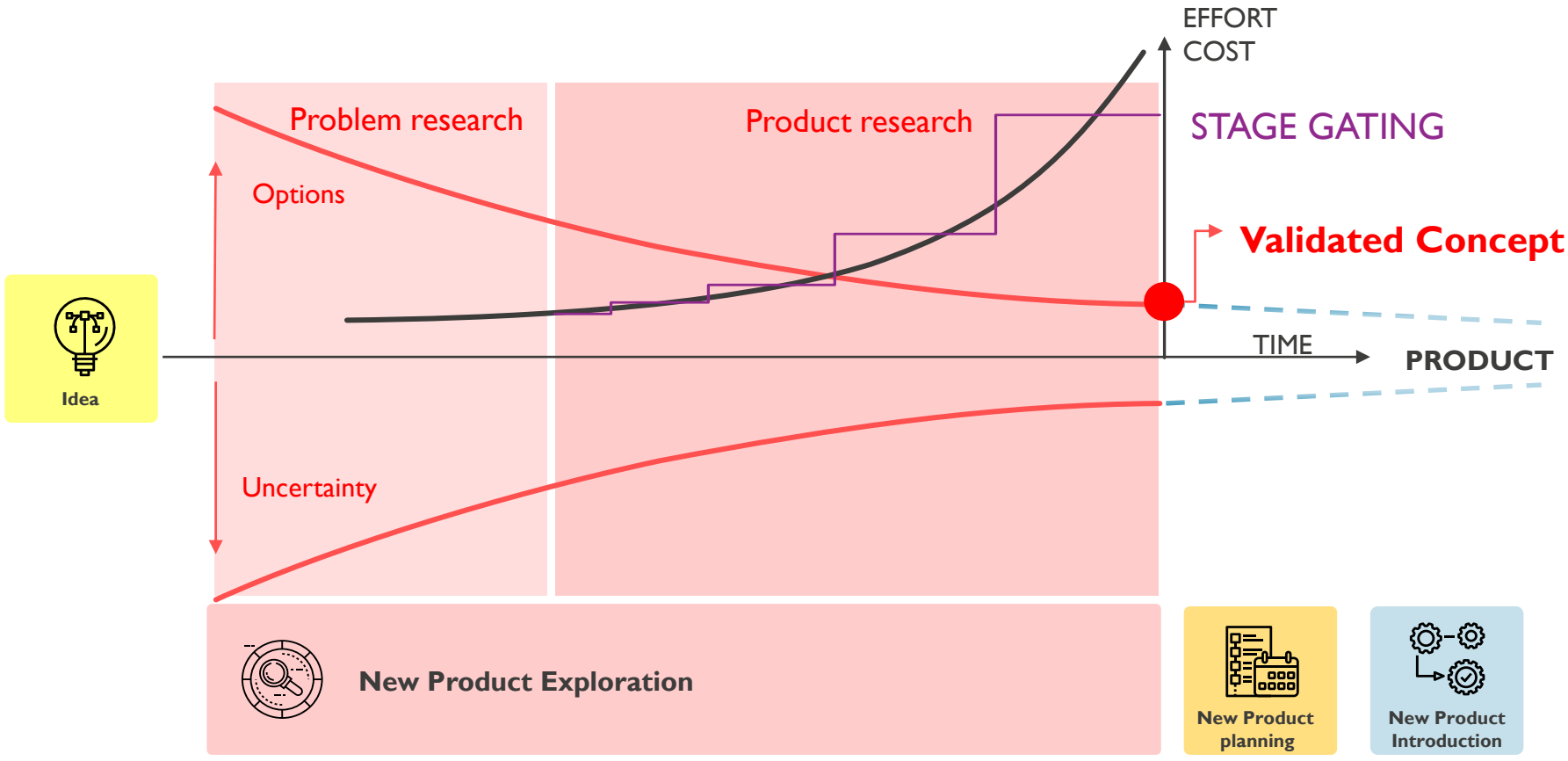
Low-Cost PROBLEM RESEARCH



How to manage this Fuzzy Front End?

3. NEW PRODUCT EXPLORATION

FUNNELING THE OPTIONS



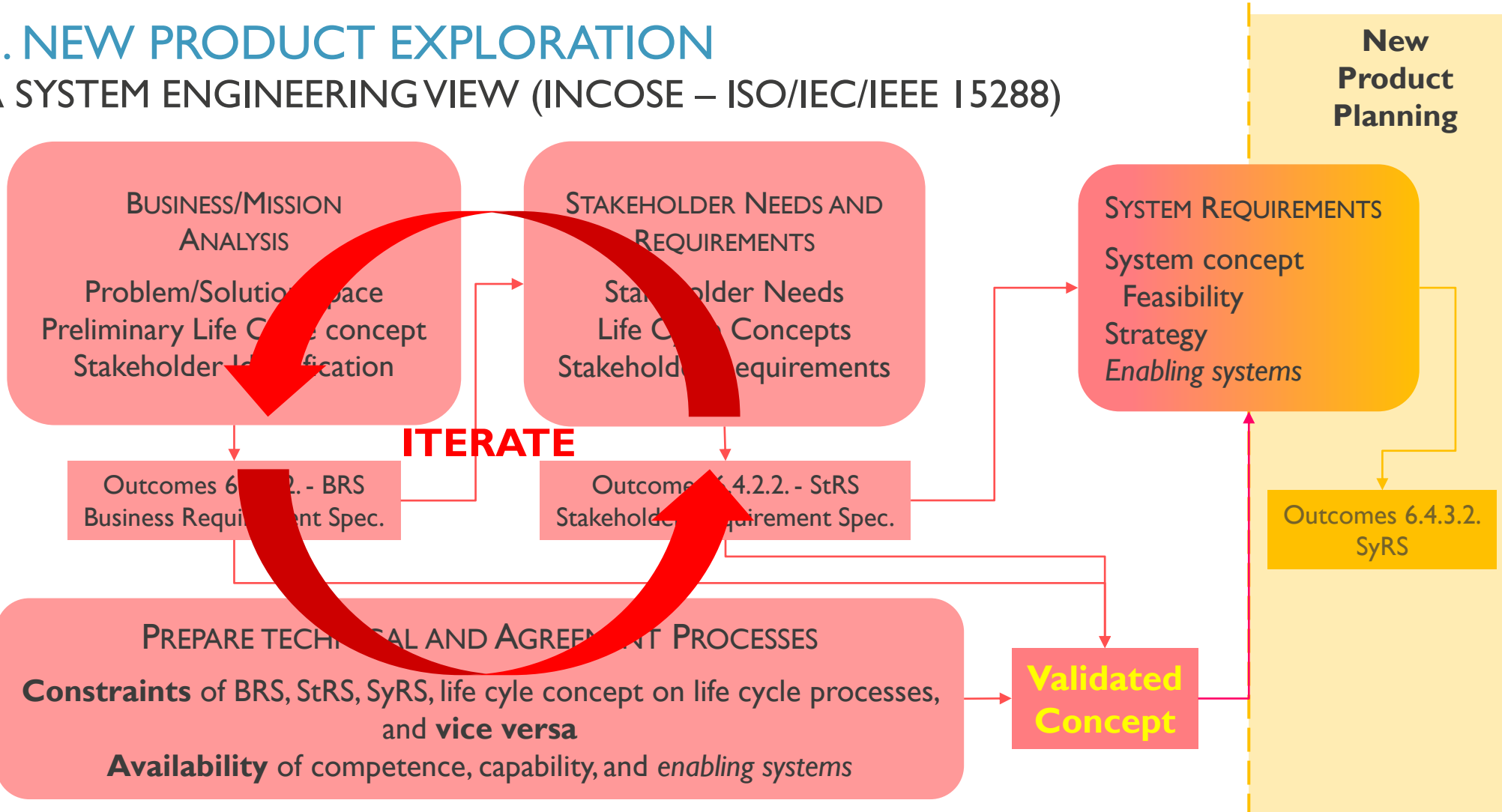
3. NEW PRODUCT EXPLORATION

WHAT TO CREATE? PROBLEM RESEARCH (PRE-STUDY)

- First low-cost assessment of all relevant topics, e.g., desk research et al.
- Identification of problem/need - solution options
- First "filtering"
- Identification of items that require further exploration and validation.
- Exploration plan for Product Research:
  Output:
- Obtain go for investment in further exploration: PRODUCT RESEARCH.

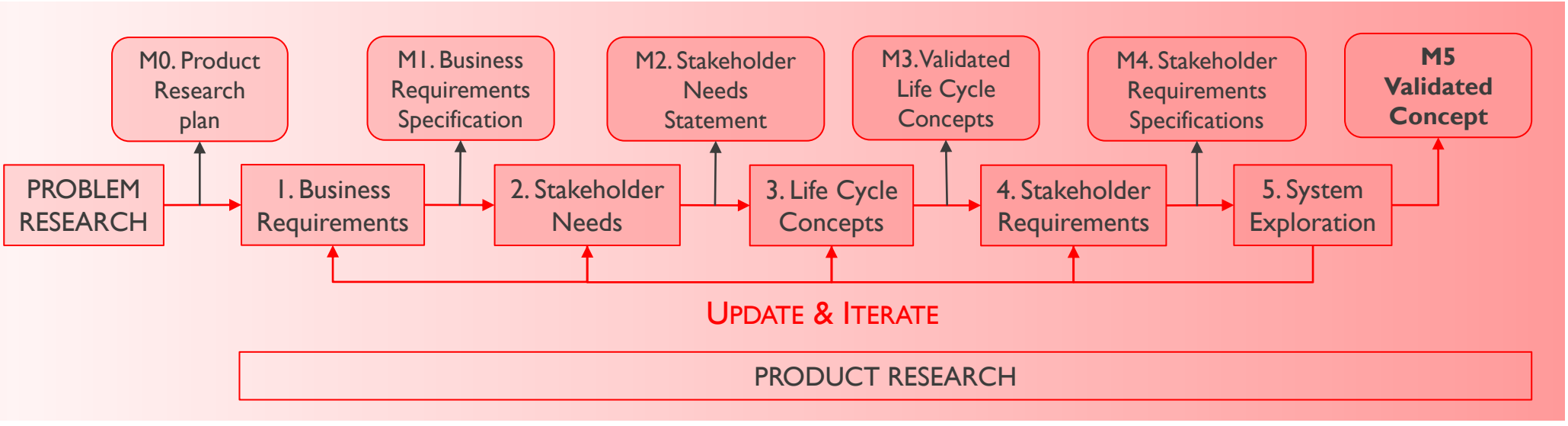
3. NEW PRODUCT EXPLORATION

A SYSTEM ENGINEERING VIEW (INCOSE – ISO/IEC/IEEE 15288)



3. NEW PRODUCT EXPLORATION

MILESTONE BASED STAGE GATING:



STAGE GATE DECISIONS:

continue phase - go to next phase - return to previous phase - hold - stop project

4. BUSINESS/MISSION ANALYSIS: PHASE 1

WHAT IS ADDRESSED?

WHAT problem do we want to solve? What opportunity do we want to address?
→ Problem/Opportunity statement

Problem contexts:

- Internal problem/opportunity: *ex. Industry 4.0 upgrade of own production plant.*
- Customized solution for external customer: *ex. ODM & EMS services, infrastructure project...*
- Product or service to a market of customers: *ex. product sales*

Organization contexts:

- Mission/vision, strategic plan, Concept of Operation (ConOps), competences/capabilities...
- Constraints: competition, ecosystem, environment, society...

MILESTONE 1: BUSINESS REQUIREMENTS SPECIFICATION (BRS):

- Defines business framework
- Constraints, business & revenue models...

4. BUSINESS/MISSION ANALYSIS PHASE I

WHO: IDENTIFY STAKEHOLDERS

WHO are the target customers/users? WHO are the stakeholders?

Identify stakeholders

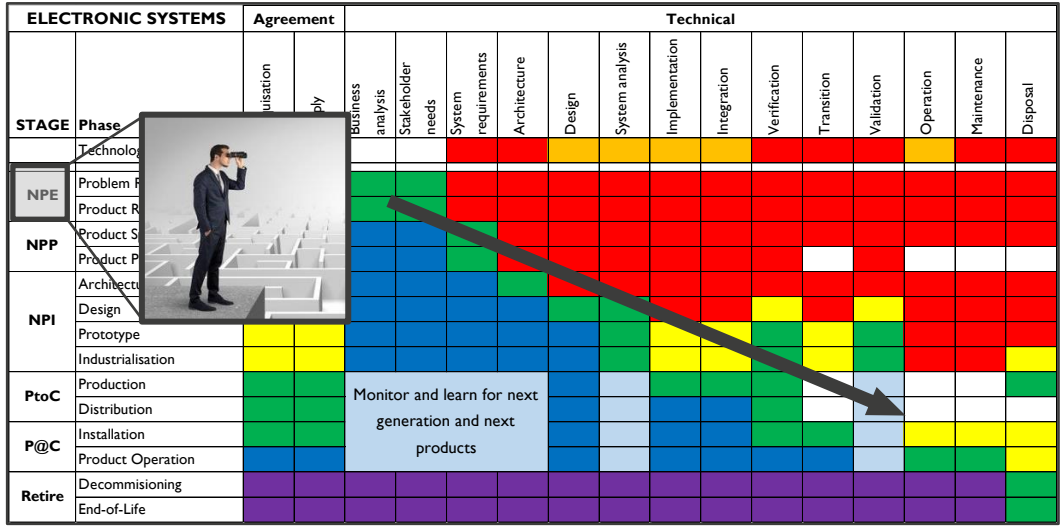
1. System OEM **organization**: organization that engineers and markets the system.
2. System OEM **shareholders**: owners of the system OEM.
3. System OEM **management**: management of the system OEM.
4. System OEM **employees**: employees of the system OEM.
5. System OEM **partners**: partners of the system OEM.
6. System OEM **suppliers**: product and service suppliers of the system OEM.
7. System **user**: uses/operates the system.
8. System **owner**: owns the system.
   This can be the customer or the system OEM organization itself operating in a XAAS-model.
9. System **customer**: buys the system provided by the system OEM organization.
10. System **service customer**: buys services from a service provider that uses the system to provide these services.
11. **Society** and its representatives.
12. **Environment** and its representatives.
13. Others...

4. BUSINESS/MISSION ANALYSIS : PHASE 1
HOW: SOLUTION CHARACTERIZATION

HOW will the problem be addressed: solution candidates

LIFE CYCLE CONCEPTS

- Operational Concept (OpsCon)
- Development
- Supply chain,
  production,
  transition to user
- Operations, support & maintenance
- End-of-Life



CANDIDATE SOLUTION CLASSES

4. BUSINESS/MISSION ANALYSIS: PHASE 1

ILLUSTRATION: THE COFFEE CASE

WHAT for WHO?
Quality coffee with a value adding experience for the active professional in a work context.

Business/revenue models:
equipment sales (1), coffee & accessories sales (2), Coffee-As-A-Service (3), community membership...

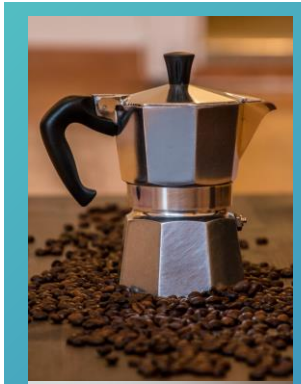
HOW: Life Cycle concepts aligned with the type of business

1. Equipment production, retail sales, after sales service...
2. Consumable sales orientation, active community, coffee promotion...
3. Service concept, 24/7 online user support, preventive maintenance...

...

4. BUSINESS/MISSION ANALYSIS: PHASE I

THE COFFEE CASE: SOLUTION CLASSES



Vintage

Classic

Clooney

Smart Barista

5. STAKEHOLDER NEEDS AND SOLUTIONS

PHASE 2: STAKEHOLDER NEEDS

The view of the stakeholders on what is needed

MILESTONE 2: STAKEHOLDER NEEDS STATEMENT.

*A **need** is something that **is wanted or required**.*

1. Define the **context of use** within the ConOps of the user.
2. Explore, validate, prioritize and define the **user and other stakeholder needs**.
3. **Refine** the **preliminary life cycle concepts** concepts and solution classes.
4. **Align** BRS and stakeholder needs. Create consistent Stakeholder Needs statement.
5. **Update** Problem/opportunity statement.

5. STAKEHOLDER NEEDS AND SOLUTIONS
PHASE 3: LIFE CYCLE CONCEPTS

MILESTONE 3: VALIDATED LIFE CYCLE CONCEPTS DEFINITION

1. Define, explore, and validate **OpsCon** and other **life cycle concepts** with stakeholders.
2. Identify preliminary **system concepts** to validate life cycle concepts.
3. **Refine** the stakeholder needs.
4. **Define** the **solution classes**.
5. **Align** BRS (M1), Stakeholder Needs statement (M2), life cycle concepts, and solution classes and define the validated life cycle concepts (M3).
6. **Update** Problem/opportunity statement.

5. STAKEHOLDER NEEDS AND SOLUTIONS
PHASE 4: STAKEHOLDER REQUIREMENTS

MILESTONE 4: STAKEHOLDER REQUIREMENTS SPECIFICATIONS (STRS)

A **requirement** is a statement that **can be verified and validated**.

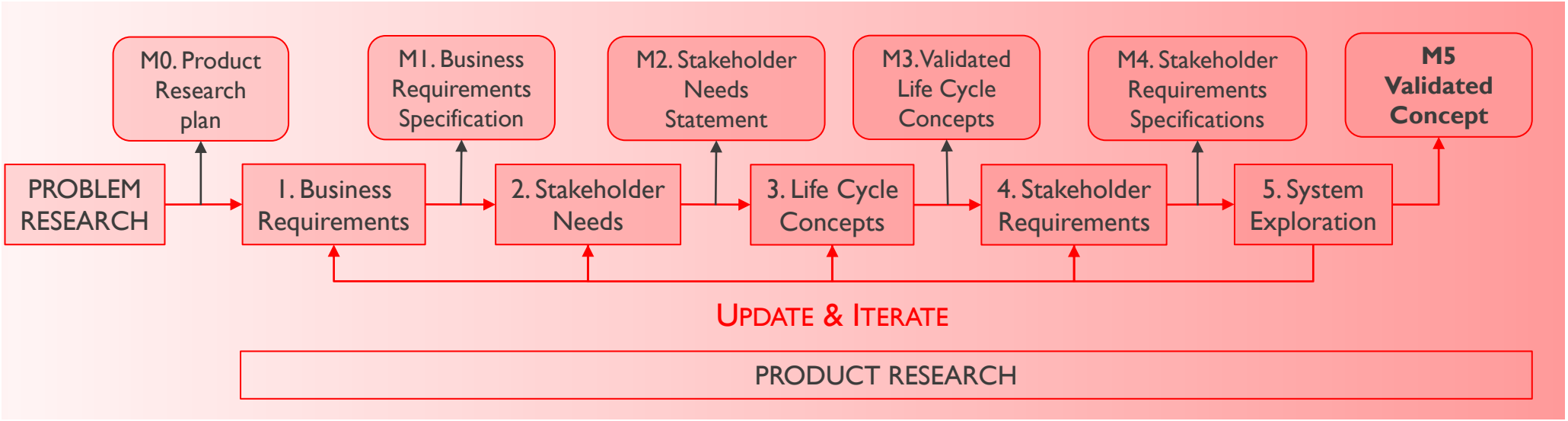
1. Identify **constraints** on the life cycle concepts
2. Specify the **critical qualities** such as safety, security, availability, etc.
3. **Specify stakeholder requirements**.
4. **Analyze** the requirements for clarity, necessity, consistency, completeness.
5. **Consult stakeholders** to validate that their needs are addressed and to resolve requirement issues.
6. **Create the StRS** consistent with the BRS (M1), the stakeholder needs statement (M2), and the life cycle concept definitions (M3). Resolve inconsistencies. Obtain agreement.

5. STAKEHOLDER NEEDS AND SOLUTIONS
PHASE 5: SYSTEM EXPLORATION

MILESTONE 5: VALIDATED CONCEPT

1. Explore **feasibility of system concepts**, embedded technologies and critical system elements.
2. Prove the **realizability** of the system concepts and critical system elements.
3. Define **preliminary System Requirements**.
4. Show **accessibility** to competences, systems, services for System Requirements Specification.
5. Validated life cycle (M3), system and system element concepts versus BRS (M1) and StRS (M4).
6. Draft a **preliminary development project plan**.

6. CONCLUSION



PREPARE TECHNICAL AND AGREEMENT PROCESSES

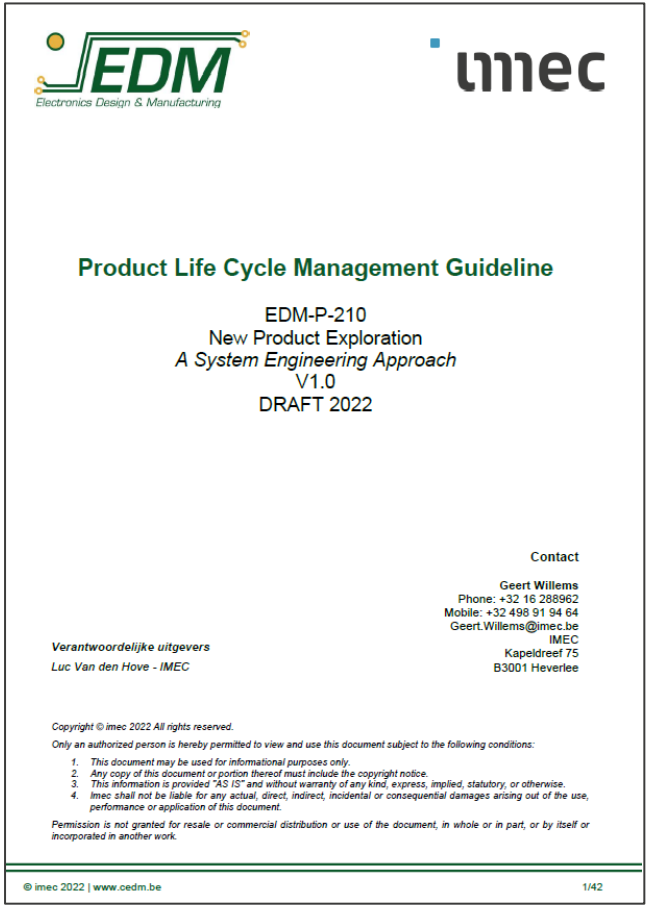
Constraints of BRS, StRS, SyRS, life cyle concept on life cycle processes, and **vice versa**

Availability of competence, capability, and *enabling systems*

→ **Validated Concept**

6. CONCLUSION

NPE GUIDELINE



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Product Life Cycle Management Guideline

EDM-P-210
New Product Exploration
A System Engineering Approach
V1.0
DRAFT 2022

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