Life-cycle and Reliability of accelerators

JUAS 2016

part 1: life-cycle

part 2: reliability- representative slides

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Definition of reliability

1st basic approach

$$\text{Reliability} = \frac{\text{Time the systems works} - \text{Time of breakdowns}}{\text{Time the system works}}$$

Definitions of reliability

The **reliability** is the ability of a system or component to perform its **required functions** under **stated conditions** for a specified **period of time**

The reliability (R(t)) is the probability to have no failure at the time t.

MTBF: Mean Time Between Failures

MTTR: Mean Time To Repair

The **availibility** of the system is the ratio of the time when the system is operational by the time it was supposed to be operational

$$\text{Availibility} = \frac{MTBF}{MTBF + MTTR}$$

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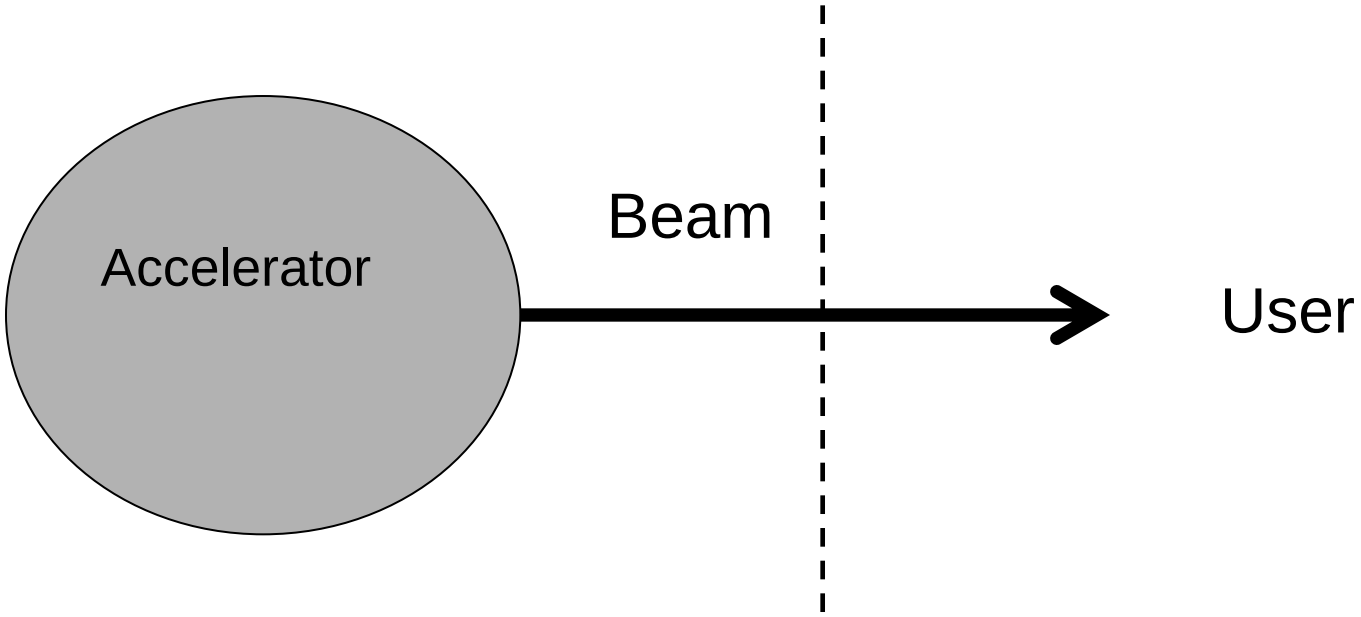

What is the **product (service)** delivered ?

What is the **quality** defined ?

Who is defining the reliability ?

Reliability and Accelerators

- Power- Energy & Motion

Electricity, cooling, regular motion systems

-Critical and/or sensitive Technologies

Radio-Frequency, vacuum, electronics, cryogenics, software, …

- Risks

radiation-protection, costs, …

-Complexity

mix of technologies, %research%production, regulations

- Using &Users (Customers / Providers)

beams: current, energies, duration, …

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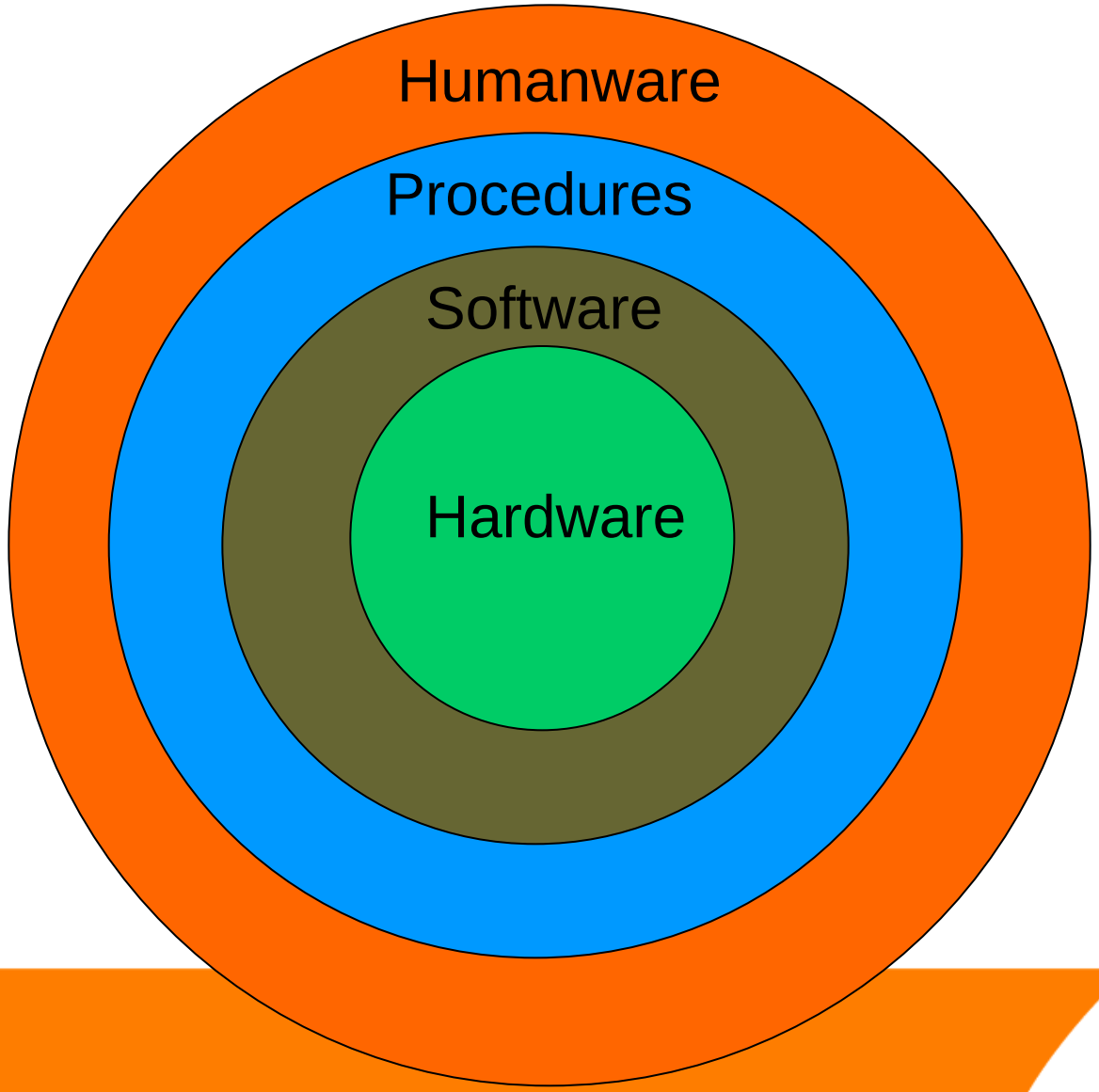
the 4 layers of reliability



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2. Life-cycle of accelerators and reliability

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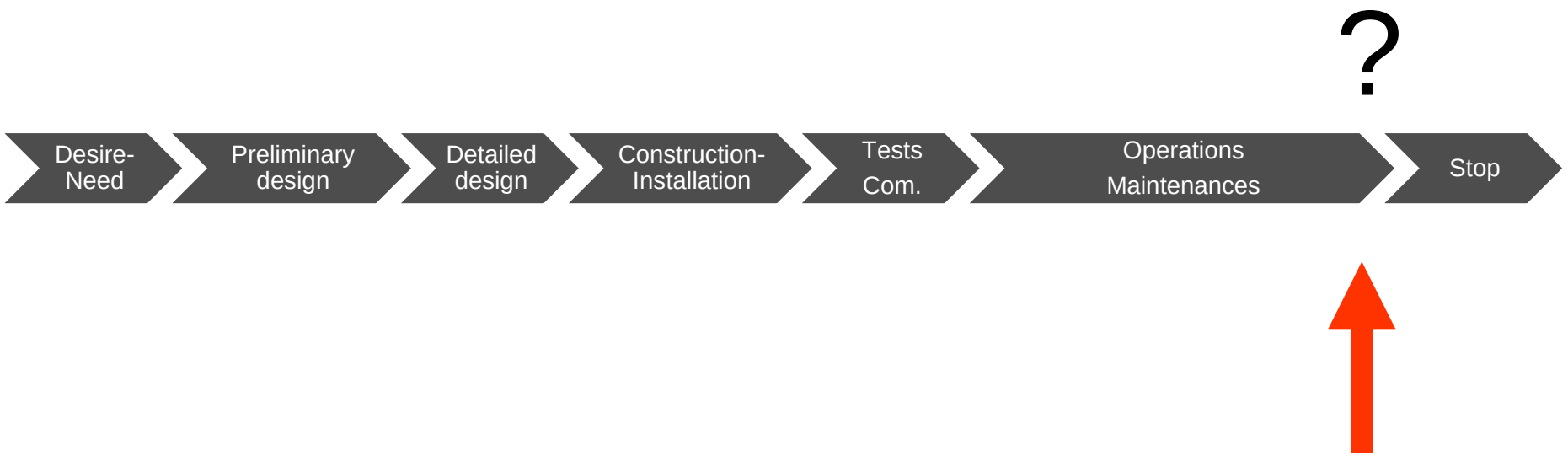
Life-cycle of accelerators



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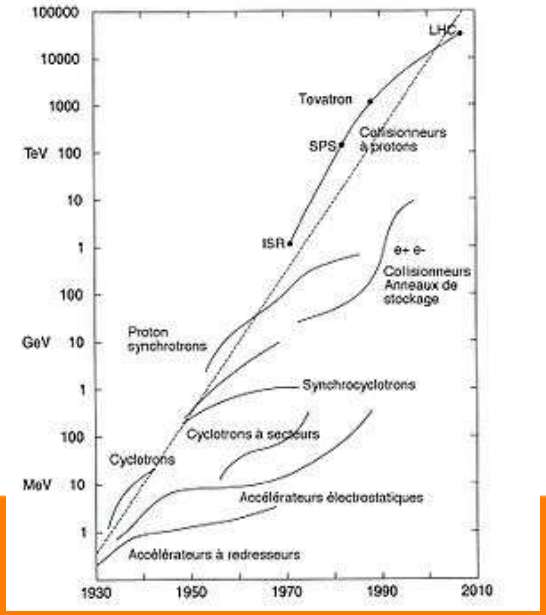
A failure – a small (or big) death

Connection (ESRF)

Main coil (SC200-Orsay)

Obsolescence



Orphan system

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The « operations » for an accelerator

- **All the process to be managed in order to deliver the required beam (and associated services) during the planned period**

This includes:

- Startup of the system, Tuning of the beam
- check of the normal behaviour of the systems during
- monitor and record parameters (automatic or manual, log-books, …)
- fix any unplanned event (troubleshooting, corrective actions level 1,2,…)

- planning of the activities (discussion with users): day, month, year
- managing the documentation (procedures, drawings, …)
- training of operators level 1, 2, …

- in direct relation with maintenance and project issue

Operations / Projects

Goal: keeping a process stable

Key Performances Indicators (KPI): reliability, production outputs for users (ex: hours of beam)

Goal: reaching a specific target (new)

Key Performances Indicators (KPI): Milestones (dates), level of completion achieved, performances reached,reliability of planning …

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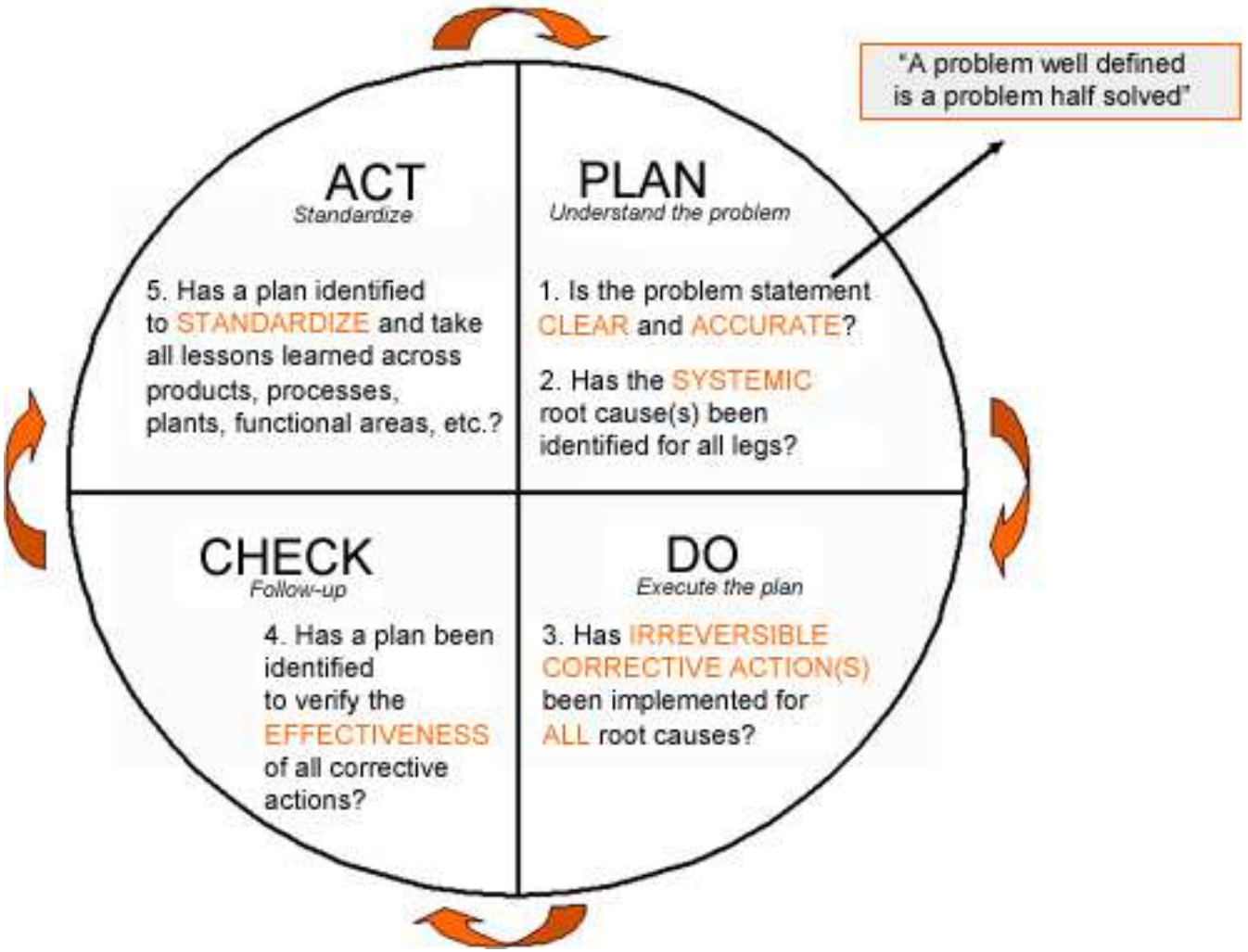
Plan – Do –Check – Act (PDCA)

(to manage Operations)



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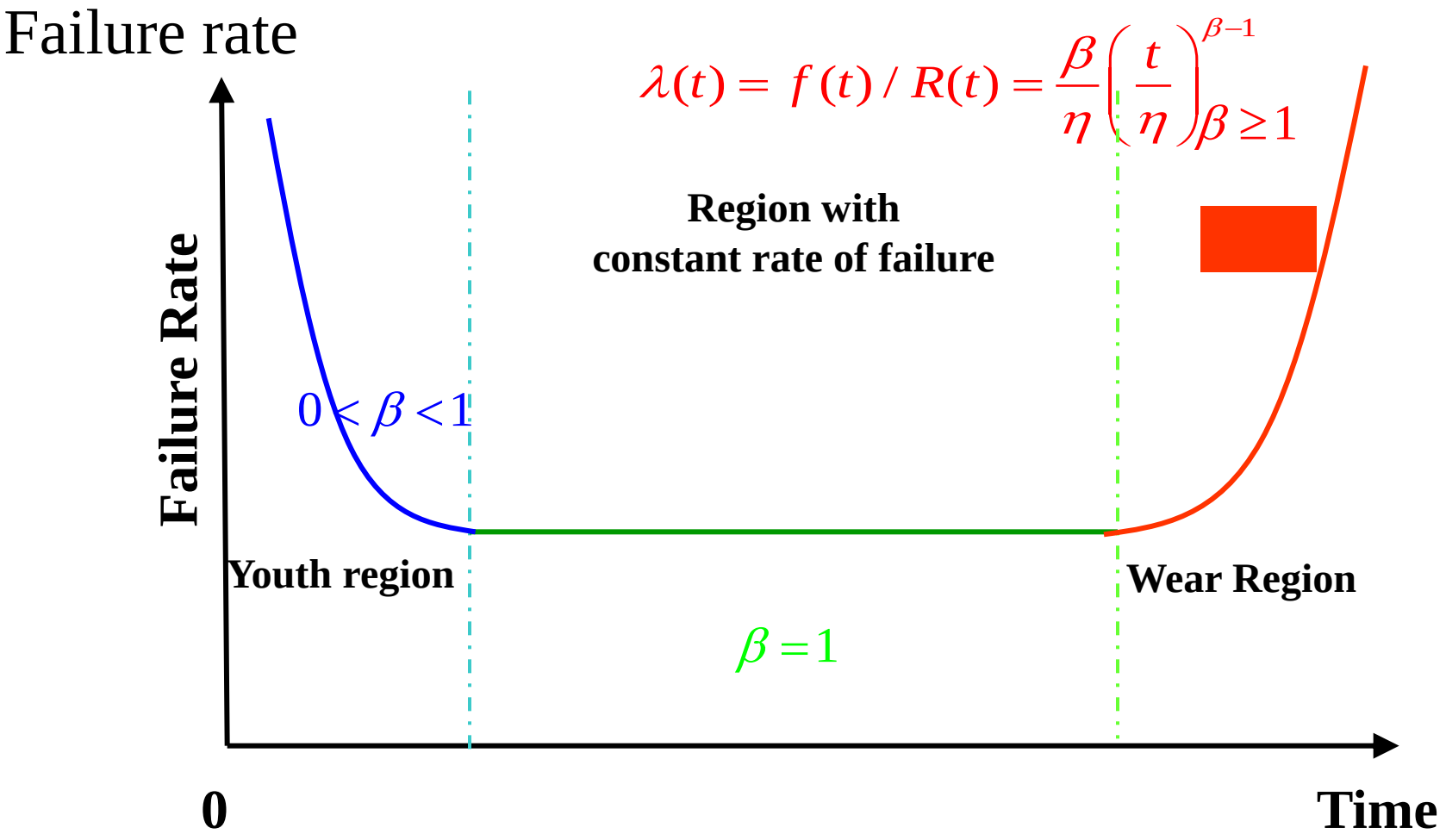
The reliability Weibull Model



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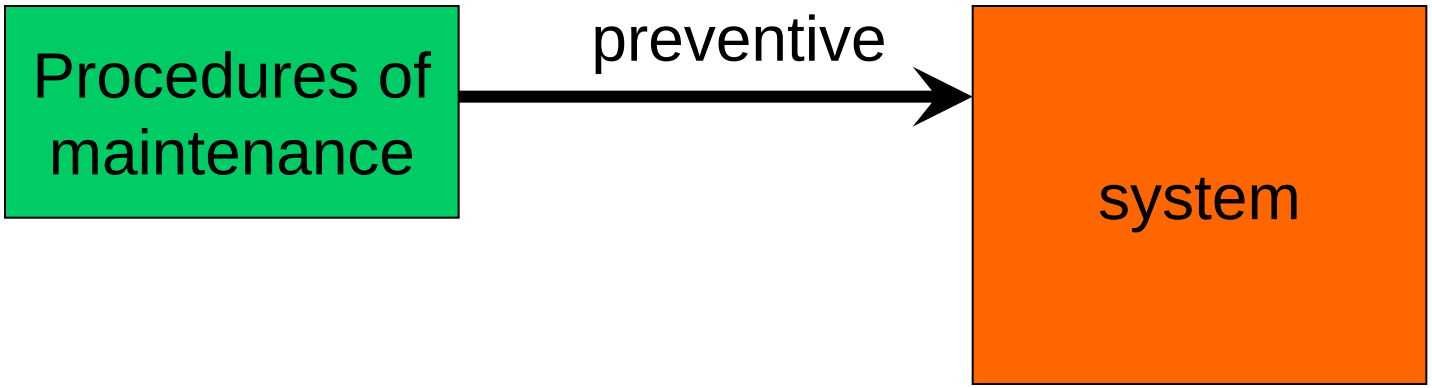
Maintenances

Modelisation, experience

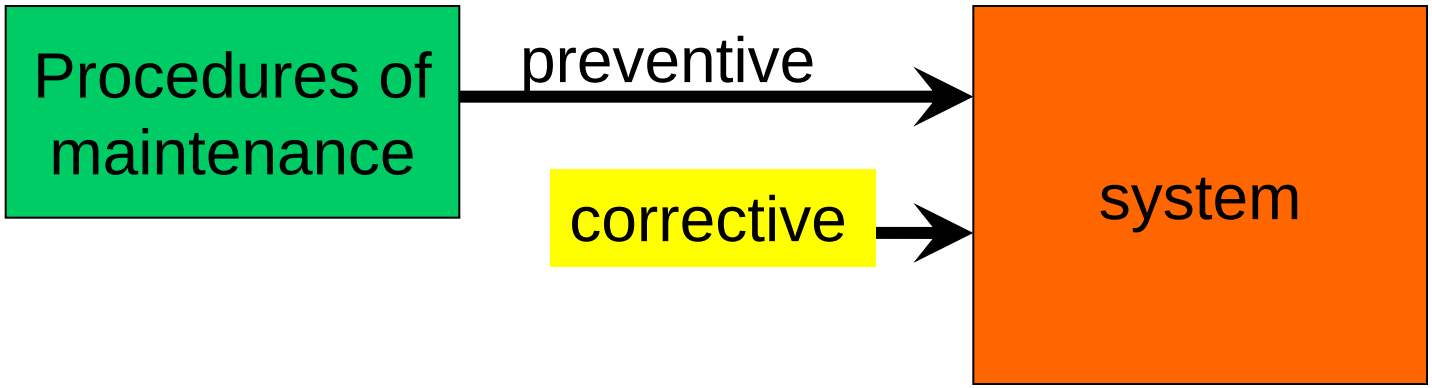


Inspect, clean, check, lubrify, calibrate, read, replace, test ,…

< 20% with high periodicity
Ex: Ions Sources

Maintenances

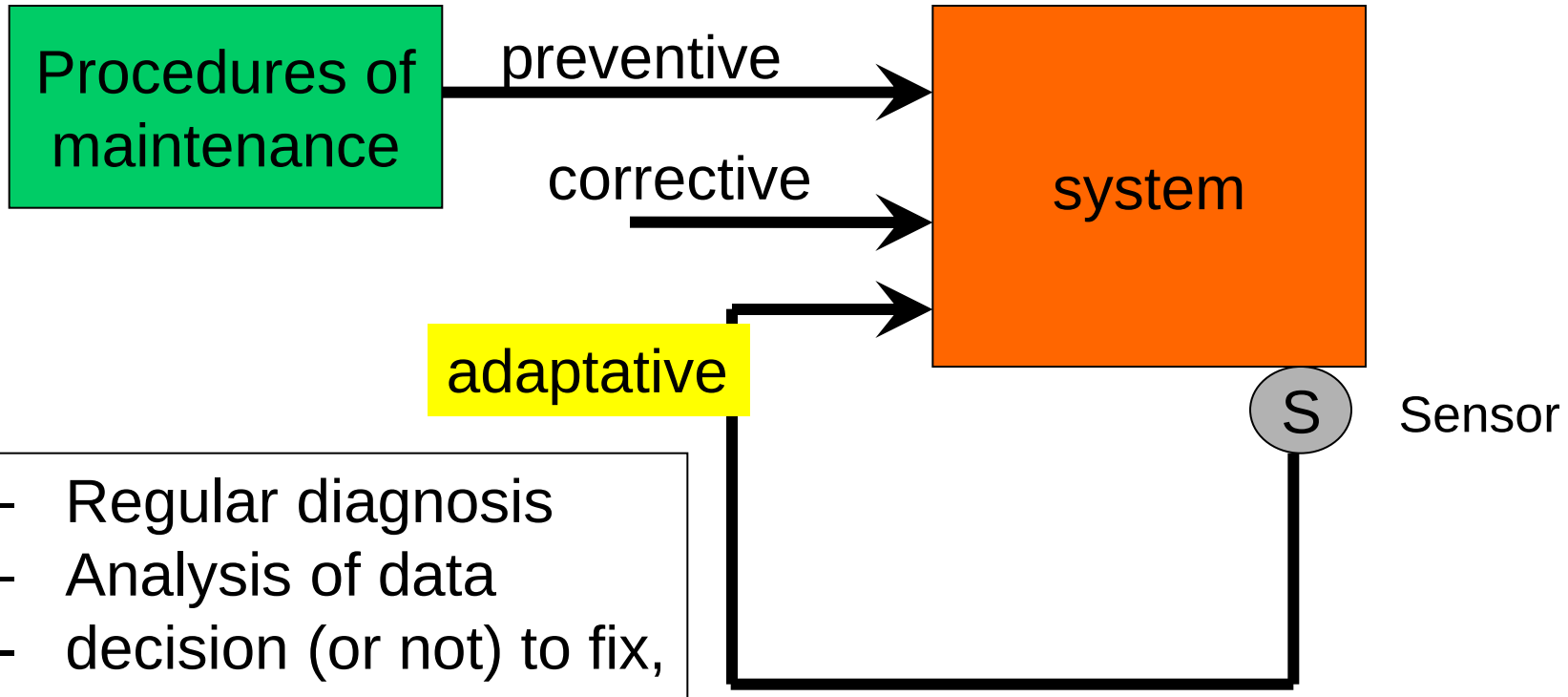
Modelisation, experience



- Awareness of problem(s)
- Diagnosis
- Fix-replace
- test

Maintenances

Modelisation, experience



- Regular diagnosis
- Analysis of data
- decision (or not) to fix, inspect, more analysis

History of the aircraft maintenance

Maintenance concept had been changing

Overhauled | **Decision logic(MSG) provide a tasks**

MSG-1 ⟶ **MSG-3**

The Boeing 747
A four- engine
Produced 1970-Present

The Douglas DC-8
A four- engine
Produced 1960-1972

The Boeing 767
A twin-engine
Produced 1982-Present

The Boeing 787
A twin-engine
Produced 2011-Present

Year ⟶ **1960** **1970** **1975** **1980** **1985** **1990** **1995** **2000** **2005** **2010** **2015**

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Comparing Maintenance Strategies

Comparison of the availability analysis

	Mechanical Component with wear out	Electrical Component
Run to Failure	95%	98%
Preventive Replacement	98%	97%

Provided by RelaSoft corp.

$$\text{Average Availability} = \frac{\text{Uptime}}{\text{Operating Time}}$$

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Why transition « project » to « operation » so critical ?

- **ALL the systems must be ready AND OK (ancilaries, control system, …)**

- **often, the first time in « REAL » conditions**

- **Atmosphere of « pressure »:**
  - Important milestone for contract (penalties)
  - users « wants » the beam

~~Maintenance~~ ⇒ Projects to set, keep, improve the operations

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Contracting with

With the provider of the accelerator

- **performances and acceptance tests**
- **contents and limits of interfaces (beam, building , control, …)**
- **training - documents**
- **budgets (bonus / penalties)**
- **maintenance contract**

With the provider of building and ancilaries

With the users (« real » needs, constraints, freedoms, evolutions…)

With the payers (budget and resources)

- **for investment**
- **for ramp-up and contengencies**
- **for operations, maintenance, …**

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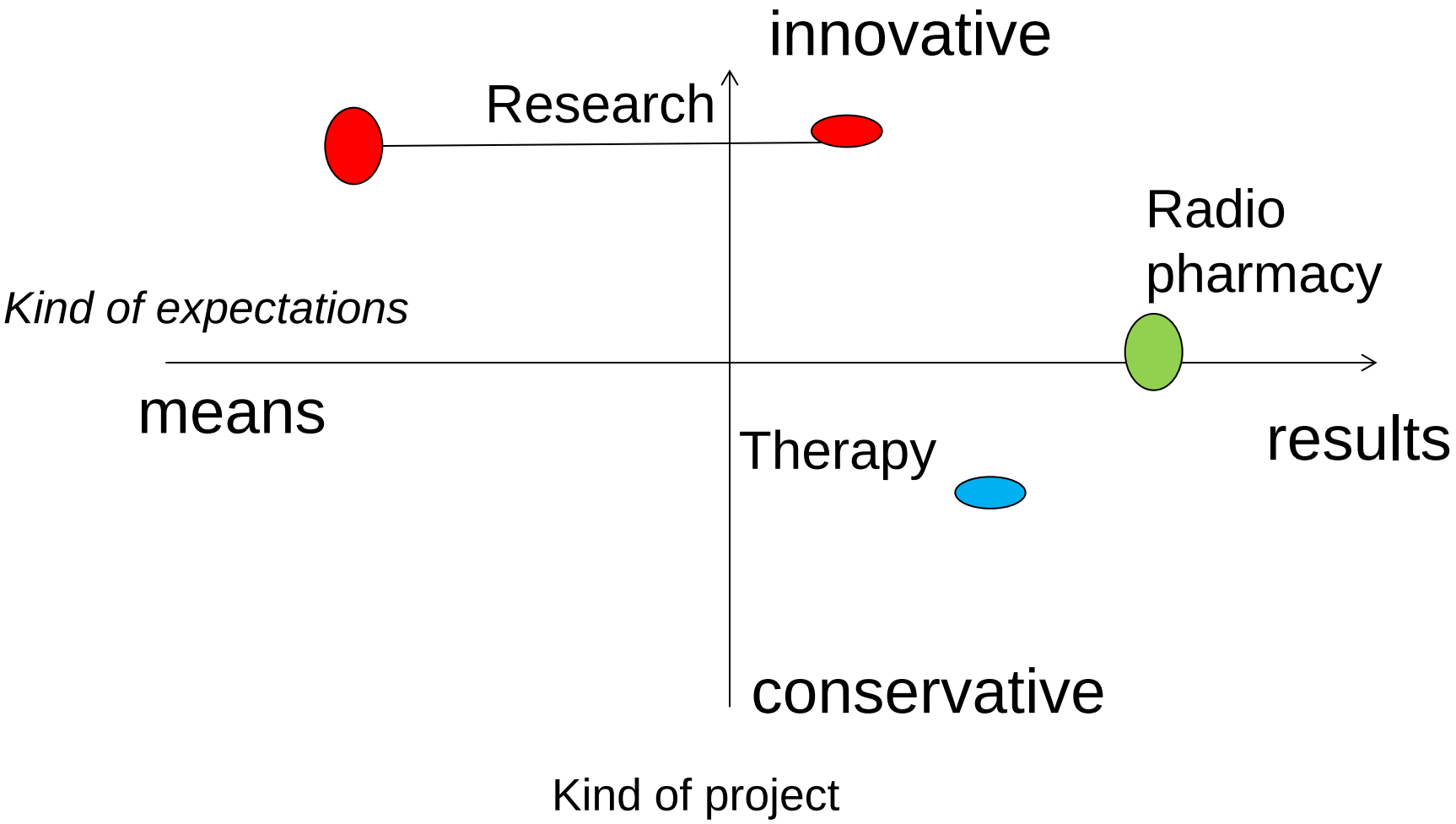
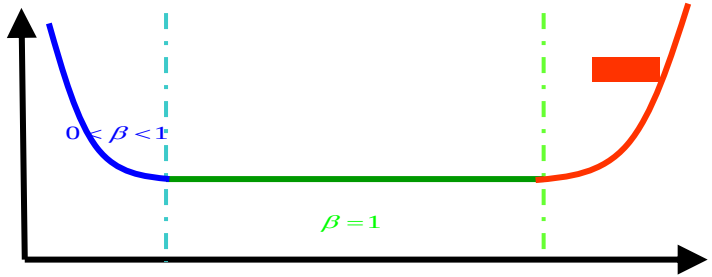

innovative
Research
Radio
pharmacy
Kind of expectations
means
results
Therapy
conservative
Kind of project

+

Quality Assurance

Desire-Need → Preliminary design → Detailed design → Construction-Installation → Tests Com. → Operations Maintenances → Stop

contract



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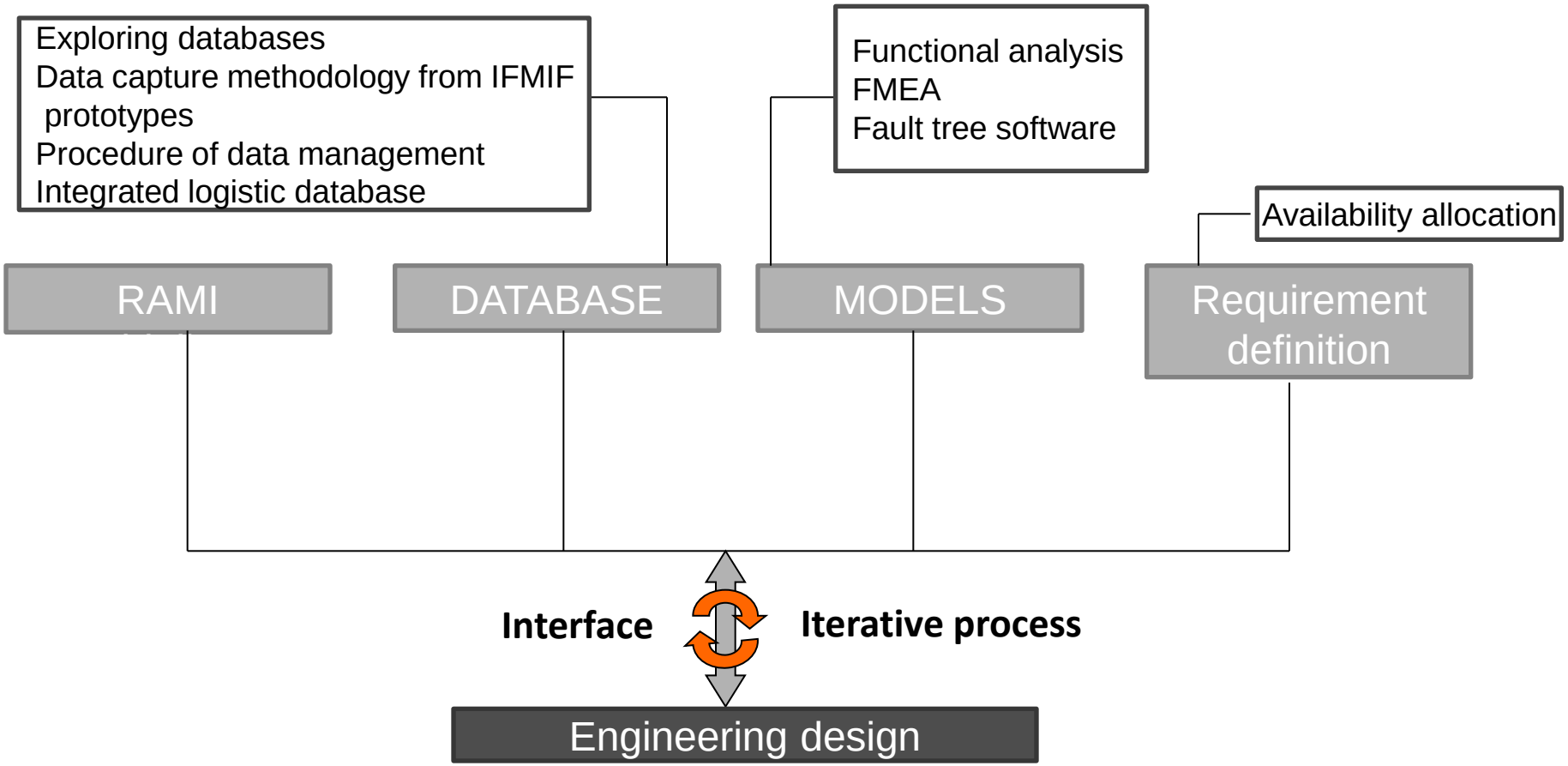
RAMI approach (Reliability, Availability, Maintainability, Inspectability) for project IFMIF



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Concepts and reliability

Principles to increase reliability:

- Redundancy
- accessibility
- over -engineering
- maintainability
- …

Parameters increasing risks on reliability

- Technological innovations
- Lonely experience
- Number of specific interfaces
- pressure on quality, budget, delay
- …

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The (wellknown) recipes for a good reliability

A system (hardware & software) well designed

- specifications, model of developpement, tests
- principles of reliability, a lot of diagnosis

A well-maintained system

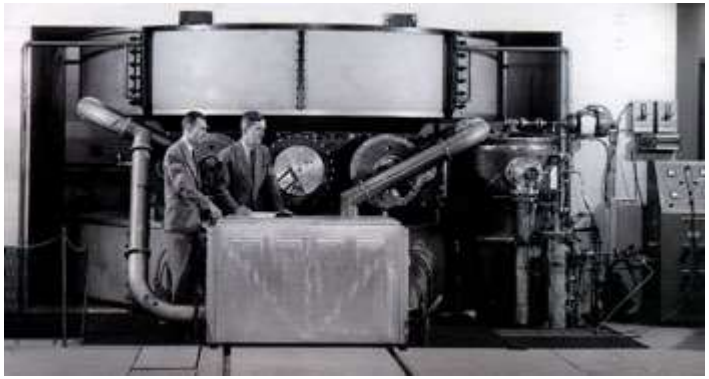
- Preventive, real, adaptative, reactivity for corrective
- Spare parts (a lot, ready for use)
- time dedicated for operations

Human resources and good organization

- people trained, skilled, enough, here when required
- efficient and clean organization, data-base, Knowledge Management

Briefly: resources (men, budget), consistency, willingness…

Synchro-cyclotron - HCL
Harvard (1949-2003)



Cyclotron 88 inch - LBL
Berkeley (1961 - …)

Cyclotron PSI (590 MeV)- CH
designed for 100 µA (1974)
an now at 2,2 mA (2012)

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Reliability and accelerators

- **Concepts**: principles to increase reliability, risks to consider

- **Definition** : Importance to agree on (what, how, mode, constraints/freedoms, …)

- **Maintenance**: % determinist (mechanical, cooling, …) % based on monitoring (systems + organisations)

- **Responsabilities**: to etablish and clarifiy (systems, organization, Quality assurance, test, …)

- **Information**: how to get as soon as possible (other experiences, test, …), how to keep during the life of accelerator.

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