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Risk management for asset management

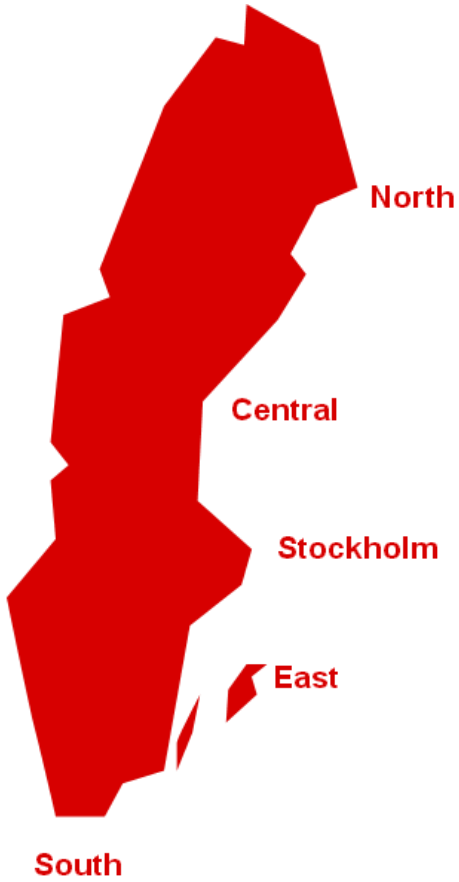
Peter Söderholm

Agenda

- Trafikverket (Swedish transport administration)
- Railway asset management
- Opportunitets and threats
- Some railway regulations and standards
- Risk-based railway improvements
- Reliability-Centered Maintenance (RCM)
- Some risk models
- Discussion

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Trafikverket – Swedish transport administration



Railway

14,200
km of track

525
Stations

11,000
Switches and crossings

4,100
Bridges

165
Tunnels

Board of Directors
Director-General Roberto Maiorana

10,000
Employees

150
Different professions

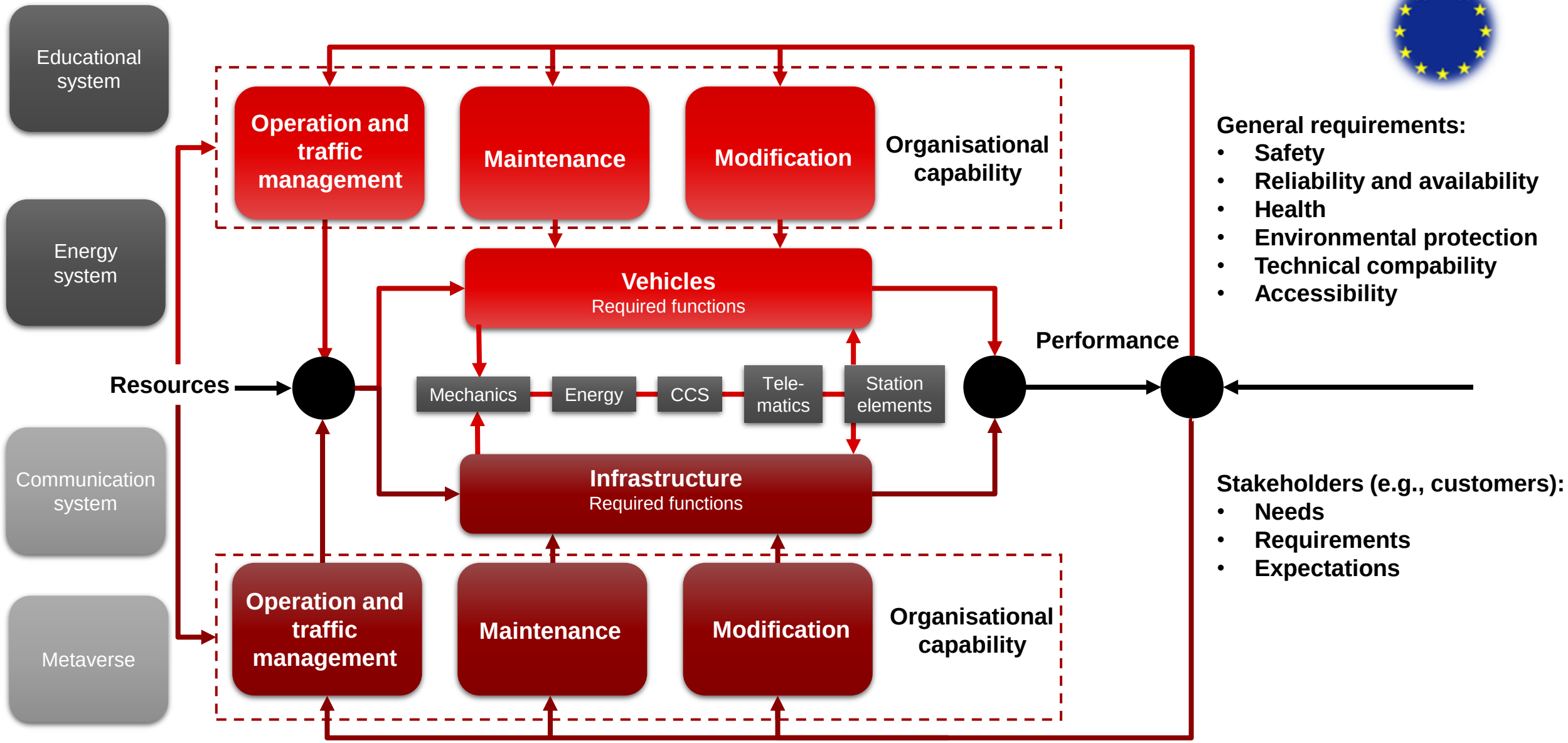
Business volume 2022
SEK 94,1 billion

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Railway asset management

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Based on Interoperability directive (EU) 2016/797



General requirements:

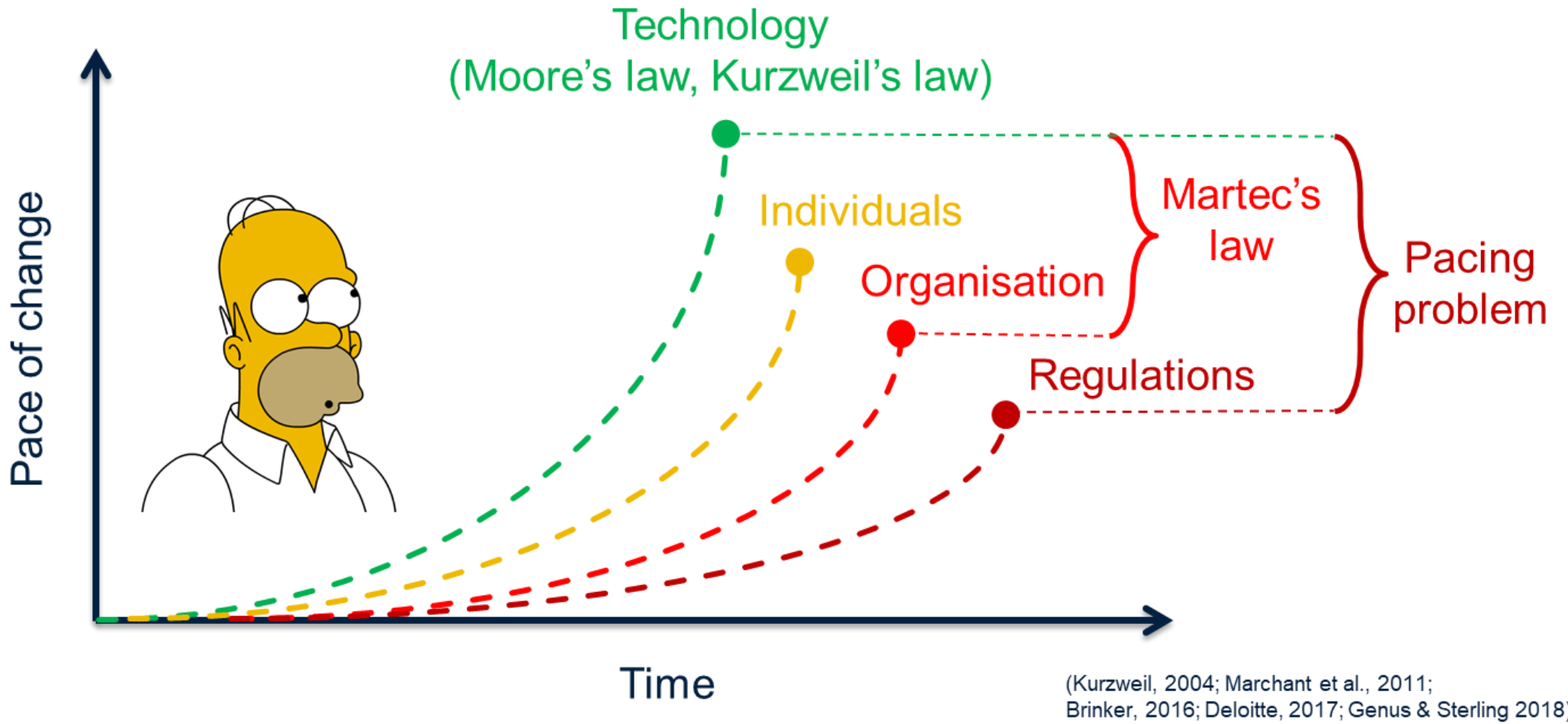
- **Safety**
- **Reliability and availability**
- **Health**
- **Environmental protection**
- **Technical compability**
- **Accessibility**

Stakeholders (e.g., customers):

- **Needs**
- **Requirements**
- **Expectations**

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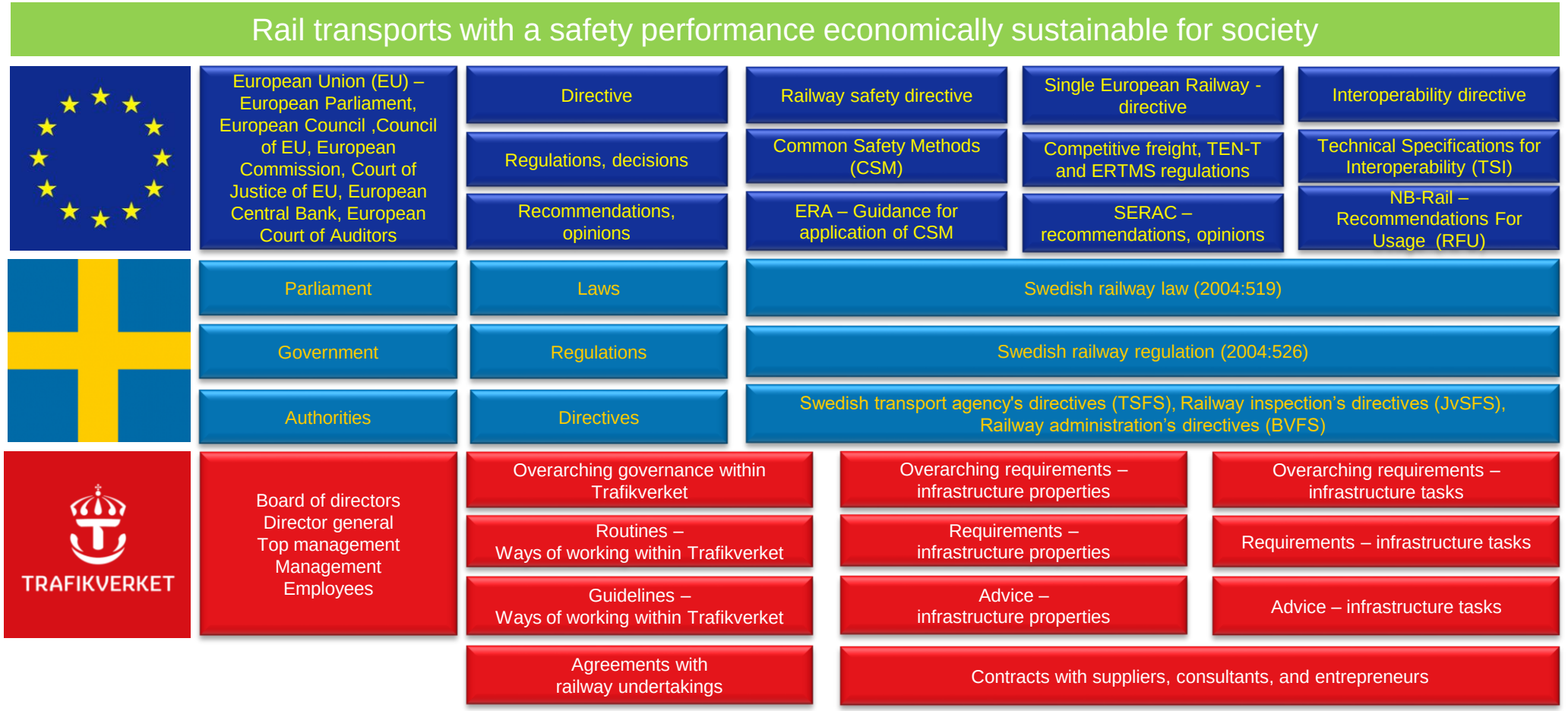
Opportunities and threats



(Kurzweil, 2004; Marchant et al., 2011;
Brinker, 2016; Deloitte, 2017; Genus & Sterling 2018)

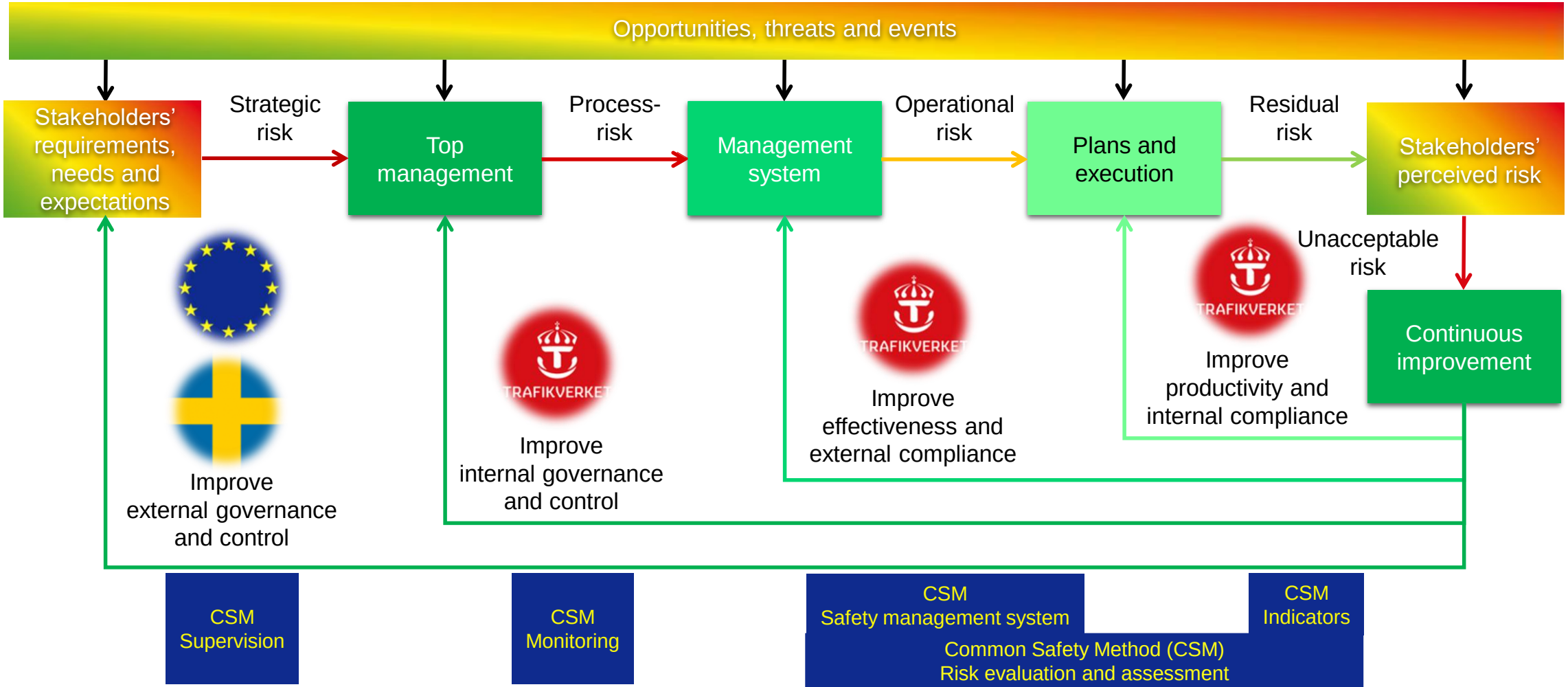
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Some railway regulations



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Risk-based railway improvements



Some requirements and support to risk-based railway improvements



Railway safety directive (EU) 2016/798

Directive for interoperability of railway systems (EU) 2016/797

ERA's guidance CSM SMS TR-06-22-120-EN-N

ERA's guidance CSM-RA ERA/GUI/01-2008/SAF

Common safety methods (CSM)

Technical specifications for interoperability (TSI) Command-control and signalling (CCS)

TSI Energy

TSI Infrastructure

TSI Accessibility

TSI Telematics

TSI Operation and traffic management

TSI Locomotives and passenger rolling stock

EN 50126-1 & -2 Railway RAMS

EN 50159 Transmission systems

IEC 60812 FMEA/FMECA

EN 61508 Safety-related systems

EN 50129 Hardware and software

IEC 61025 FTA

EN 61703 Mathematical expressions for dependability

EN 50128 Software

IEC 61165 Application of Markov techniques

IEC 60300-3-11 RCM

IEC 62502 ETA

IEC 60050-192 International electro-technical vocabulary

ISO 3534-1 Statistics – Vocabulary and symbols

IEC 60605-2 Design of test cycles

IEC 60605-4 Exponential distribution

IEC 60605-6 Constant failure rate and failure intensity

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Risk-based railway improvements

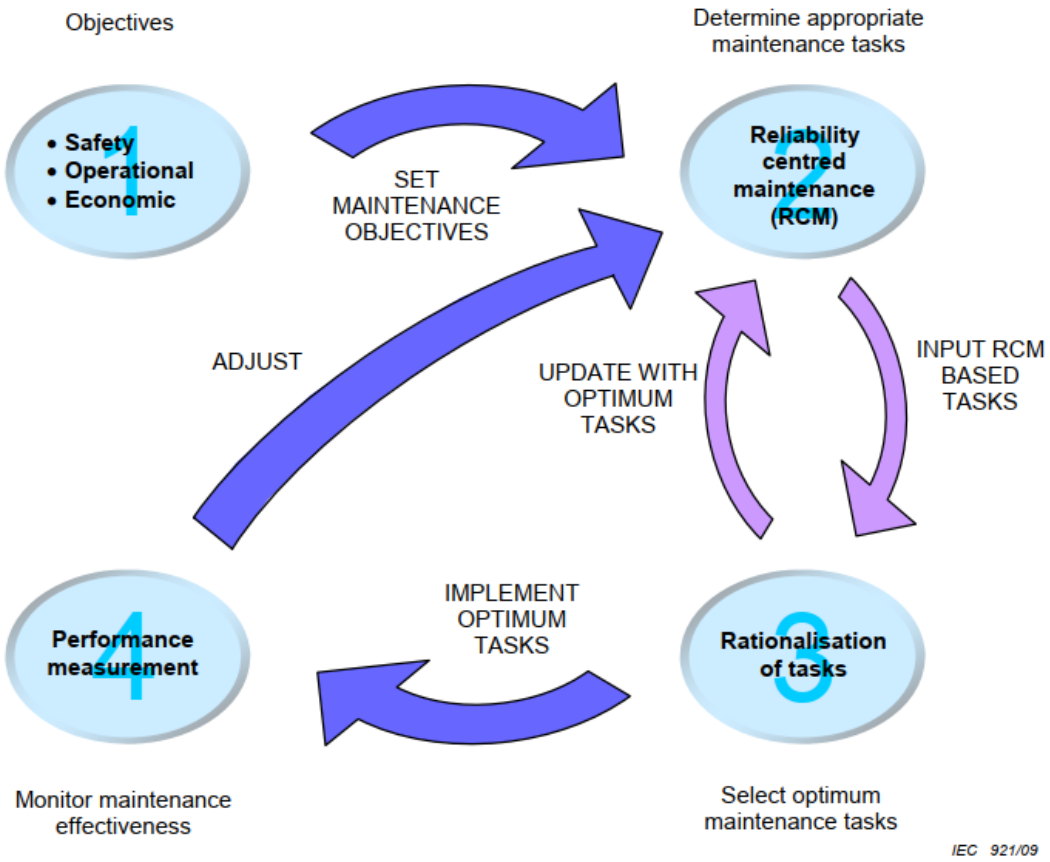
- Regulations
  - Common Safety Methods (CSMs) – Indicators, Risk evaluation and assessment, Safety management system, Monitoring, Supervision
- Standards
  - Management system (e.g., Dependability management, IEC 60300-3-1, Asset management, ISO 55001)
  - Methodologies (e.g., RAMS-process - EN 50126-1, System safety - EN 50126-2, Reliability-Centered Maintenance, RCM, IEC 60300-3-11)
  - Tools (e.g., sheets for Failure Modes, Effects & Criticality Analysis, FMECA, IEC 60812)

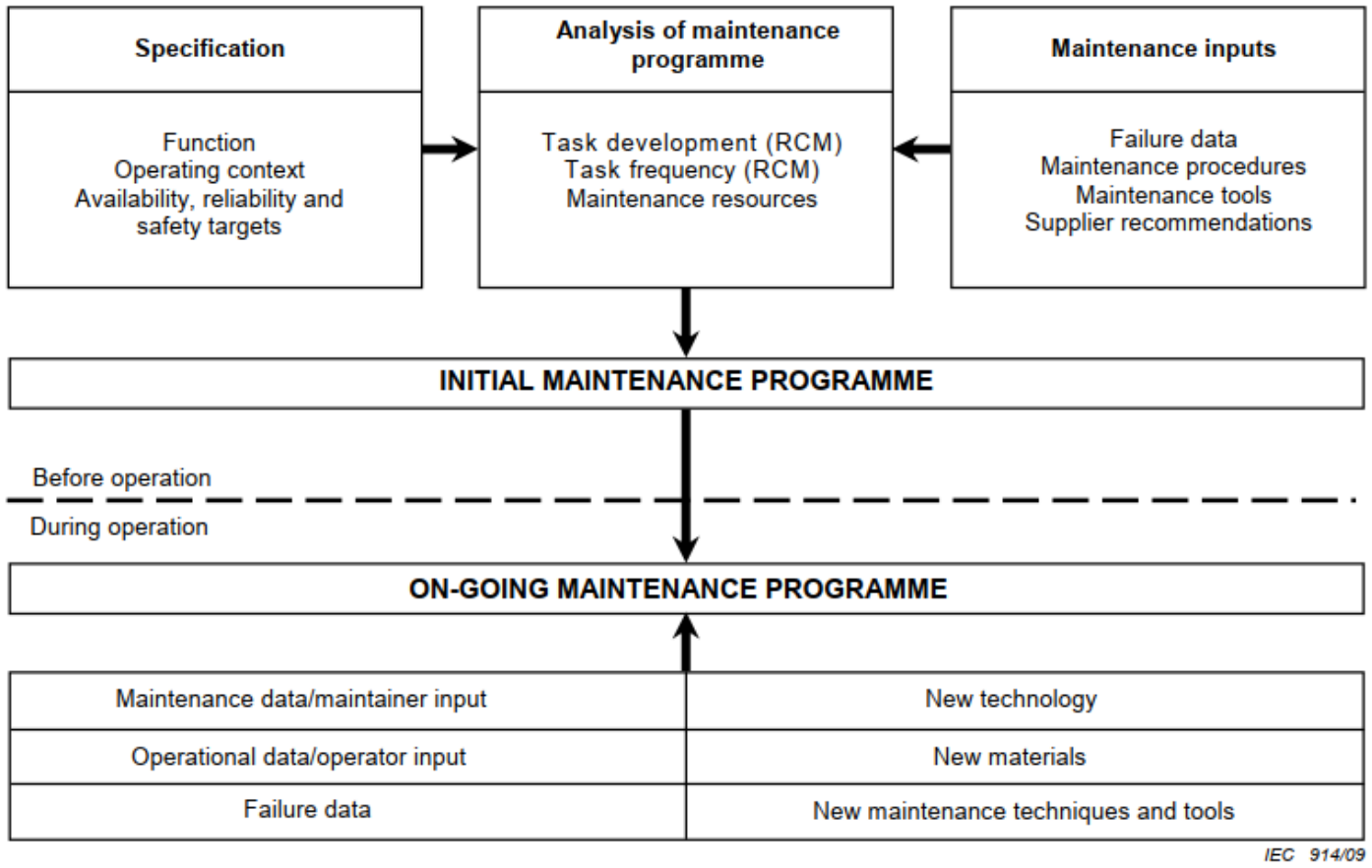


- Usually two types of improvements
  - To do things the right way (compliance and productivity) – single-loop learning
  - To do the right things (effectiveness and goal fulfilment) – doble-loop learning

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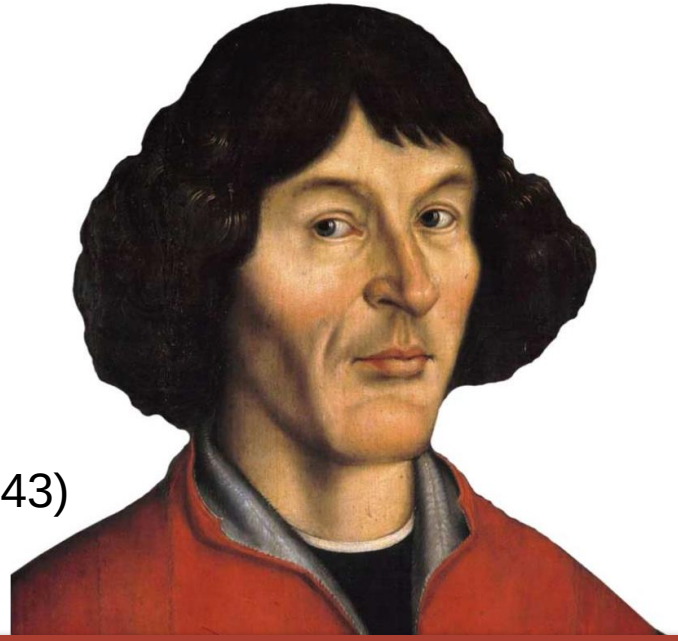
RCM – single- and double-loop learning



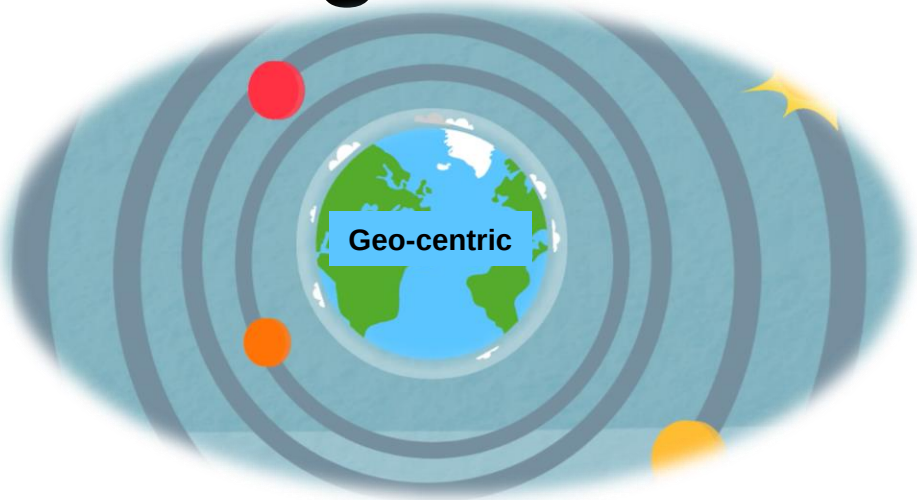


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One example of triple-loop learning or paradigm shift



Copernicus (1543)





Earth-centric (Geo-centric) model of Cosmos

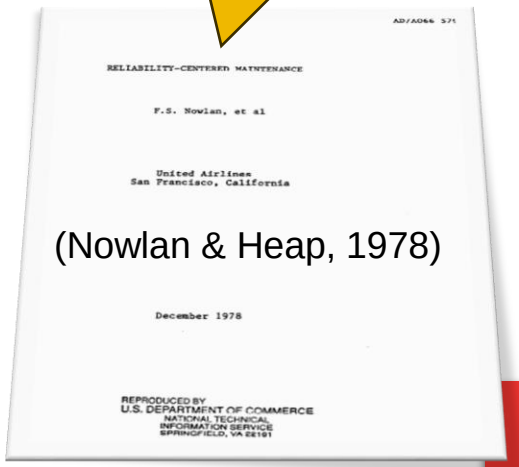
replaced by

Sun-centric (Helio-centric) model of Universe.

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Another example of tripple-loop learning or paradigm shift – Reliability-Centered Maintenance (RCM)

The driving element in all maintenance decisions is...


RELIABILITY-CENTERED MAINTENANCE

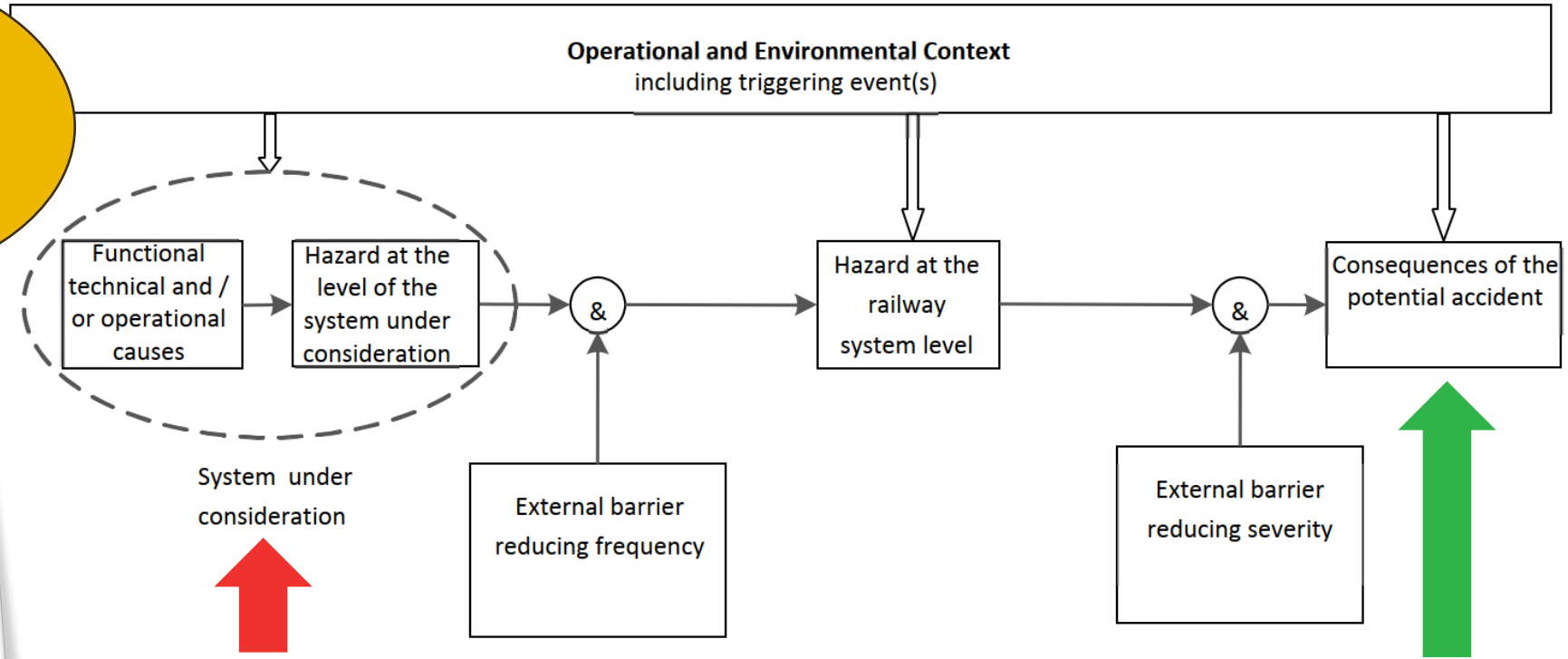
F.S. Nowlan, et al

United Airlines
San Francisco, California

December 1978

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA 22161

(Nowlan & Heap, 1978)



… not the failure of a given item, …

… but the consequences of that failure for the equipment as a whole.

Reliability-Centered Maintenance, RCM
(Nowlan & Heap, 1978)

as support to

three loops of learning, three conceptualizations of triple-loop learning
(Tosey et al., 2012)

and

a generic maintenance process
(IEC 60300-3-14)

Bateson	Argyris and Schön		Nowlan and Heap
Learning 0			
Learning I	Single-loop learning ⇨	Conceptualization B: *Deutero-learning* Reflexivity about processes of learning at either single- or double-loop levels, which Argyris (2003: 1179) characterizes as 'going meta'.	⇦ Maintenance planning and execution
Learning II	Double-loop learning ⇨		⇦ Maintenance support planning
Conceptualization C: *Learning III* Change of epistemology, or 'a corrective change in the system of sets of alternatives from which choice is made' (Bateson, 1973: 264). Learning III cannot be pursued instrumentally, entails significant risk, and is beyond language. Bateson's levels are organized recursively.	Conceptualization A: *Beyond and superior to double-loop learning* A level that is beyond, and considered by proponents to be superior to, Argyris and Schön's single-loop and double-loop learning in that it concerns underlying purposes and principles. It does not appear in Argyris and Schön's work.		
Learning IV			

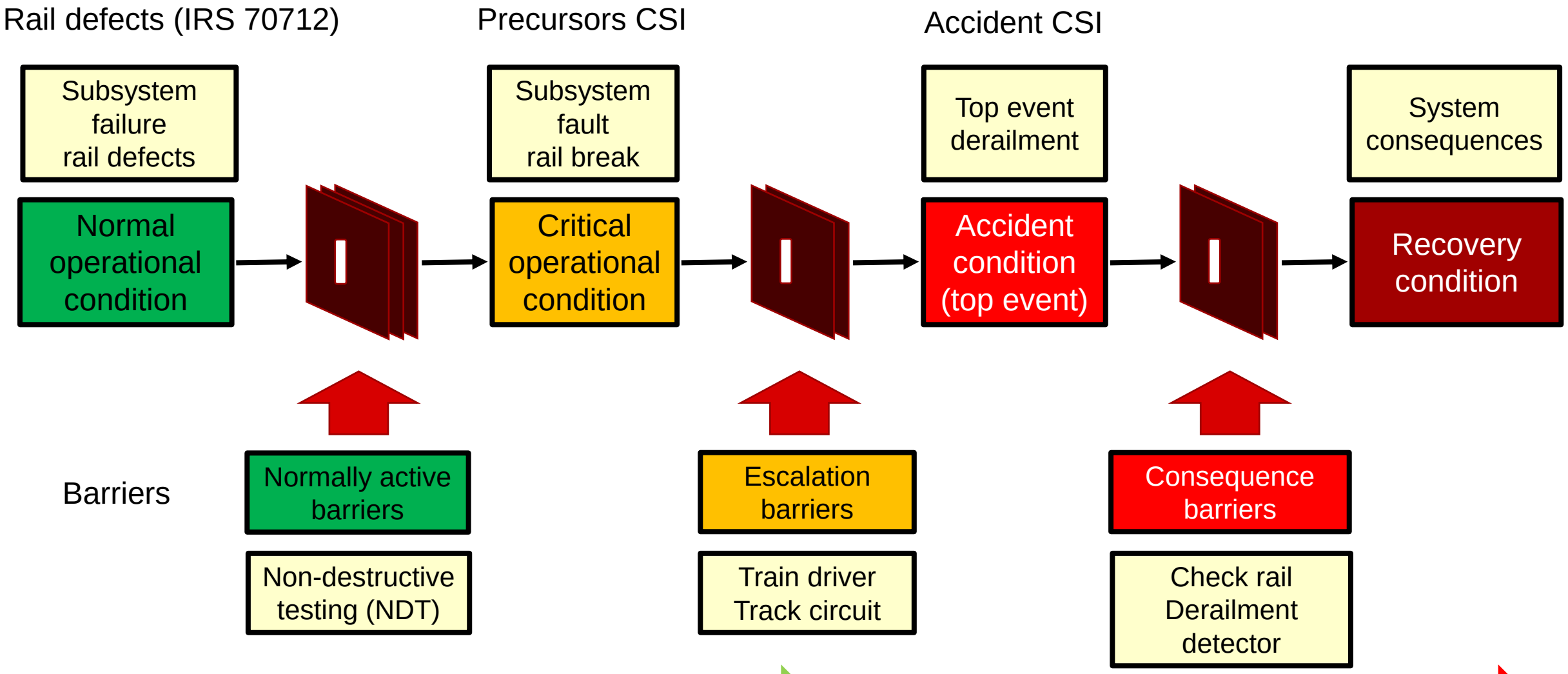
Maintenance management - RCM purpose and principles: the driving element in all maintenance decisions is not the failure of a given item, but the consequences of that failure for the equipment as a whole. ⇨ An applicable maintenance task is one that addresses the failure mode and is technically feasible.

An effective maintenance task is one that's worth doing and successfully deals with the consequences of failure.

Risk model

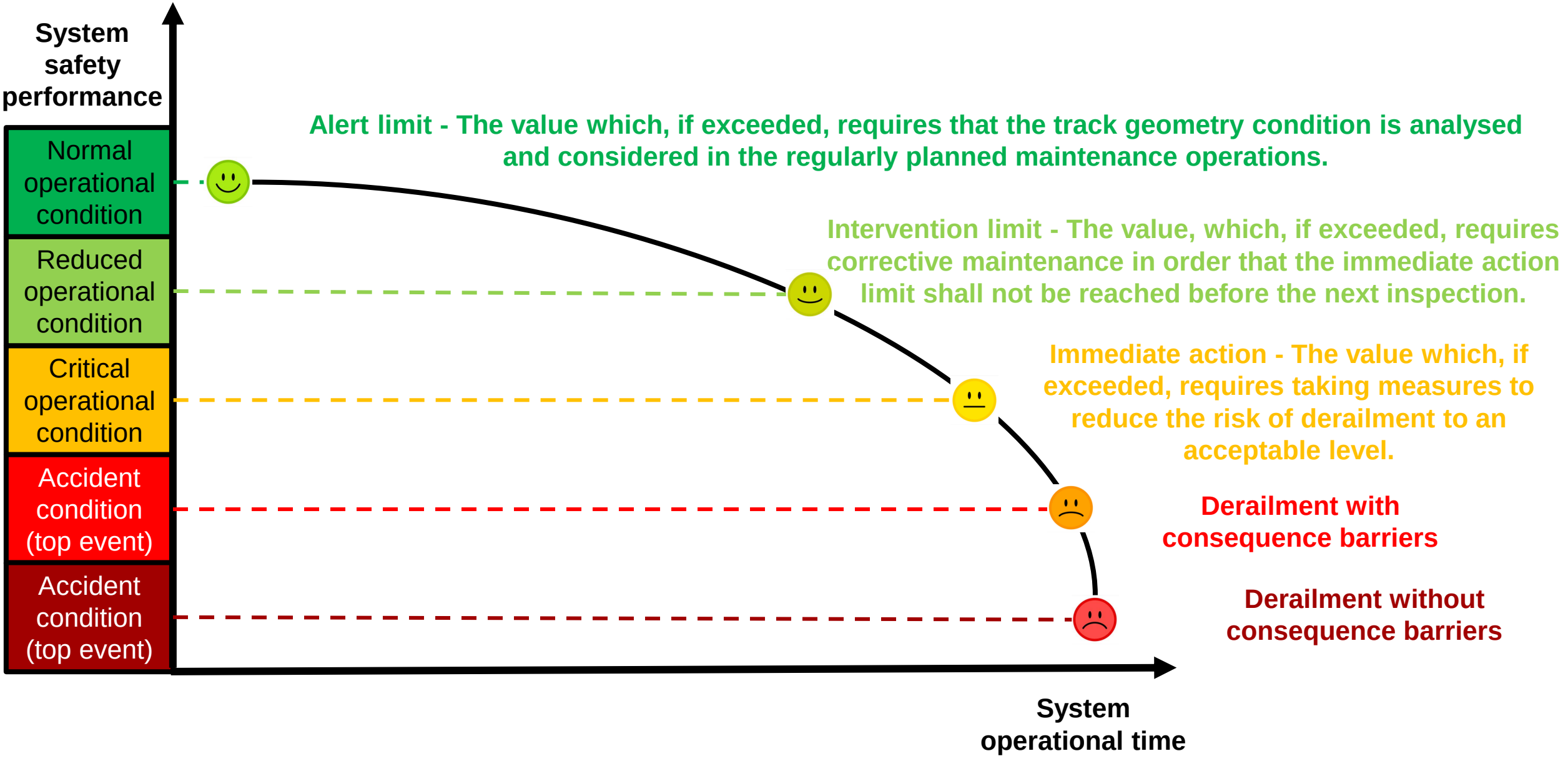
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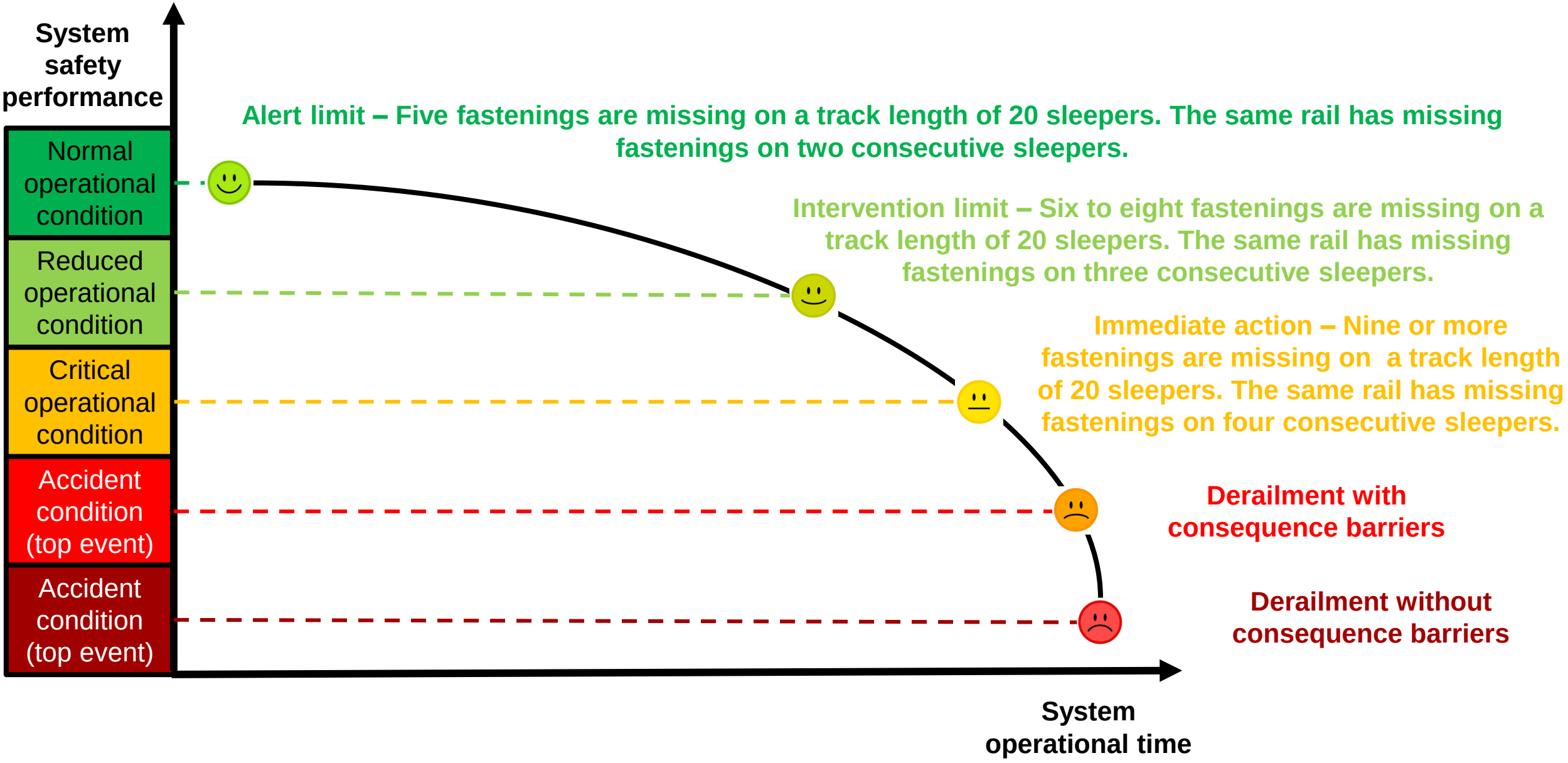
CSI = Common Safety Indicators

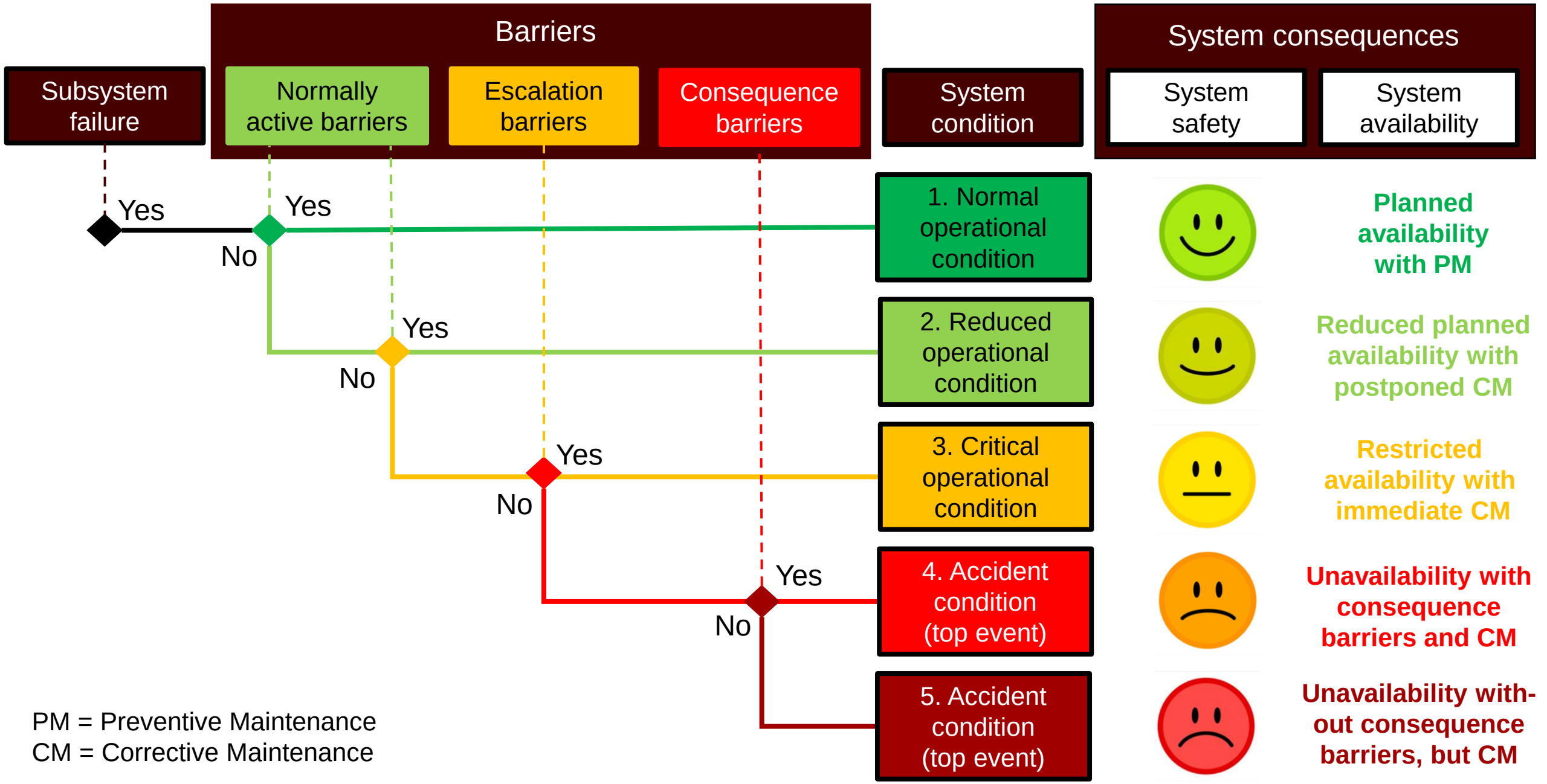


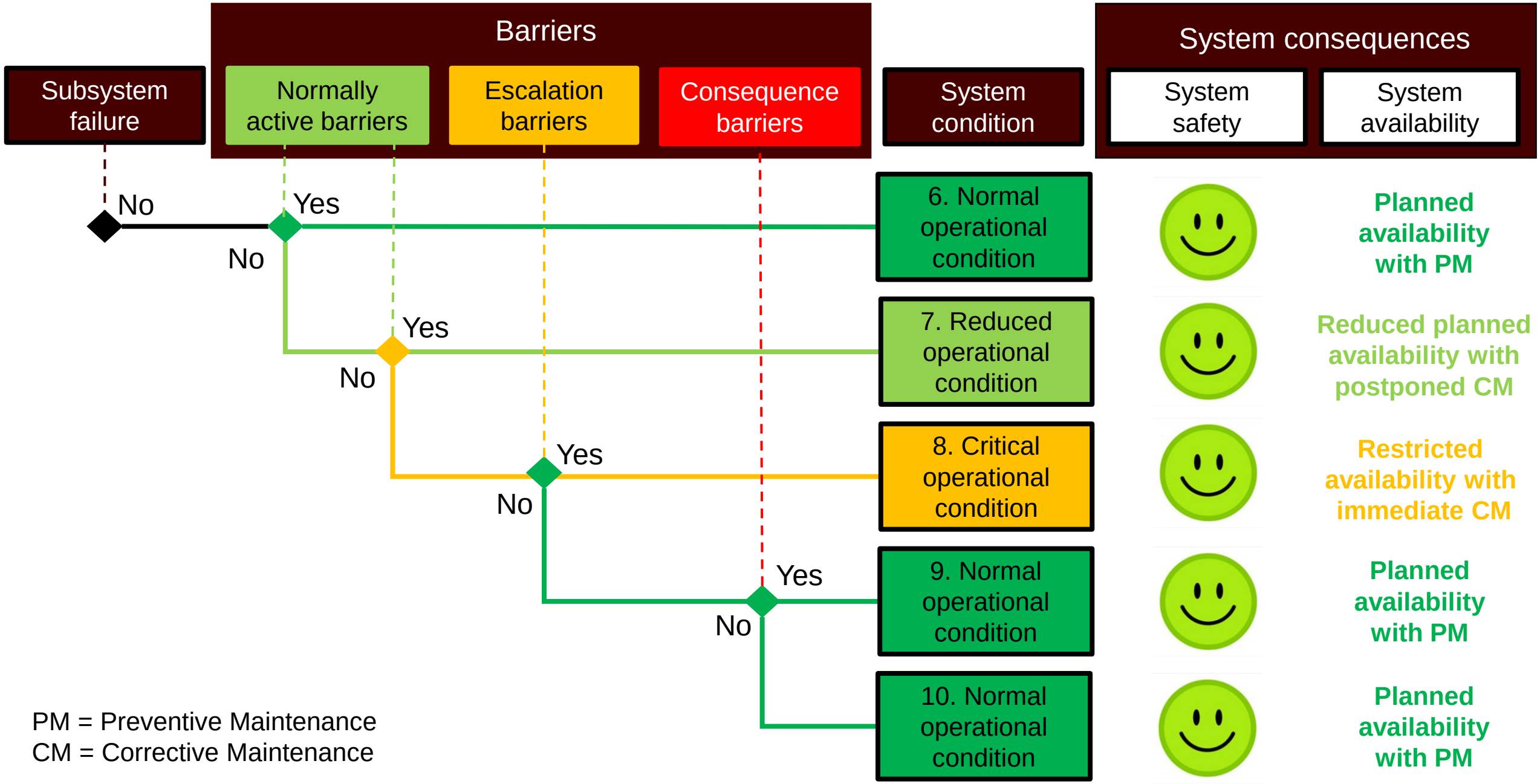
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EN 15273-3 - Railway applications – Gauges – Part 3: Structure gauges




System safety performance
Normal operational condition
Reduced operational condition
Critical operational condition
Accident condition (top event)
Accident condition (top event)
Alert limit – Five fastenings are missing on a track length of 20 sleepers. The same rail has missing fastenings on two consecutive sleepers.
Intervention limit – Six to eight fastenings are missing on a track length of 20 sleepers. The same rail has missing fastenings on three consecutive sleepers.
Immediate action – Nine or more fastenings are missing on a track length of 20 sleepers. The same rail has missing fastenings on four consecutive sleepers.
Derailment with consequence barriers
Derailment without consequence barriers
System operational time


Barriers
Subsystem failure
Normally active barriers
Escalation barriers
Consequence barriers
System condition
System consequences
System safety
System availability
Yes
No
Yes
No
Yes
No
Yes
No
1. Normal operational condition
2. Reduced operational condition
3. Critical operational condition
4. Accident condition (top event)
5. Accident condition (top event)
Planned availability with PM
Reduced planned availability with postponed CM
Restricted availability with immediate CM
Unavailability with consequence barriers and CM
Unavailability with-out consequence barriers, but CM
PM = Preventive Maintenance
CM = Corrective Maintenance

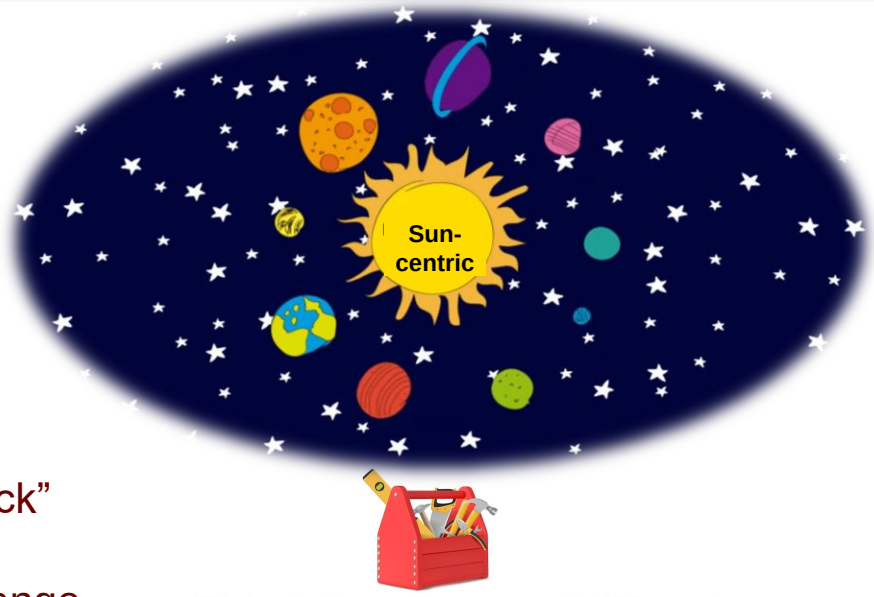

Barriers
Subsystem failure
Normally active barriers
Escalation barriers
Consequence barriers
System condition
System consequences
System safety
System availability
No
Yes
No
Yes
No
Yes
No
Yes
No
6. Normal operational condition
7. Reduced operational condition
8. Critical operational condition
9. Normal operational condition
10. Normal operational condition
Planned availability with PM
Reduced planned availability with postponed CM
Restricted availability with immediate CM
Planned availability with PM
Planned availability with PM
PM = Preventive Maintenance
CM = Corrective Maintenance

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Discussion

Relibility-Centered Maintenance (RCM)

Rail transport with a safety performance that is economically sustainable for society



”Future chock” stress
Too much change in too short time





(Inspirerad av Carnell, 2019)

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Some additional model support

Level	Description of organisational learning	Learning models	Management models
1	“Learn to do things the right way”. Incremental continuous improvement focused on compliance and productivity.	Single-loop learning (Argyris & Schön, 1978) Assimilation (Piaget, 1968, 1973) Adaptive learning (Senge, 1990) Reinforcement of competence (Sandberg & Targama, 1998) Lower levels of learning (Maltén, 2000) Bourdieu – social capital (Broady, 1998; Olesen & Pedersen, 2004)	“Formal manager” (Blake & Mouton, 1964, 1985) Guild system of craftsmen with apprentices, journeymen and masters (Maltén, 2000) Stability, structure, routines and instructions (Maltén, 2000) Management by resources and regulations (Maltén, 2000) Interpretation of regulations and administration (Maltén, 2000)
2	“Learn to do the right things”. Incremental continuous improvement focused on effectiveness and achievement of goals.	Double-loop learning (Argyris & Schön, 1978) Accommodation (Piaget, 1968, 1973) Generating learning (Senge, 1990) Competence renewal (Sandberg & Targama, 1998) Higher level of learning (Maltén, 2000) Bourdieu – cultural capital (Broady, 1998; Olesen & Pedersen, 2004)	“Strong Ideal leader” (Blake & Mouton, 1964, 1985) Goals, plans and means (Maltén, 2000) Communication, coordination, cooperation and trust (Maltén, 2000) Management by goals och decentralisation (Maltén, 2000)
3	“Creative learning, unlearning and relearning”. Radical innovation and creativity.	Triple-loop learning and unlearning (Wang & Ahmed, 2003) Highest level of learning (Maltén, 2000) Ziehe - cultural exemption, cultural expropriation and reflexivity (Lalander & Johansson, 2012) Hyper-learning, i.e., continual learning, unlearning and relearning (Hess, 2020) Treble-loop (spiritual) learning (Hawkins, 1991) Intelligent trial-and-error learning (Woodhouse & Collingridge, 2019) Informal and incidental learning (Marsick et al., 2015)	”First among equals” servant leadership (Williams et al., 2017; Greenleaf, 2008) Scientific management (Taylor, 1919) Creativity and creation of new knowledge (Maltén, 2000) Super-flexibility (Evans & Bahrami, 2020) Transformative leadership (Zimmerli et al., 2007)

Acknowledgements

Reality Lab
Digital Railway

VINNOVA

* ASSET * Aktiv, Systematisk Styrning för Effektivare Tillgångsförvaltning *

PDSA 5.0

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