Additional critical factors of success for hyper complex railway projects

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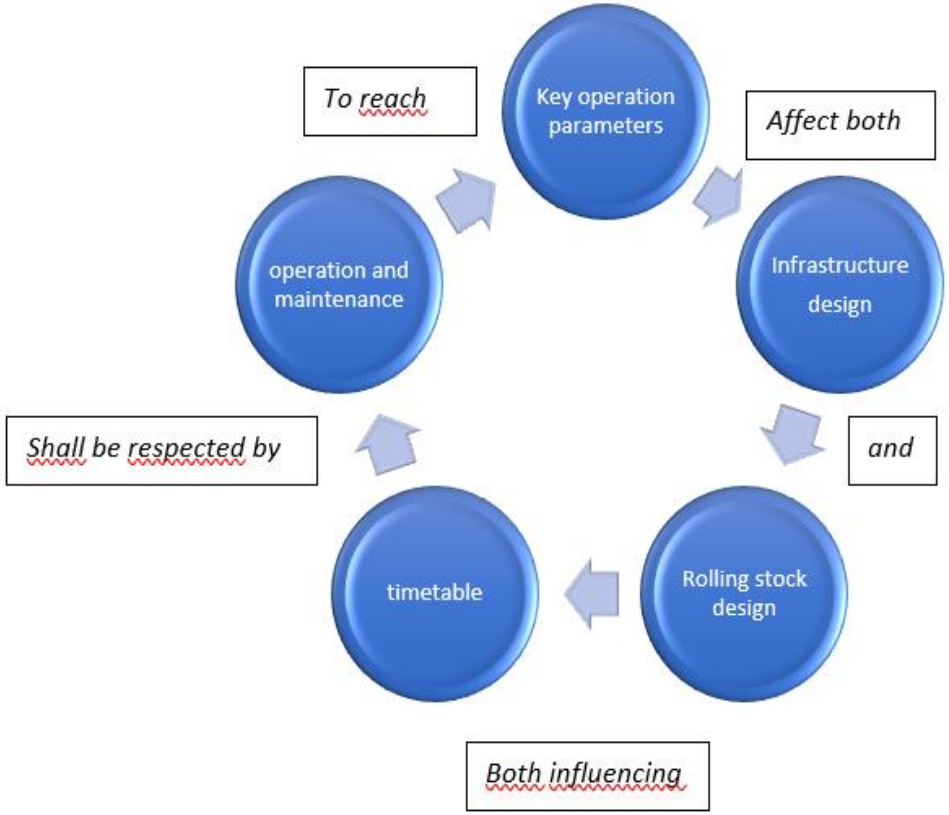
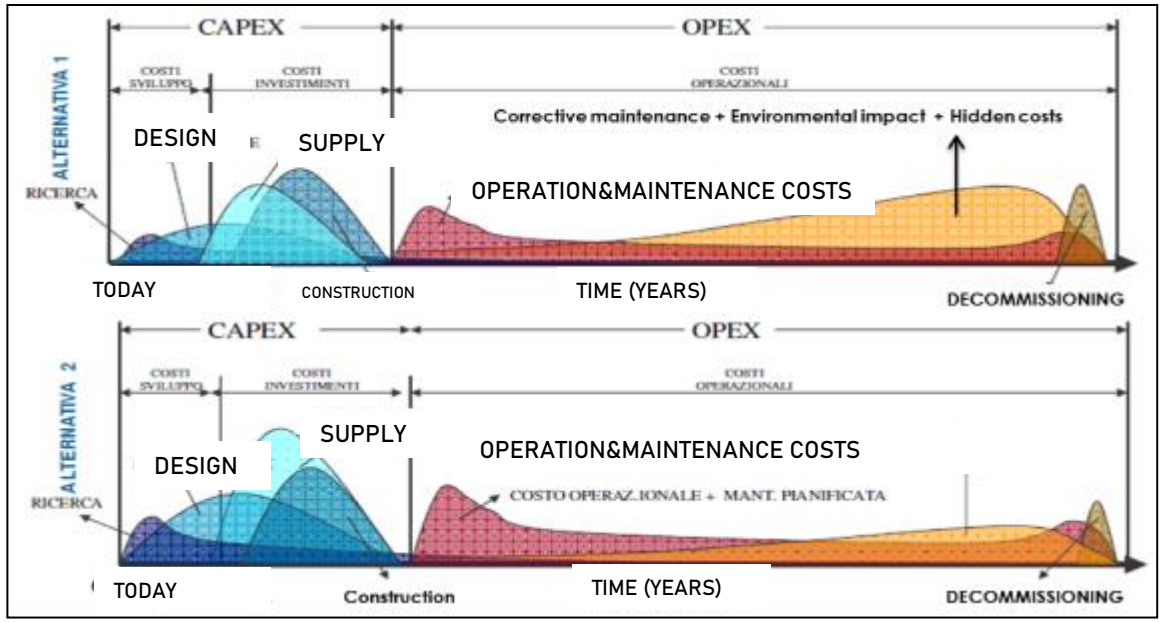
Having assessed and clarified the importance of having a strong and comprehensive organization (such as process specialists and systems integrator) two more aspects should be considered:

1. **the Operator perspective:** to harmonize the project design with rail Operator's eye (the Operator undertaking O&M activities is responsible for targeting KPI's, contractual expression of the key parameters approved during the design phase);

2. **full lifecycle cost approach (LCC):** through a methodology adopting technical and functional references pursuing cost-effective solutions on a life cycle term. (maintenance service and operational efficiency)



Functional and technical specifications: RAMS methodology is recommended because is based on continuous improvement throughout the whole system life cycle (LCC approach).



RAMS is an engineering discipline that looking at the quality of the rail services integrates reliability, availability, maintainability and safety characteristics by establishing operational objectives of a railway through performance KPI's.

RAMS management focus on the railway risks (The railway risks have a great potential to cause injury and/or loss of life of staffs and passengers, environmental degradation, damage to railway property or freight, and adverse economic impacts).

RAMS management key aspects:

1. the definition of RAMS characteristics: a check list of quantitative parameters prepared by designer and Suppliers to set up RAMS process (Targets, KPIs and penalties related to LCC and RAMS data).

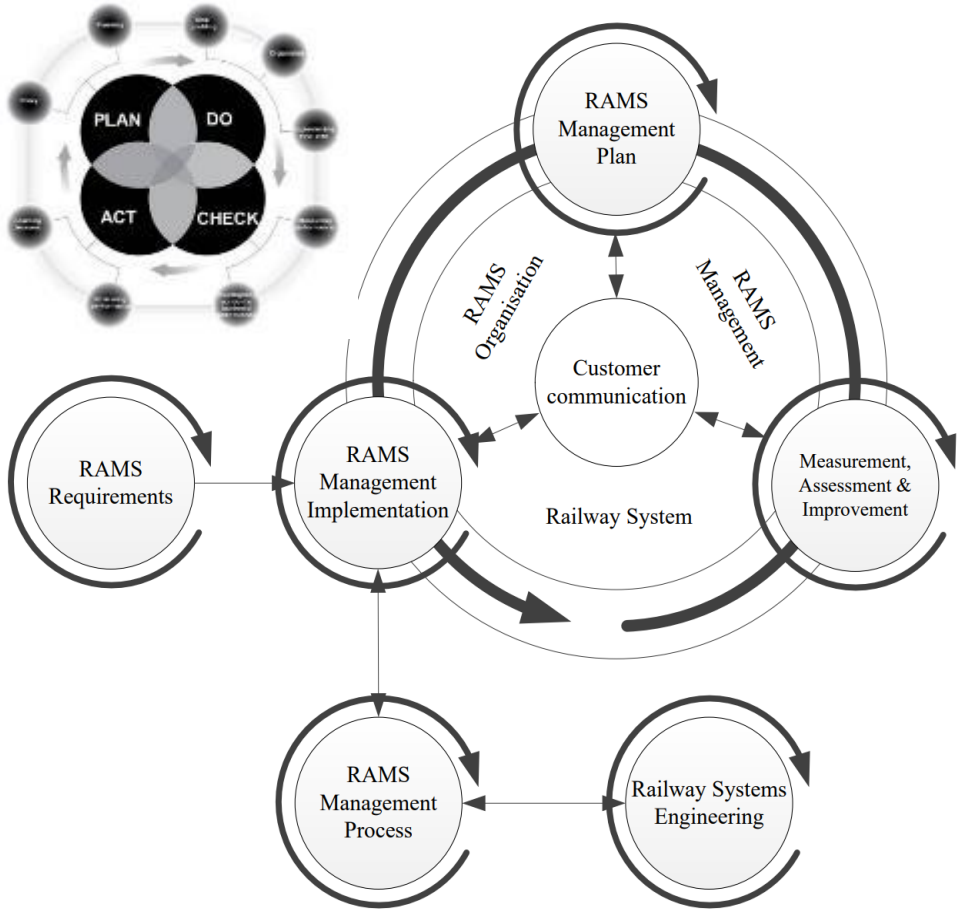
Non Comprehensive check list of RAMS KPI's	
1	Mission profile (working schedule, daily utilization, basic profile, etc..)
2	Duration of the Life Cycle to be analyzed
3	Expected life of the asset
4	Minimum duration of the warranty period
5	Calculation rules for service reliability and availability
6	List of safety constrains
7	Hourly cost of the reference personnel for maintenance
8	Minimum List of the systems to be covered by the CMS, qualitative and quantitative list
9	Frequency of the diagnostic data flows
10	Interval Time of communication between Asset and Servers (i.e. 30 sec)
11	List of basic constrains and fault severity definition
12	Software and Databases technical and functional requirements
13	Definition of applicable penalties for non-compliance with the data provided (penalties applicable, maximum applicable, contract cancellation clauses
14	Product tree developed up to the first 6 levels (for each level LRU, maintenance tools to remove, exchangebility,etc)
15	Calculation of asset reliability (MTBF, MDBF, MCBF) for every level of product tree
16	FMECA analysis of the systems with an impact on Safety or Service
17	Presentation of the F.T.A. (Fault Tree Analysis)
18	Presentation of the Asset Maintenance Plan
19	Definition of the list of applicable predictive maintenance and preventive intervention rules
20	Labor and material costs for preventive maintenance activities
21	Estimated labor and material costs for Predictive/Corrective maintenance activities
22	Estimated labor and material costs of Major Overhauls
23	Definition of the maintenance tools necessary to support
24	Presentation of the LCC parameters (such as energy consumption, final recycling, etc.)
25	Training plans to be provided

2 the assessment and control of the potential threats, such as faults, failures and errors, that affect the quality of rail traffic service and

3 the provision of the controlling processes, such as failure prevention, fault tolerance, fault removal and fault prediction

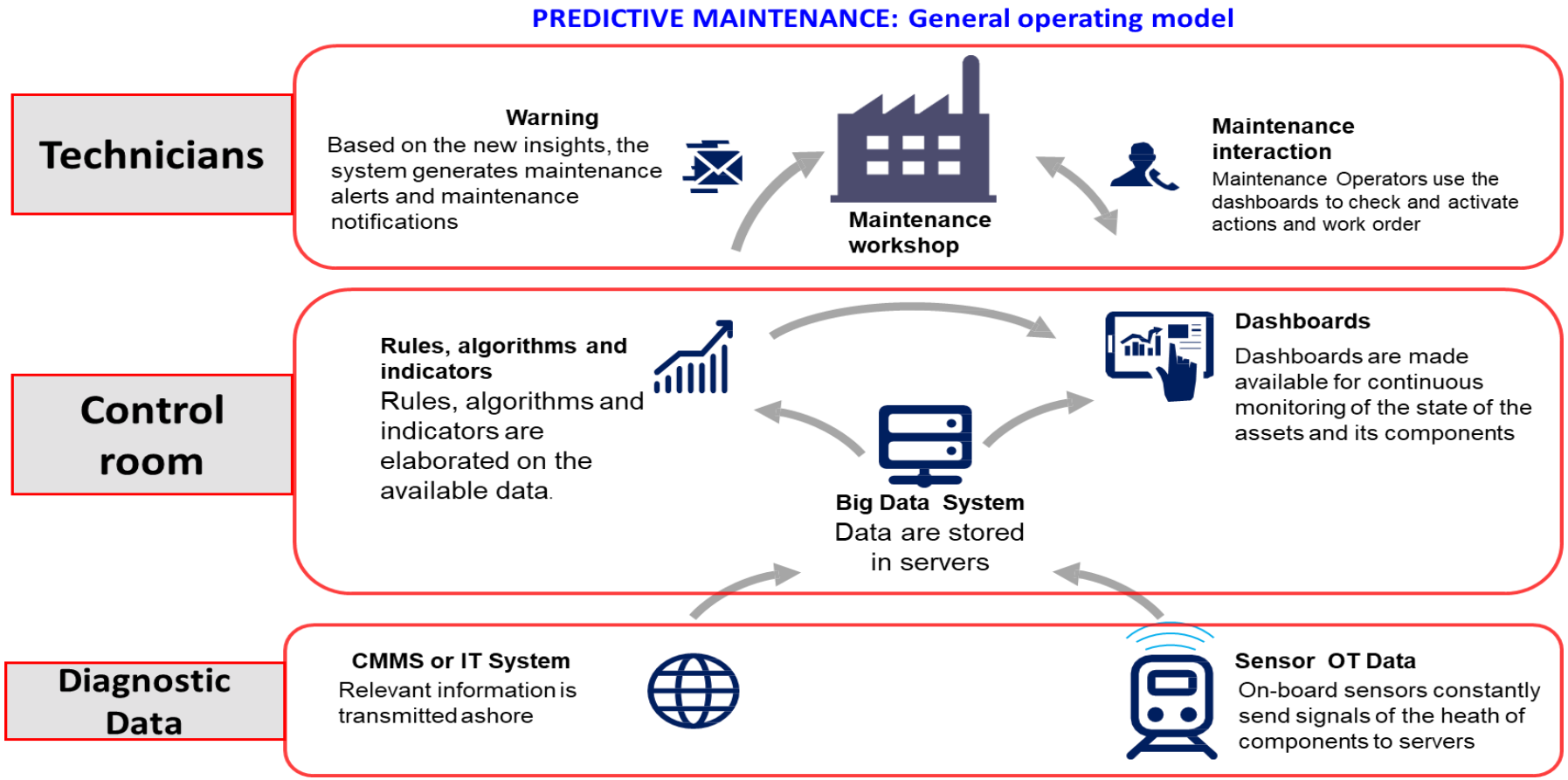
RAMS is a structured approach, based on international standards (PDCA) and consolidated experiences stemming from aviation and automotive.

RAMS is coherent with rail SMS inspired to same principles



Focusing on the third item (failure prevention and fault prediction) RAMS support the application of new technologies for maintenance engineering in the light of cost-effective solutions:

- requirements regarding the organization of a diagnostic system to increase asset availability and cost reduction (equipment, organization and staff, IOT, software applications);
- requirements regarding the operating model of predictive maintenance system.



Maintenance engineering as an application of RAMS approach

BENEFITS

- Engineering of the maintenance process: GO BEYOND CORRECTIVE (fault not avoided) and PREVENTIVE (more effort than strictly necessary);
- Identification of anomalies and faults in «Real time» because state of health of components is monitored continuosly with huge increase in asset availability;
- Maintenance costs reduction because no redundancy of components and breakage reduction.

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