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Reliability Engineering – an essential engineering discipline of the modern world

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Introduction

- "Reliability" is a common word used in daily conversion to describe how a product, equipment or services perform and in particular, the trustworthiness of its performance over a period of time, in a given operating environment and condition.
- Reliability Engineering as an engineering discipline is dedicated to the elimination of assets, equipment, process, services failures throughout the life-cycle.
- This paper discuss how reliability engineering skills contribute to the life-cycle performance of a product/asset/services.
- Further this paper will discuss the role of RE in industry 4.0 and Big Data Analytics.

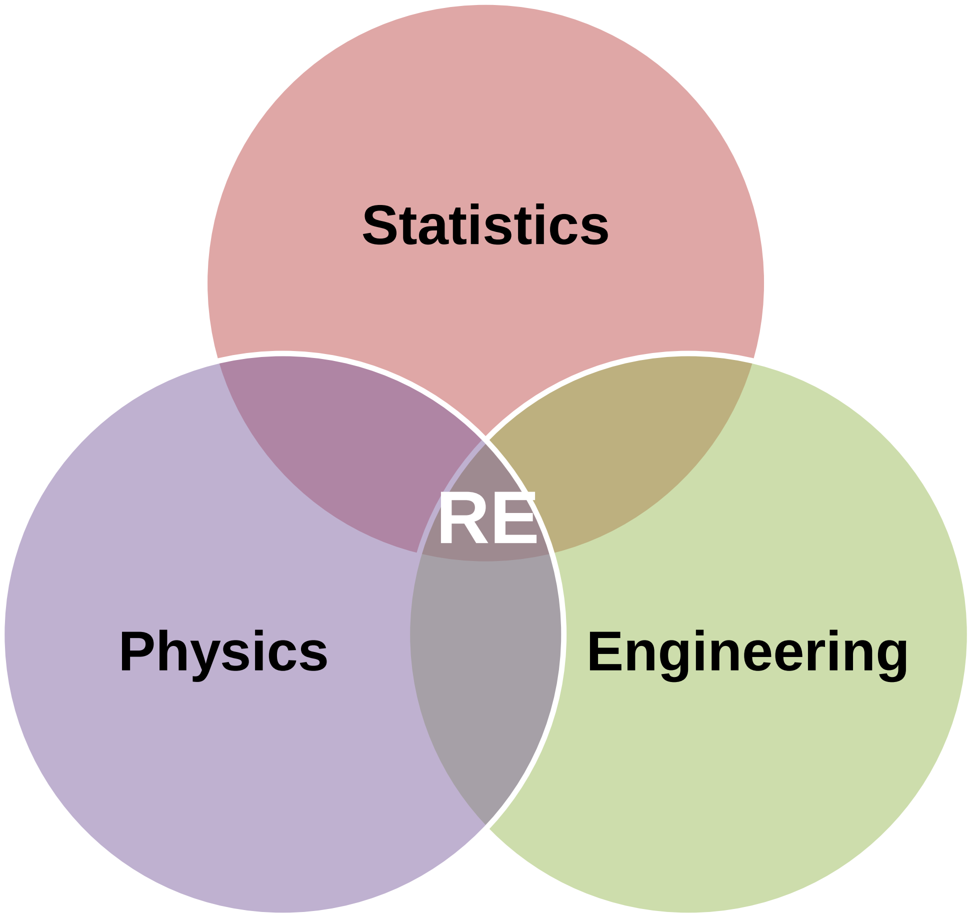
What is Reliability?

The probability of an item to successfully perform a required function under stated conditions without failure for a specified period of time.

"Stuff works when you want it to…"
- Ron Moore

Reliability Engineering

Reliability Engineering is an engineering discipline that combines **statistics, physics and engineering** practices and is dedicated to the study of the **uncertainty of performance over time**.



Application at different lifecycle stages

ISO/IEC TR24748-1:2018 Lifecycle Phases: Concept → Development → Production → Utilisation and Support → Retirement

Generic Lifecycle: Design → Build → Operate & Maintain → Disposal, replace, renew

Key Questions

Design
- How long it can last?
- What is the operating condition?
- What reliability is needed for each component?

Build
- Is it built as per design?
- Material used as per specified?
- System works when assembly together?
- Confident the system will last as specified?

Operate & Maintain
- Performance meet target?
- Design issues? Defects?
- Doing right maintenance, correctly at the right time?
- Operating the assets as per design?

Disposal, replace, renew
- Shall we keep maintaining / repairing?
- Shall we dispose and replace with like-for-like or shall we upgrade?
- Can we get spares from disposed assets?

Reliability Engineering Analysis

Design
- Expected life
- Risk appetite
- Reliability allocation
- Determine and plan for integration, verification, validation

Build
- User acceptance
- Reliability demonstration test
- Key production deliverables to YT

Operate & Maintain
- Performance objectives
- Reliability and performance analysis
- RCA and defect elimination
- Reliability growth
- Maintenance task analysis
- Info for resource analysis

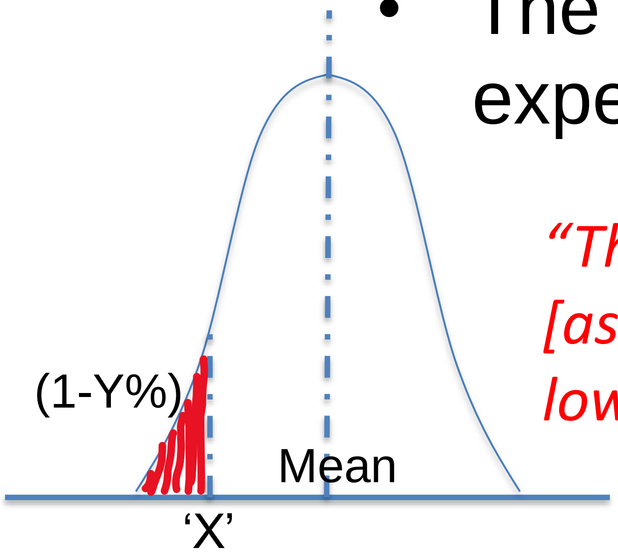
Disposal, replace, renew
- Lifecycle modelling and cost analysis
- Preventive replacement optimisation

Reliability Engineering in the Design stage

- Design stage includes activities of the concept and development stages as per ISO15288 (ISO/IEC24748-1:2018).
- The process begins with the recognition of a need for a new or modified asset (and/or system), writing the requirements, developing the specification and designing the asset/system.
- Key analyses are:
  - Determination of expected life and the risk appetite for the asset/system's expected life
  - Reliability allocation for sub-system and components
  - Determination and planning for the integration, verification and validation (IV&V) activities needed

Expected life and the related risk appetite

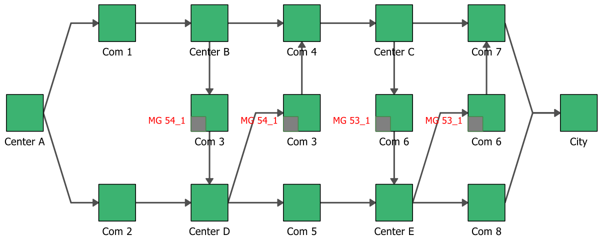
- The activities here include documenting stakeholder's expectation of product's expected life and their risk appetite for this figure.
- The process includes consultation and agreement on the expected "failure-free" period of a given product design.
- The outcome of this is a statement on the reliability expectation of a given asset/system:

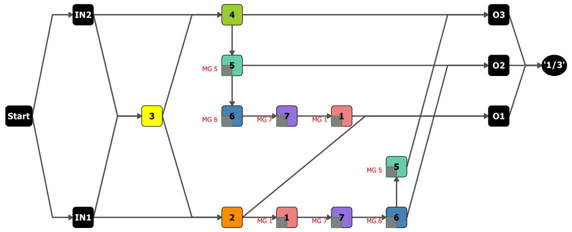


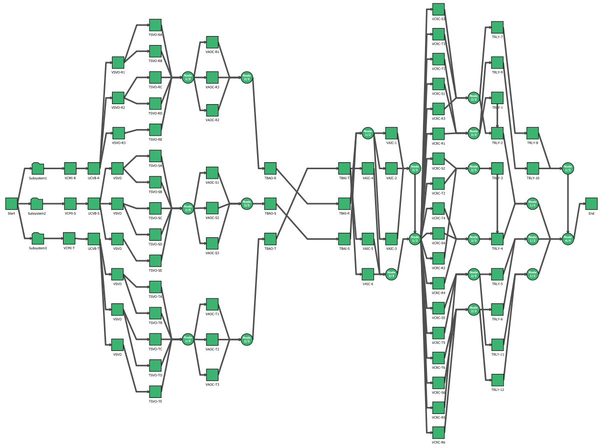
"The Mean Time [distance / cycles] Between Failure of [asset/system] is 'X' [Time Unit – days, years, km, cycles] at 'Y%' lower confidence."

Reliability allocation for sub-system & components

- A complex system is made up of many sub-systems and components.
- For a given complex systems' reliability performance requirements, it is necessary to allocate the reliability required for each sub-system and component.
- We can use Reliability Block Diagram.





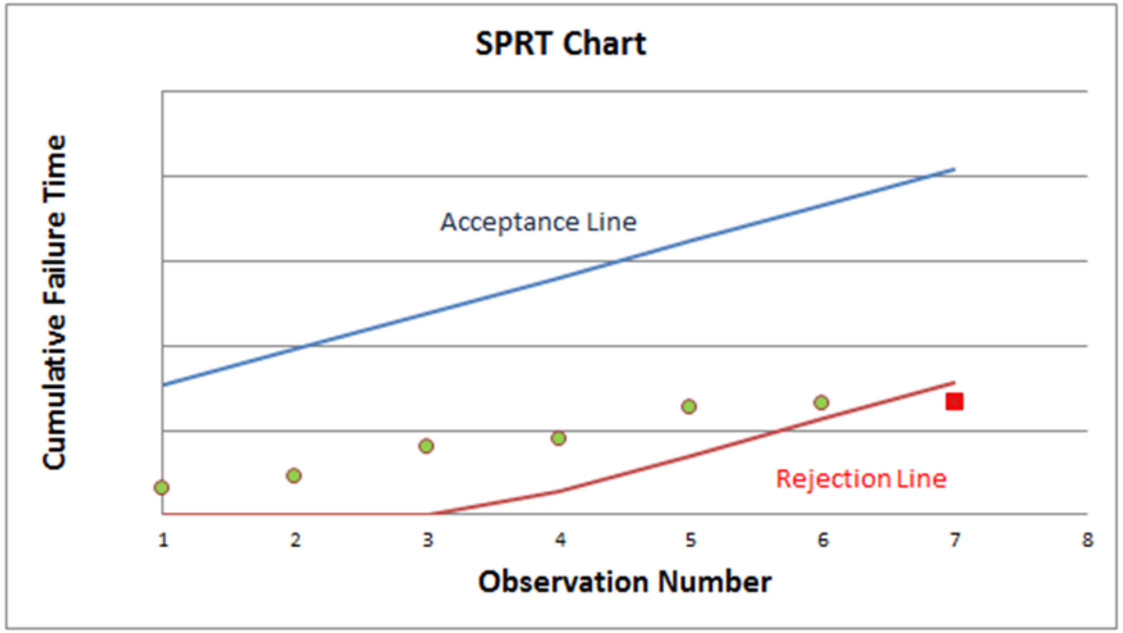


Determine and plan for the integration, verification and validation (IV&V) activities

- A complex system design may include sub-system and components' design and manufacture by different suppliers. The **integration** process is about combining all these into a single system.
- Once these components are combined into a system, the system will need to be tested that it has been "built right" – this is the **verification** process.
- The **validation** process will then ensure that the designed system, when in use, will fulfil its business or mission objectives and stakeholder requirements, achieving its intended use in its intended operational environment.

Reliability Engineering for IV&V stage

- Depending on the expected life and confidence level needs, the test sample and duration of the test can be calculated, this is known as Reliability Test Design.
- A number of tests available for reliability demonstration such as the Sequential Probability Ratio Test.



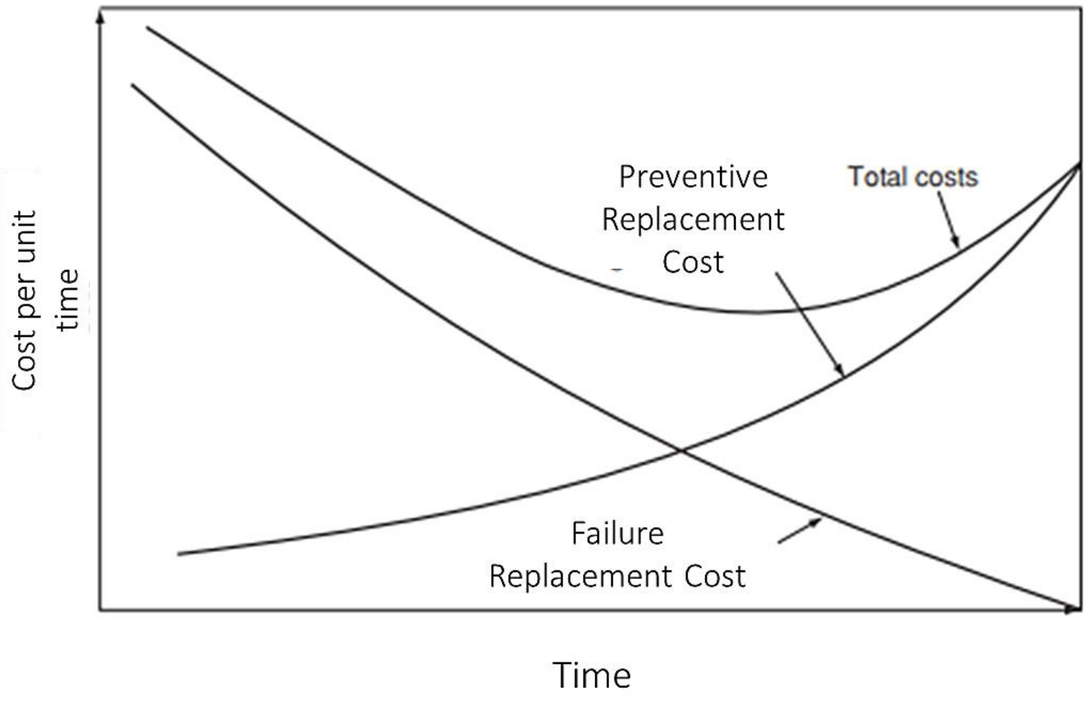
Reliability Engineering in the Build stage

- The Build stage incorporate the Production phase of the ISO15288 life cycle.
- Depends if you’re the consumer or producer of the system.
- The focus is to establish plans and mechanisms to ensure system delivered to Consumer is fit for purpose and meets reliability expectation – and at optimal cost (Producer)
- The key process applied during this stage is Reliability Demonstration Test.
- A number of artefacts are also expected: Asset Information, FMEA, RCM, Maintenance Plan, Manual, Logistics Support Requirement (spares, tools, competency, facilities)

Reliability Engineering in the O&M Stage

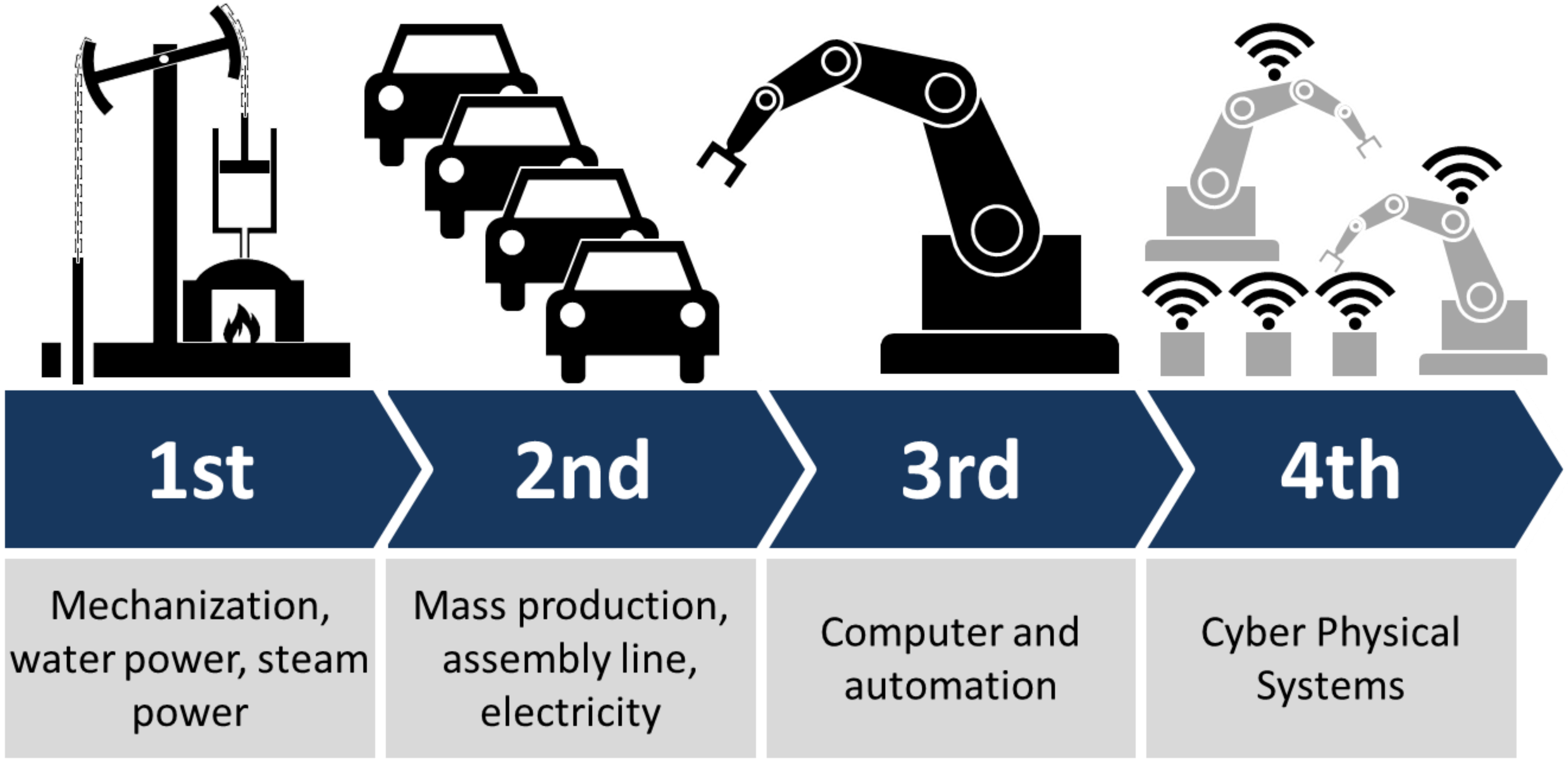
- Key questions:
    - Performance meet target?
    - Design issues? Defects?
    - Doing right maintenance, correctly at the right time?
    - Operating the assets as per design?
- RE analysis:
    - Monitor and Review asset performance objectives
    - Reliability and performance analysis (Repairable / non-repairable)
    - Defect elimination, root cause analysis and reliability growth
    - Maintenance task analysis and optimisation
    - Resource analysis

Dispose Stage



- The disposal stage covers the requirement of ending the existence of a system for use and ensuring that the required function of that system is replaced by appropriate replacement system.
- The Lifecycle Analysis and Preventive Replacement Optimisation decision approach are the initial analyses from a reliability engineering perspective where the decisions are made to retire (or dispose) an asset.

Industry 4.0, Big Data Analytics & RE…



What is it all about?

- Get to the failure just before it occurs (Just-in-time maintenance)
- Get most life out of the component
- No need to do more Planned Maintenance, all just in time
- Low to No Failure – because we know what is going to happen next and we fixed them just in time
- Fix the problem by itself if possible

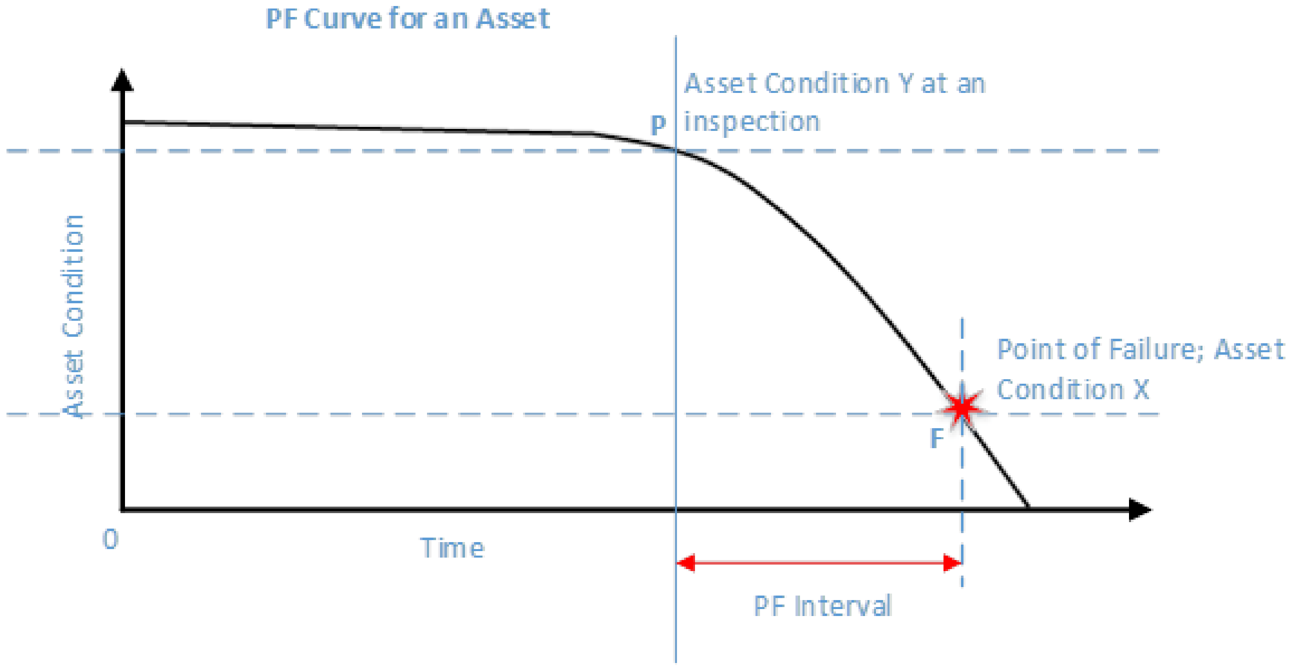
Big Data Analytics and Reliability Engineering

- Big data
  - Advancement in modern information and communication technologies allowing more and more data being generated and are captured
  - Technologies such as cloud based computing, IoT and mobile technologies give raise more data being generated an available
- Analytic – the process of discovery, interpretation and communication of meaningful information (patterns in data)

PF Curve and Big Data Analytics

Inspections check for key health parameters to assess asset condition
To prevent failure, we need to perform these at a frequency less than the PF Interval
PF Interval tells us how quickly we need to take the necessary corrective actions in order to prevent the Functional Failure from occurring.

Ideal Case with BDA:
Replace all inspections and checks by machine condition data, and let the computer tells you when is the best time to do something.



Big Data, IoT, Industry 4.0 & Reliability

- Need data – lots of it (hopefully with good quality).
  - Need to understand the Failure Mechanism (Engineering)
  - Need to understand the Probability of failure (Statistics)
  - Need to understand the material and physical behaviour of materials and mechanism (Physics)
- Need analytic and computation power
- Supply Chain will need to be spot on
- Best to be done during Design Stage!

Key Take Away…

- Reliability Engineering is an essential Engineering discipline applicable in most engineering environment
- Reliability Engineering Combined Statistics, Physics and Engineering
- This paper highlighted various Reliability Engineering tools applicable in an asset life cycle
- Reliability engineering should be offered as an elective course in all post-graduate engineering degree

Thank you!

Reliability Engineering is working when nothing exciting happens…

#Dr Allen Tam