Reliability Centered Maintenance & Maintenance Planning

Jordan Holt

Director Performance Improvement

Francesco Palmeri | CRE. PMP, PE

Director Reliability Centered Maintenance Planning

Washington Metropolitan Area Transit Authority

Key References

a. Nowlan & Heap (Dec 1978), ***Reliability Centered Maintenance,*** United Airlines, San Francisco, CA, USA.

b. John Moubray (1990), ***RCM2,*** Industrial Press Inc, NY, USA

c. SAE International Standard JA1011 (Aug 2009), ***Evaluation Criteria for RCM Processes***

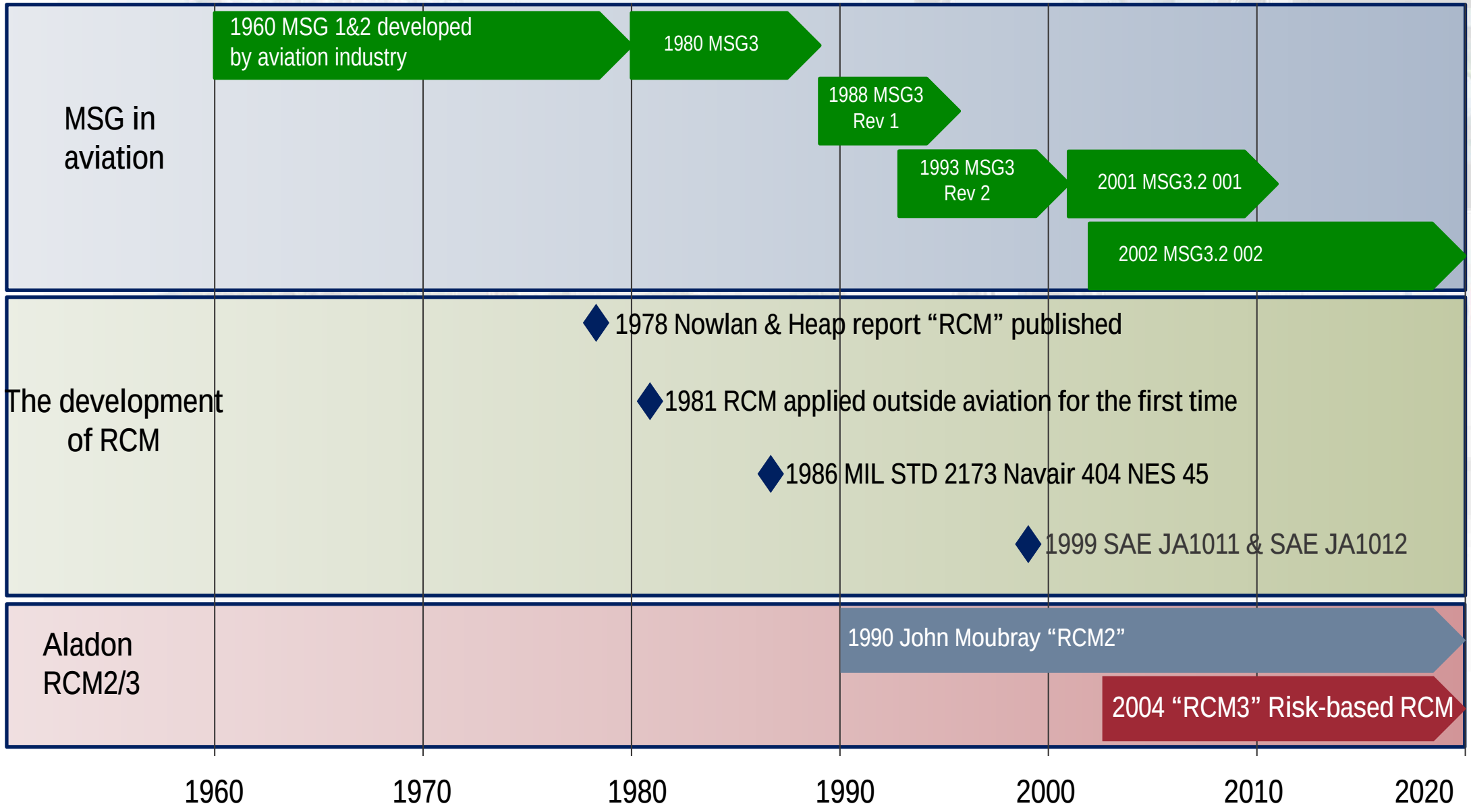
d. SAE International Recommended Practice JA1012 (Aug 2011), ***A Guide to the RCM Standard***

e. Marius Basson (2018), ***RCM3,*** Industrial Press Inc, NY, USA

Another very useful reference

a. Doc Palmer (1999), ***Maintenance Planning & Scheduling*** *3rd Edition,* McGraw Hill, NY, USA

Historical Timeline of the Notable Developments in RCM



What is Reliability Centered Maintenance (RCM)?

- **Nowlan & Heap:** A logical discipline for the development of scheduled maintenance programs to realize the inherent reliability capabilities of equipment.

- **RCM2:** A process used to determine what must be done to ensure that any physical asset continues to do what its users want it to do in its current operating context.

- **RCM3:** A process used to define the minimum required safe amount of maintenance, engineering and other risk management strategies to ensure a tolerable level of safety and environmental integrity and cost effective operational capability as specified in the organization's asset management standards.

Steps of the RCM3 Process

The eight (8) steps of RCM3:

Step 1: What are the operating conditions? (Define the operating context)

Step 2: What are the functions & performance stds? (What do users want it to do)

Step 3: In what ways can it fail? (Define the failed states)

Step 4: What causes it to fail? (Determine failure causes & mechanisms)

Step 5: What happens when it fails? (Determine failure effects & consequences)

Step 6: What are the risks associated with each failure? (Inherent risks)

Step 7: What must be done to reduce intolerable risks to a tolerable level? (Proactive risk management)

Step 8: Can anything be done to reduce tolerable risks in a cost effective way? (Default risk management)

Risk = Probability x Consequences

- In order to reduce an Intolerable risk to a Tolerable level, we have three (3) choices. We could:

  a. Reduce the Probability of occurrence through proactive maintenance,

  b. Reduce the Severity of consequences through a one-time change (modification, training, change in process or procedures),

  c. If possible; do both (depending on the severity of the consequences).

Proactive Task Options

- Predictive or condition-based maintenance
- Preventive maintenance – scheduled restorations
- Preventive maintenance – scheduled discards
- Failure finding tasks (only for protective devices)
- Functional checks
- One-time changes (Modification, Training, Procedures).

Generation I – Maintenance / Design Philosophy

- Run everything to failure - repair or replace as required (Run to failure)

Generation II – Maintenance / Design Philosophy

- Assume all components have a useful life limit. Replace components before they reach that useful life limit (Safe life)
- Add redundancy (Fail safe)

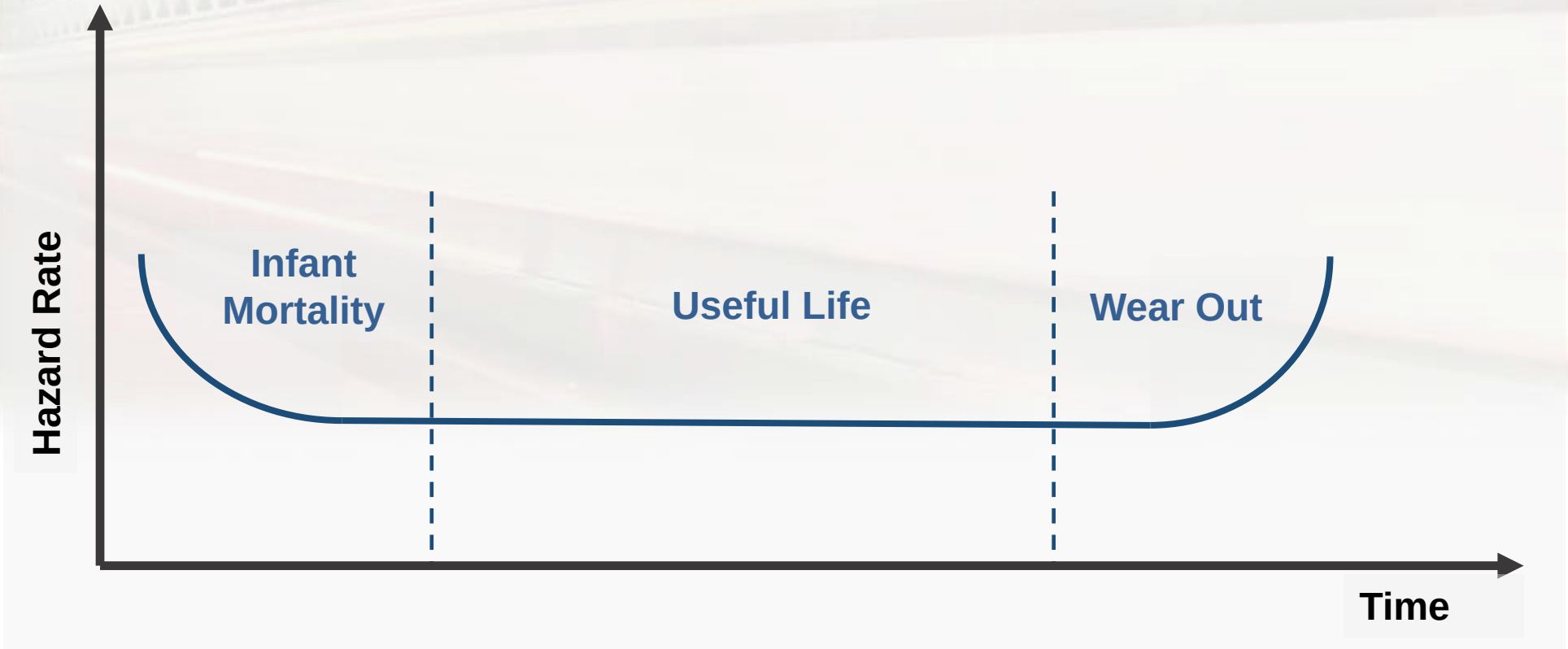
Generation III – Maintenance / Design Philosophy

- Design for Reliability - only do maintenance when required (Damage tolerant)
- Introduce Condition Monitoring
- Adopt a Condition Based Maintenance approach

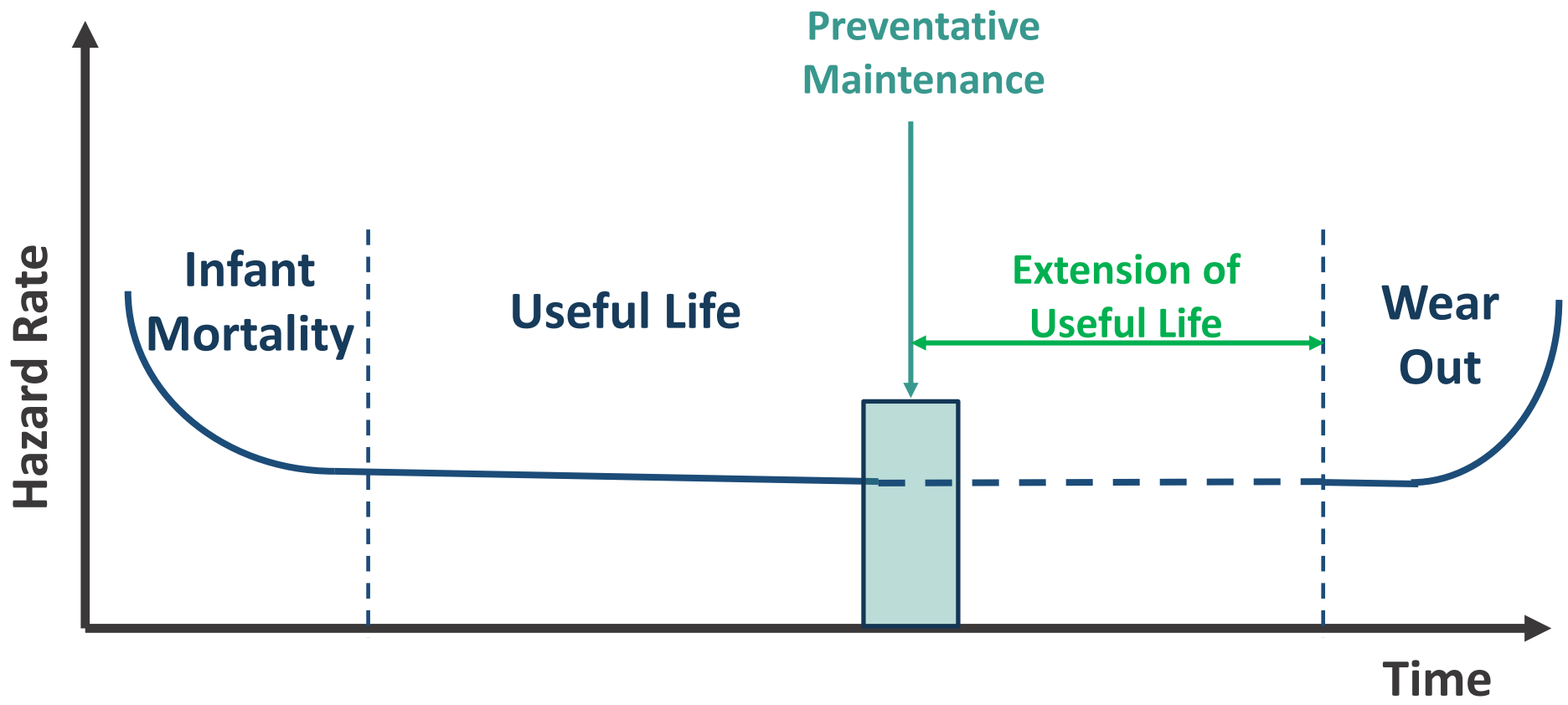
Generation IV – Maintenance / Design Philosophy

- Industrial Internet (IIoT)
- Making use of the real time data capture and wireless technology
- Integration with the Computerized Maintenance Management System

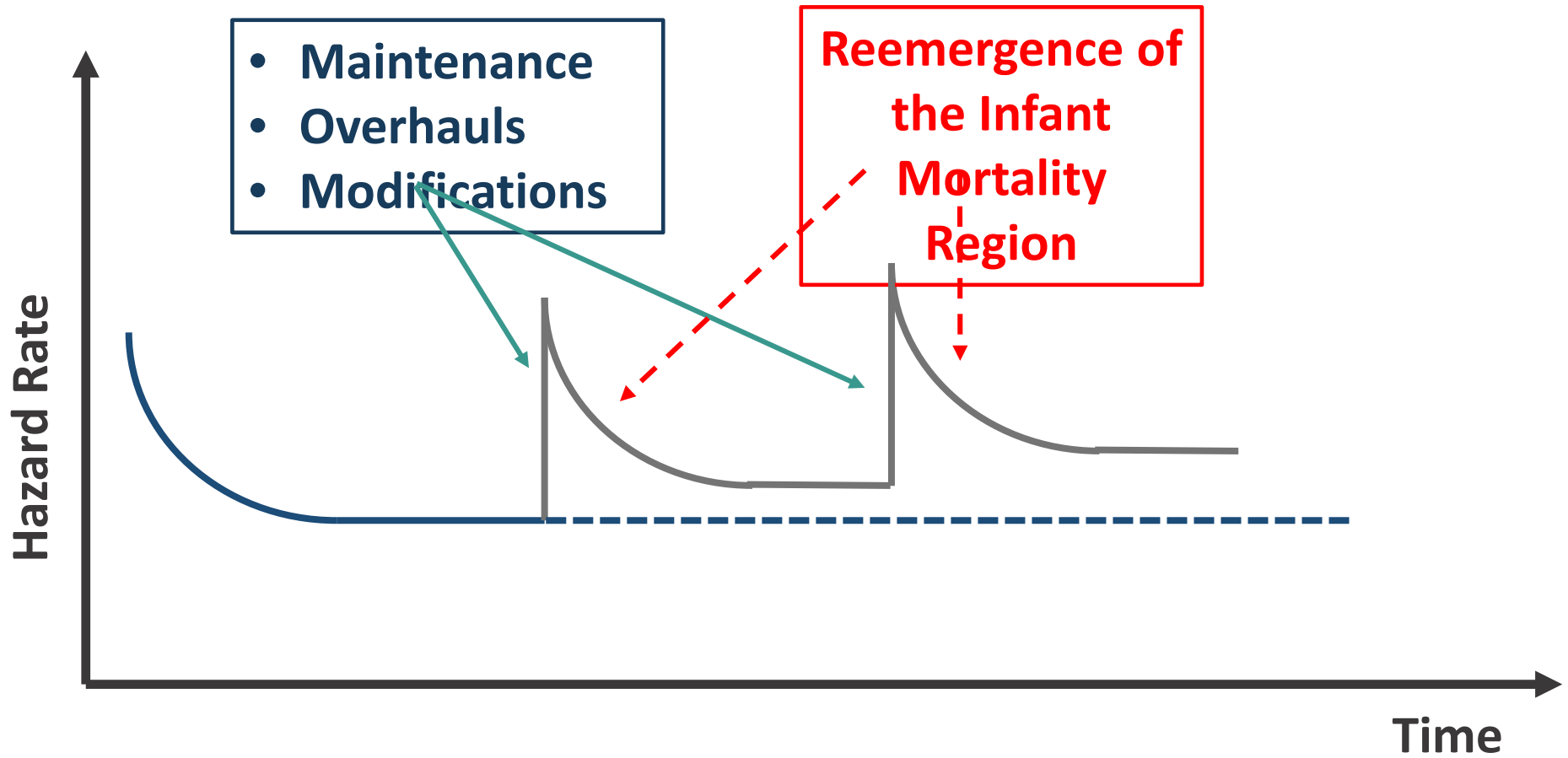
Idealized bathtub curve model for the time to failure of a component



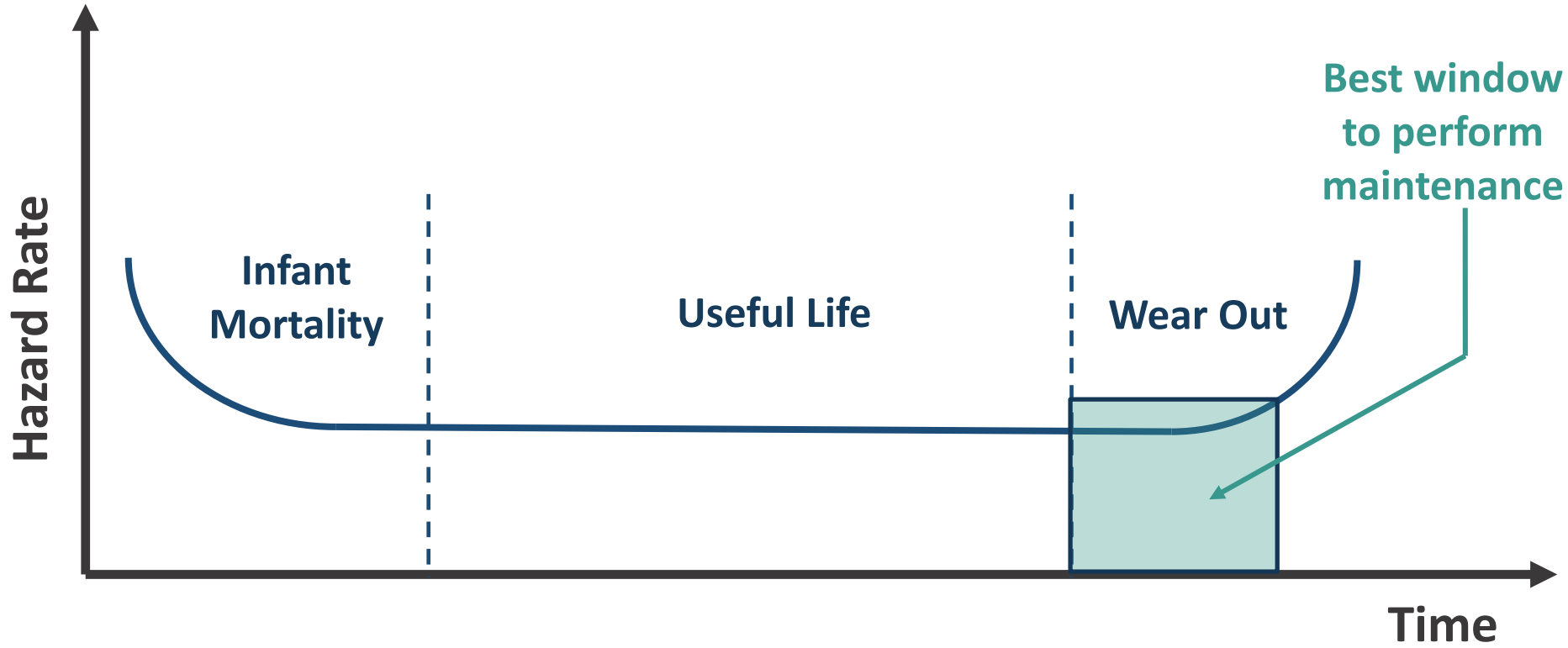
Idealized effect of Maintenance on the bathtub curve



Realistic effect of Maintenance on the bathtub curve



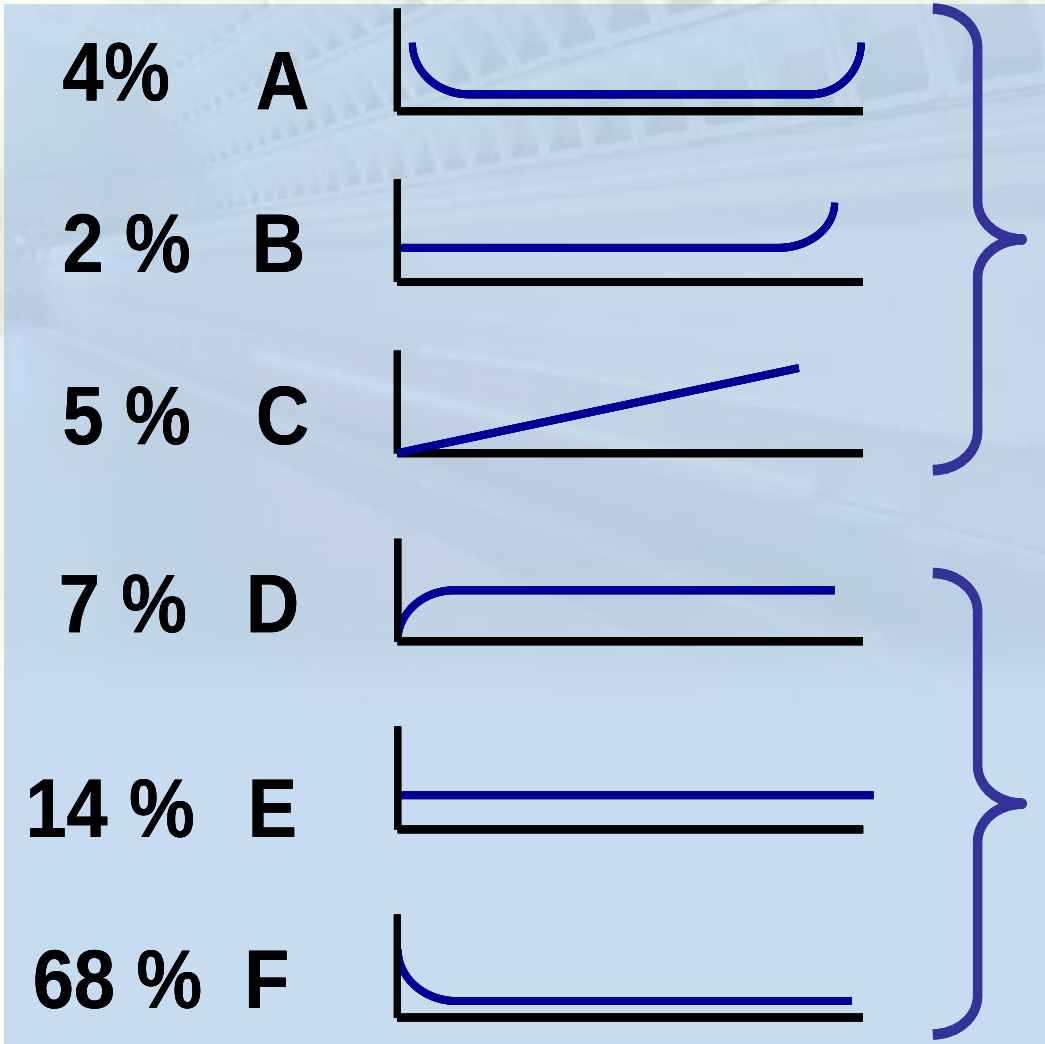
Idealized view of maintenance optimization



Historical Failure Patterns

Research shows the following six failure patterns across many industries.

Originally performed by United Airlines and Boeing as part of the 747 program (MSG 1 & 2)



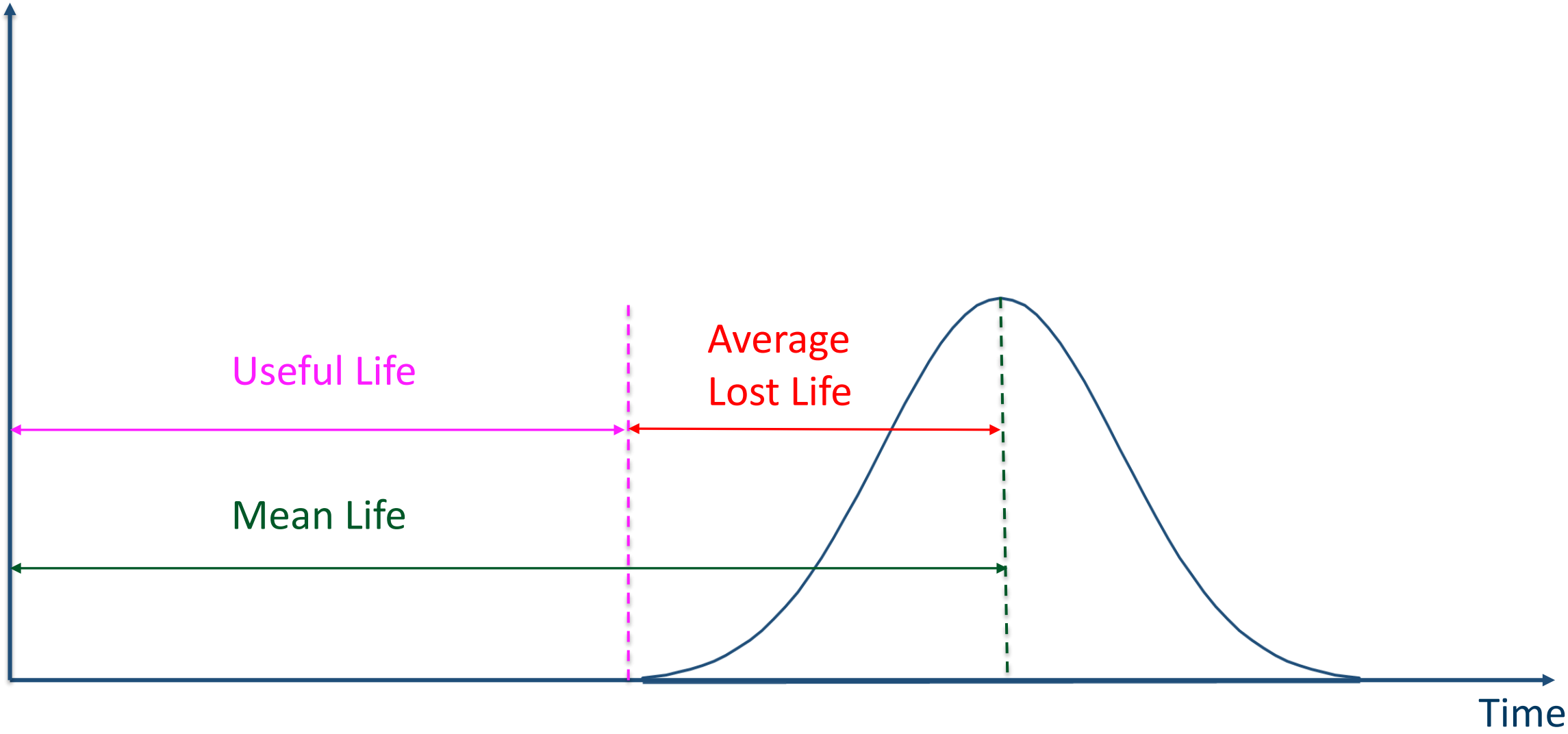
Generally applies to simple items or complex items with dominant failure modes.

11% - Might benefit from limit on operating age

Associated with complex equipment such as electronics, hydraulic and pneumatic systems.

89% - No benefit from limit on operating age

Explaining Useful Life

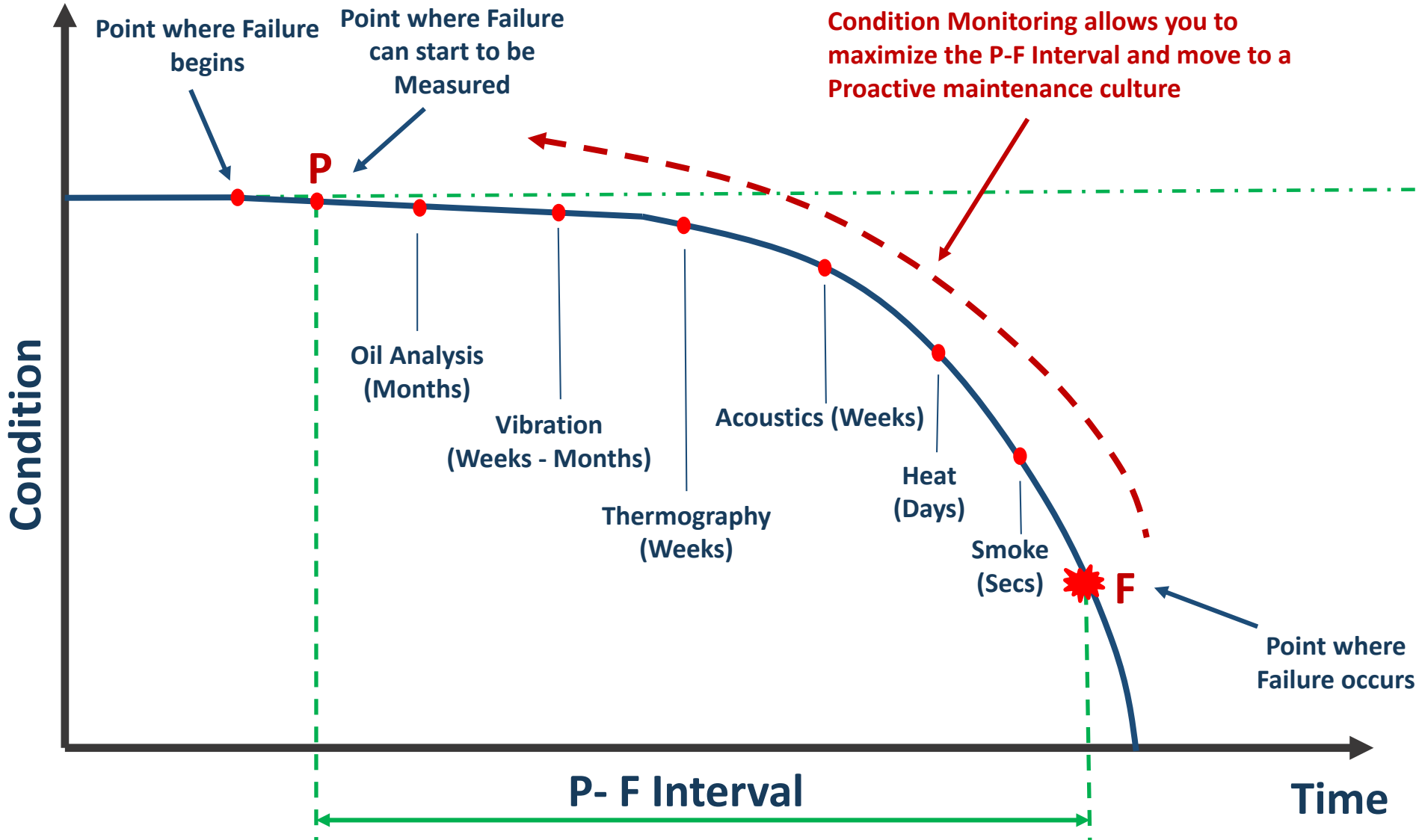


What does all this mean for WMATA

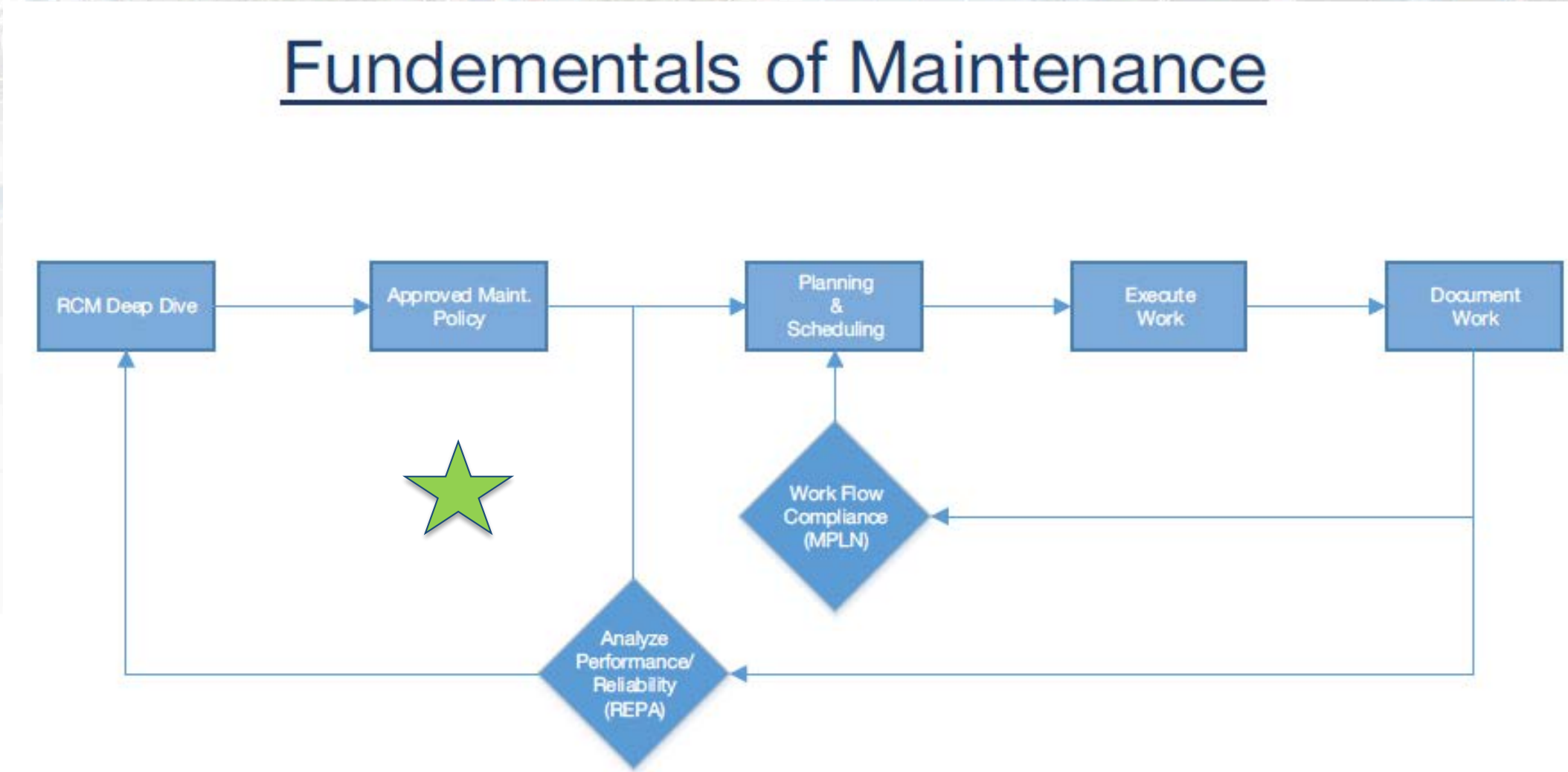
Historically, WMATA relies on OEM maintenance program for the entire lifecycle of our Assets'

- Time Based Maintenance is prevalent
- **Little to No** consideration of Operational Performance and/or Changes to our Operating Context
- **Little to No** consideration of adopting a Condition Based Maintenance approach
- PM Compliance is consistently above 90% and yet over 40% of our maintenance is corrective action

Benefits of Adopting a Condition Based Maintenance Approach



Analyze performance of programs in place and loop back if further refinement required



RCM at WMATA

- Around 100 people trained via six 3-day sessions
- Six deep dives conducted with 7th planned
  - Chosen based on reliability reporting
  - Switches, track circuits, DC breakers, Track/third rail, Railcar pneumatic system, Railcar doors
  - Two weeks (about a week on proces and a second week on the system)
  - Cross-section of maintenance, operations and engineering staff
- Working through implementing deep dive recommendations

Common Myths about RCM

- *"It's too hard…"*
- *"It takes too long…"*
- *"It's too expensive…."*
- *"That's just an Aviation thing; it won't work in our industry…."*
- *"That's just another name for condition monitoring…."*

Summary

- RCM is a process (structured, scientific, repeatable, defendable)
- It is not new…….RCM has been around for over 40 years
- When applied correctly, RCM will provide the best maintenance program for your Asset given the Operating Context & Risk profile.
- Step 7 provides the pathway for addressing Risk proactively