TOOLBOX
SESIÓN

CONGRESO DE MANTENIMIENTO & CONFIABILIDAD MÉXICO 16 EDICIÓN

September 6, 2023

Reliability Centered Maintenance (RCM)

A Case Study for FMEA, Criticality, and Task Selection

Workbook

Nancy Regan, Workshop Instructor

RCM TRAININGONLINE.COM

What you will learn in this Workshop

Reliability Centered Maintenance (RCM) is a powerful Reliability improvement process. RCM isn't a new process. The application of its principles spans five decades. It has been - *and is being* - applied in nearly every industry throughout the world. When it is **applied correctly**, with the **right people**, overwhelming positive results can be reaped that can transform an organization. *I've seen it first-hand*.

RCM embodies many Reliability fundamentals. Learning, understanding, and applying these fundamentals at a basic level can help you achieve Reliability goals. But here's the catch. ***You have to actually apply them***!

RCM is the technical love of my life and I often apply RCM principles in my own life. But, just as it often happens in the Reliability "real world," I got busy and didn't take the time to "walk my own talk." And I suffered the **Consequences** for it.

On a recent 400-mile journey in my 2014 Subaru Forrester (coming home from speaking at a Reliability conference!), I experienced an **unanticipated failure** with my boxer engine's lubrication system that interrupted my trip. While driving on the highway, my **Low Engine Oil Light** illuminated on the dashboard so I had to pull over at the nearest gas station to troubleshoot.

I could have completely avoided the situation if I had **proactively managed** one **Failure Mode**. But I didn't. Instead, I was thrown into full-blown **Reactive Mode** 150 miles from my home.

Given what I do for a living, I asked myself, *how did I let this happen*? I felt embarrassed until I realized that many organizations experience the same thing. "*Running from to fire*" and living in Reactive Mode is (unfortunately) a common circumstance in our industry. But it is largely avoidable. So I decided to make lemonade out of my lemons, and that's how this Workshop was born.

What you will learn in this Workshop, continued

I deconstructed my (unfortunate) event and created this real-life **RCM Case Study**. Together, we will **learn and demonstrate** some of RCM's most important principles at a very basic level including:

- Building a Failure Modes and Effects Analysis (FMEA)
- Assessing Criticality
- Assigning safe and cost-effective maintenance tasks by applying the the **P-F Interval** versus the **useful life**
- Discovering what **Protective Devices** are, why they are so important, and how RCM can help you to properly take care of them

This workshop is not a comprehensive introduction to RCM. But you will leave understanding what RCM is and you will have a working knowledge of some very important Reliability fundamentals because we are going to apply them - *together*!

My mentor John Moubray taught me that **time is our most valuable asset**. I know you had a choice of workshops today, and you chose to spend your time with me. For that, I am sincerely grateful ❤️!

Nancy Regan
Monterrey, Mexico
September 6, 2023

Case Study
2014 Subaru Forester Low Engine Oil Light

Operating Context Excerpt

- 2014 Subaru Forester – personal use vehicle. (I drive it almost exclusively.)
- Drive approximately 12,000 miles per year in the Southeastern United States (almost entirely in Alabama). Longest journey ~ 4 hours from home.
- I do have a “backup” car – 2004 Toyota Corolla.
- Scope of analysis is limited to Failure Modes that result in illumination of the Low Engine Oil Light and the “Low Engine Oil Light system” itself.
- 2.5-liter horizontally opposed four-cylinder (boxer) engine, 170 horsepower.
- Low Engine Oil Light illuminates in the event that the engine oil decreases to the lower limit (2 quarts low).

Reliability Centered Maintenance

Definition

RCM is a zero-based process used to identify the **Failure Management Strategies** that are required to ensure an asset meets its **mission requirements** in its **operational environment** in the most **safe and cost effective** manner.

RCM Process

1. Functions
2. Functional Failures
3. Failure Modes
4. Failure Effects
5. Failure Consequences
6. Proactive Maintenance and Intervals
7. Default Strategies

Notes

Reliability Centered Maintenance

Step 1: Functions

Primary Function: My 2014 Subaru Forester

To + Verb + Object + Performance Standard(s) + Operating Context

Verb	
Object	
Performance Standards	
Operating Context	

Evident Function

Failure of the Function becomes evident to the operating crew under normal conditions.

Hidden Function

Failure of the Function is not evident to the operating crew under normal conditions. Hidden Functions are almost always **Protective Devices**. A Protective Device is a device or system that is intended to protect *in the event that* another failure occurs.

Multiple Failure

Includes the failure of a Protective Device and another failure (e.g., low pressure switch fails and system pressure falls below the normal level).

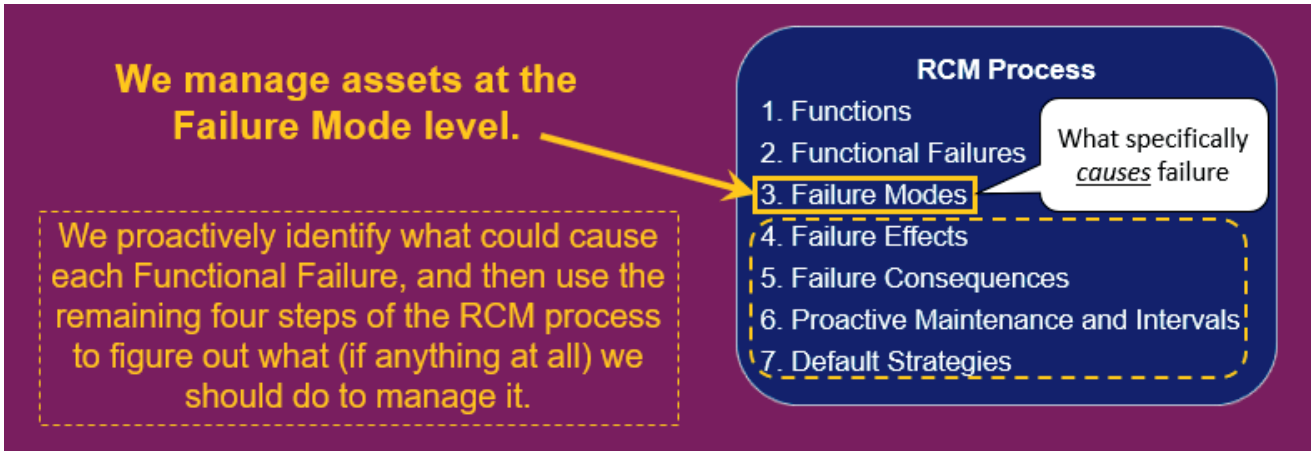
Reliability Centered Maintenance

Step 2: Functional Failures

Total Failure
Complete loss of Function

Partial Failure
The inability to function at the level of performance specified as satisfactory.

Step 3: Failure Modes



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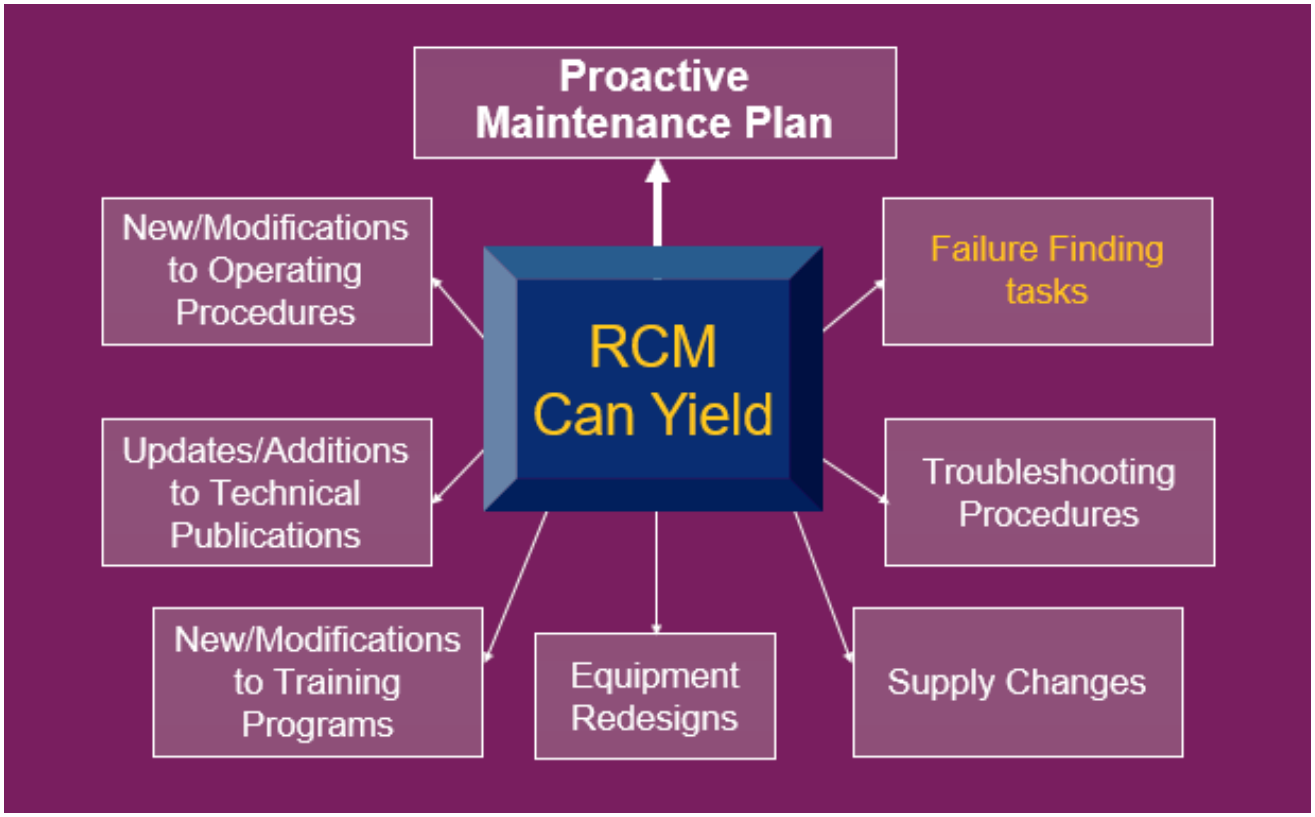
Potential Products of an RCM Analysis

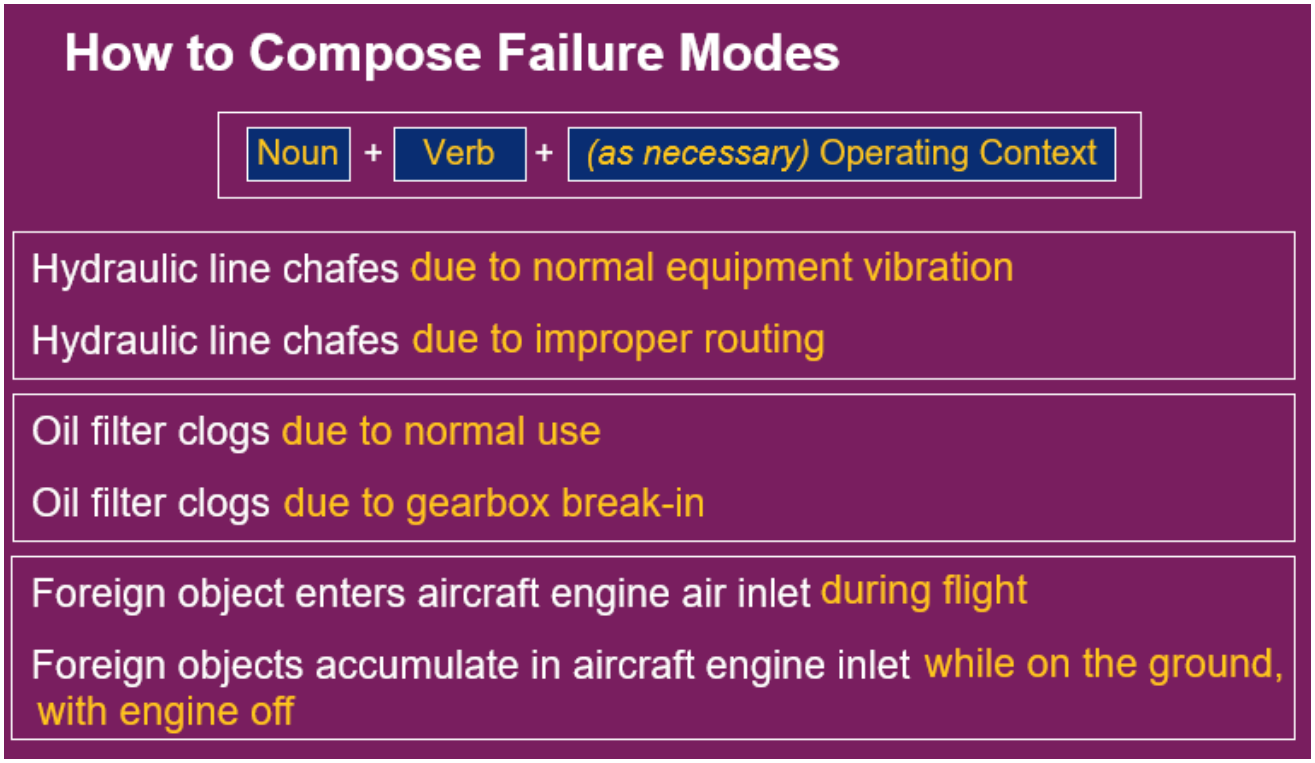


and many others…

Notes

Reliability Centered Maintenance

Step 3: Failure Modes



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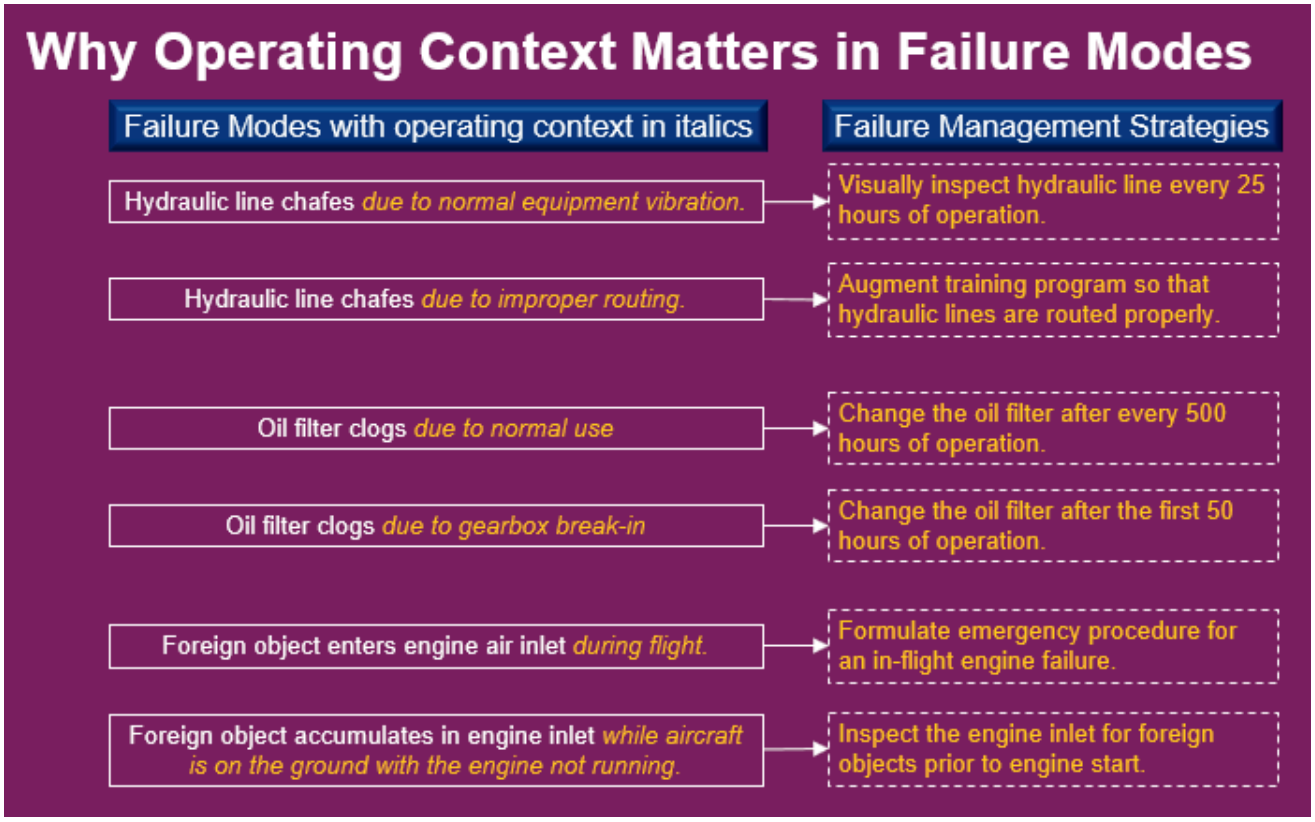
Step 3: Failure Modes



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Step 3: Failure Modes

What specifically could cause the engine oil to drop to the low level limit and illuminate the LOW OIL LEVEL LIGHT?

1

2

3

Notes

Reliability Centered Maintenance

Step 4: Failure Effects

Failure Effect

A story of what would happen if nothing were done to predict, prevent, or manage its associated Failure Mode.

Important Points

- Document worst-case-scenario
- Write in enough detail to assess consquences

Failure Effects Include

- A description of the failure process from the occurrence of the Failure Mode to the Functional Failure
- Physical evidence that the failure has occurred
- How it adversely affects safety and/or the environment
- How it affects operational capability/mission
- Specific operating restrictions as a result of the failure
- Secondary damage
- What must be done and how long it takes to repair the failure

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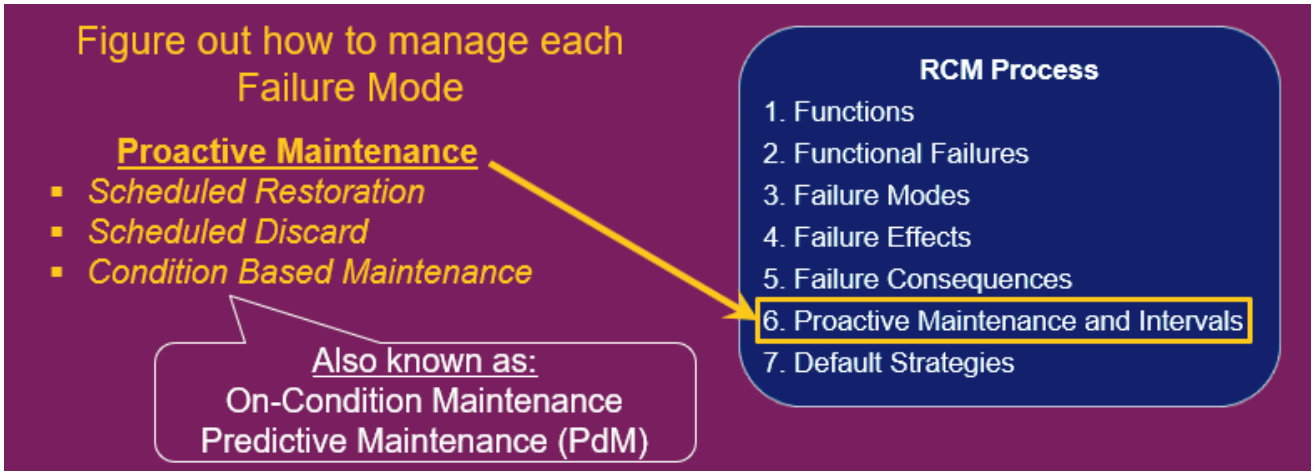
Step 5: Failure Consequences

How a Failure Mode or a Multiple Failure *matters*

- Safety
- Environmental
- Operational
- Non-Operational

Step 6: Proactive Maintenance and Associated Intervals



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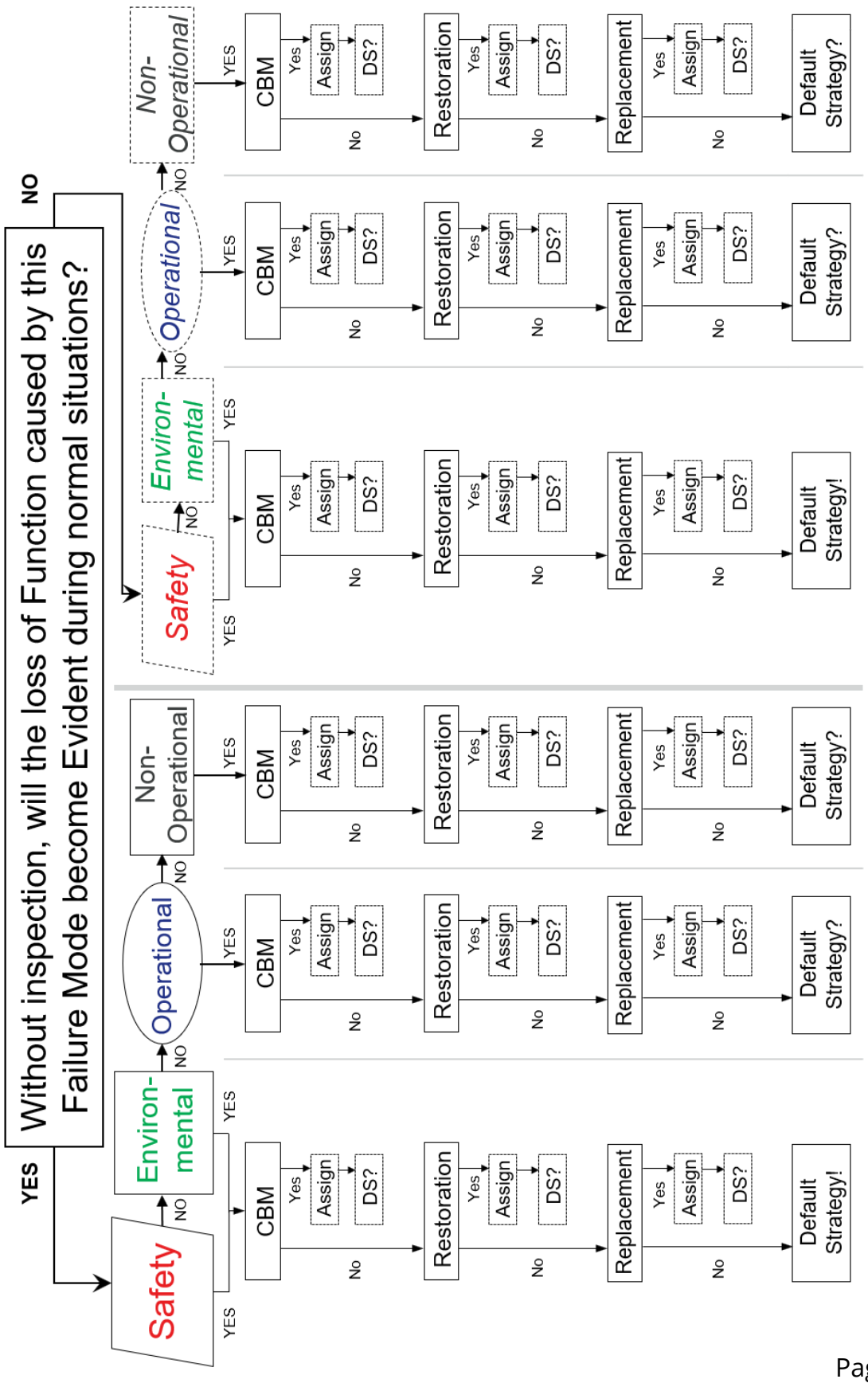
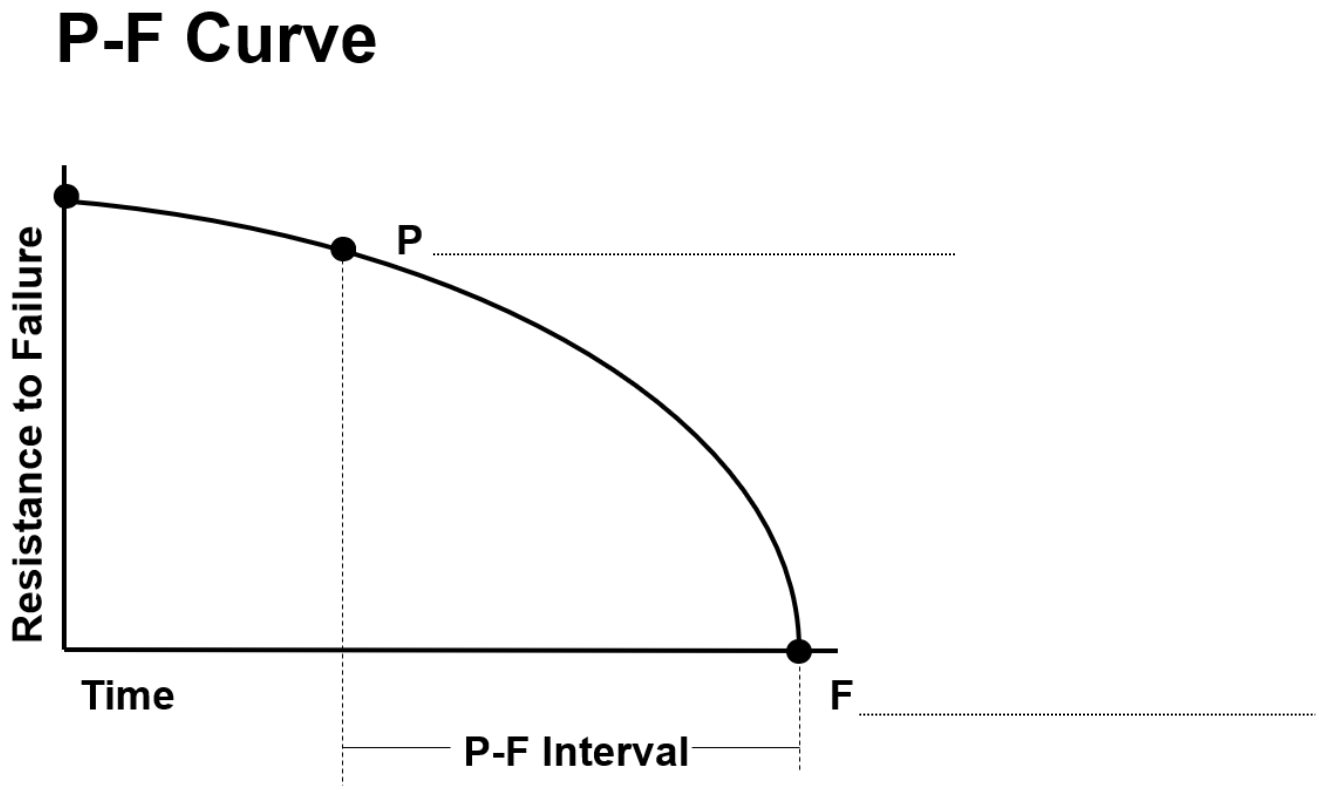
RCM Decision Diagram Outline



Step 6: Proactive Maintenance and Associated Intervals

In the context of RCM, in order to assign a proactive maintenance task, it must be ***Technically Feasible*** AND ***Worth Doing***.

On-Condition Task
Performed at a defined interval to detect a *Potential Failure Condition* so that maintenance can be performed *before* the failure occurs.



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Reliability Centered Maintenance

Step 6: Proactive Maintenance and Associated Intervals

P-F Curve: Four Key Points

- On-Condition maintenance task intervals are NOT based upon *MTBF*.
- On-Condition maintenance task intervals are NOT based upon the *useful life* of a component.
- On-Condition maintenance task intervals are NOT based upon the *criticality of the failure*.
- On-Condition maintenance task intervals are based upon the P-F Interval.

In other words, On-Condition maintenance task intervals are based upon how _____ failure occurs once a _____ _____ _____ is *detectable*.

Question: Let's assume a P-F interval of 6 months has been established. Therefore, an inspection is performed every 3 months. Now, let's assume a technician has done the inspection every 3 months for two years and has never found the Potential Failure Condition. Does this justify extending the P-F interval (and thus the inspection interval)? ***Yes or No?***

Notes

Subaru Forester P-F Curve Example

If inspected, is it possible to detect evidence of impending failure? What is it? What is the P-F Interval? Is it reasonably consistent? Is it practical to monitor the item at intervals less than the P-F interval? Is it long enough to manage the consequences of failure?

- *Is the task cost effective? (Task cost* vs. *operational consequences + repair costs)*

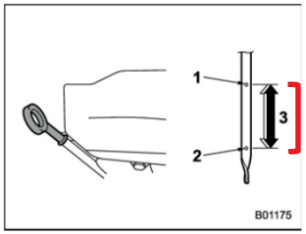
On-Condition: O, OC

NO TO ANY

YES TO ALL → Assign On-Condition Task → Default Strategy?

Failure Mode
Engine consumes oil due to normal use.

According to my Subaru Forester manual



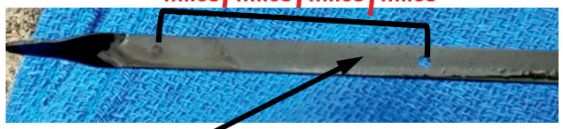
1) Full level
2) Low level
3) Approximately 1.1 US qt (1.0 liter, 0.9 Imp qt) from low level to full level

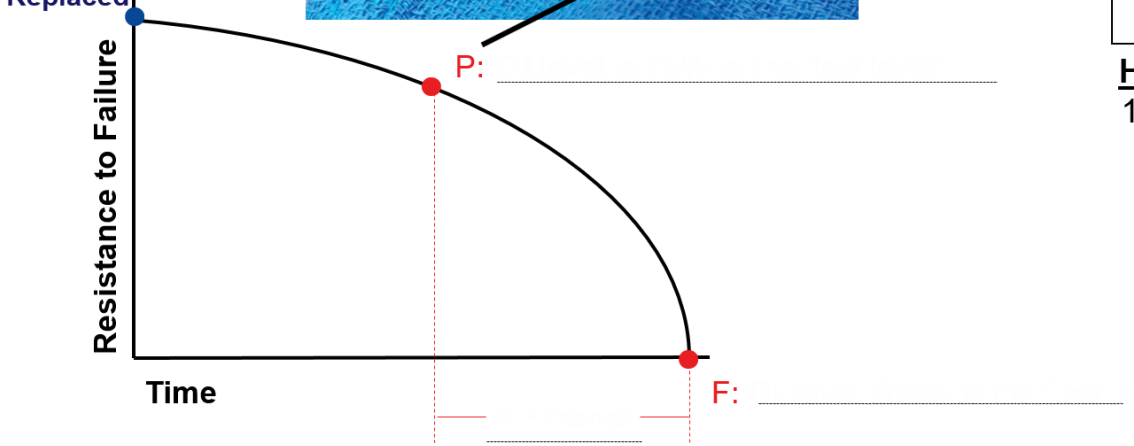
<1200 Miles

- Subaru manual states that "consuming more than 1 quart per 1,200 miles" is abnormal.
- They recommend checking the engine oil level at each fuel stop.

How far can I go on one tank of fuel?
16 gallons of fuel x 30 mpg = 480 miles

P-F Curve





Task:

_____

_____

_____

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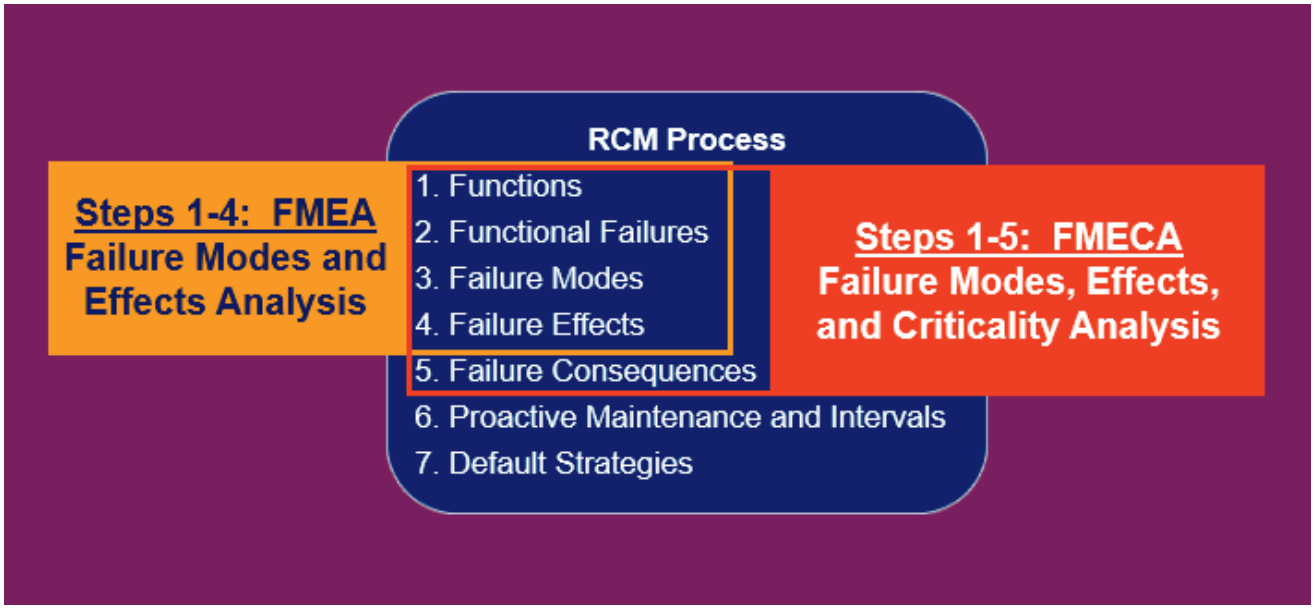
Step 7: Default Strategies

Default Strategy

A failure management strategy, other than Proactive Maintenance, implemented to manage the consequences of failure (e.g. engineering redesign, Failure Finding task, no scheduled maintenance)

Final Notes



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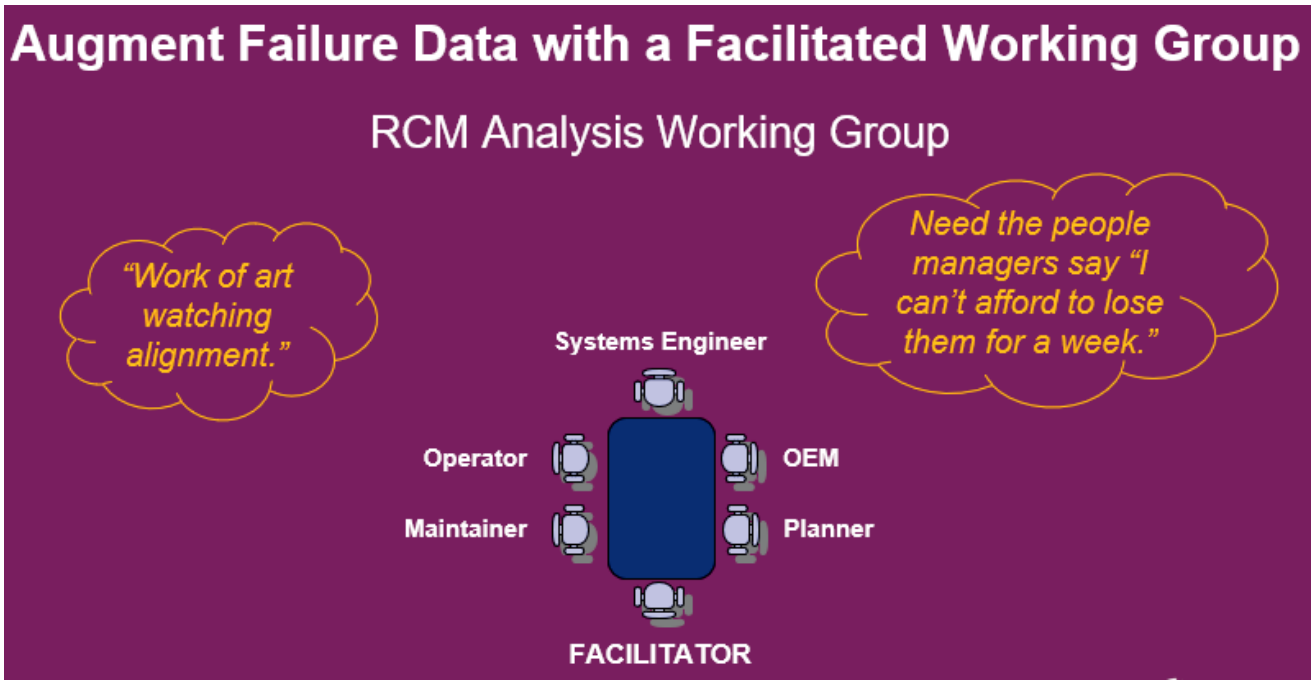
Facilitated Working Group Approach to RCM



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Nancy Regan, RCM Practitioner Workshop Instructor

Nancy Regan is a leading authority on Reliability Centered Maintenance (RCM) and has over 25 years' experience of hands-on practice facilitating RCM analyses, conducting RCM training, and assisting her clients in implementing RCM programs.

Amongst her largest projects are the CH-47 Chinook helicopter and her work with the National Security Complex in Oakridge, Tennessee. Both projects spanned years and yielded amazing benefits for both organizations!

Nancy was mentored by the late John Moubray. She is a graduate of Embry-Riddle Aeronautical University with a B.S. degree in Aerospace Engineering. She is the author of *The RCM Solution, A Practical Guide to Starting and Maintaining a Successful RCM Program*.

NancyReganRCM

RCM Training with Nancy Regan

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Email: NancyRegan@RCMTrainingOnline.com

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