



CBM

- ## Potential Failure



How NAVAIR^[1] (N&H / Moubray/ “classic” CBM theory) determines:

1. The P-F Interval, and

2. The Inspection Interval

[1] NAVAIR 00-25-403 RCM Guideline

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NAVAIR Methodologies for determining or estimating PF intervals:

1. **Laboratory testing** (accelerated life testing (ALT)),

2. **Analytical** methods

3. **Judgment** based on inputs from operators and maintainer,
(i.e. Classic RCM method, two bearing example) and

4. **Similar** design and application

5. **Age exploration** (i.e. Reliability Analysis)

NAVAIR does not provide details about any of the above PF methods in its public documentation.

Conditional Probability Density Function, CPDF

RULE

t₀

Working age

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Once we have established the PF interval we'll need to convert it into a
CBM Inspection interval.

$$I = PF/n$$

Where:

I = Inspection interval

PF = potential failure to functional failure interval

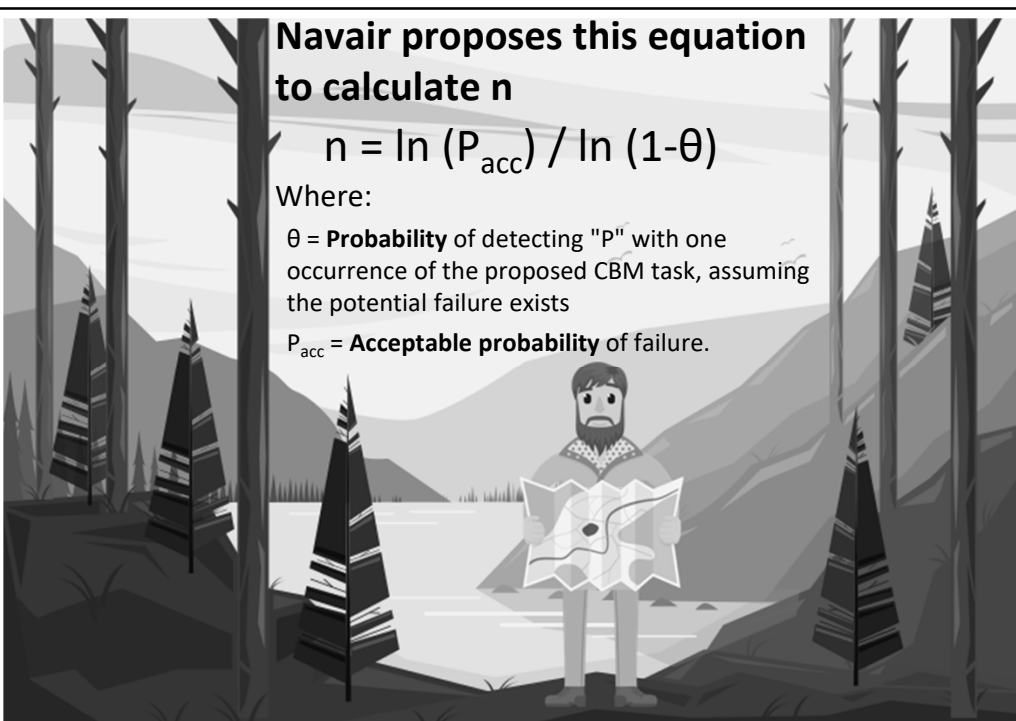
n = number of inspections in the PF interval. Will depend on

1. the **consequences** of failure, and
2. the **effectiveness** of the proposed task. ??

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Navair proposes this equation to calculate n

$$n = \ln(P_{acc}) / \ln(1-\theta)$$

Where:

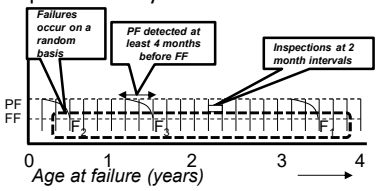
θ = **Probability** of detecting "P" with one occurrence of the proposed CBM task, assuming the potential failure exists

P_{acc} = **Acceptable probability** of failure.

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Classical (RCM II) CBM theory addresses only two extreme cases*

Special case 1 – completely random (age independent, dependent only on condition monitoring data)



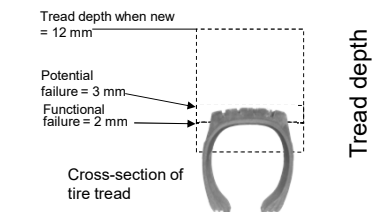
Failures occur on a random basis

PF detected at least 4 months before FF

Inspections at 2 month intervals

Age at failure (years)

Special case 2 – completely age dependent



Tread depth when new = 12 mm

Potential failure = 3 mm

Functional failure = 2 mm

Cross-section of tire tread

Tread depth

Operating Age (x 1000 km)

Maximum rate of wear

P-F interval At least 5000 km

General Case

Most failure modes encountered in maintenance are dependent on both:

1. **Age** and
2. **Condition** indicator(s)

The Weibull age parameter β includes the influence of all unmonitored yet significant factors.

We need a CBM model that accounts for both age and condition.

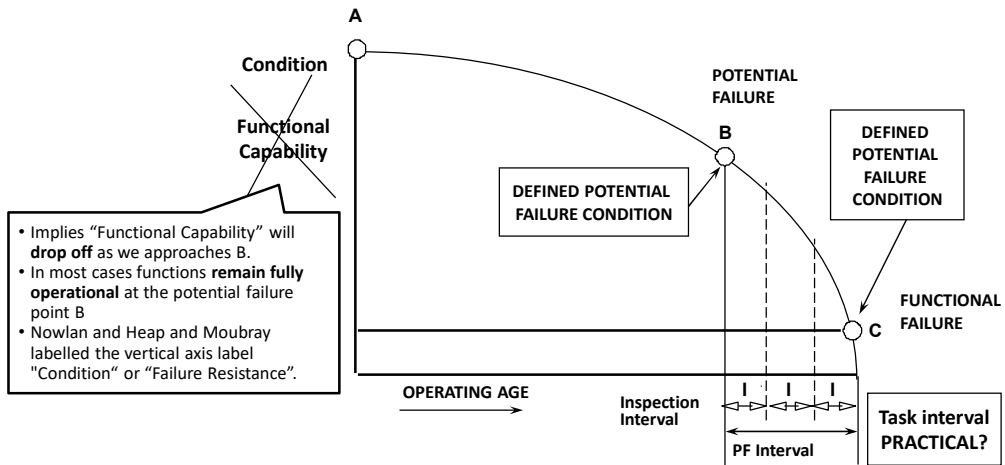
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*RCM II Moubray pp 156-162

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Navair Mistake



Condition

Functional Capability

OPERATING AGE

POTENTIAL FAILURE

DEFINED POTENTIAL FAILURE CONDITION

DEFINED POTENTIAL FAILURE CONDITION

FUNCTIONAL FAILURE

Inspection Interval

PF Interval

Task interval PRACTICAL?

- Implies "Functional Capability" will **drop off** as we approach B.
- In most cases functions **remain fully operational** at the potential failure point B
- Nowlan and Heap and Moubray labelled the vertical axis label "Condition" or "Failure Resistance".

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What can we conclude about the P-F interval CBM model?

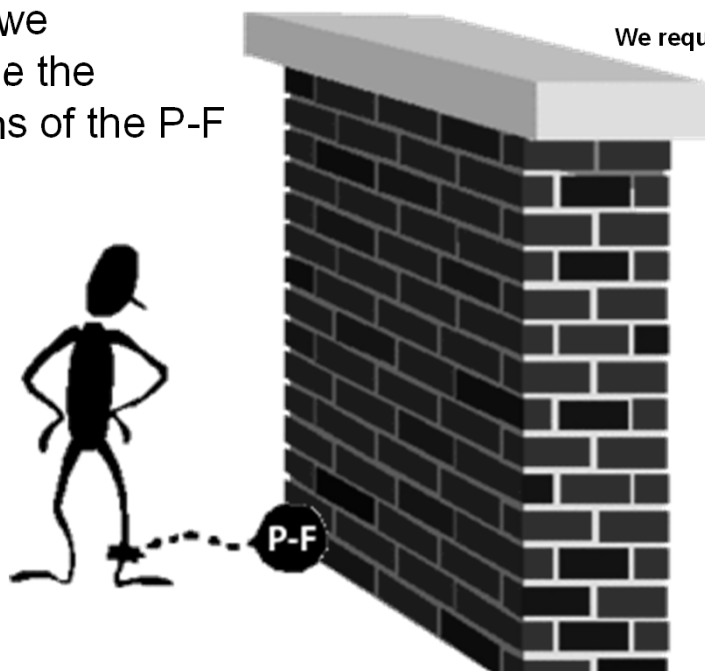
1. The P-F Interval is a reasonable **first approximation**
2. The P-F is usually developed during an RCM analysis in the **absence** of data
3. It is usually **subjective** based on recollections of potential and functional failures.
4. Age **exploration** techniques should be used in day-to-day work order procedures to:
 1. confirm inspection frequencies and
 2. Set the CI level for declaring P.
 3. measure the performance of and continuously refine the predictive model (better "P", more confident RULE).

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How do we overcome the limitations of the P-F model?



We require a method that will discover:

1. The **influential** condition indicators,
2. Their critical **levels** (i.e. P),
3. The influence of age (i.e. **unmonitored** variables),

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4.3.1 Quiz 1 CBM Concepts

<https://forms.gle/Z3E9yqSdFytBzjFW7>

1. CBM is considered a more conservative maintenance policy than TBM because: *

1 point

☐ It is less tolerant of a failure's consequences.

☐ It is a more expensive policy.

☐ It intervenes more frequently to avoid failure.

☐ All of the above.

☐ None of the above.

2. CBM monitoring frequency depends on: *

1 point

☐ The reliability of the item.

☐ The availability of the item.

☐ The criticality of the item.

☐ The warning time between potential failure detection and loss of function.

☐ All of the above.

☐ None of the above.

3. The P-F model: *

1 point

☐ Provides a first approximation of a warning interval for determining a CBM inspection frequency.

☐ Is a method for determining P the potential failure signal.

☐ Depends on an item's criticality.

☐ Depends on an item's reliability.

☐ All of the above.

☐ None of the above.

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