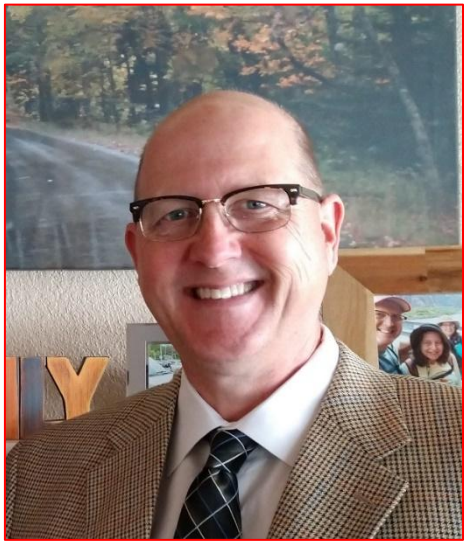
BNY
Bus Association of New York State, Inc.

MaintenanceInnovators
Reliability on Purpose

Preventive Maintenance

Just the Good Stuff…



Dr. John L. Ross, Jr.

- 41-year reliability veteran
- Published author – three best-sellers:
  - The Reliability Excellence Workbook, From Ideas to Action
  - Cover Your Assets, Asset Management at Your Place and at Your Pace
  - The Storeroom Roadmap, 32 Processes for Efficiency and Sustainability; and
  - 19 periodical publications
- Public speaker – sessions, workshops, keynotes
  - SMRP (x6), Reliable Plant conference (x4)
  - Keynote speaker for numerous events (20+)
- Dr. John's Maintenance Minute
- Principle instructor for University of Wisconsin's Maintenance and Reliability Management certificate series
- CMRP, College Professor, U.S. patent holder, A.S., B.S., M.S., Ph.D.

www.maintenanceinnovators.com

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AR&MI

American Reliability & Maintenance Institute

Lead with Authority

www.ARMIcerts.com

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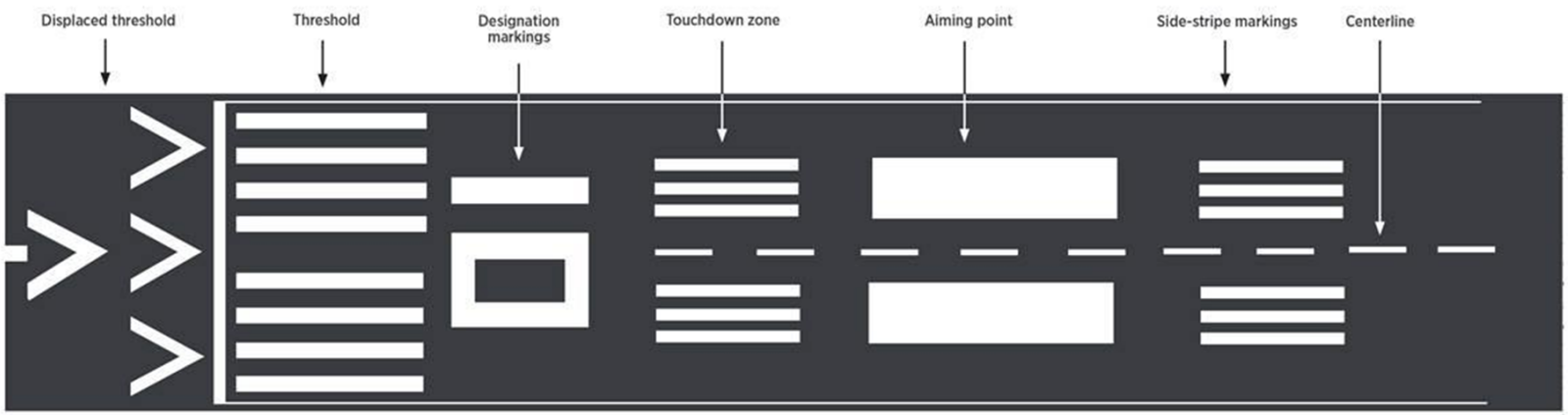
Reliability on Purpose

Maintenance Philosophy

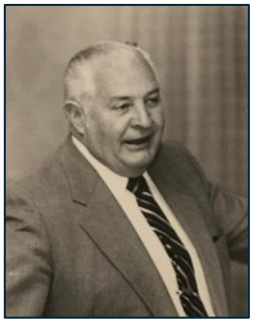
- Equipment failures are a process which can be ‘discovered’ as they are happening
- The earlier we discover those failures in progress, the better we can make a ‘business decision’
- Equipment arrives at the plant with ‘inherent’ reliability
- The job of maintenance is to guard the inherent reliability
- Until the maintenance technicians are turning wrenches or screwdrivers, their job is to provide technical advice…the best technical advice
- There is a million-dollar difference between, “I wouldn’t do that if I was you,” and “I wouldn’t have done that if I was you”



TPM
Total Productive Maintenance

Total Productive Maintenance

- Pre WWII
- George Smith
- Seiichi Nakajima



- Root Cause Analysis
- Small Group Activities
- Equipment Improvement Teams
- 5 Why

- Shop Floor Involvement
- Standardized Parts
- Documentation
- PM, Parts, and Training

- Operator Daily and Weekly Care
- Standards
- Visual Controls
- Defect Tagging

- Preventive Maintenance
- Predictive Maintenance
- Storeroom
- Planning & Scheduling
- Work Order Control
- CMMS

- Expert OJT
- Training Matrix
- Competency-Based

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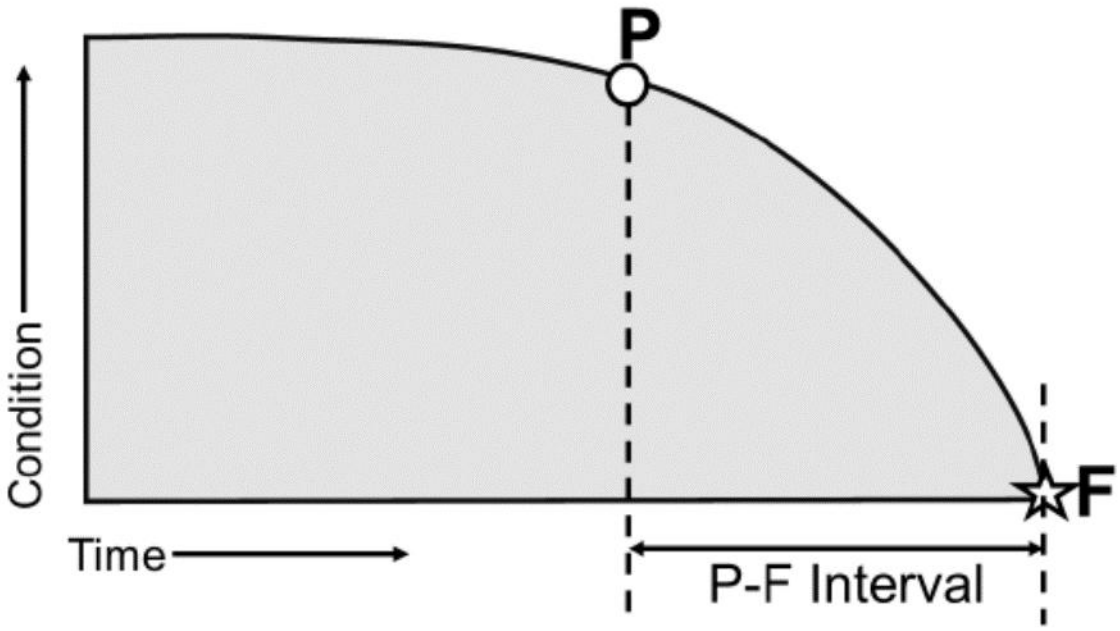
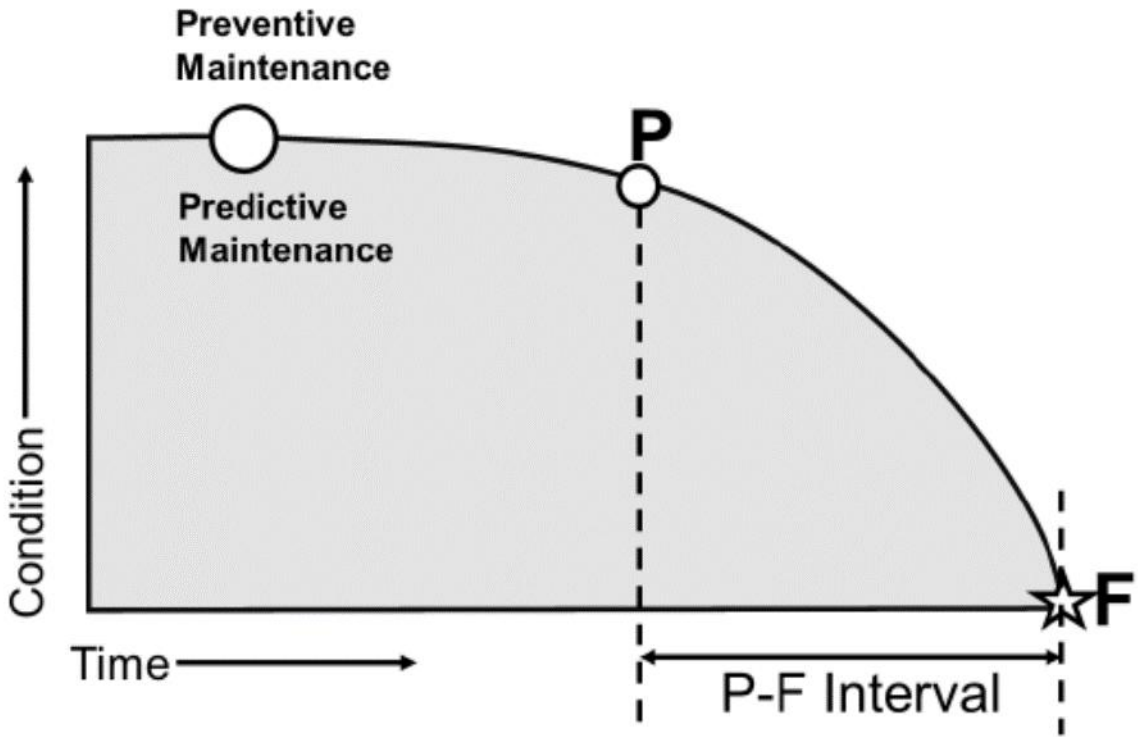
P-F Curve

The P-F Curve



Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

Where PM and PdM should be



Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

PM Types

- PM
  - *Servicing*
  - *Installation/Replacement*
  - *Calibration*
  - *Alignment*
  - *Adjustment*
  - *Inspection*
  - *Lubrication*

Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

PM Types

- PM
  - ***Servicing***
  - *Installation/Replacement*
  - *Calibration*
  - *Alignment*
  - *Adjustment*
  - *Inspection*
  - *Lubrication*

When you think of completing a servicing task on an asset, give some thought to what it takes to get the machine ready for its next production run.

Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

PM Types

- PM
  - *Servicing*
  - ***Installation/Replacement***
  - *Calibration*
  - *Alignment*
  - *Adjustment*
  - *Inspection*
  - *Lubrication*

A very common maintenance activity is removing and replacing a component…When we are replacing a component on hard time, we are actually performing a type of preventive maintenance.

Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

PM Types

- PM
  - *Servicing*
  - *Installation/Replacement*
  - ***Calibration***
  - *Alignment*
  - *Adjustment*
  - *Inspection*
  - *Lubrication*

It might be hard to consider calibration as a distinctive type of preventive maintenance, but if you recall, preventive maintenance is a maintenance activity designed to keep more consequential maintenance from being required.

Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

PM Types

- PM
  - *Servicing*
  - *Installation/Replacement*
  - *Calibration*
  - ***Alignment***
  - *Adjustment*
  - *Inspection*
  - *Lubrication*

Essentially, if we take care to align components that need to be aligned, to the degree that is acceptable and within tolerance, then we can be certain that the component will last as long as it is supposed to.

Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

PM Types

- PM
  - *Servicing*
  - *Installation/Replacement*
  - *Calibration*
  - *Alignment*
  - ***Adjustment***
  - *Inspection*
  - *Lubrication*

…these are horribly suggestive PM tasks. But the intent is in the right direction. We need the applicable components to be adjusted to the proper value, depending on what the component is.

Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

PM Types

- PM
  - *Servicing*
  - *Installation/Replacement*
  - *Calibration*
  - *Alignment*
  - *Adjustment*
  - ***Inspection***
  - *Lubrication*

In this category we are simply asking the technician to look at a component and determine if it is in good order or not…Care should be taken to ensure that the person performing the inspection PM is made aware of what is acceptable in terms of condition.

Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

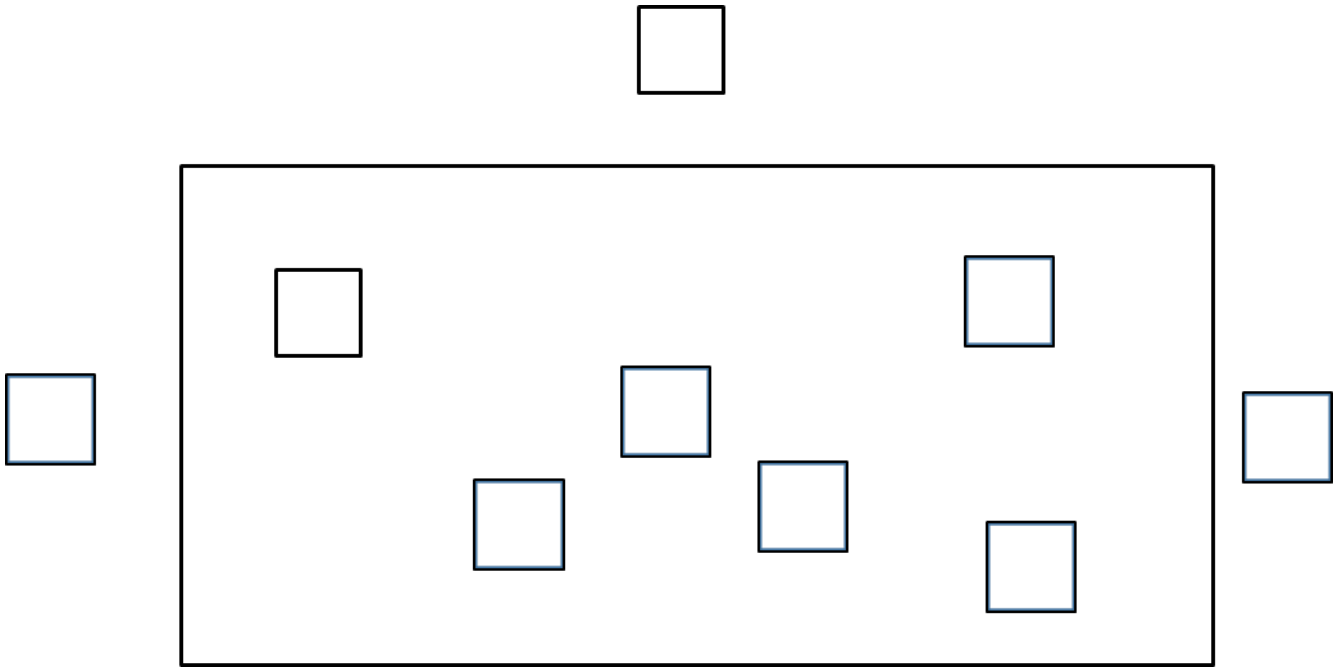
PM Types

- PM
  - *Servicing*
  - *Installation/Replacement*
  - *Calibration*
  - *Alignment*
  - *Adjustment*
  - *Inspection*
  - ***Lubrication***

This type of PM is quite literally applying the proper greases and oils as required by the equipment and lubrication program.

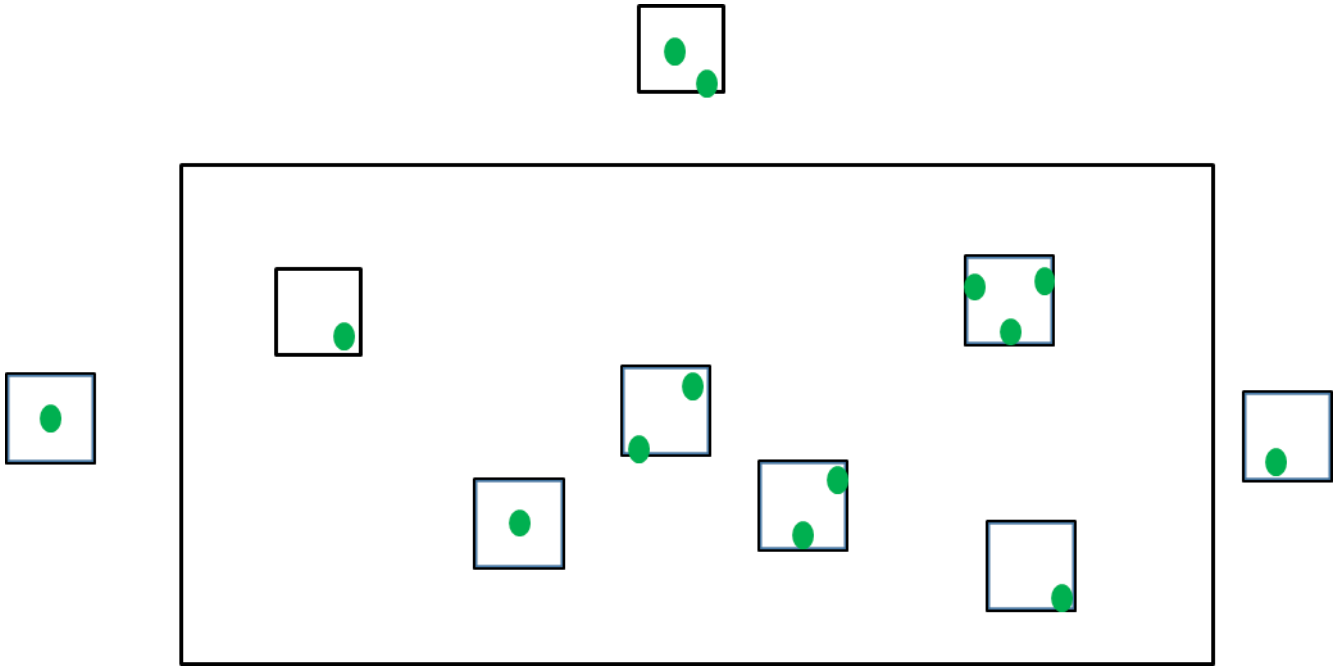
Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

Our Ineffective PMs



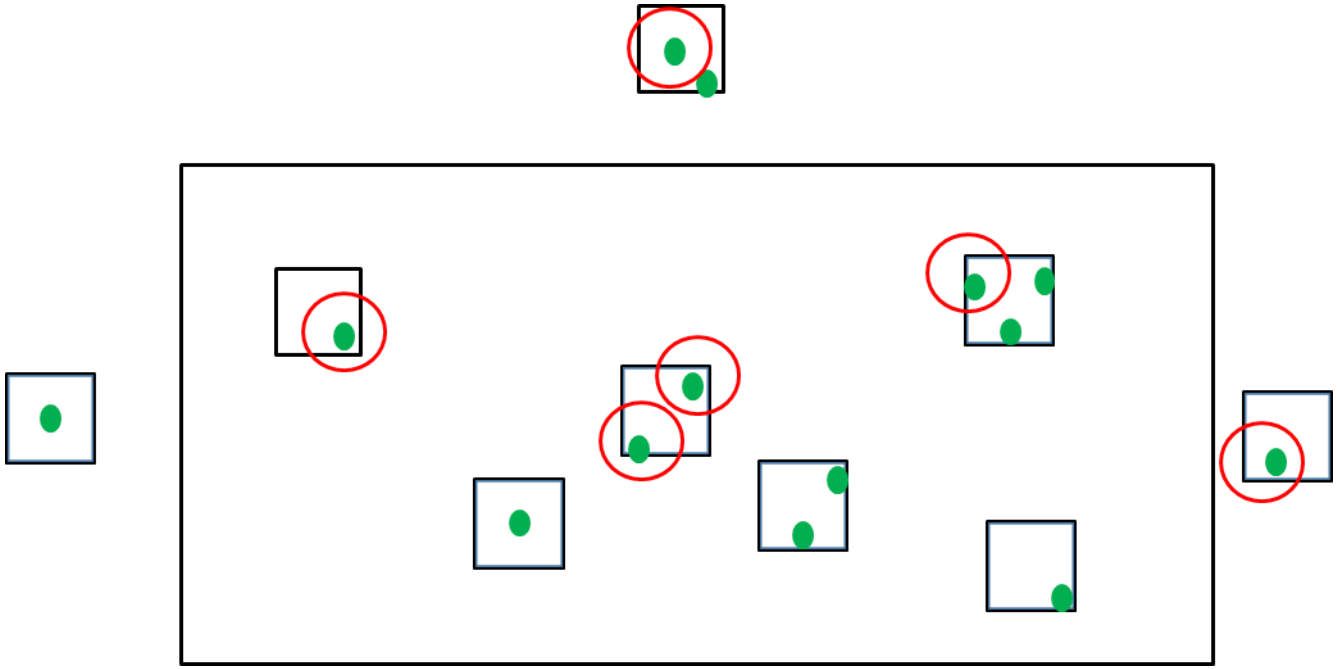
Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

Our Ineffective PMs



Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

Our Ineffective PMs



Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

An effective PM

Day 0

Day 30

Source: Maintenance Innovators, Inc.

Risk Matrix

SEVERITY \ FREQUENCY	FREQUENT (A) 1 every 1,000 or less Hours	PROBABLE (B) 1 every 1,001 to 10,000 Hours	OCCASIONAL 1 every 10,001 to 100,000 Hours	REMOTE (D) 1 every 100,000 to 1 million Hours	IMPROBABLE (E) 1 every >1 million Hours
CATASTROPHIC (I) ▪ Death or Permanent disability ▪ Significant Environmental breach ▪ Damage > $1M, Downtime>2 days ▪ Destruction of system/equipment	1 HIGH	2 HIGH	4 HIGH	8 MED	12 ACCEPT
CRITICAL (II) ▪Personal Injury ▪Damage >$100K and < $1M ▪Loss of availability > 24 hrs and < 7 days	3 HIGH	5 HIGH	6 MED	10 LOW	15 ACCEPT
MARGINAL (III) ▪Damage >$10K and < $100K ▪Loss of availability > 4 hrs and < 24 hrs	7 MED	9 MED	11 LOW	14 ACCEPT	17 ACCEPT
MINOR (IV) ▪Damage <$10K ▪Loss of availability < 4 hrs	13 ACCEPT	16 ACCEPT	18 ACCEPT	19 ACCEPT	20 ACCEPT

1000=42d
10,000=417d
100K=11.4y
1MM=114y

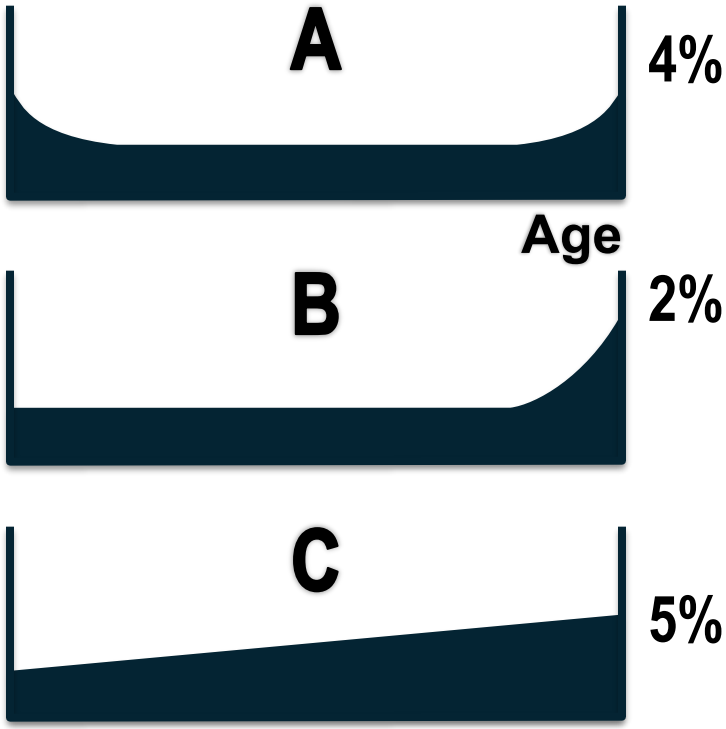
Source: MRM III

RCM
Reliability Centered Maintenance

Concepts of RCM

Age Related Failure Patterns

- Few failures are age related
- Common in structures and direct wear components
- May be prevented through scheduled discard or refurbishment, or inspected for condition



A Electric motors B Reciprocating engines C Turbine engines

Note: Only 11% of the items will benefit by limiting operating age!

Source: Marshall Institute PMO workshop

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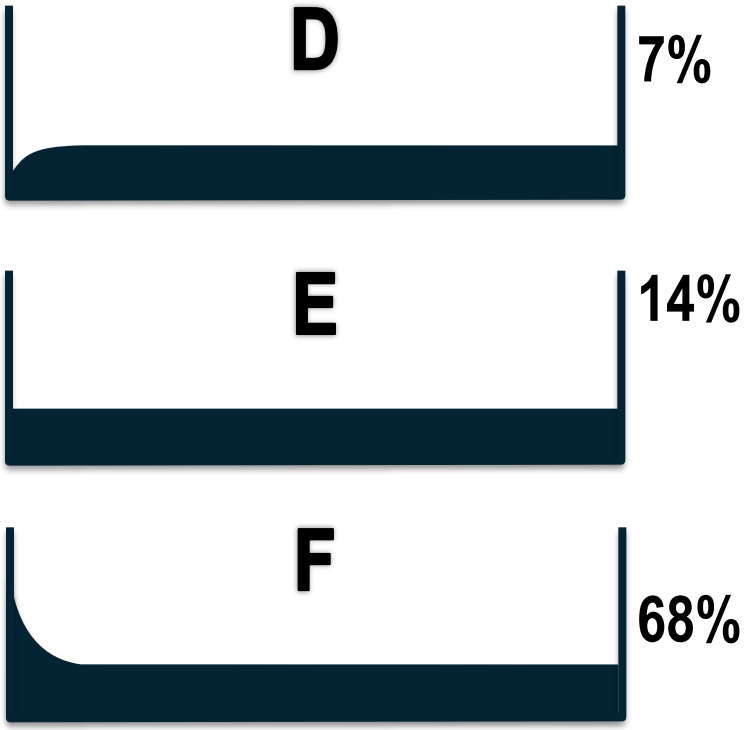
Concepts of RCM

Random Failure Patterns

- Majority of failures are random in nature
- Common in hydraulics, electronics, etc.
- Overhaul based policy will not prevent failures



D Centrifugal pumps E Light bulbs F Electronics

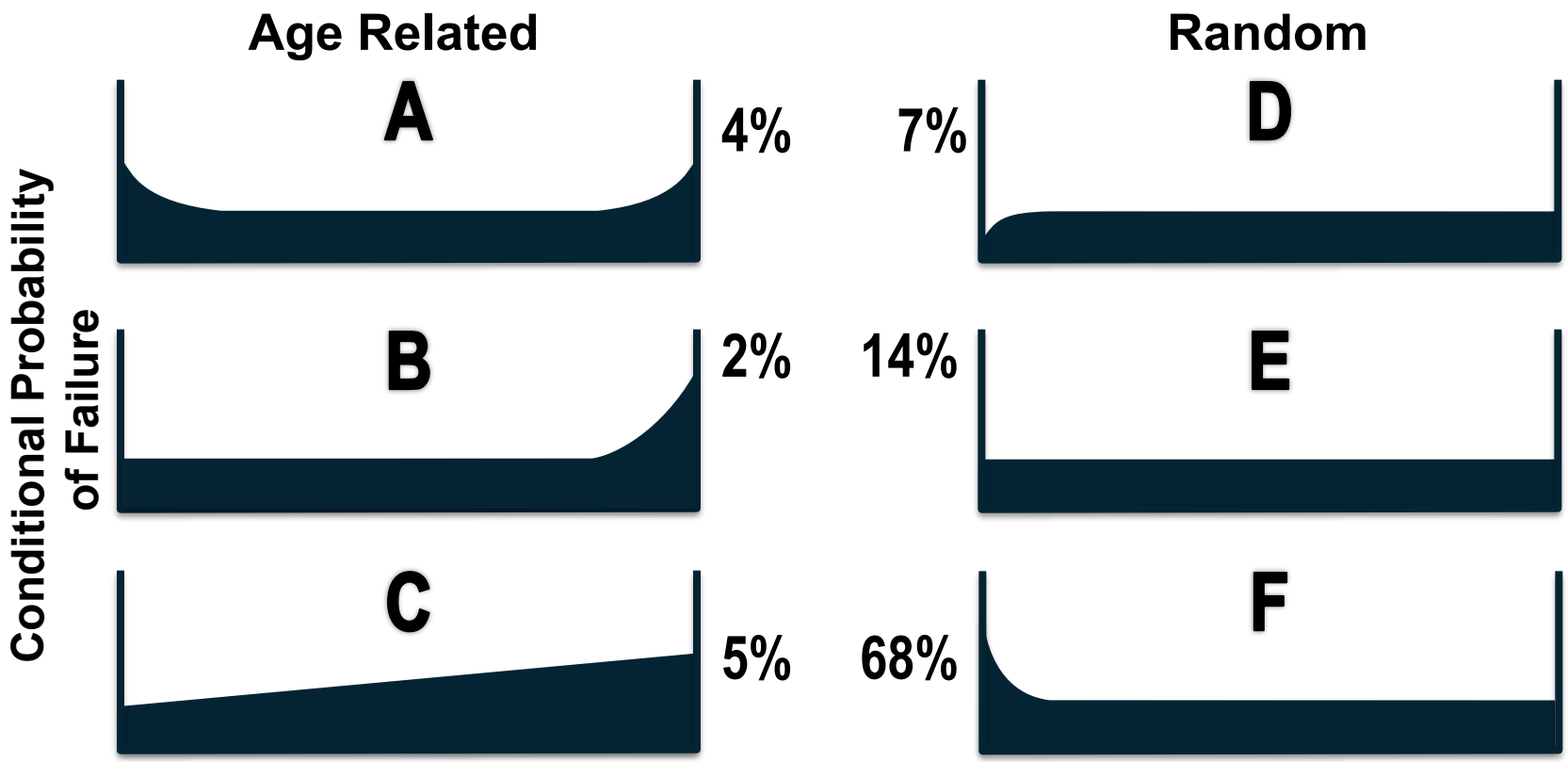
In practice, many (89%) failures were not age related at all!

Source: Marshall Institute PMO workshop

Concepts of RCM

Failure Patterns

Adapted from Reliability-Centered Maintenance: The Wave of the Present
by Donald A. Morton, PE, CPE AIPE FACILITIES, Sept/Oct 1994



Source: Marshall Institute PMO workshop

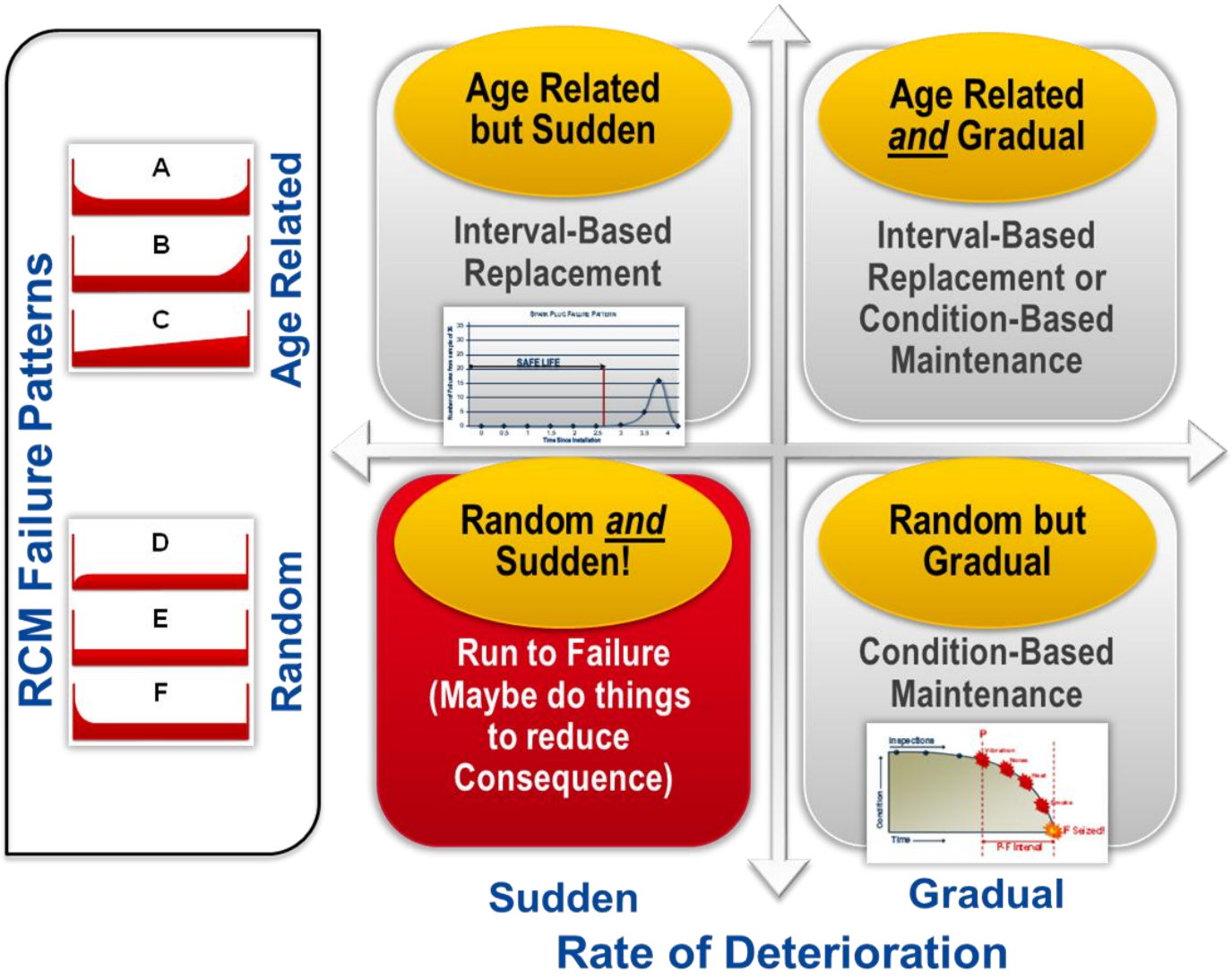
Concepts of RCM

Putting it all together

- Failure Patterns and Failure Quadrants help us understand how a component fails
- P to F and Safe Life Intervals help us understand when failure will occur
- Consequence helps us understand how much we care about the failure

Source: Marshall Institute PMO workshop

PMO seen through 4 quadrants



Source: MRM II

PMO workshop – old PM

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Criticality cl	3	PRODUCTION
Document ID	RUSSELL SIEVE SEMI ANUAL PM	
Ref order no		
Event type	OPMO999924	SEMI ANNUAL PM
Equipment no	Z11.SC592	RUSSELL EUROPA 1200 SIEVE
NH position	Z11.OPMZM402A	PA1_SCREEN/SIEV
Production line	OPMSCR01	SCREENING

Requested by		Tel no
Approved by		Tel no
Reason code	CODE	
production stop	0	
Start date	092515	
Finish date	092515	

MOS143WO-A4

LUBRICATE TOP BEARING 4 GRAMS
LUBRICATE BOTTOM BEARING 4 GRAMS
CHECK BAND CLAMPS FOR TIGHTNESS
CHECK ALL HOSES & BELLOWS FOR CRACKS OR LEAKAGE
CHECK FOR LOOSE FASTENERS
CHECK CONDITION OF MOUNTING SUPPORTS ON FLOOR
CHECK PIPING FOR LEAKS
INSPECT MOTOR COUPLING
INSPECT WAGON WHEEL MOUNTS

SEMI ANNUAL PM RUSSELL SIEVE

Op description	RUSSELL EUROPA 1200 SIEVE		
Work center	ZOOGPRE	0010	MAINT. PM WORKS (STONY CREEK)
Employee no			
001			

Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

PMO workshop – new PM

5. **Flexible Coupling** Visually inspect flexible coupling for evidence of excessive normal wear, dry rot, and missing material, there should be none. If evidence exists, notify maintenance lead. (flexible coupling part # ZO00109010).

OK	ADJ	CM

6. **Flexible Coupling** Using a wrench, confirm that the flexible coupling fasteners are tightly secured to the drive flange. Additionally, ensure the set screws on the drive and the driven coupling flange are secure.

OK	ADJ	CM

7. **Flexible Coupling** Using a scraper device, or can of compressed air, clean the gap between the flexible coupling and the driven flange. There should be a gap between these two surfaces.

OK	ADJ	CM

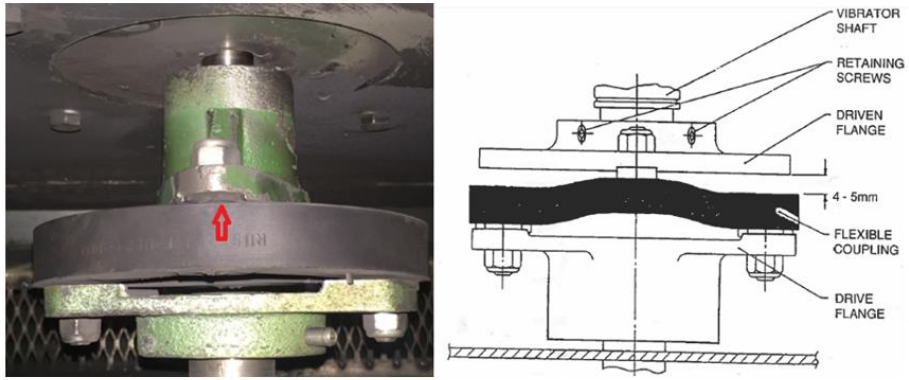


Figure 3: Flexible coupling and schematic

Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

PM example – pre and post PMO workshop

- Old PM task

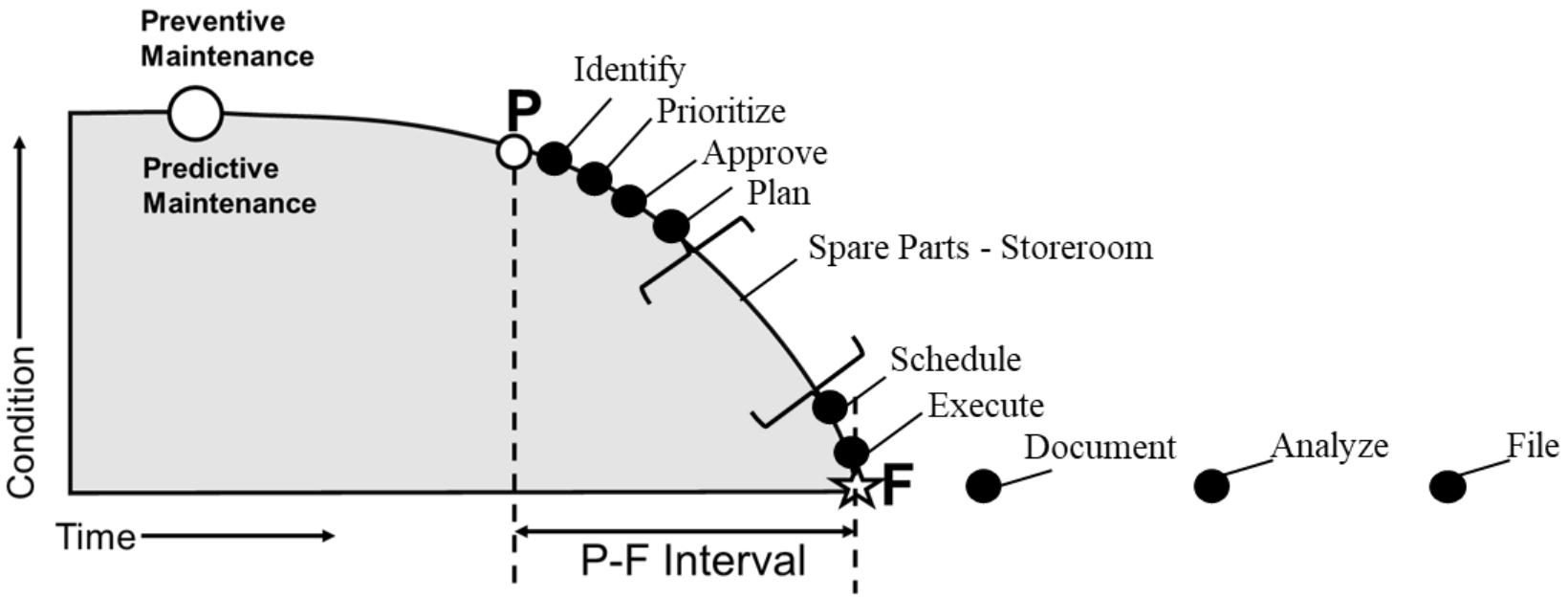
"Apply 4 grams of grease to bearing"

- New PM task

"While the machine is running, with a clean rag, wipe grease zerk clean: apply 4 grams of Mobile XHP222 grease using a calibrated grease gun; with a clean rag, wipe grease zerk clean. If the bearing will not take 4 grams of grease, or if it will not take any grease, notify the maintenance supervisor immediately. (Bearing #Z000002407)"

Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

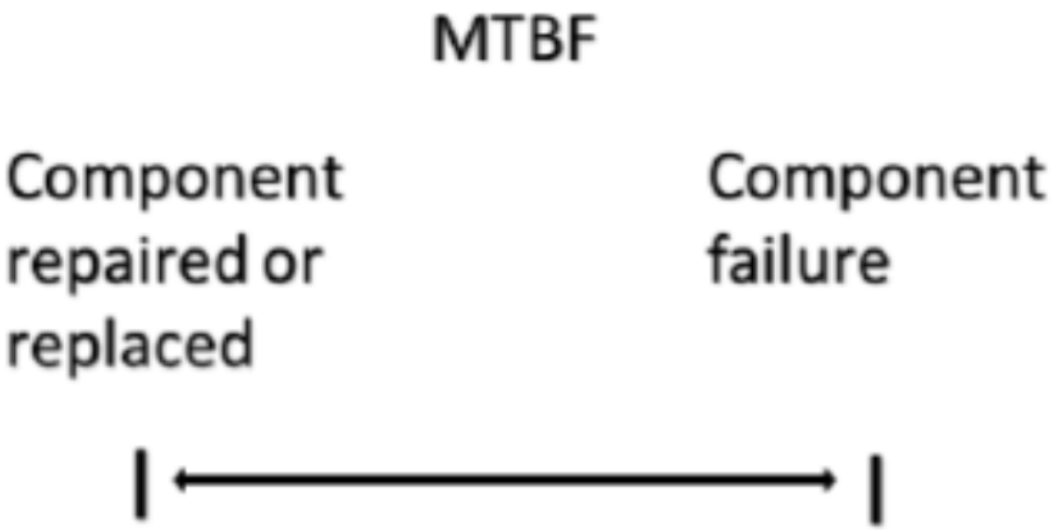
Full Work Management



Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

RAM
Reliability, Availability, Maintainability

Mean Time Between Failures - MTBF

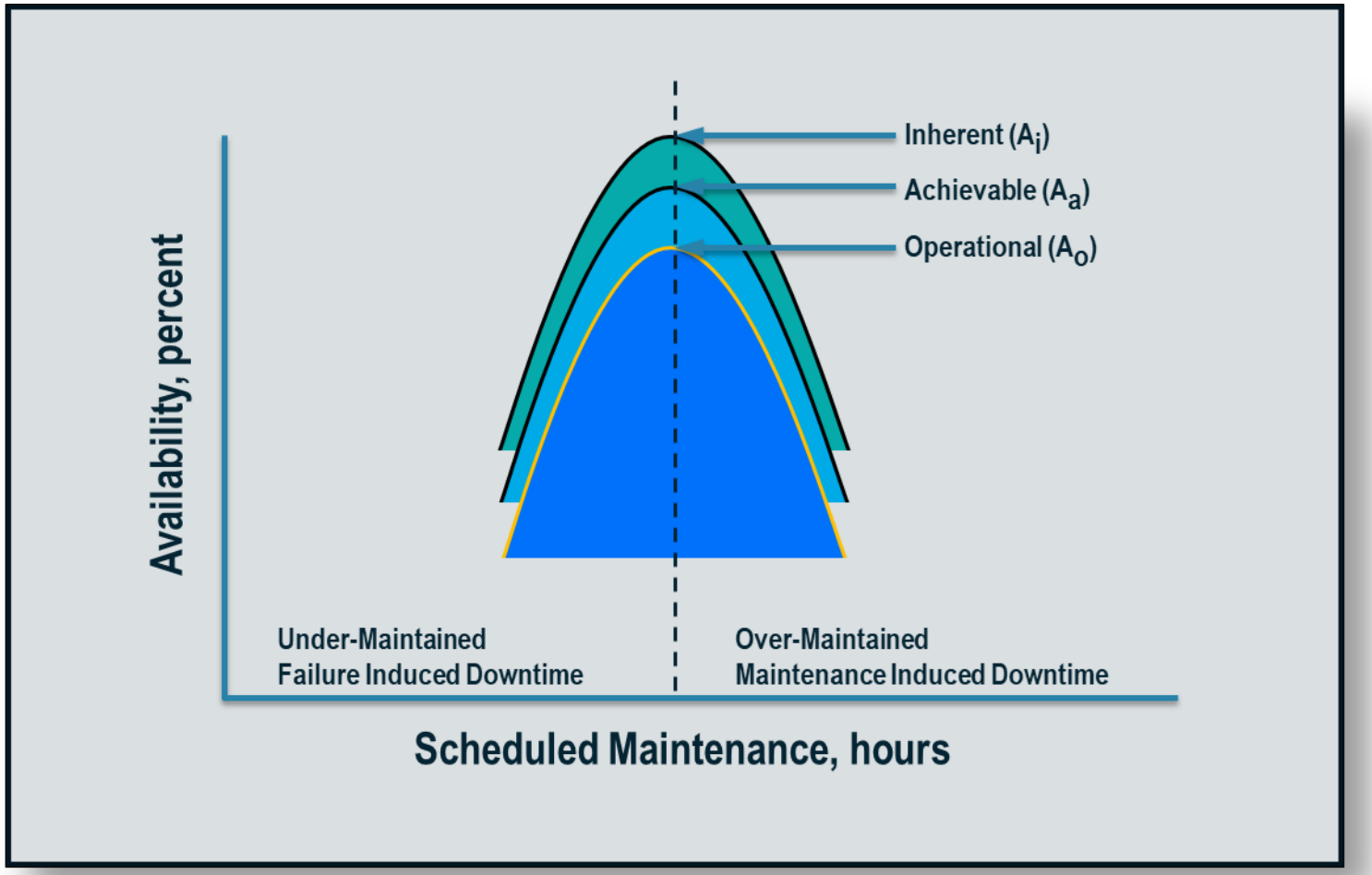


Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

Mean Time To Repair - MTTR

Source: The Reliability Excellence Workbook, From Ideas to Action - Ross

Availability



Source: MRM III

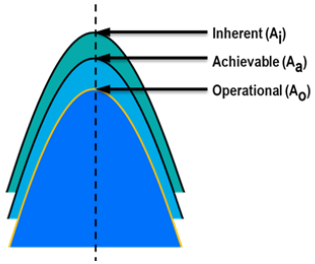
RAM

Reliability	Maintainability	Availability
Constant	Decreases	Decreases
Constant	Increases	Increases
Increases	Constant	Increases
Decreases	Constant	Decreases

Source: MRM III

Inherent Availability

$$A_i = \frac{MTBF}{(MTBF+MTTR)}$$

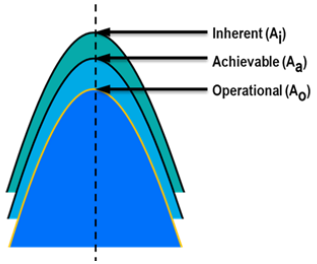


Source: MRM III

Achievable Availability

$$A_a = \frac{MTBM}{(MTBM+MAMT)}$$

Where MTBM is mean time between corrective and preventive maintenance actions and MAMT is the mean active maintenance time (PM&CM).

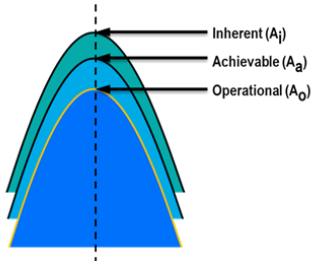


Source: MRM III

Operational Availability

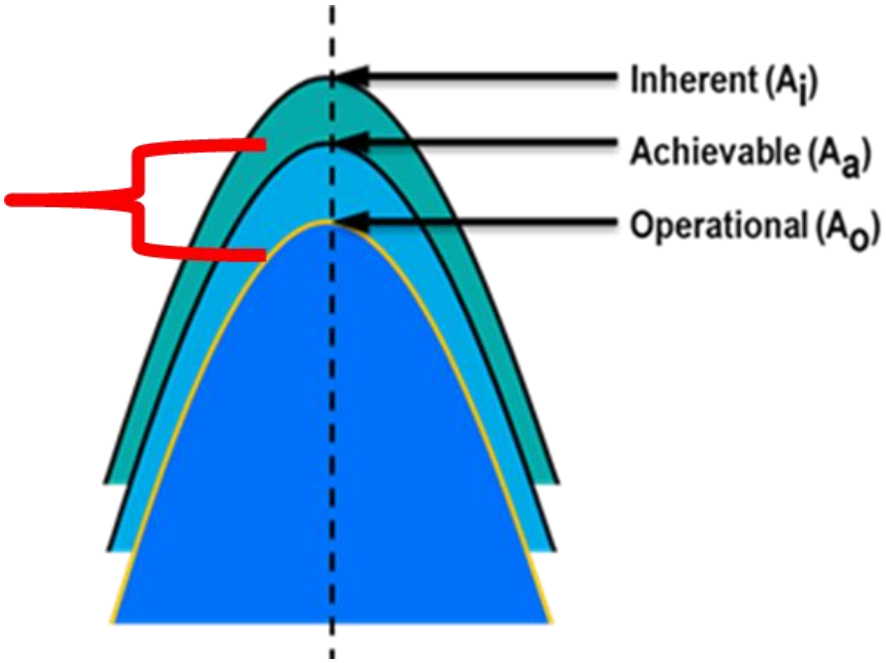
$$A_o = \frac{MTBM}{(MTBM + MDT)}$$

Where MTBM is mean time between corrective and preventive maintenance actions and MDT is the mean down time = the time a fault is detected to the time it is restored. This includes administrative and logistic delay times.



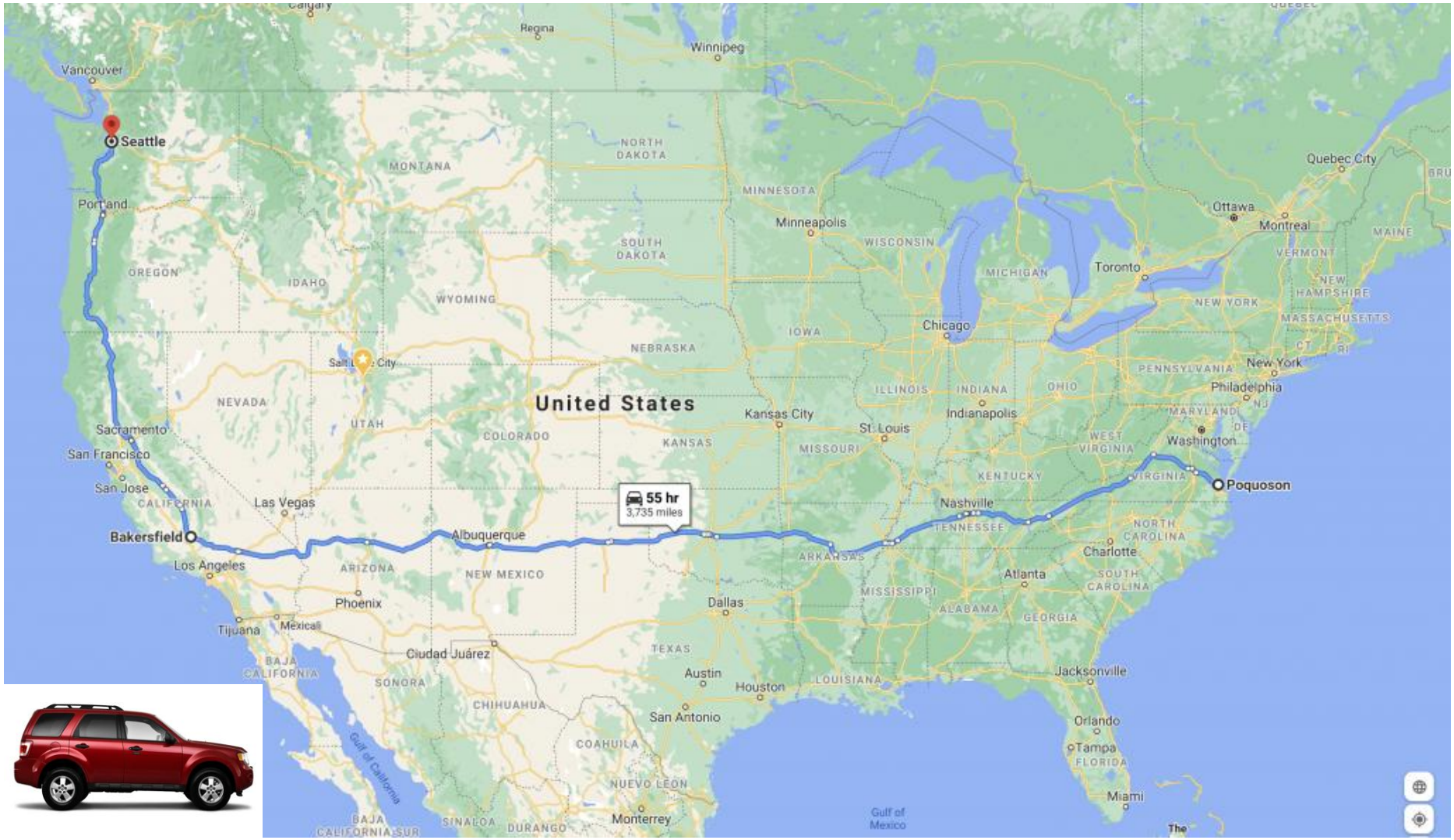
Source: MRM III

The Target



Source: MRM III

A Practical Example



Source: MRM III

Dr. John's Maintenance Minute

John Ross, CMRP

Questions?

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