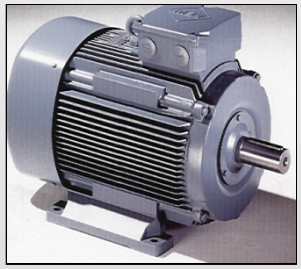
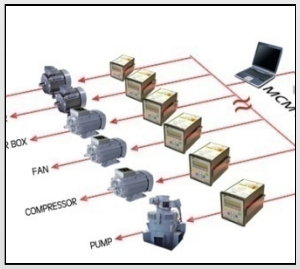
Developing a Business Strategy for Predictive Maintenance

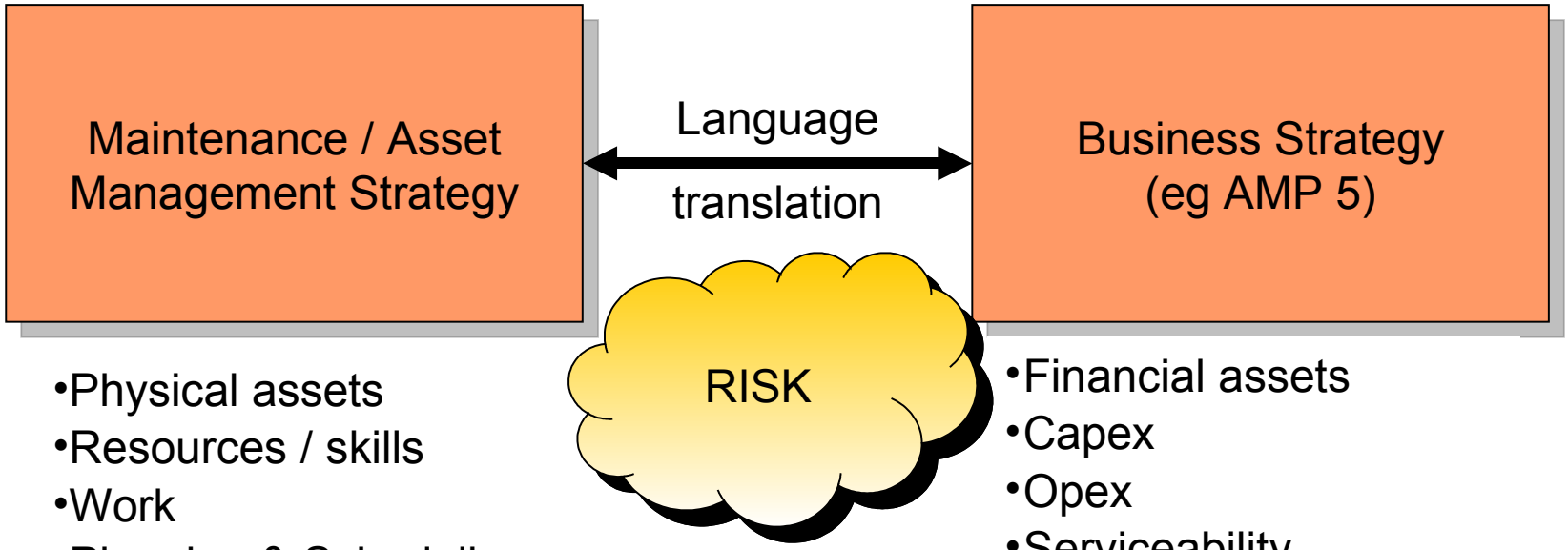



Geoff Walker, September 09

How to develop a Business Strategy for Predictive Maintenance? Or for any Maintenance strategy?

"if engineers can't express themselves in terms of time or money, business managers simply can't hear them" Paul Barringer BE



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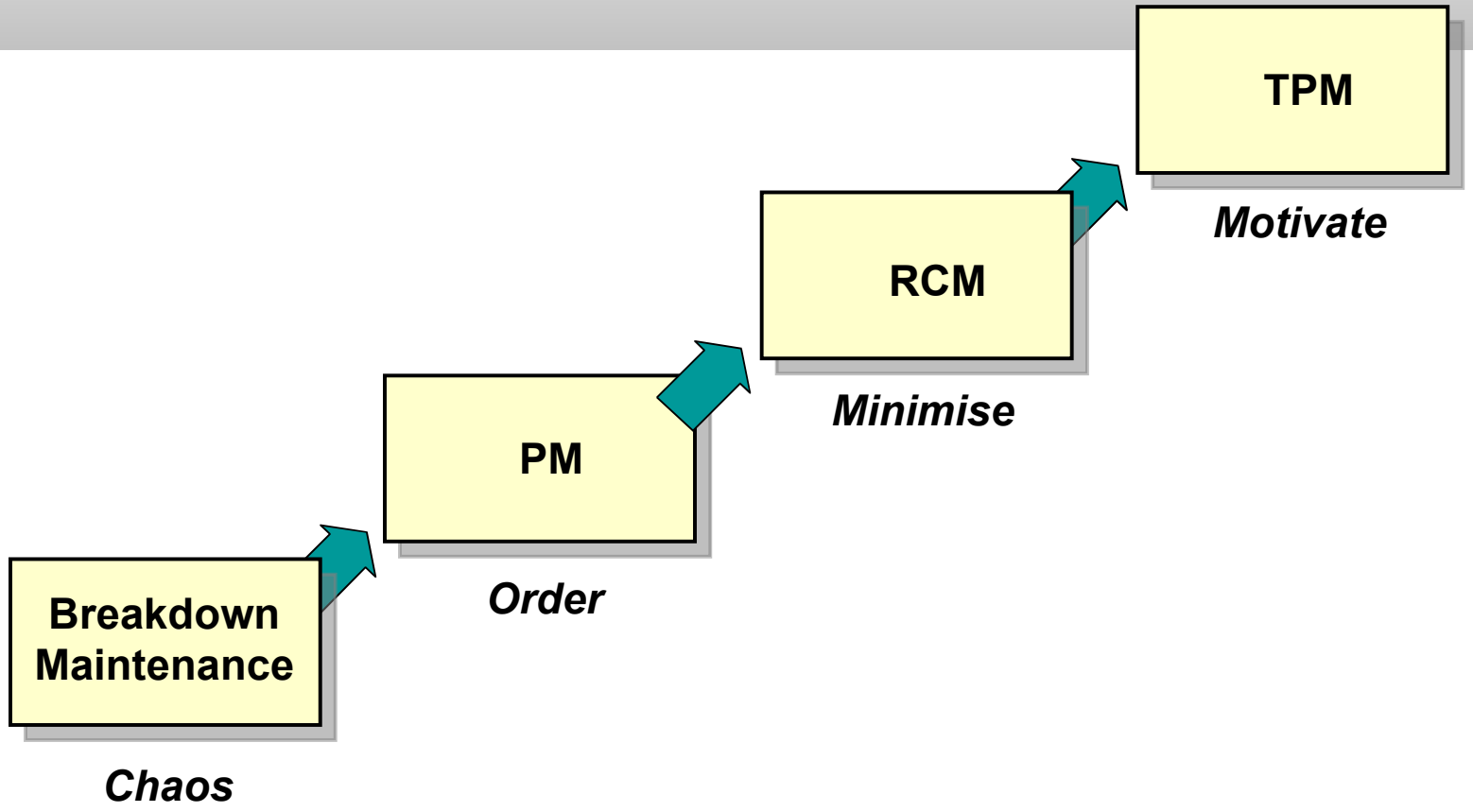
Evolution of maintenance techniques – early 1990s picture



So where is Condition Based Maintenance (CBM)/ Predictive Maintenance (PdM)?

And is there nothing new since 1990?

And how do we articulate decisions in terms of time and money?

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Breakdown Maintenance Strategy

Characteristics:

- Run to failure is still the predominant approach in many (most) organisations
- May still dominate even after repeated attempts to adopt Planned Maintenance
- Strong cultural constraints

Advantages

- Easy to understand
- Doesn't need complicated planning
- Doesn't need much data
- The default condition
- Maintainers can be seen as heroic firefighters

Disadvantages

- Chaotic
- Impossible to plan – so can't optimise use of resources
- Lack of spare parts planning leads to either long downtime or huge stock levels
- Massive downtime cost
- Stressful

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Cost and Time of Breakdown Strategy

Do no planned work

Yr 1	£0
Yr 2	£0
Yr 3	£0
Yr 4	£100k, out of action for 38 weeks
Yr 5	£?

With no preventative care or monitoring, gradual pump impellor erosion / damage resulted in imbalance, overloading bearings, thence damage to casing requiring welding and re-machining, and detected only when motor failed by burning out, requiring new motor, as well as shaft, bearings, impellor, emergency overtime, etc.

Probably not the best business strategy – but we were OK because there were three other pumps we could use.

Preventive Maintenance Strategy

Characteristics:

- Maintenance performed at fixed time or usage intervals *(eg annually, or every 1000 runhours)*
- Planned approach, typically with people, plant and materials all pre-organised
- Based on the concept of the "Bathtub Curve"

Advantages

- Easy to understand
- Predictable
- Leads to "order"
- Can fit into planned production schedules
- The default condition for safety critical items (lifting gear, pressure systems)

Disadvantages

- Needs to be planned!
- Needs planning resources
- Needs good data
- Can be inflexible
- What is the right frequency?
- Tends to over-maintenance
- Can create worse reliability
- Can't do everything in time
- Needs downtime

Cost and Time of Preventive Strategy

Do "all" planned work

Yr 1	£5k – one week
Yr 2	£5k – one week
Yr 3	£10k – two weeks
Yr 4	£5k – one week
Yr 5	£5k – one week

Routine overhaul every year, team of two guys for a week.

In year 3, they discover the beginnings of a problem, and replace impellor before serious damage that would have become catastrophic in year 4

Looks like a better business strategy – but we still spent 30k and 6 weeks outage.

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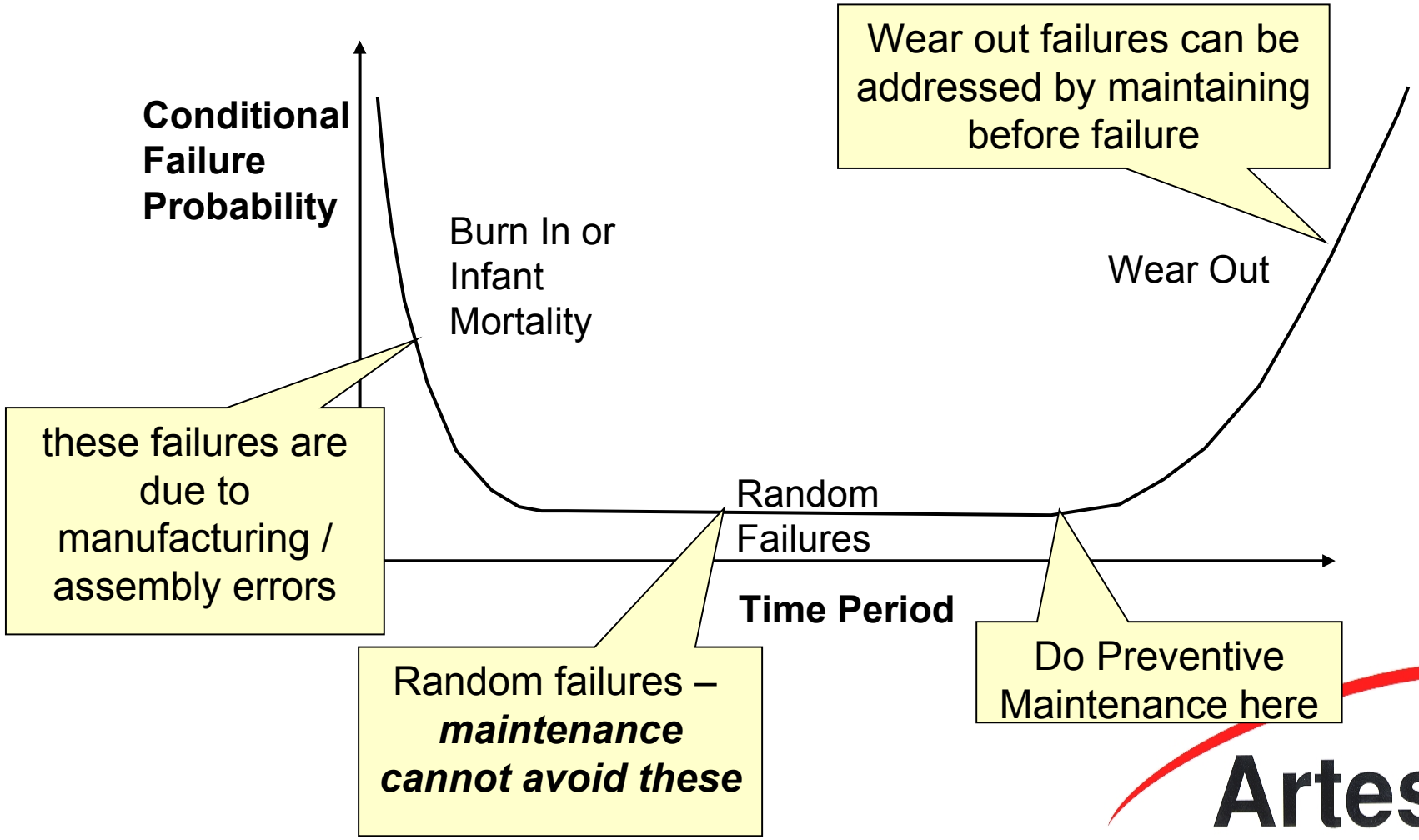
Why do Preventive Maintenance? It all depends on the 'Bathtub' Curve concept



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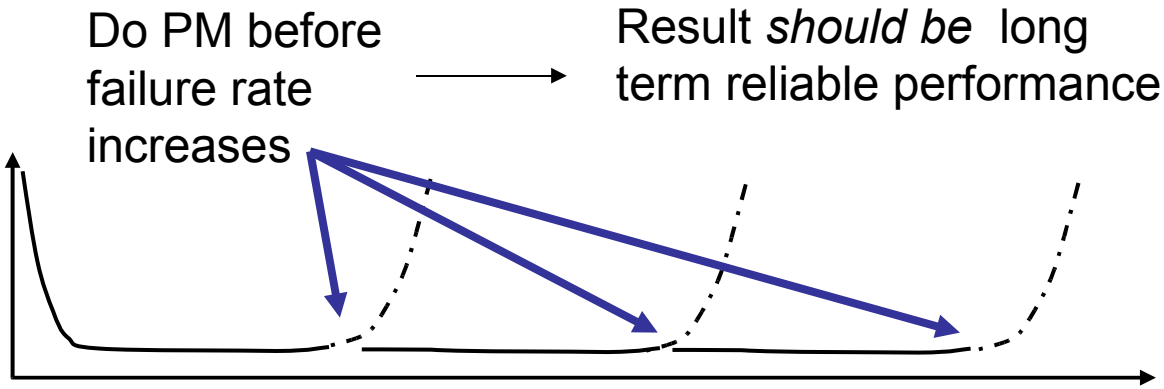
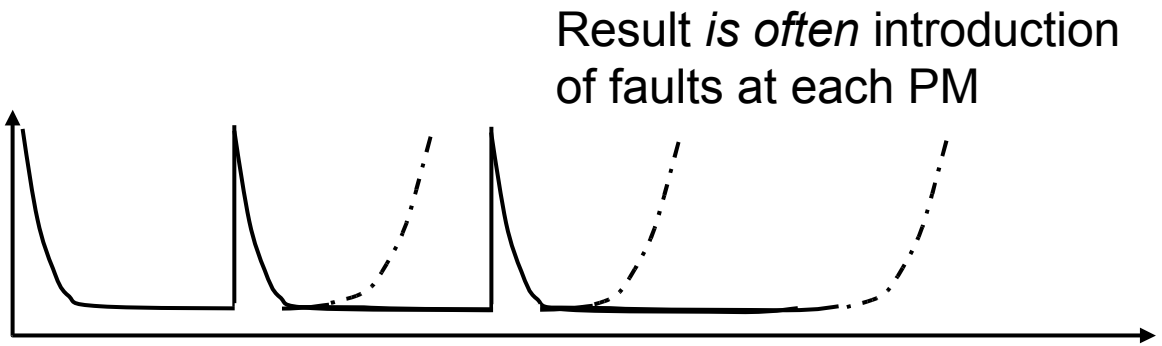
This concept forms the basis for the concept of scheduled preventive maintenance (PM)

Intent:



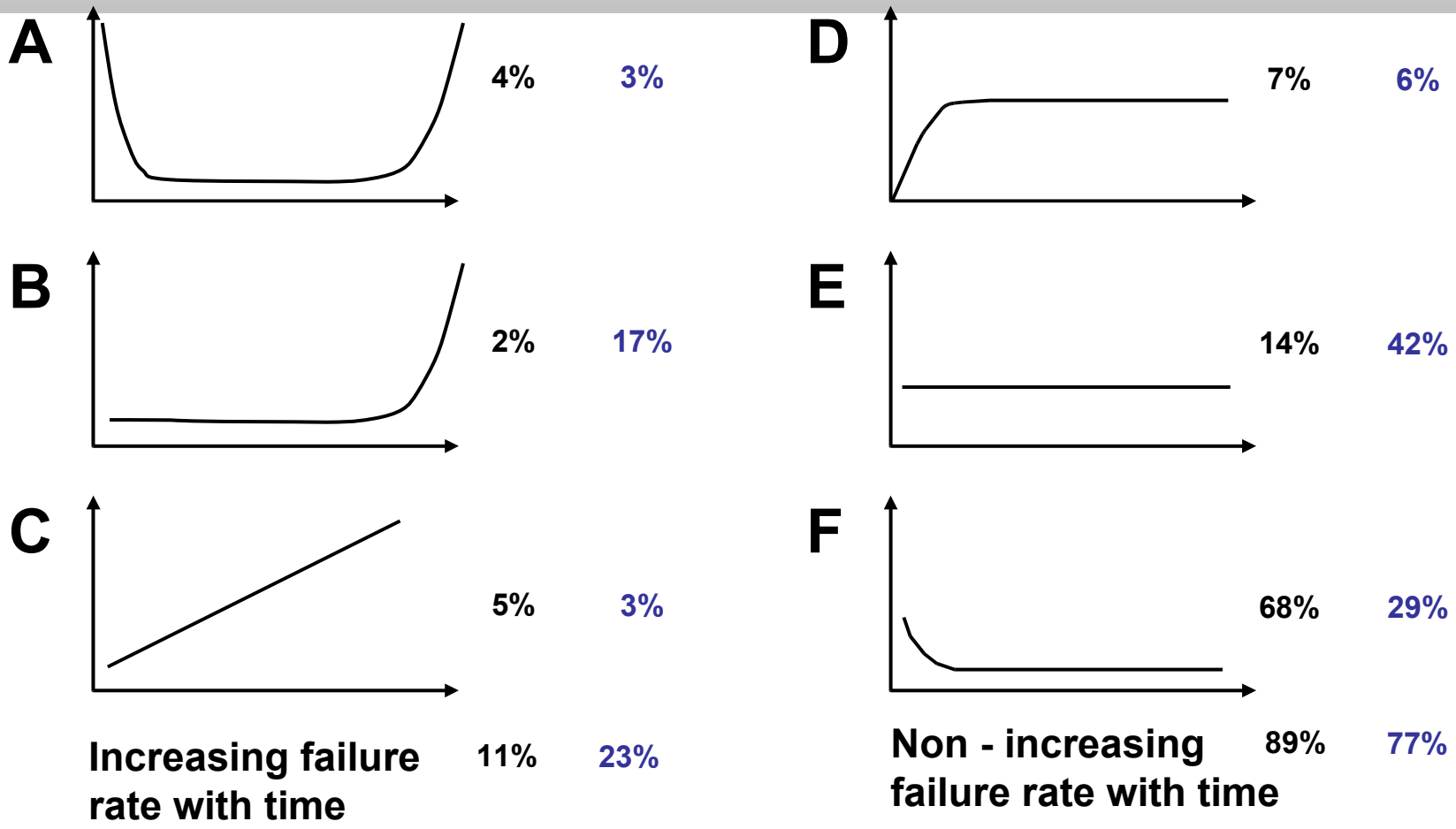
Reality:



So PM is frequently not very effective in improving reliability.
And it is almost always maintaining too soon – ie too frequently

In reality, PM is often inappropriate anyway, owing to the Patterns of Failure found in practice

Source: Nolan & Heap



Routine, time based, PM is only applicable to the left column.
For the right column, Condition Based is required (or run to failure)

Reliability Centred Maintenance Strategy (RCM)

Characteristics:

- A structured approach to identifying the most appropriate maintenance regime
- Developed in US Aircraft industry in 1960s, now widely adopted
- Recommends PM, or BD, or CBM depending on particular situation
- Based on the updated understanding of the “Bathtub Curve”

Advantages

- Identifies the “correct” maintenance regime
- Achieves “inherent reliability level” of equipment
- Should result in minimum cost
- Defensible against challenges – eg cost, risk, safety.

Disadvantages

- Huge effort needed to perform initial analysis
- Hungry of scarce people’s time
- Expensive
- Can be slow
- Risk of “can’t see the wood for the trees”

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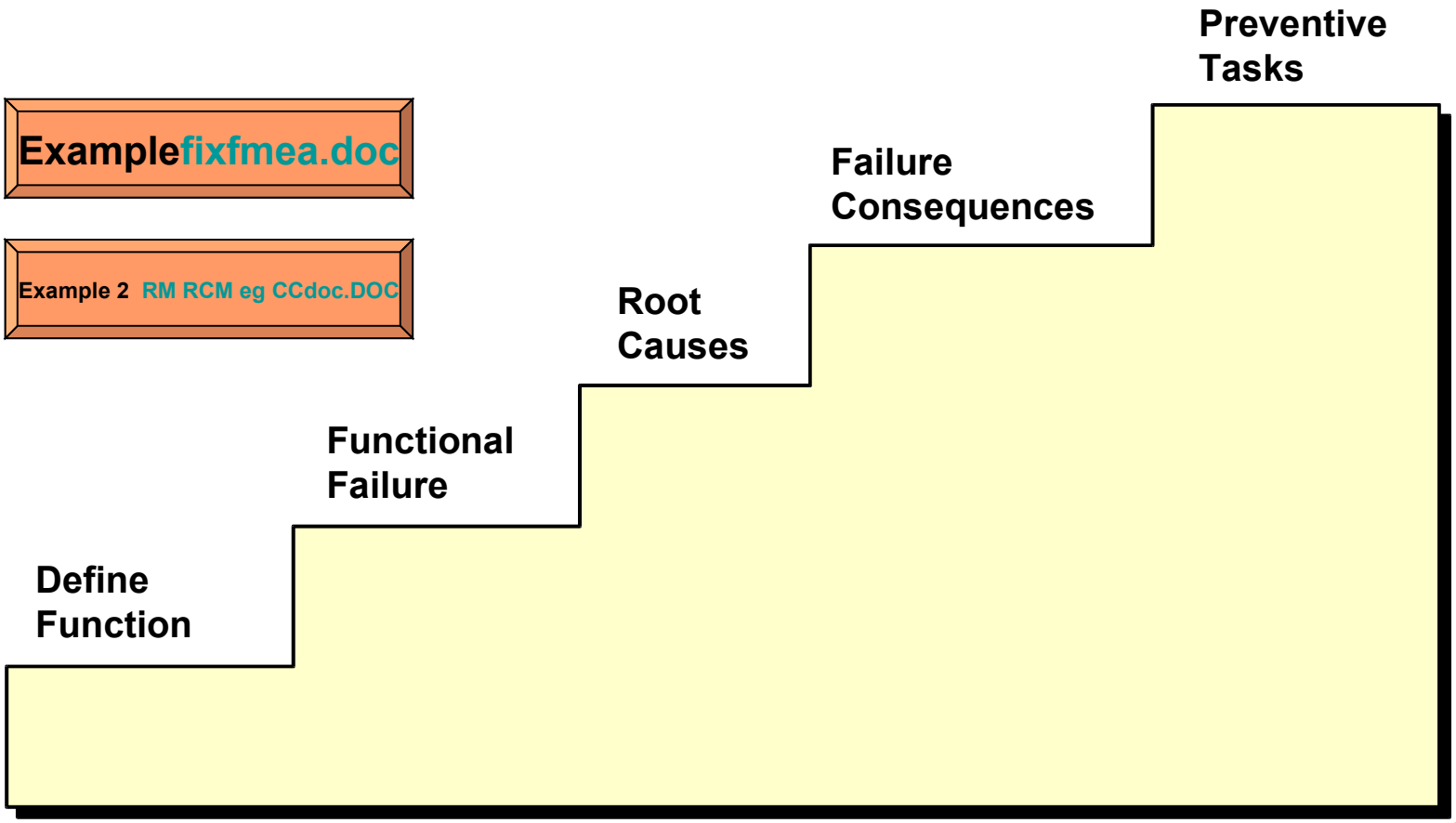
Key steps in the RCM process



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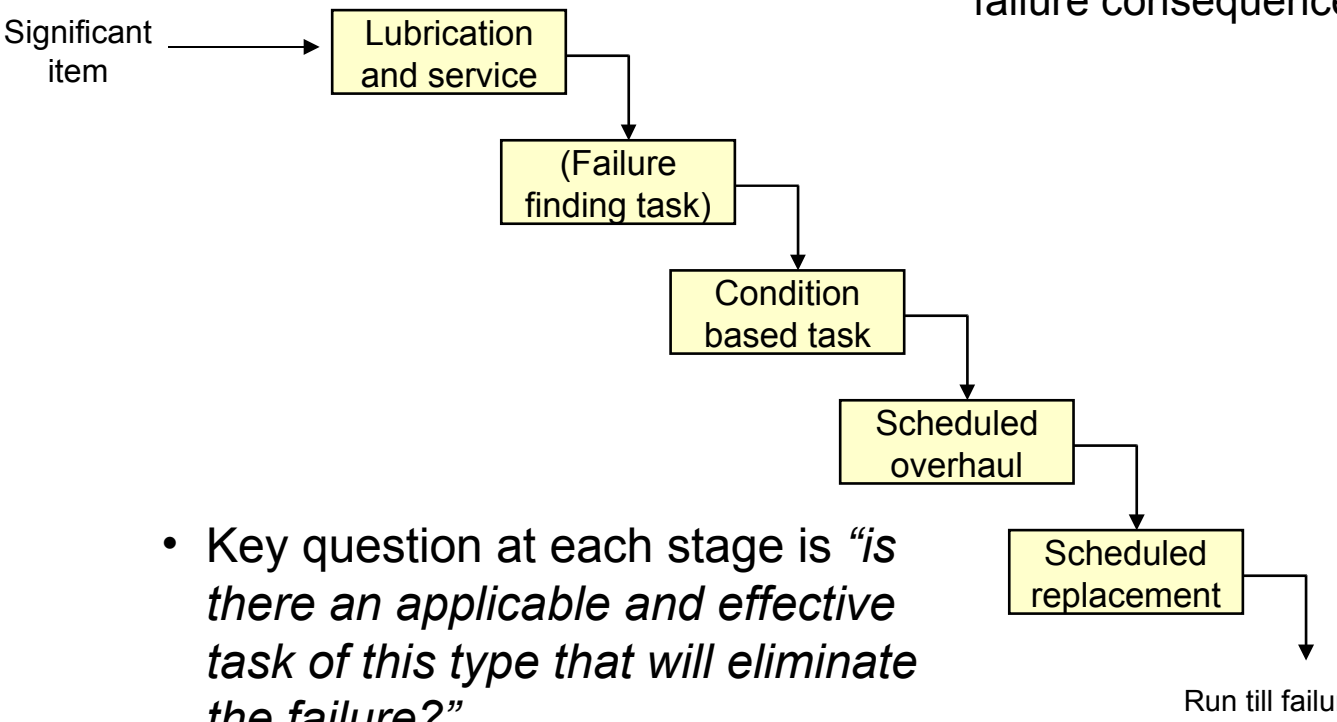
RCM selects maintenance regime in a preferred sequence – depending on consequence of failure

- Simplified decision diagram
- Tasks vary in sequence as a function of failure consequence



- Key question at each stage is *"is there an applicable and effective task of this type that will eliminate the failure?"*

...and then task intervals set for schedules

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Total Productive Maintenance Strategy (TPM)

Characteristics:

- Close attention to detail of equipment based on a concept of “operator ownership”
- Operators are empowered to decide what maintenance work is required, when, and then to do it themselves
- “Japanese” approach to maintenance, that fits with JIT & TQM
- Aim is “zero defects”, key measure is Overall Equipment Effectiveness, OEE

Advantages

- Achieves outstanding results in manufacturing industry
- Doesn’t rely on clever technology or systems
- Good for workforce motivation and morale
- Use of OEE covers all aspects of machine performance (uptime, running rate & quality)

Disadvantages

- Not so appropriate to unmanned equipment
- Not highly technical – relies on operators
- Hard to implement required culture shift

TPM claims dramatic results:

700 breakdowns/month ➔ zero breakdowns in five years

11 defect per million units produced

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Condition Based Maintenance Strategy (CBM)

Characteristics:

- Maintain only when measurement of condition indicates there is a need
- Move away from fixed schedules
- Should result in reduction of overall workload AND achievement of maximum inherent reliability levels

Advantages

- Should result in the maximum reliability AND minimum maintenance work

Disadvantages

- Not applicable to all equipment
- Planning and scheduling can be more difficult
- Requires appropriate measurement technique
- Manual measures easy to get missed
- Has required high skill levels to interpret and decide

Cost and Time of Condition Based Strategy (Walkaround)

Do routine walkaround patrols

Yr 1	£1k – no downtime
Yr 2	£1k – no downtime
Yr 3	£9k – one & half weeks
Yr 4	£1k – no downtime
Yr 5	£50k – four weeks

Routine patrol readings monthly – one guy, drive to site. No routine PM, no downtime

In year 3, they discover the beginnings of a problem, and replace impellor before serious damage that would have become catastrophic in year 4. By planning, it is less downtime than in PM case.

In Yr 5, an obstruction passes through the pump between measurements, resulting in a burned out motor.

Looks like a better business strategy still – but we are still vulnerable to damage with short P-F time failure modes

Cost and Time of Condition Based Strategy (Online – permanently installed)

Wait until alerted automatically

Yr 1	£500 – no downtime
Yr 2	£500 – no downtime
Yr 3	£9k – one & half weeks
Yr 4	£500 – no downtime
Yr 5	£10k – two weeks

Readings taken continuously and any alerts fed direct to relevant staff / managers. No site visits required.

In year 3, the beginnings of a problem is detected, and impellor replaced before serious damage that would have become catastrophic in year 4. By planning, it is less downtime than in PM case.

In Yr 5, an obstruction passes through the pump. The alert is raised and the pump impellor and shaft is replaced without further damage

Looks like the best business strategy yet – but there may be more...

Don’t forget Energy Consumption and Capital Efficiency

Capital Efficiency

Year 1	£?
Year 2	£?
Year 3	£?
Year 4	£?
Year 5	£?

Through confidence in both **reliability** and ***detectability***, redundancy can be safely reduced.

Do you really need 4 pumps?

How much could you save if you only had 3?

Given all-up installation cost is a multiple of the equipment cost, the potential benefit is significant.

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Don’t forget Energy Consumption and Capital Efficiency

Electricity Costs

(100kw, 8,000hr / yr, 6.25p/kWHr = £50,000 pa)

Year 1	£50k
Year 2	£50k
Year 3	£50k
Year 4	£50k
Year 5	£50k

So in 5 years, we spend more on electricity than the replacement value of the pump.

This is a significant cash cost – and is also a major contributor to **Climate Change**.

Industry uses approx 60% of electricity driving electric motors.

Some large water companies are spending >£30m pa on electricity bill for pumping water. Even 1% of this is significant.

So installing efficient motors is essential, but it is not sufficient...

Climate change obligations: high efficiency motors are just the starting point

For a typical 75kW motor:

- **Replacing EFF3 motor with EFF1 motor gains 1.1% increase in efficiency**
- **2.5% voltage unbalance loses 1.3% in efficiency***
- **mechanical imbalance & misalignment can waste up to 1-3% efficiency.**

* US Department of Energy, Energy Efficiency and Renewable Energy

The efficiency gains from replacing old motors with high efficiency ones can be completely wasted if plant is not installed and adjusted ***correctly***.

The potential for **benefit** from ***correct, optimised plant care is greater than*** the benefit of installing higher efficiency motors

Motor Power [kW]	Minimum Efficiency		
	EFF3 [%]	EFF1 [%]	(EFF1 – EFF3) [%]
1,1	<76,2	>83,8	7,6
1,5	<78,5	>85,0	6,5
2,2	<81,0	>86,4	5,4
3	<82,6	>87,4	4,8
5,5	<85,7	>89,2	3,5
7,5	<87,0	>90,1	3,1
15	<89,4	>91,8	2,4
22	<90,5	>92,2	1,7
30	<91,4	>93,2	1,8
37	<92,0	>93,6	1,6
45	<92,5	>93,9	1,4
55	<93,0	>94,2	1,2
75	<93,6	>94,7	1,1
90	<93,9	>95,0	1,1

CEMEP : European Committee of Manufacturers of Electrical Machines and Power Electronics

Optimisation strategy

- Electrical energy wasters
  - Phase imbalance
  - Ground faults
  - Worn bushes
  - Overloading
  - Insulation
  - Loose connections
    - Eg loose connection. 400hp, 480v, 9.5c/kwHr, 25kW loss, $16,633 annual savings
- Mechanical energy wasters
  - Looseness
  - Imbalance
  - Wear
  - Misalignment: 6 – 15% energy loss

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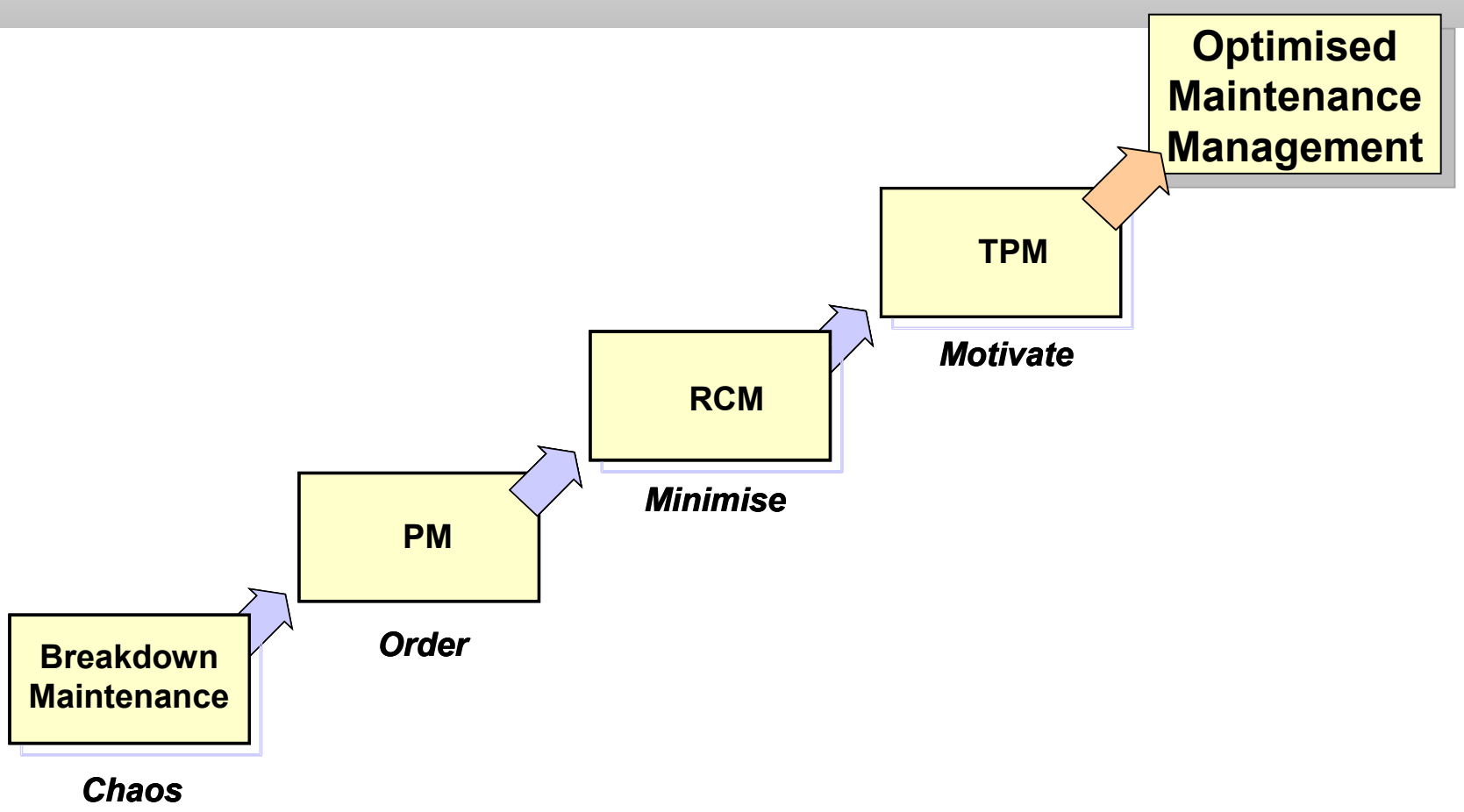
Evolution of maintenance techniques – the 1990s picture can now be updated to reflect the availability of new monitoring technologies



Optimised Maintenance Management will allow you to reduce costs, improve performance & serviceability, contribute to Climate Change challenge, and allow greater capital efficiency – which should fit perfectly with your business strategy

Summary of business opportunities from the best performance monitoring / condition monitoring / predictive maintenance techniques:

- **Reduced energy consumption** — **£10k**
  - **Measurement of power used, and measurement of causes of loss could lead to savings of 5-10% of energy bill**
- **Greater Capital Efficiency** — **£600 – 750k**
  - **Confidence in condition assessment and detection can permit lower levels of redundancy – saving 4-5x equipment cost**
- **Lower Maintenance cost** — **£50 - 80k**
  - **Avoidance of un-necessary work, and monitoring of effectiveness of the work done to avoid infant mortalities**
- **Lower downtime / higher customer serviceability** — **£?k**
  - **Prediction of faults to avoid customer disruption**
- **Total potential for saving:**
  - **Total from these factors is of the order of** — **£80 – 100k pa**

So can you find a solution that delivers these benefits for less than this price? – if so, it sounds a solid business strategy case!

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Your challenge for subsequent speakers today:

- Do their techniques give continuous monitoring, that will alert you when or before a problem condition occurs? – unlocks scope for Capital Efficiency
- Can the output be readily understood by normal staff, with little or no need for specialist experts?
- Does their technique measure energy consumed, and can it give indications of energy efficiency opportunities, eg by measuring the power wasting causes: low power factor, imbalance, misalignment and harmonics

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Discussion / Questions

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