IMPACT OF MAINTENANCE STRATEGIES IN REDUCING COSTS AND BUDGET

PRESENTED BY: Amine MALLEK

Outline:

- ✓ How to build a Maintenance Strategies capable to reduce deeply the costs by selecting the right combination of different maintenance philosophies: corrective, preventive, time-based, risk-based and condition-based maintenance.
- ✓ How to reduce Maintenance Budget while preserving the optimum level of Maintenance Effectiveness and Efficiency.
- ✓ Best Practises and approach to reduce Maintenance costs by executing the right Preventive, Corrective and Predictive Maintenance.
- ✓ Integrated cost and progress tracking benefits.

The Maintenance Strategies that will be described is the outcome of many studies by Reliability and Maintenance professionals from many organizations in the world (*) , the benefits are estimated to :

- Increase revenue
- ≈ 90% less downtime
- ≈ 15% extra uptime
- Reduce Maintenance costs by an average between ≈ 25% to ≈ 35%

(*) This study is based on a number of key sources listed at the end of the presentation (like: Moubray, NAVSEA, …) .

PRESENTED BY: Amine MALLEK
aminemallek@gmail.com

Summary:

I. Introduction.

II. High Risk of reducing maintenance costs without a clear Maintenance Strategies.

III. How to build a Maintenance Strategies capable to reduce deeply Maintenance Costs.

IV. Practical Maintenance methodology to cut Maintenance Cost.

V. 3 Main areas of Maintenance Strategies to decrease Maintenance Budget.

VI. Best practices to reduce maintenance costs

VII. Measuring Maintenance Productivity.

I. Introduction

How much of your operating budget is spent annually on plant maintenance?

Unfortunately, there is no quick fix. Spending more on plant maintenance doesn't result in fewer failures.

It's about spending on just the right Maintenance and stop spending on an unnecessary works.

The right Maintenance could only be assured through a strong Maintenance Strategies (or Philosophies) that is able to allow the reduction of Maintenance Budget & costs while preserving the optimum level of Maintenance Effectiveness and Efficiency.

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aminemallek@gmail.com

Times are tough. Your company isn't making as much " **Revenue** " as it used to. You need to cut " **Costs** ", but where ? How ?

Maintenance costs is a lot of money that frequently represent the biggest percentage of operating costs. (perhaps as high as 50% of total costs)

For this reason, most professionals try to reduce as much as possible maintenance Budget and costs.

It is important to highlight that reducing Maintenance budget is NOT Deferring or Not Performing Maintenance.

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aminemallek@gmail.com

II. High Risk of Reducing Maintenance Costs without a Clear Maintenance Strategies

Q: What are the Risks Associated with simply Deferring or Not Performing Maintenance to reduce costs?

Insufficient spending on maintenance has been a significant contributor to a number of industrial accidents with serious safety, environmental and political consequences:

- The explosion at “Union Carbide’s Bhopal Pesticide Plant” in India occurred as a result of under-maintenance of significant safety critical systems.

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aminemallek@gmail.com

- The Piper Alpha explosion in the North Sea killed 167 men. The cause was inadequate maintenance and safety procedures.

- An explosion at the Varanus Island Gas Plant in Australia, caused by lack of Maintenance (rupture of a corroded pipeline).

- At Potters Bar in the UK, a train derailment killed 7 people and injured 76. The principal cause is a set of points was poorly maintained.

The cost to Repair some Equipment After it has Failed
is much more important
compared with Preventing it from Failing.

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aminemallek@gmail.com

III. How to build a Maintenance Strategies capable to reduce deeply Maintenance Costs

HOW TO CHOOSE THE RIGHT MAINTENANCE STRATEGY ?

Across industry, many definitions are used for the different types of maintenance:

- Preventive maintenance.
- Corrective maintenance.
- Condition based maintenance.
- Predictive maintenance.
- etc

I'll offer you the view of experienced Maintenance professionals of the different types of maintenance and more importantly, when to use them.

Preventive Maintenance	vs	Corrective Maintenance
before a failure has occurred		*after a failure has occurred*

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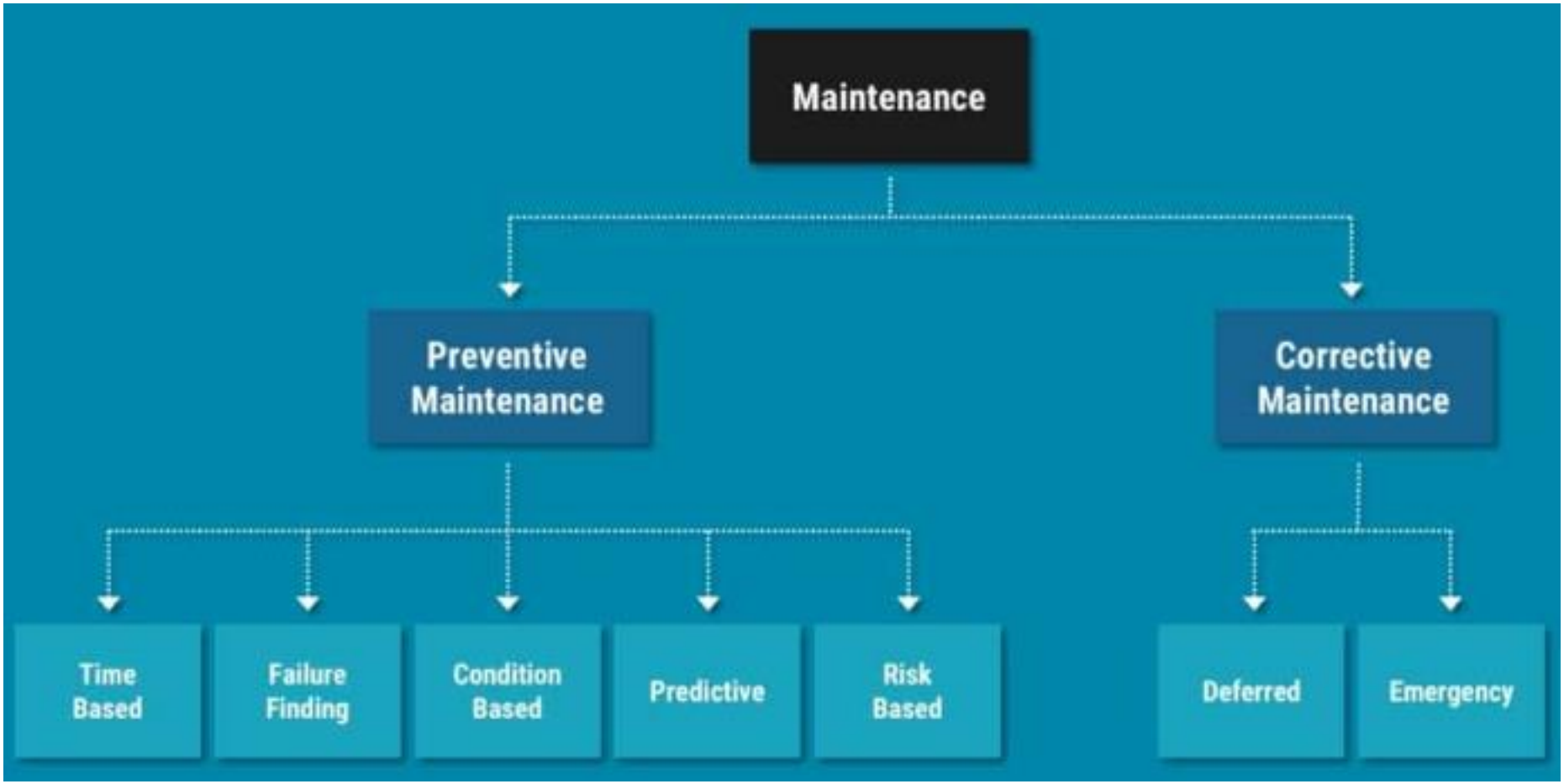

Preventive maintenance: an equipment maintenance strategy based on replacing, or restoring, an asset at a fixed interval or fixed condition.

Type of Preventive Maintenance:

- Time Based Maintenance (TBM)
- Failure Finding Maintenance (FFM)
- Risk Based Maintenance (RBM)
- Condition Based Maintenance (CBM)
- Predictive Maintenance (PDM)

So, When we should select the right type of each Maintenance ?

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aminemallek@gmail.com

Time Based Maintenance (TBM) :

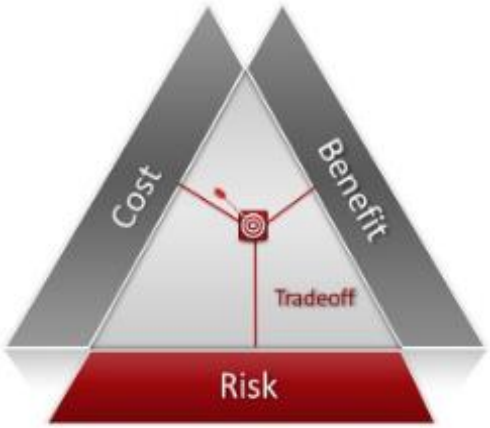
- ✓ Definition : replacing or renewing an item to restore its reliability at a fixed time, interval or usage regardless of its condition.

- ✓ Purpose : protect installation against the failure of known wearing parts which have predictable Mean Time Between Failure (MTBF) (age related and a clear service life can be determined).

As much as Maintenance team are trained and experienced, they could manage better :
- ⇒ the right time to replace parts
- ⇒ extend safely the life cycle of wearing parts
- ⇒ reduce maintenance cost.

Failure Finding Maintenance (FFM):

- ✓ Definition: detect hidden failures typically associated with protective functions. Think pressure safety valves, trip transmitters and the like.
- ✓ Purpose: protect equipment from Hidden failures and prevent equipment to function until something else has failed (find and fix the failure before you are relying on that equipment to protect you).



Risk Based Maintenance (RBM) :

- ✓ Definition: use a risk assessment methodology to assign your scarce maintenance resources to those assets that carry the most risk in case of a failure (risk = likelihood x consequence).
- ✓ Purpose: prevent failure with very high risk.

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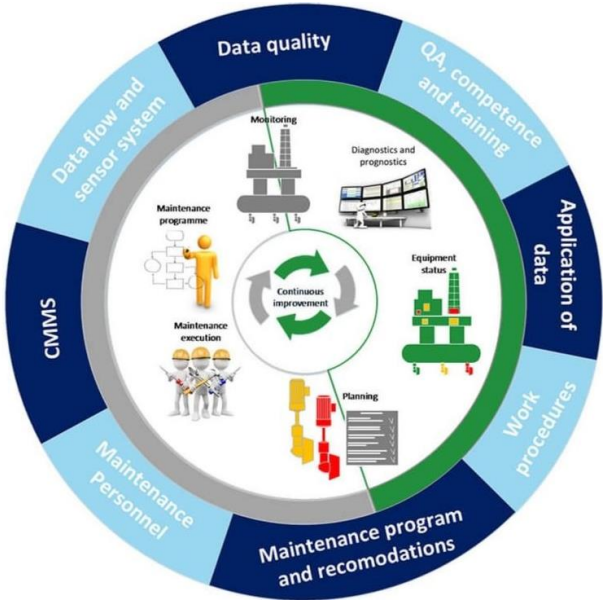
aminemallek@gmail.com

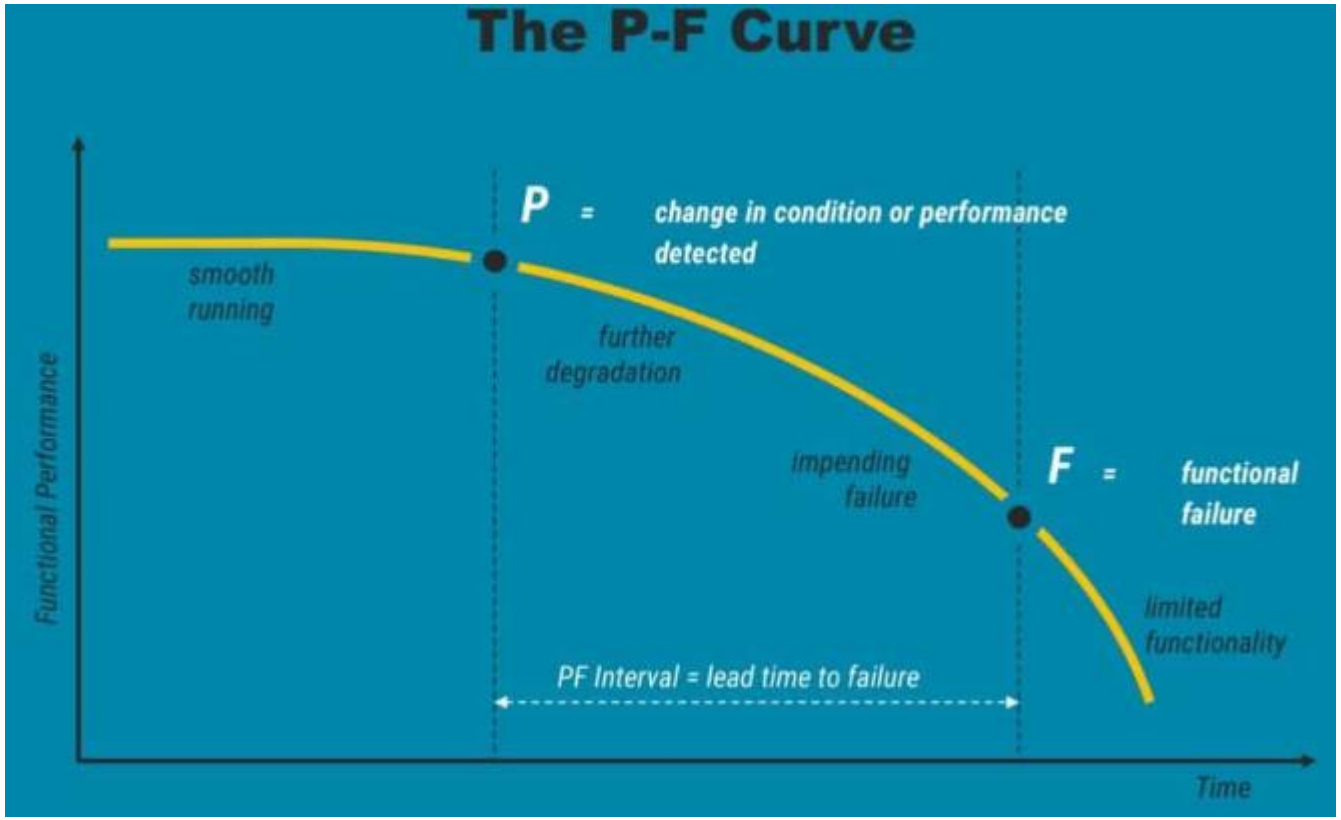
Risk Based Maintenance should be carefully implemented by reducing the total risk of failure across your plant in the most economical way.

The scope should be continuously optimised / minimised based on the findings from testing or inspection and a through risk assessment.

Condition based Maintenance (CBM)

- ✓ Definition: detect physical evidence that a failure is occurring or is about to occur, then it may be possible to take action to prevent it from failing completely and/or to avoid the consequences of failure.
- ✓ Purpose: act before the failure occurs, on the premise that this is more economical and should have less of an impact on availability.





If the failure is not detected and mitigated, it continues until a functional failure occurs (point “F”). The time range between P and F, is the window of opportunity during which an inspection can possibly detect the imminent failure and give you time to address it.

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aminemallek@gmail.com

CBM requires an efficient and effective process for data gathering, data analysis, decision making and finally intervention.

PREDICTIVE MAINTENANCE (PDM)

Definition: is an extension or a more advanced approach to CBM where we use potentially many process parameters gained from online sensors to determine if our equipment is moving away from stable operating conditions and is heading towards failure.

Many monitoring Techniques

are now developed:

- Vibration monitoring
- Thermographic inspection
- Oil analysis
- etc.

Typical predictive Maintenance monitoring Techniques:

Monitoring Techniques	Use	Problem Detection
Vibration Analysis	Rotating machinery, e.g., pumps, turbines, compressors, internal combustion, gear boxes	Misalignment, imbalance, defective bearings, mechanical looseness, defective rotor blades, oil whirl, broken gear teeth
Material (non-destructive) testing, e.g., ultrasonic, eddy current, borescopic inspections	Hull structure, shipboard machinery and associated piping systems and mechanical components	Corrosion, erosion, fatigue cracking, delamination, wall thickness reduction
Fluid Analysis	Lubrication, cooling, hydraulic power systems	Excessive wear of bearing surfaces fluid contamination
Infrared Thermography	Boilers, steam system components, electrical switchboards and distribution equipment, motor controllers, diesel engines, power electronics	Leaky steam traps, boiler refractory cracks, deteriorated insulation, loose electrical connections, hot or cold firing cylinders
Performance trending	Heat exchangers, internal combustion engines, pumps, refrigeration units and compressors	Loss in efficiency, deteriorating performance trends due to faulty components
Ultrasonic leak detectors	Steam hydraulic and pneumatic system piping	Leaking valves, system leaks
Fault gas analysis and insulating liquid analysis	Circuit breakers, transformers and other protective devices	Overheating, accelerated deterioration, hostile dielectric
Wear and dimensional measurements	Sliding, rotating and reciprocating elements	Excessive wear and proximity to minimum acceptable dimensions which affect performance
Signature analysis, time domain and frequency domain	Rectifiers, power supplies, inverters, AC and DC regulators, generators	Degraded solid state circuits and other electrical components

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aminemallek@gmail.com

CORRECTIVE MAINTENANCE (CM)

Definition: a Run to Failure or Corrective Maintenance strategy only restores the function of an item after it has been allowed to fail. It is based on the assumption that the failure is acceptable (i.e. no significant impact on safety or the environment) and preventing failure is either not economical or not possible (where the consequence of failure is limited and would not necessitate a need for an urgent repair).

The selection for corrective maintenance as a strategy for some equipment should be wisely defined, it is essential to ensure that the failure modes under consideration do not have the potential to become Emergency Maintenance.

A reactive maintenance environment is:

- 3 to 5 times more expensive
  then 'normal' preventive maintenance.
- less efficient.
- less safe.

DEFERRED CORRECTIVE MAINTENANCE

Maintenance that allow to defer the work request and give Maintenance team the time to properly plan and schedule the work.

This should be done through a successful Planning & Scheduling and accurate prioritization of corrective maintenance.

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aminemallek@gmail.com

EMERGENCY CORRECTIVE MAINTENANCE

Maintenance that is so urgent and it breaks into the Weekly Schedule, It upsets the plans and schedules and typically throws everything into disarray (Maintainers get heralded as heroes when they've worked 16hrs non-stop to get production back online).

World Class organisations ensure that less than 2% of their total maintenance is Emergency Corrective Maintenance.

How much Emergency Maintenance do you have? More or less 2% ?

If the percentage is estimated for more than 2%, so you are paying much more money than you should do and there is a lot of Maintenance costs that could be reduced/eliminated through a clever implementation of preventive maintenance process.

Comparison of Maintenance Types

Maintenance Type	Preventive Maintenance					Corrective Maintenance	
	Time Based Maintenance	Failure Finding Maintenance	Condition Based Maintenance	Predictive Maintenance	Risk Based Maintenance	Deferred Maintenance	Emergency Maintenance
Task Type	Scheduled Overhaul / Replacement	Functional Test	Measurement of condition	Calculation and extrapolation of	Inspection or Test	Repair / Replace	Repair / Replace
Objective	Restore or replace regardless of condition	Determine if hidden failure has occurred	Restore or replace based on a measured condition compared to a defined standard		Determine condition and conduct risk assessment to determine when next inspection, test or intervention is required.	Restore or replace following failure. Result of a Run to Failure Strategy or an unplanned failure.	Restore or replace following unplanned failure.
Interval	Fixed time or usage interval e.g. 1 month, 1,000hrs or 10,000 km	Fixed time interval (can be set based on risk assessment e.g. SIL)	Fixed time interval for condition measurements / inspections		Time based interval between tasks and scope of task is based on risk assessment	Not applicable, but intervention is deferred to allow for proper planning & scheduling.	Immediate intervention required.

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aminemallek@gmail.com

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- An efficient and effective Preventive Maintenance Program should cover a mix of the different types of maintenance previously described for each type of equipment to asset level.

- The correct implementation of preventive maintenance strategy is able to reduce Maintenance cost by an average between 25% to 35%.

- Across organizations and industries, there are profound differences in the way to control maintenance spending against the fixed budget.

IV. Practical Maintenance methodology to cut Maintenance Costs

Is there a practical confirmed approach to reduce Maintenance Cost?

You will find below a description of a Maintenance methodology that may help to reduce Maintenance spending and cost:

- ✓ Build a well-defined Asset register (or improve the old one) including equipment hierarchy (Plant, Area, System, Subsystem, Location, ….) with precise & specific criticality rankings established for each asset (a deep analysis of criticality is required).

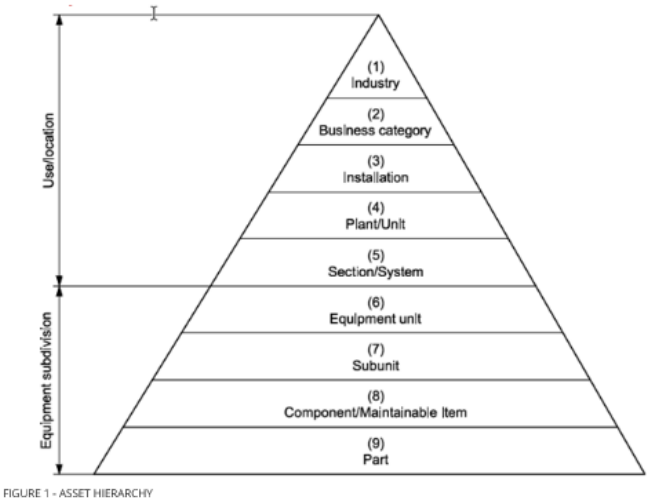

FIGURE 1 - ASSET HIERARCHY

Build or Improve Asset Register.

- ✓ Build maintenance budget to the asset level as the performance of individual assets can be closely tracked, allowing bad actors and improvement opportunities to be identified.

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aminemallek@gmail.com

- ✓ Use system to manage the maintenance budget to the asset level like: computerized Maintenance Management Systems (CMMS) or Enterprise Asset Management (EAM).
- ✓ Collect maximum data for each asset from previous year: planned PMs, overhauls and historical breakdown costs, etc.
- ✓ Evaluate and understand which assets are requiring excessive maintenance spending.

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- ✓ Develop work processes, including vigilant job planning & scheduling based on equipment criticality.
- ✓ Undertake the developed work process with continuous analysis and optimisation of identified bad actors.
- ✓ Compare real cost to the planned budget and develop the action plan to carry out the improvements opportunities of cost reduction already identified.

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aminemallek@gmail.com

The process that is able to assist on Maintenance cost reduction could be resumed on the following steps :

1. Work identification, approval, planning & scheduling.
2. Collect data, review results, identify bad actors.
3. Create improvement, Solve problems to the Root Cause,
4. Focus on leading indicators: equipment health, maintenance work performance.
5. Build a long term plan to optimize your budget on 3 years.

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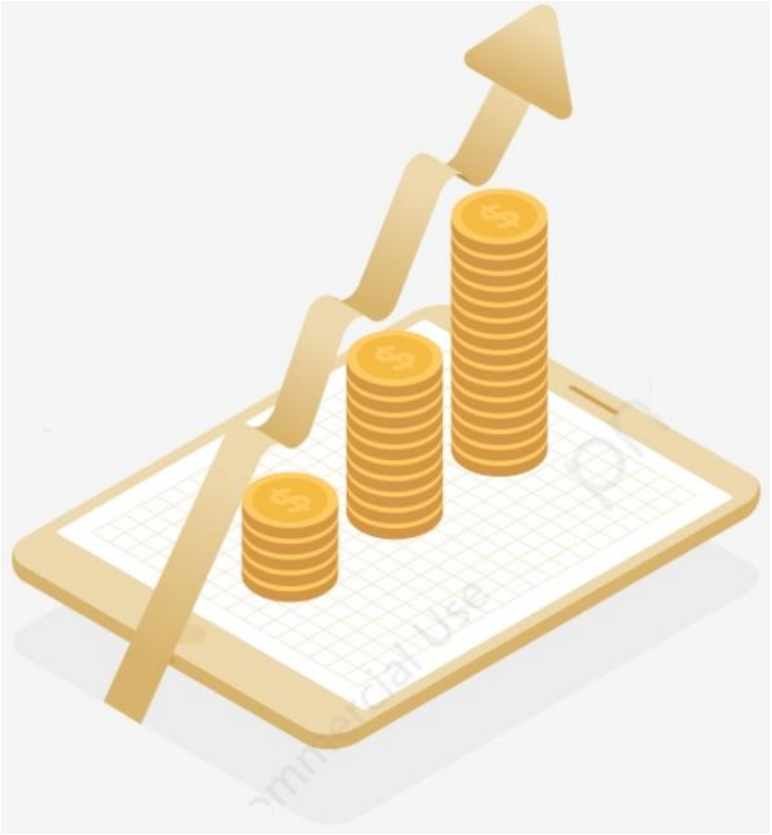
aminemallek@gmail.com

Most maintenance costs recur annually, and the development of an accurate maintenance budget to the asset level is an incremental process requiring approximately 3 years:

1) **First Year**: the maintenance requirements of individual assets will be an estimate.
2) **Second Year**: the budget will be refined based on the variances observed and experience gained from the first year.
3) **Third Year:** we will be able to further refinement and build a clear definition of annual improvement opportunities based on the second year.



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The budget for each asset should be constructed by identifying and continuously improving the required:

- ✓ Preventive & predictive maintenance.
- ✓ Historical corrective repairs.
- ✓ Expected refurbishments.

The Maintenance planning & scheduling should be builded according to the established criticality rankings and prioritized as follows:

1. Availability losses or lost production
2. Emergency work
3. Repeat failures
4. High-cost repairs
5. Systemic failures from defective parts or workmanship

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aminemallek@gmail.com

V. 3 Main areas of Maintenance Strategies to Decrease Maintenance Budget

Many study showed that top performing plants achieve 90% less downtime. And about 15% extra uptime. They achieved that by focusing on three top things:

1) Planning & Scheduling.
2) Preventive (and predictive) Maintenance.
3) Defect Elimination.

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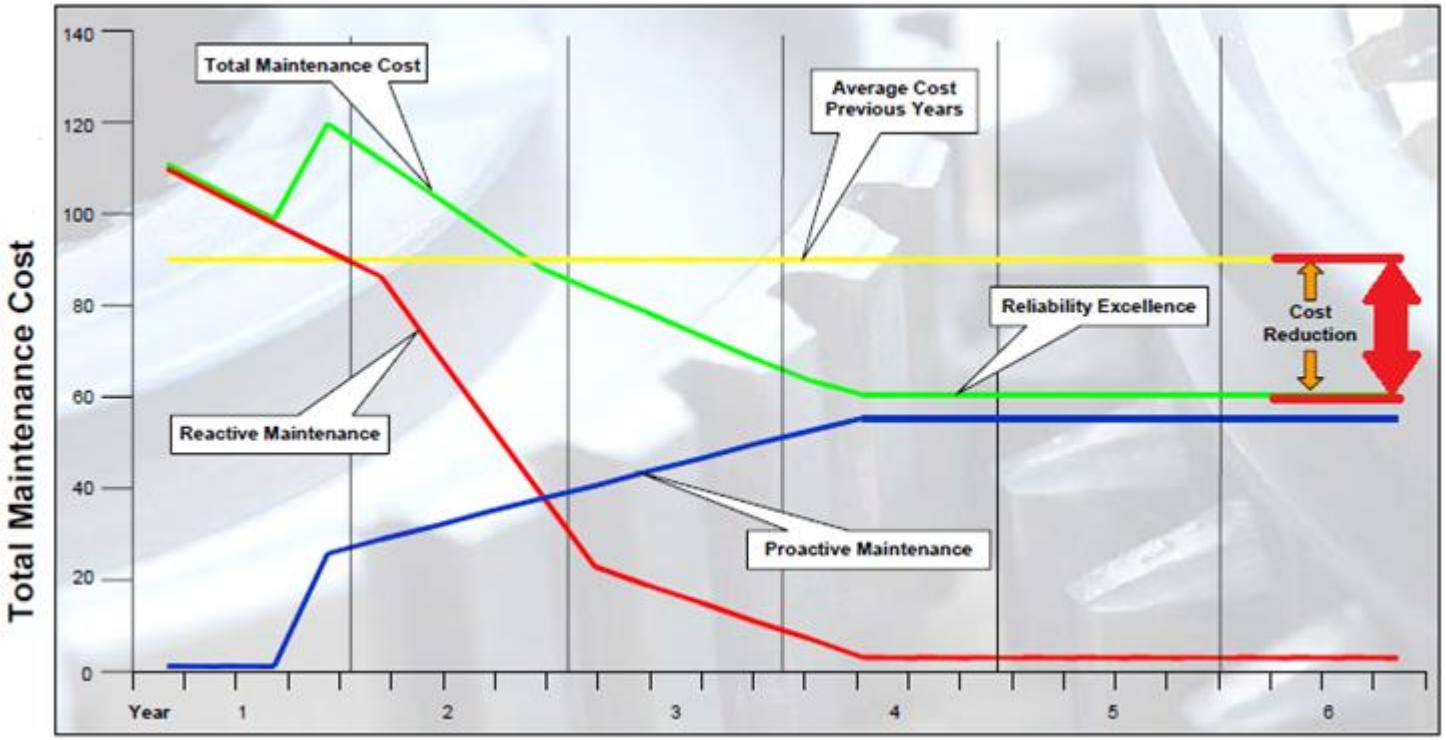
1) Planning & Scheduling.

Unplanned and unscheduled Maintenance is three to five times more expensive compared to normal (planned) maintenance.

2) Preventive Maintenance.



≈ 25% of cost reduction

3) Defect Elimination.

The defect elimination to prevent their reoccurrence has in important role in cost reduction and many tools are now developed, like:

- **FMEA or FMECA**: Failure Mode Effects and Criticality Analysis
- **RCA:** Root Cause Analysis
- **RCFA:** Root Cause Failure Analysis
- **HAZOPS:** Hazard & operability studies
- **FTA**: Fault tree analysis
- **RBI:** Risk-based inspection
- etc.

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aminemallek@gmail.com

Many Maintenance strategies are developed to ensure the defect elimination and defined as a structured, logical process for developing or optimizing the maintenance requirements including the necessary procedures and tools in order to prevent the reoccurrence of defect, like:

- **RCM:** Reliability centred maintenance
- **BCM:** Business centred maintenance
- **TPM**:Total Productive Maintenance
- etc.

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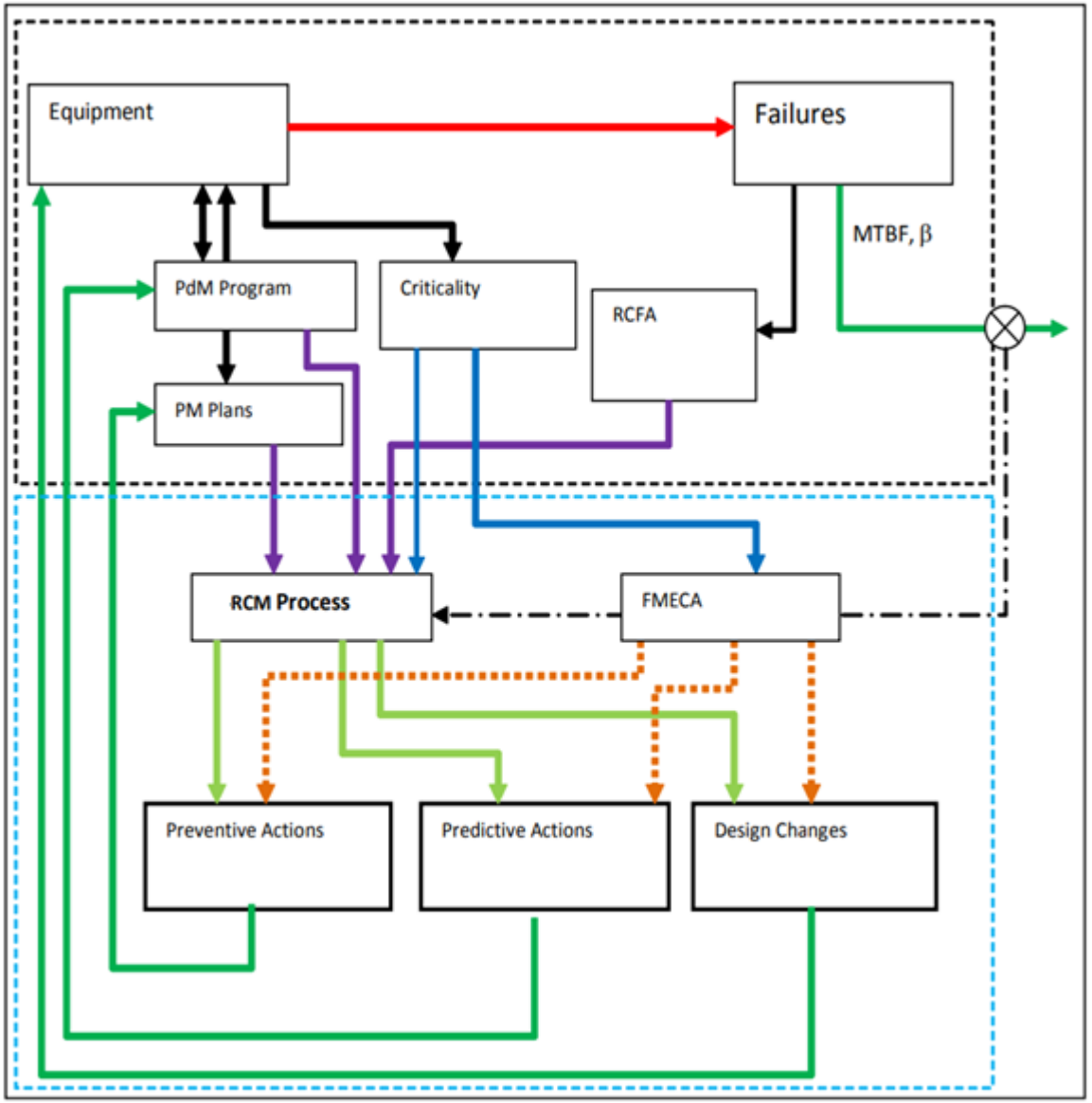
aminemallek@gmail.com

Reliability Centred Maintenance (RCM):

There are several different methods for implementing Reliability Centered Maintenance that are recommended, summarized in the following 7 steps:

- **Step 1:** Selection of equipment for RCM analysis.
- **Step 2:** Define the boundaries and function of the systems that contain the selected equipment.
- **Step 3:** Define the ways in which the system can fail (failure modes).
- **Step 4:** Identify the root causes of the failure modes.
- **Step 5:** Assess the effects of failure.
- **Step 6:** Select a maintenance tactic for each failure mode.
- **Step 7:** Implement and then regularly review the maintenance tactic selected.

Reliability Centered Maintenance Model:



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aminemallek@gmail.com

Description of BCM Business centered maintenance, TPM Total Productive Maintenance and RCM Reliability centered Maintenance:

Parameter	BCM	TPM	RCM
Core Intent	Detection of Failure	Cultural Change	Failure Prevention
Focus of Implementation	Monitoring	Planning for different conditions	Coverage of all possible failure modes
Program Initiation	Deciding on parameters, procurement of equipment	Top management announcement, launch training program	Assembling team, Training
Program support	Separate section for monitoring and recommending actions	Creation of organizational support structure, Policies	Post training implementation can begin immediately
Presumed existing systems	PM	PM	PM, RCFA
Process changes	BCM section becomes initiator of maintenance jobs	Autonomous maintenance by operators.	No changes to maintenance process PM Plan generation based on RCM outcome
Major Maintenance Activity	Predictive Maintenance. PM largely stopped	Preventive Maintenance. Operator level monitoring	Predictive, Preventive and Design change
Measures of Effectiveness	Number of Failures without notice	Equipment effectiveness	Better MTBF

Most common Defects causes:

The causes of defects could includes:

- Inappropriate operating procedures
- Inadequate operating discipline
- Poor installation and commissioning
- inadequate preventive maintenance
- Inadequate repair specifications
- Inadequately specified spare parts
- Poor spare parts care
- Shortage of proper tooling and support equipment
- Operator and Maintainer fatigue
- Inadequately skilled operators or maintainers
- etc.

MODERN PREVENTIVE MAINTENANCE PROGRAM:

A new concept of modern maintenance program is available by applying the 9 principle below:

- **Principle 1:** Accept Failures and learn lessons.
- **Principle 2:** Most Failures Are Not Age Related.
- **Principle 3:** Some Failures Matter More Than Others.
- **Principle 4:** Wear out of simple parts may provide early signals of potential equipment failure.
- **Principle 5:** Hidden Failures Must Be Found.
- **Principle 6:** Identical Equipment Does Not Mean Identical Maintenance.
- **Principle 7:** No amount of maintenance can raise the inherent reliability of a design, you need to change the design.
- **Principle 8:** Good Maintenance Programs Don't Waste Your Resources.
- **Principle 9:** Good Maintenance Programs Become Better Maintenance Programs.

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aminemallek@gmail.com

3 GOLDEN RULES TO OPTIMISE MAINTENANCE PROGRAM:

Focus on eliminating unnecessary maintenance tasks based on risk analysis.

Remove direct maintenance labour and materials, effort required to plan, schedule, manage, and report on this work.

Change time based overhaul or replacement tasks into Condition Based Tasks.

Use a condition monitoring technique to assess how much life the component has left and only replace the component when actually required.

Extend task intervals based on data analysis, operator and maintainer experience, Or simply on good engineering judgment.

The shorter the current interval, the greater the impact when extending that interval. For example adjusting a daily task to weekly reduces the required PM workload for that task by more than 80%.

VI. Best practices to reduce maintenance costs

The **medium/long term best improvements** that help to reduce maintenance costs are :

- ✓ Improve the training of Work force.
- ✓ Improve tools and technologies for the workforce.
- ✓ Improve the use of the EAM/CMMS system.
- ✓ Improve performance metrics tracking.
- ✓ Improve the use of predictive and preventive maintenance technologies.

The **short term best improvements** that help to reduce maintenance costs are :

- ✓ Optimise the waiting time for permits
- ✓ Simplify the procedure of equipment to be isolated and/or cleaned
- ✓ Improve the waiting time of parts that are needed to do a job
- ✓ Optimise the procedure of support equipment or resources, such as cranes, scaffolding, special tools etc
- ✓ Improve the availability of instructions on what job to do, or how to do it.

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aminemallek@gmail.com

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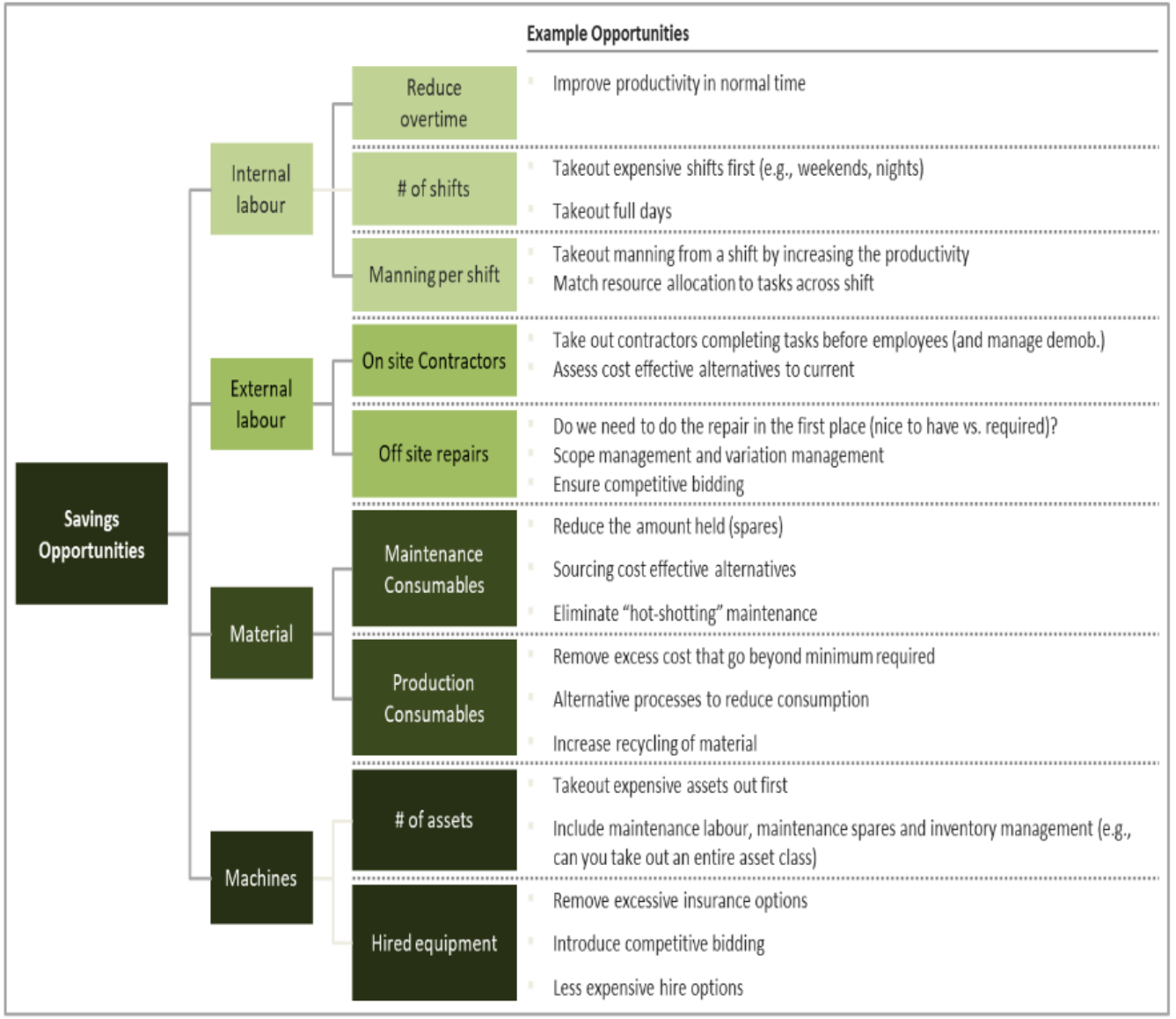
Example of costs Saving opportunities:



VII. Measuring Maintenance Productivity

Measuring Maintenance Productivity:

If you cannot measure something, then you cannot manage it (or improve it), then how would we measure the productivity of our Maintenance:

There is no single, easy way of measuring Maintenance Productivity.

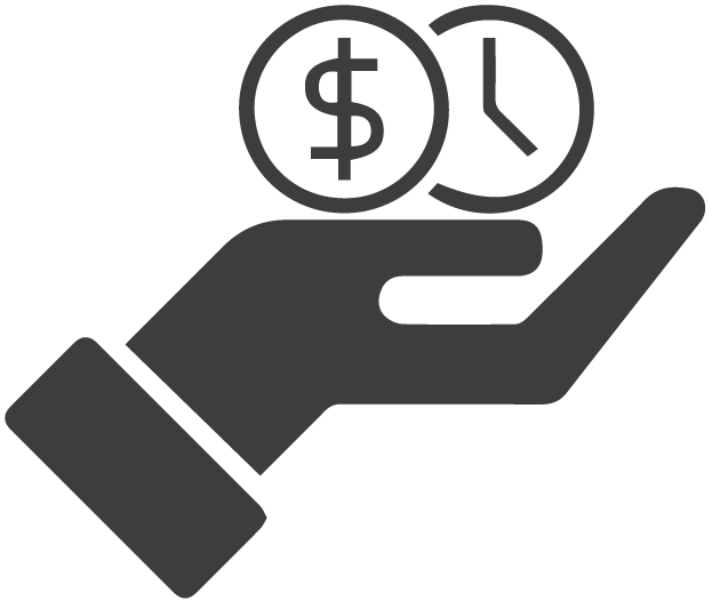
What is required is a balanced set of performance measures that assess:

- Maintenance Effectiveness.
- Maintenance Efficiency.

❖ Maintenance Effectiveness:

Measure whether Maintenance is delivering the outcomes that the organisation needs in terms of:

- ✓ Plant or equipment uptime – the level of uptime should be sufficient to meet the organisation's needs and no higher.
- ✓ Maintenance cost avoidance –the % of the Preventive Maintenance program that is delivered on time.
- ✓ Operating cost efficiency – probably best limited to specific areas of operating cost where maintenance has the greatest impact.
- ✓ Environmental and/or Safety risk reduction, this is most easily measured in terms of regulatory compliance, but this, on its own, is not a comprehensive measure of risk reduction



❖ Maintenance Efficiency:

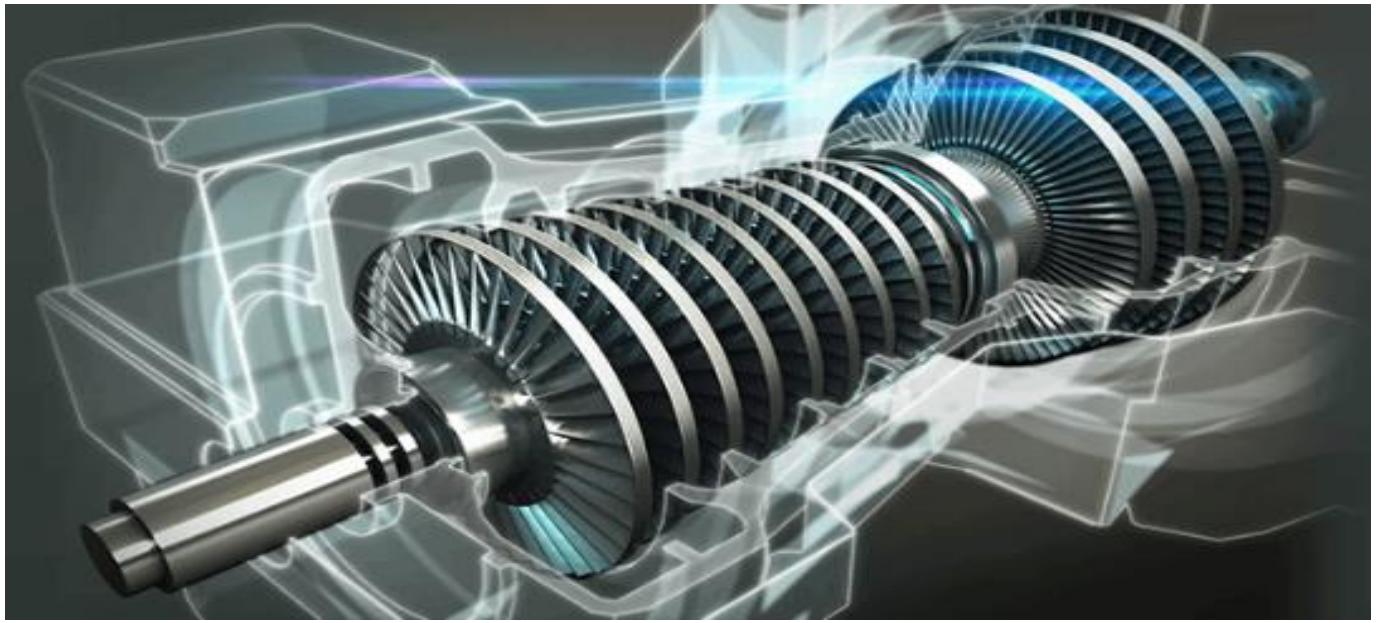
Measure the performance against a zero-based budget (either in total costs or cost per unit of output), but there are other leading measures of maintenance efficiency that may be useful, such as:

- ✓ Percent of maintenance work that is planned.
- ✓ Levels of Maintenance rework.

PRESENTED BY: Amine MALLEK
aminemallek@gmail.com

Documented and updated Maintenance strategies:

It is very important that every organization get a well detailed maintenance strategies in a document that must be carefully updated every period, reviewed and approved by company management, this document should include the full description of Maintenance Strategies.



Summary:

- Simply reducing the maintenance budget without a clear understanding of what maintenance practices and strategies will need to be changed in order to achieve the target reduction in costs is a high risk strategy.
- Description of Maintenance Strategies capable to reduce deeply Maintenance Costs in safe and effective manner.
- Practical Maintenance methodology to cut Maintenance Cost.
- 3 Main areas of Maintenance Strategies to decrease Maintenance Budget: Planning & Scheduling, Preventive Maintenance and Defect Elimination.
- Best practises to reduce maintenance costs.
- Measuring Maintenance Productivity.

PRESENTED BY: Amine MALLEK
aminemallek@gmail.com

ANY QUESTION PLEASE ?

For any further information, please do not hesitate to contact Me:

Amine MALLEK
Offshore Maintenance Superintendent.
Head of Mechanical and Maintenance Engineering Department.

SEREPT
a JV Company between « **Perenco Oil & Gas Ltd** » and « **ETAP**».

Asset management systems and maintenance strategies expert.
Turnaround & Shutdown Management expert.
Main speaker for maintenance and reliability conferences in Europe, North America and Middle East.
Diploma of Mechanical Engineer from Sfax National Engineering School.
Master Diploma in Engineering Management from Sfax National Engineering School.

Email: aminemallek@gmail.com

Phone Number: +216 98 42 41 70

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PRESENTED BY: Amine MALLEK
aminemallek@gmail.com