

Pillar 1 - Business and Management



1.3 Measure performance

ENGINEER ACADEMY

Select key performance indicators

Track and report

MEASURE
SUCCESS



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1.3 Measure performance

Select key performance indicators

Why Do We Need to Measure?

- Control: To understand our processes & reduce variation.
- Self-Assessment: How well a process is doing.
- Continuous Improvement: identify opportunities for improvement.
- Management Assessment: Are we meeting objectives.

***What you can't measure you can't control,
and what you cant control you can't improve.***



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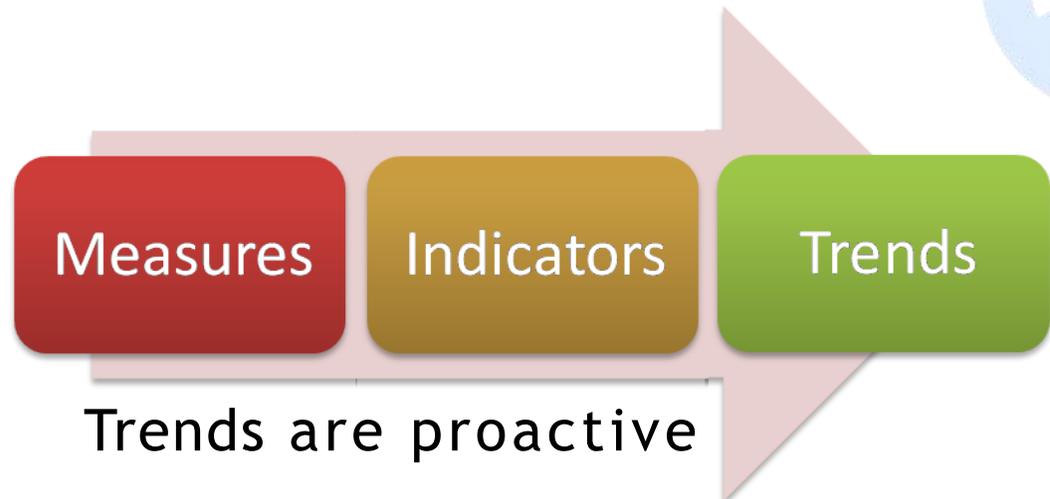


1.3 Measure performance

Select key performance indicators

What you can't measure you can't control,
and what you can't control you can't improve.

Measuring Process.



Benchmarking.

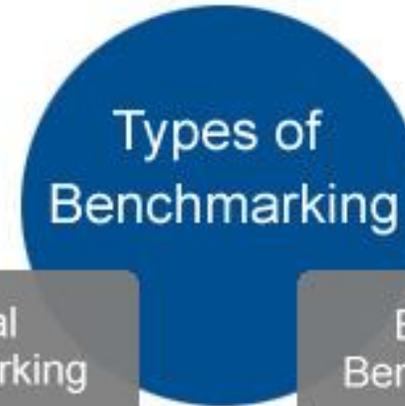


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Levels of Benchmarking

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Further distilled as



product
Benchmarking

Process
Benchmarking

Performance
Benchmarking

Strategic
Benchmarking

competitive
Benchmarking

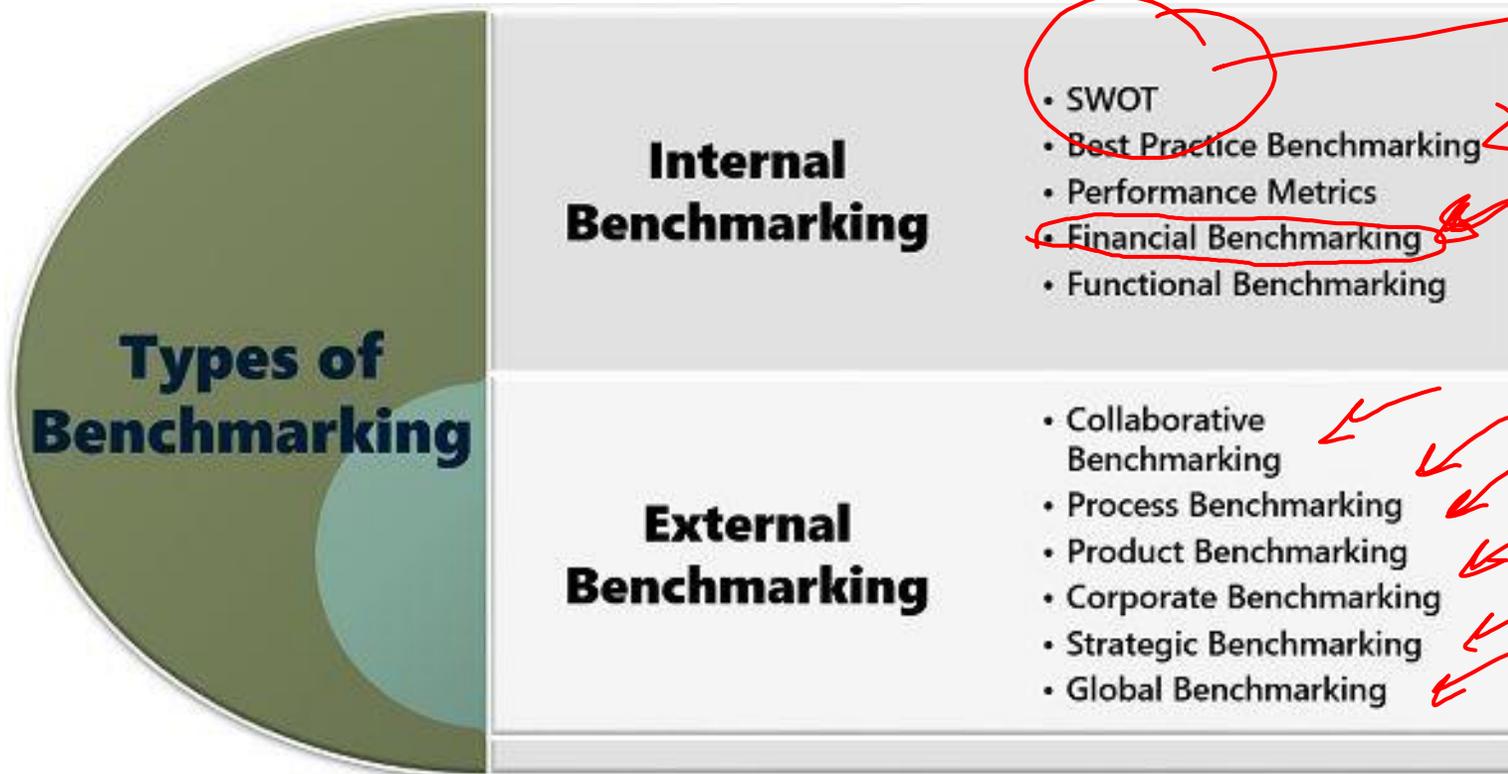


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1.3 Measure performance



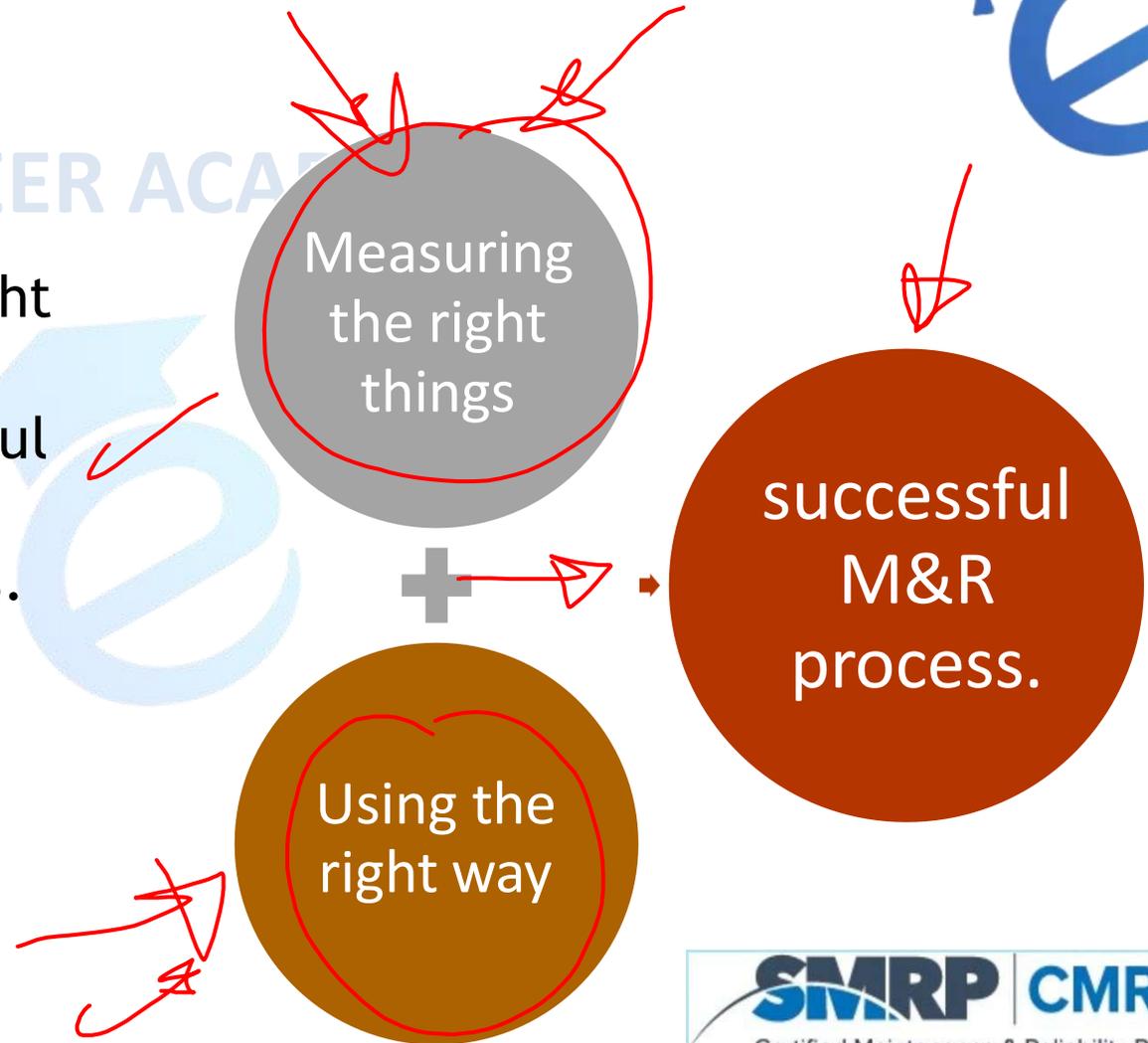
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1.3 Measure performance

Measuring the right things the right way is a key to any successful maintenance and reliability process.



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1.3 Measure performance

Lagging & Leading Indicators

Lagging Indicator:

An indicator that measures performance after the business or process result starts to follow a particular pattern or trend. Lagging indicators confirm long-term trends, but do not predict them.

Exam

Leading Indicator:

An indicator that measures performance before the business or process result starts to follow a particular pattern or trend. Leading indicators can sometimes be used to predict changes and trends.

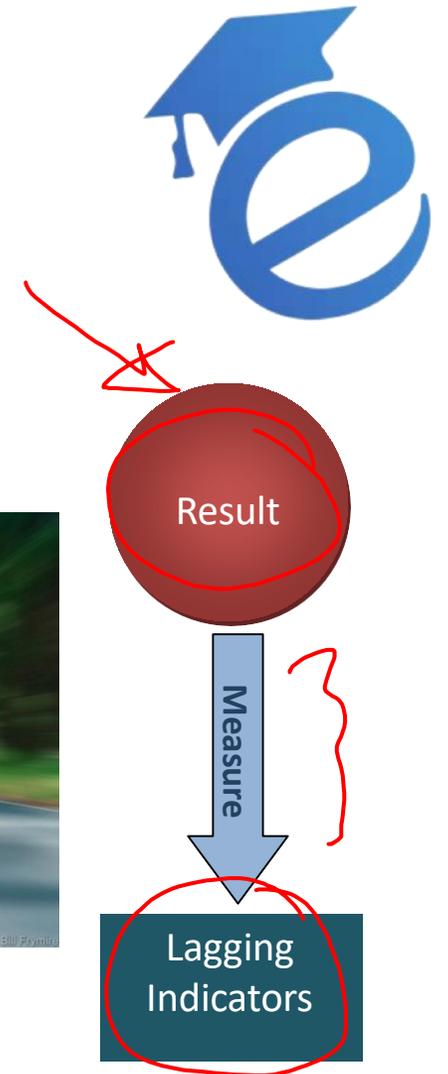


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Lagging & Leading Indicators

- Lagging Indicators focus on results at the end of a time period. (Reactive)
- Historical in nature.
- Don't reflect current activities
- Lacks predictive power

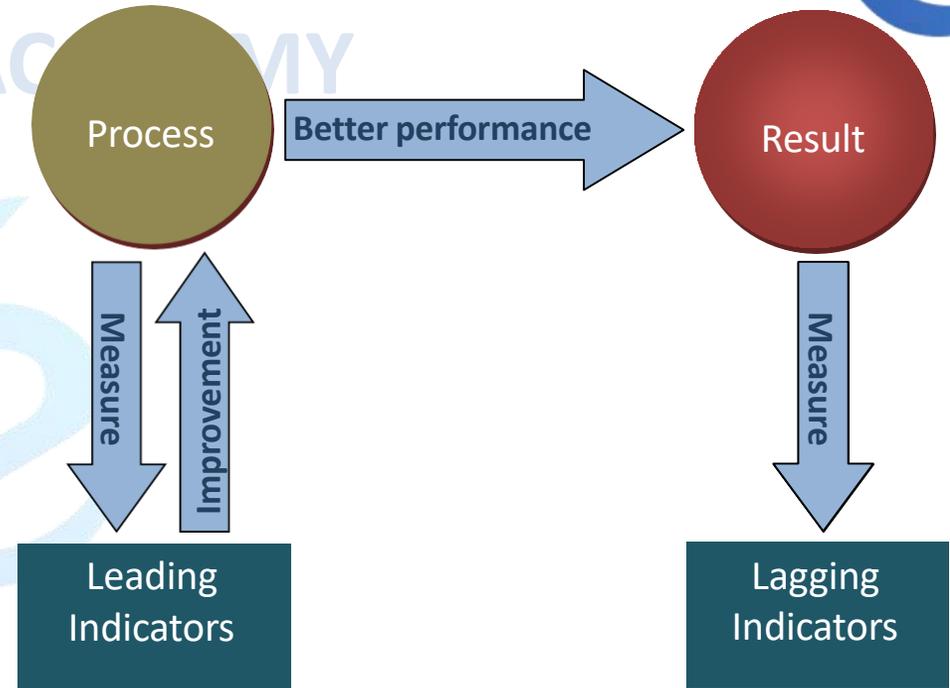


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Lagging & Leading Indicators

- Leading indicators measure intermediate processes and activities.
- Lead performance (Proactive)
- Influence lag measures
- Predictive in nature



Planning Indicators ?

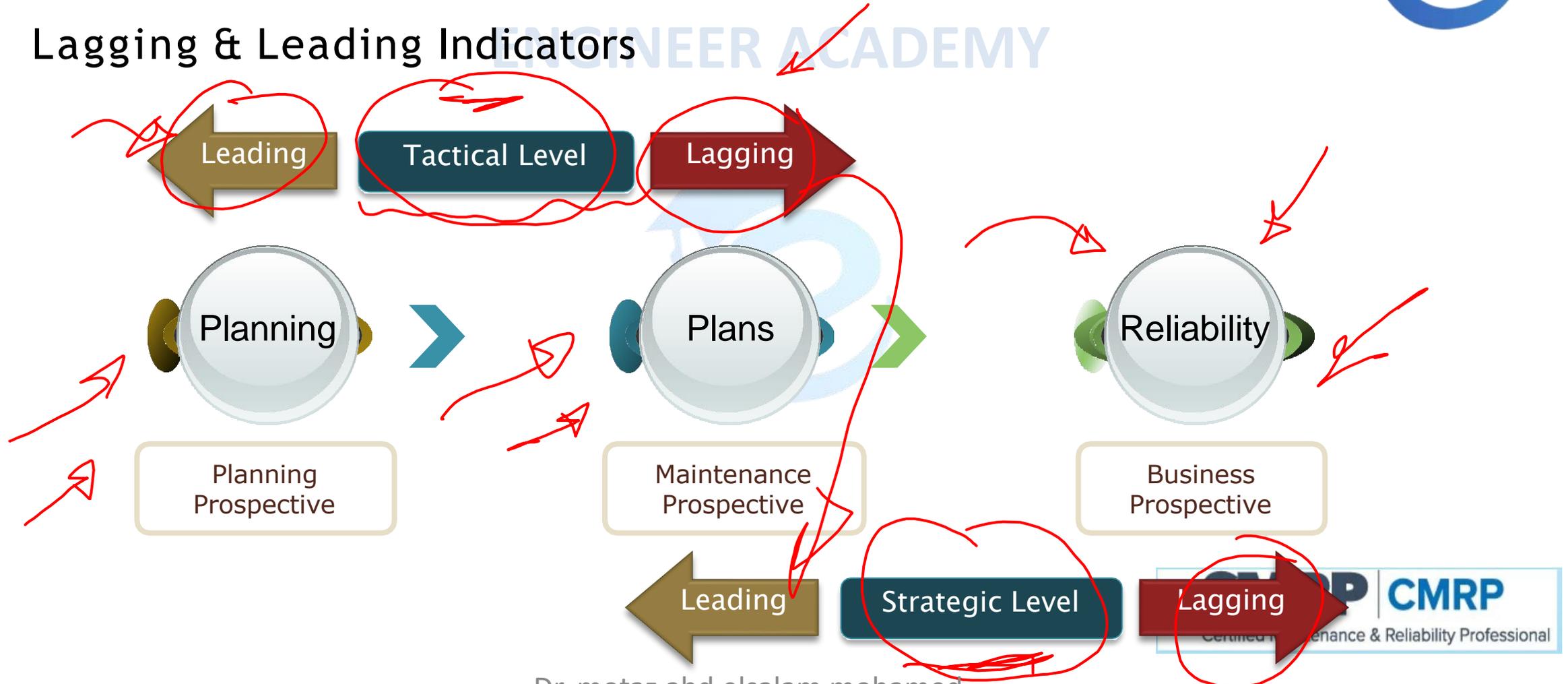


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Lagging & Leading Indicators

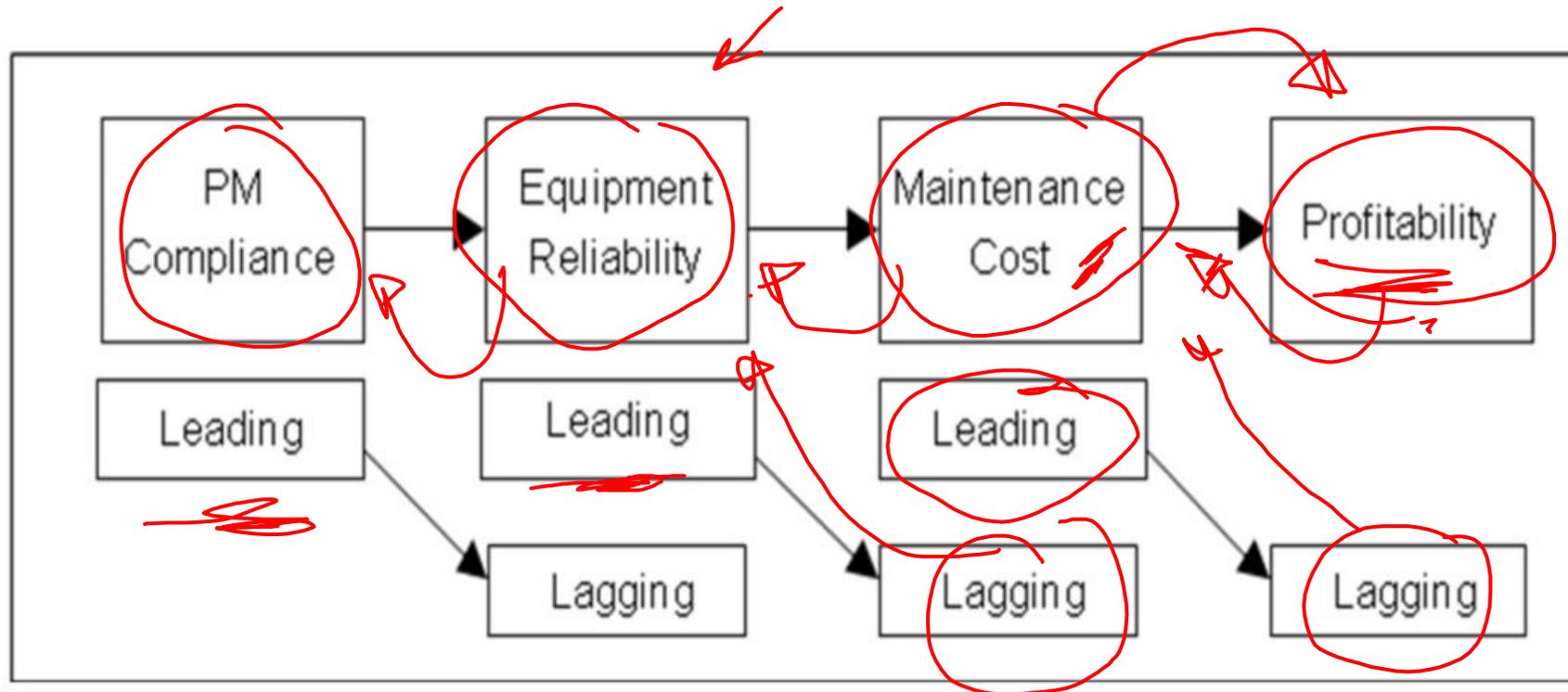


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Lagging & Leading Indicators



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SMRP BoK

1.3 Measure performance

Lagging & Leading Indicators

Different maintenance and reliability processes components, their alignment with the SMRP Body of Knowledge (BoK) and the concept of leading and lagging indicators.

	Behaviors & Processes	Operational Execution	Manufacturing Performance
BoK - Business & Management			
Maintenance Margin (COGS)			Lagging
Maintenance Unit Cost			Lagging
Maintenance Cost per RAV			Lagging
BoK - Manufacturing Process Reliability			
OEE			Lagging
Availability			Lagging
Total Operating Time			Lagging
BoK - Equipment Reliability			
Systems Covered by Criticality Analysis	Lagging	Leading	Leading
Scheduled Downtime		Lagging	Lagging
Unscheduled Downtime		Lagging	Lagging
MTBF		Lagging	Leading
BoK - People Skills			
Rework	Lagging	Leading	Leading
Maintenance Training - \$	Lagging	Leading	Leading
Maintenance Training -MHRs	Lagging	Leading	Leading
BoK - Work Management			
Corrective Maintenance Hours		Lagging	Leading
Preventive Maintenance Hours		Lagging	Leading
Condition Based Maintenance Hours		Lagging	Leading
Planned Work	Lagging	Leading	Leading
Reactive Work	Lagging	Lagging	Leading
Proactive Work	Lagging	Lagging	Leading
Schedule Compliance Hours		Leading	Leading
Schedule Compliance Work Orders		Leading	Leading
Standing Work Orders		Leading	Leading
Work Order Aging	Lagging	Leading	Leading
Work Order Backlog	Lagging	Leading	Leading

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Leading KPIs (Predictive / Proactive)

Planning future

Preventive Maintenance (PM) compliance rate - % of scheduled PM tasks completed on time.

Schedule adherence - % of planned work executed as scheduled.

Condition monitoring coverage - % of critical assets under vibration, infrared, or oil analysis monitoring.

Training hours completed - amount of skill development for technicians and operators.

Work order planning accuracy - % of work orders with complete job plans before execution.

Spare parts stockout rate - frequency of missing parts when needed (low rate = proactive control).

Safety audits completed - proactive checks to prevent incidents.



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Lagging KPIs (Outcome / Historical)

Cost - money + time

Mean Time Between Failures (MTBF) - average time between equipment failures.

Mean Time To Repair (MTTR) - average time required to restore equipment after failure.

Overall Equipment Effectiveness (OEE) - actual performance combining availability, performance, and quality.

Unplanned downtime hours - total time equipment was unavailable due to breakdowns.

Maintenance cost as % of Replacement Asset Value (RAV) - historical spending benchmark.

Number of safety incidents - recorded accidents or near misses.

Production losses due to equipment failure - output lost because of reliability issues.

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MTBF = $\frac{1}{\text{failure rate}}$



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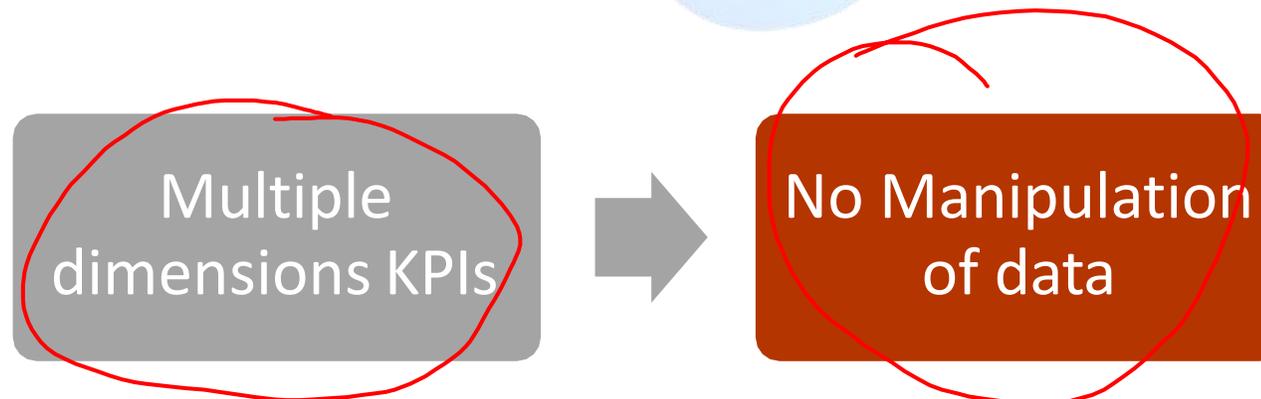
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Each KPI should be the result of multiple dimensions that check for:

1) Quantity

2) Quality.

This will magnify any manipulation of data and enable achievement of each goal.



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1.3 Measure performance

To ensure successful measuring system with continuous improvement:

Written definitions of roles and responsibilities

Getting everyone in the organization involved in the process

Providing good and bad feedback in weekly basis.

RASH

Exam





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A maintenance and reliability leader is implementing a new measurement system. Which of the following best reflects the *primary* purpose of selecting Key Performance Indicators (KPIs)?

- A. To ensure all financial audits are passed without exception.
- B. To predict market trends and future production output prices.
- C. To understand processes, reduce variation, and identify opportunities for continuous improvement.
- D. To justify the current level of maintenance staffing and budget.

Correct Answer: C





A Maintenance Manager introduces a KPI tracking the percentage of planned work completed on schedule. This is considered a **Leading Indicator** because it is:

- A. Predictive in nature and measures intermediate processes and activities.
- B. A historical measure that confirms long-term trends in failure rates.
- C. Directly related to financial results at the end of the year.
- D. Used solely for management assessment of compliance.

Correct Answer: A





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Which practice is essential for ensuring a successful measuring system and fostering continuous improvement within the maintenance organization?

- A. Limiting KPI data to management only to maintain confidentiality
- B. Providing good and bad feedback to employees on a weekly basis.**
- C. Using only a single, simple dimension for all KPI calculations.
- D. Focusing on historical data without involving current process activities.

Correct Answer: B





Which of the following is considered a *leading KPI* in maintenance and reliability?

- A) Mean Time Between Failures (MTBF)
- B) Preventive Maintenance (PM) compliance rate
- C) Equipment downtime hours
- D) Maintenance cost per unit produced

Answer: B (*Leading KPIs measure proactive activities that drive future performance, like PM compliance.*)





Which of the following is a *lagging* KPI?

- A) Percentage of work orders completed on schedule
- B) Number of safety incidents reported
- C) Preventive maintenance tasks scheduled
- D) Training hours completed by technicians

Lagging

Answer: B (*Lagging KPIs measure outcomes after events occur, such as safety incidents.*)





Leading KPIs are best described as:

- A) Metrics that measure historical performance outcomes
- B) Indicators that predict future performance and reliability
- C) Financial ratios used in cost accounting
- D) Measures of spare parts inventory value

Answer: B (*Leading KPIs are predictive and proactive, unlike lagging KPIs which are retrospective.*)





Why are leading KPIs critical in reliability management?

- A) They provide financial justification for past investments
- B) They identify root causes of failures after they occur
- C) They allow organizations to take corrective actions before failures happen
- D) They measure total downtime costs for the last fiscal year

Answer: C (*Leading KPIs are proactive tools to prevent failures and improve reliability.*)





Which of the following KPI pairs correctly matches *leading vs. lagging*?

- A) PM compliance (leading) - MTBF (lagging)
- B) MTTR (leading) - PM compliance (lagging)
- C) Safety training hours (lagging) - Incident rate (leading)
- D) Spare parts stockouts (leading) - Work order backlog (lagging)

Answer: A (*Preventive maintenance compliance is leading; MTBF is lagging because it reflects past failures.*)



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1.4 Manage organizational changes

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Develop change management process

Communicate benefits



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1.4 Manage organizational changes

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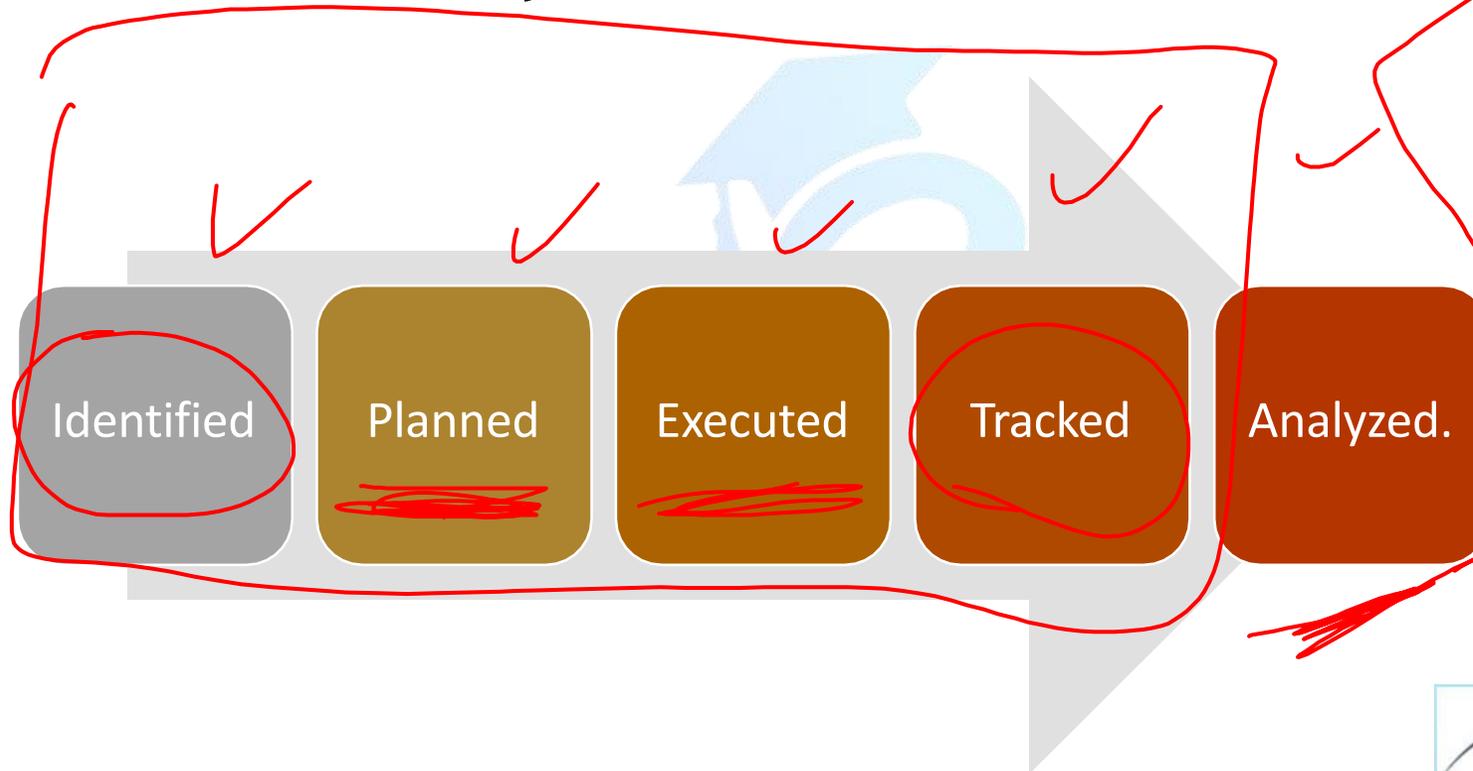
An organization's natural resistance to change needs a counter effort by leadership to :



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1.4 Manage organizational changes

Changes include the way that maintenance is:



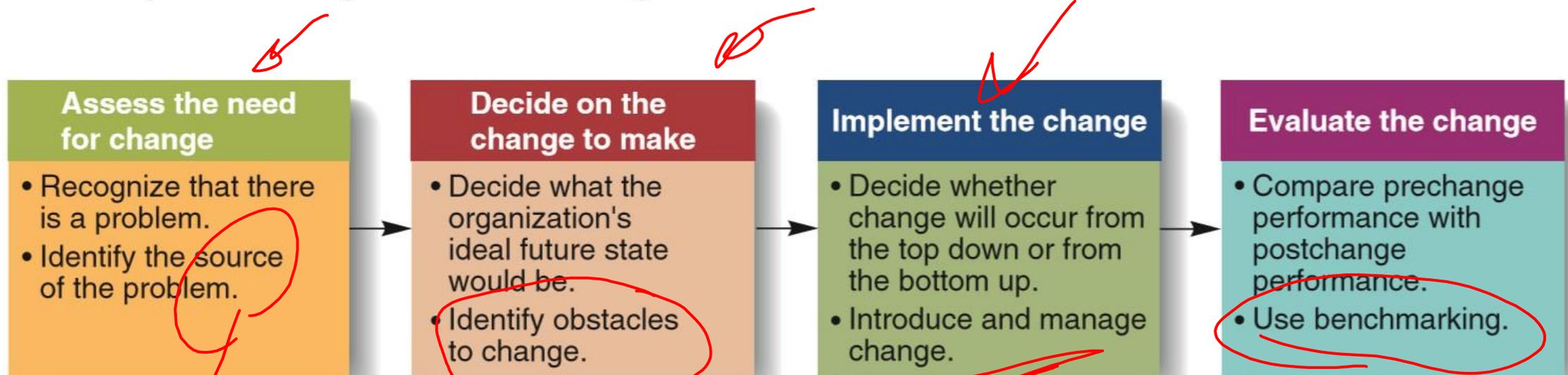
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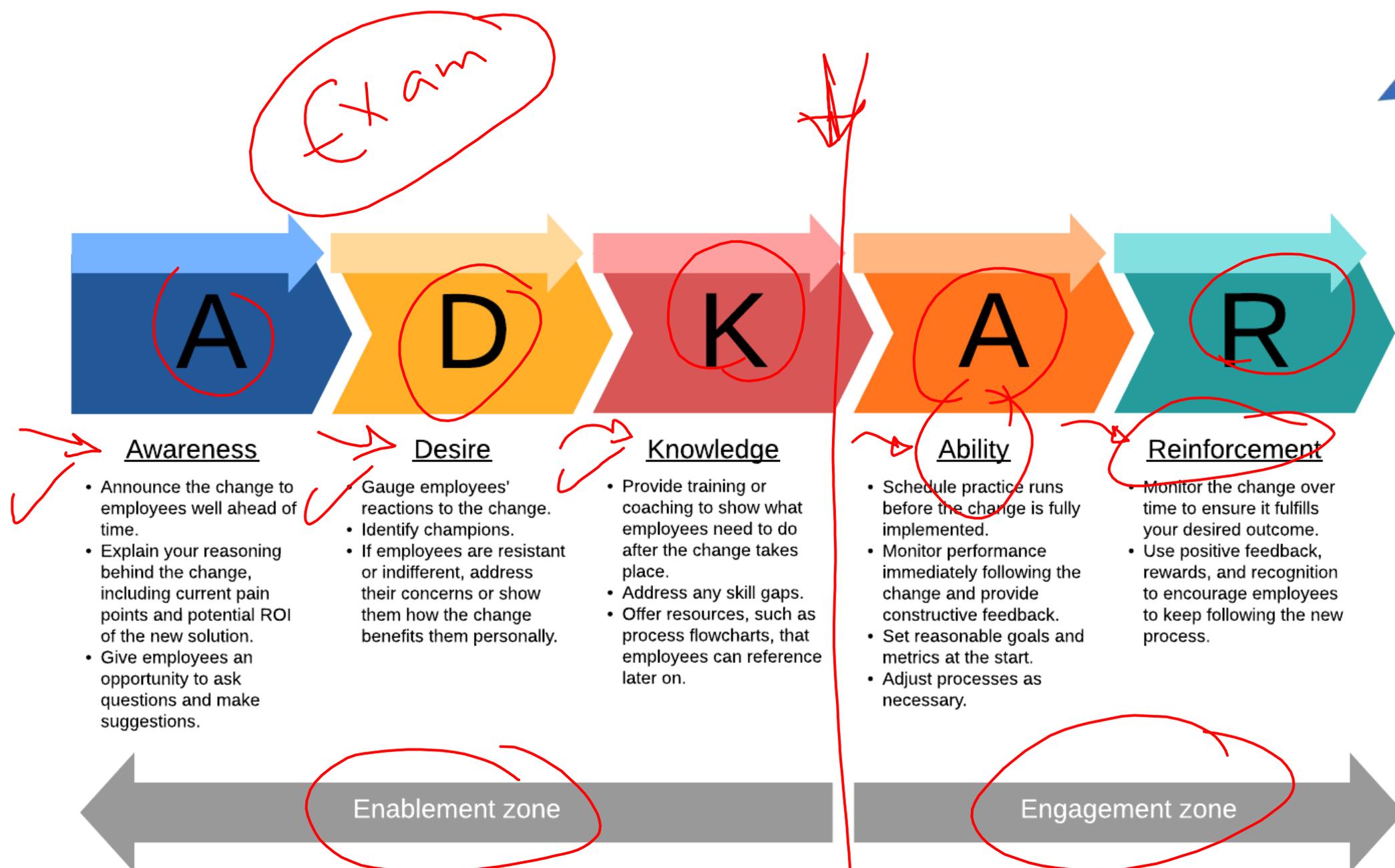
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Four Steps in the Organizational Change Process



RCFA





Exam

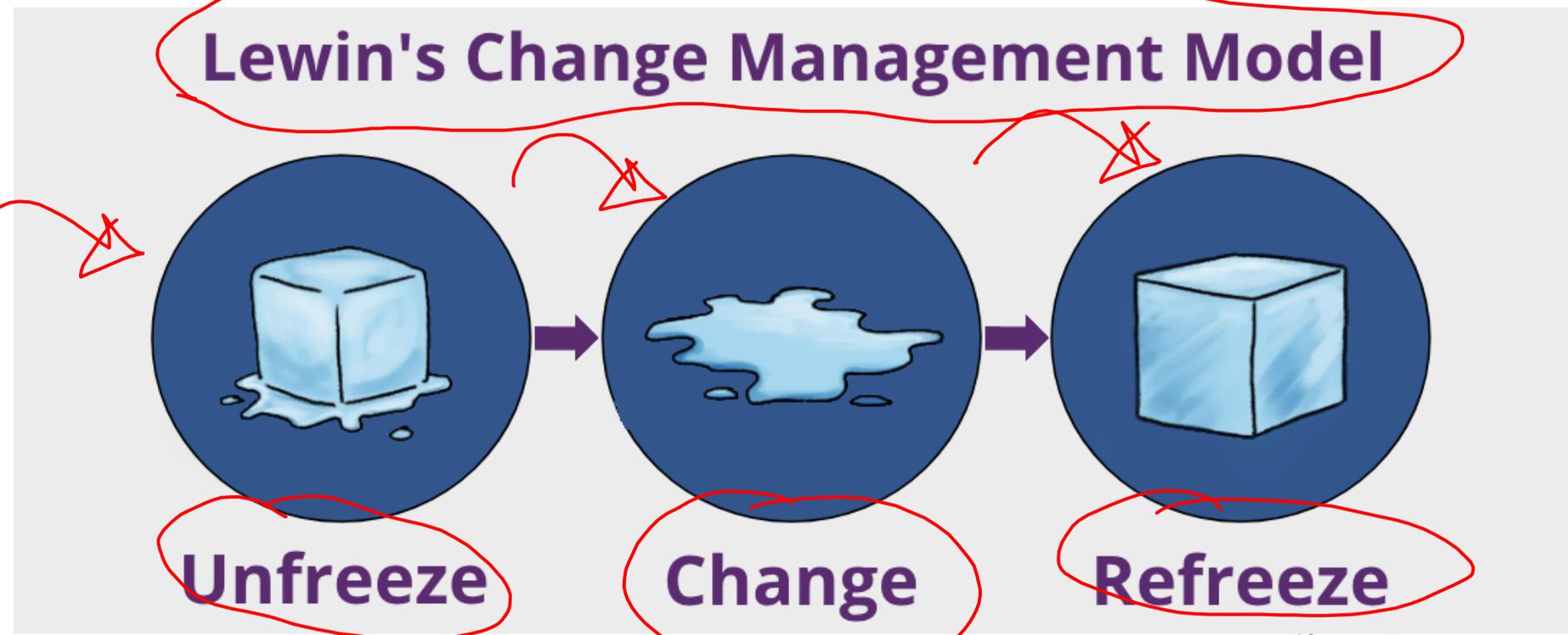
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1.4 Manage organizational changes

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Exo



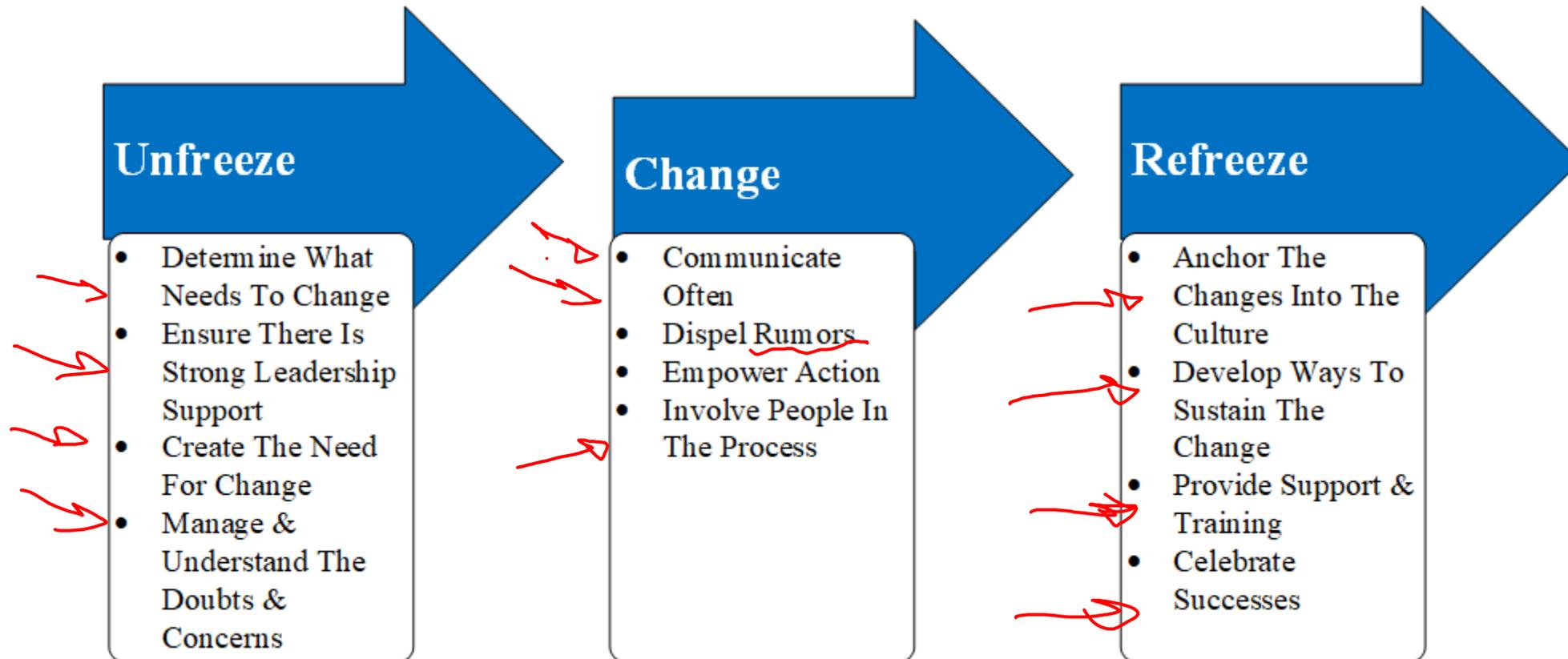
CMRP
Certified Maintenance & Reliability Professional

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1.4 Manage organizational changes

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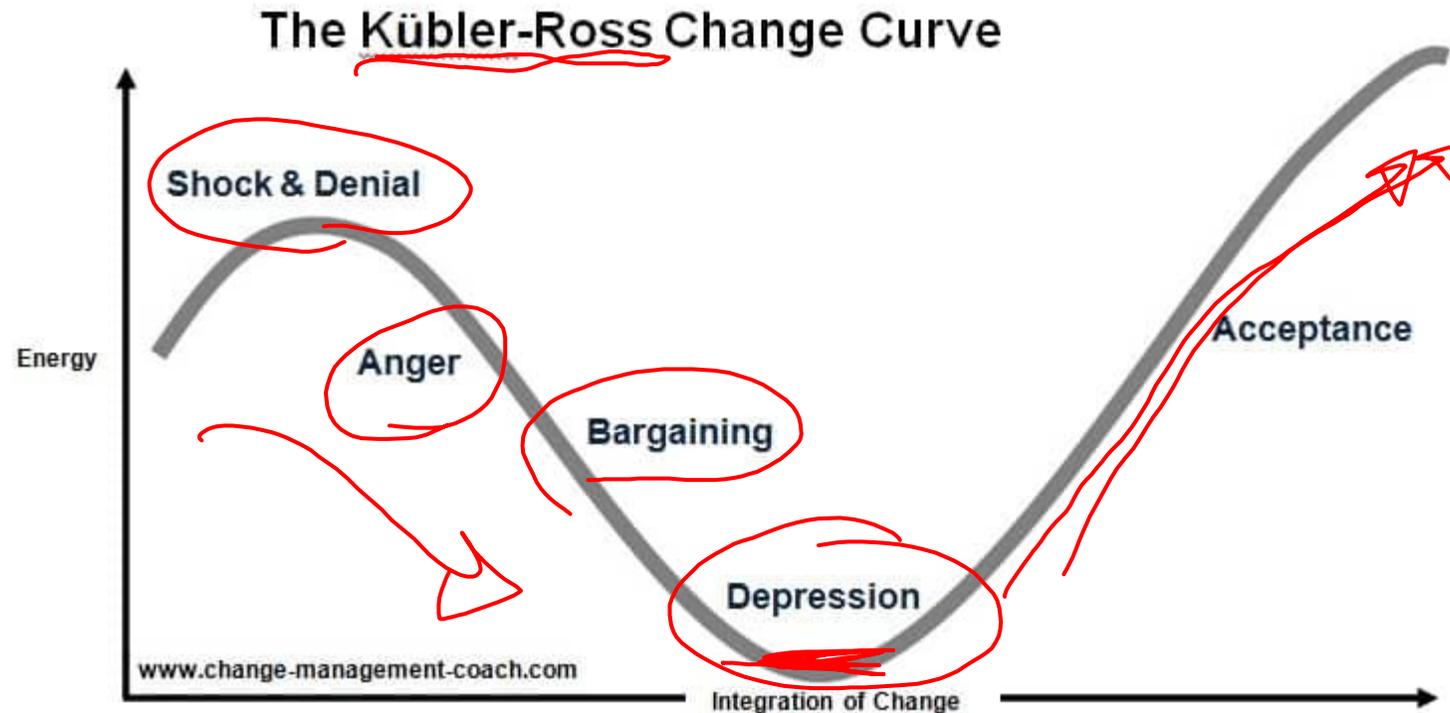


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1.4 Manage organizational changes



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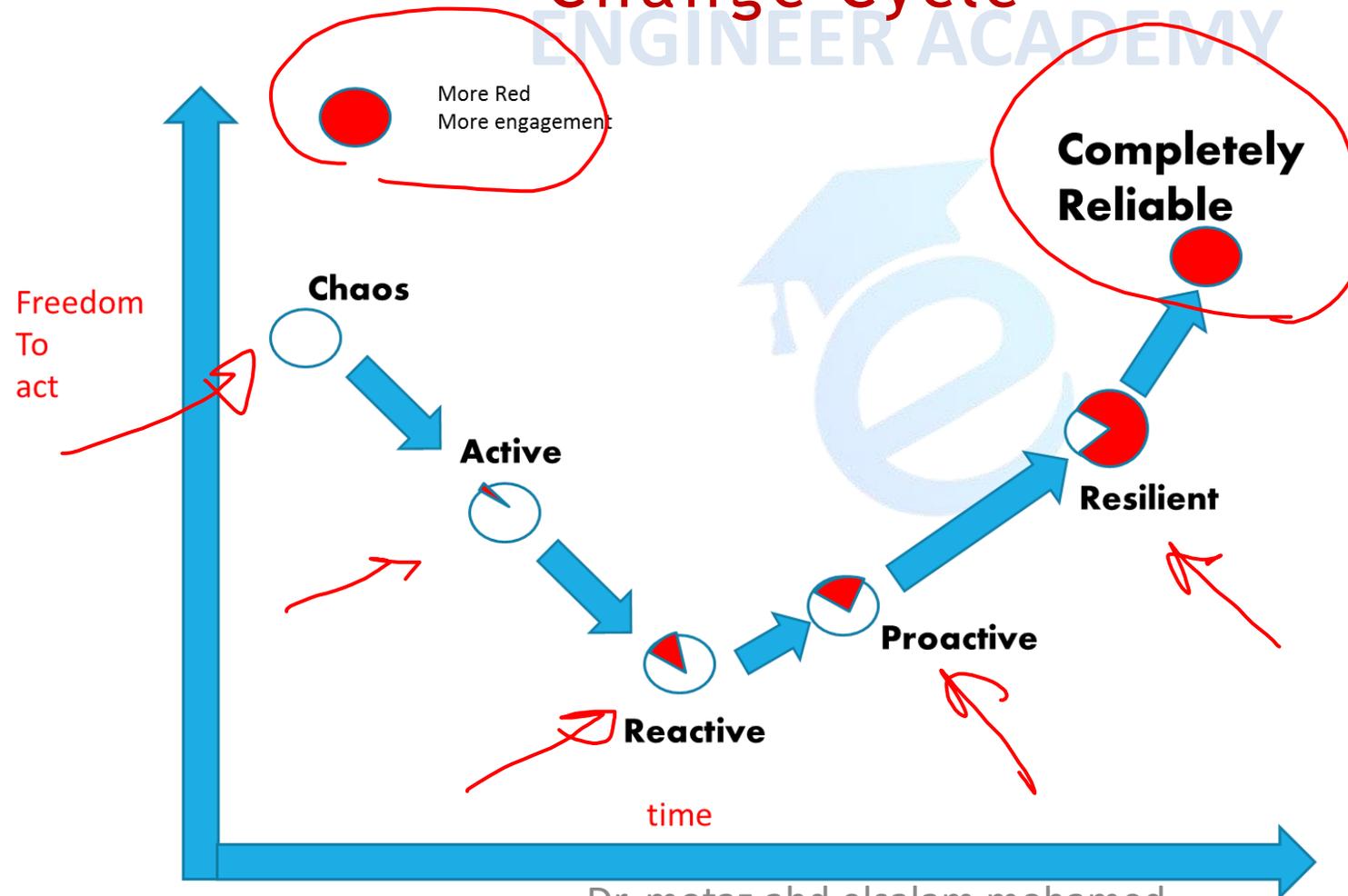
Dr. motaz abd elsalam mohamed



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1.4 Manage organizational changes

Change Cycle



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1.4 Manage organizational changes

Change Cycle

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We start by determining:

- Case for Change, Why do we need to change
- Vision, What is best in class maintenance and reliability
- Skills, What are the skills gap we need to address
- Incentives, Aligned and personalized goals and opportunities
- Resources, The right resources in the right places
- Action plans, Engage our people in the system
- Change, What we want to accomplish



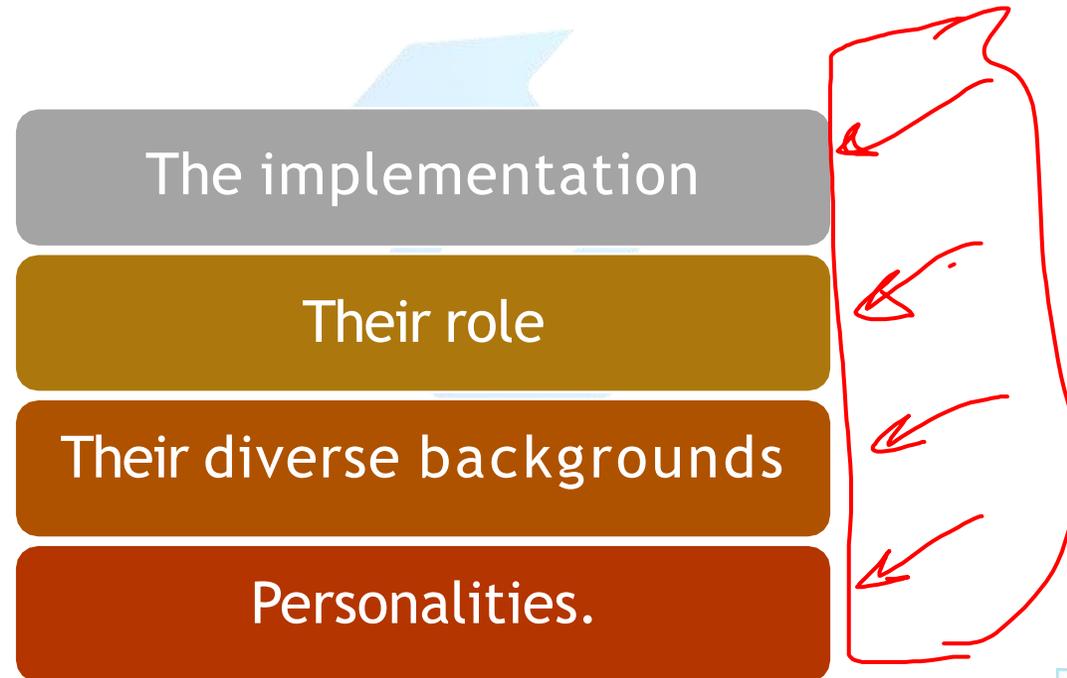
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People have a different ability to change depending on :



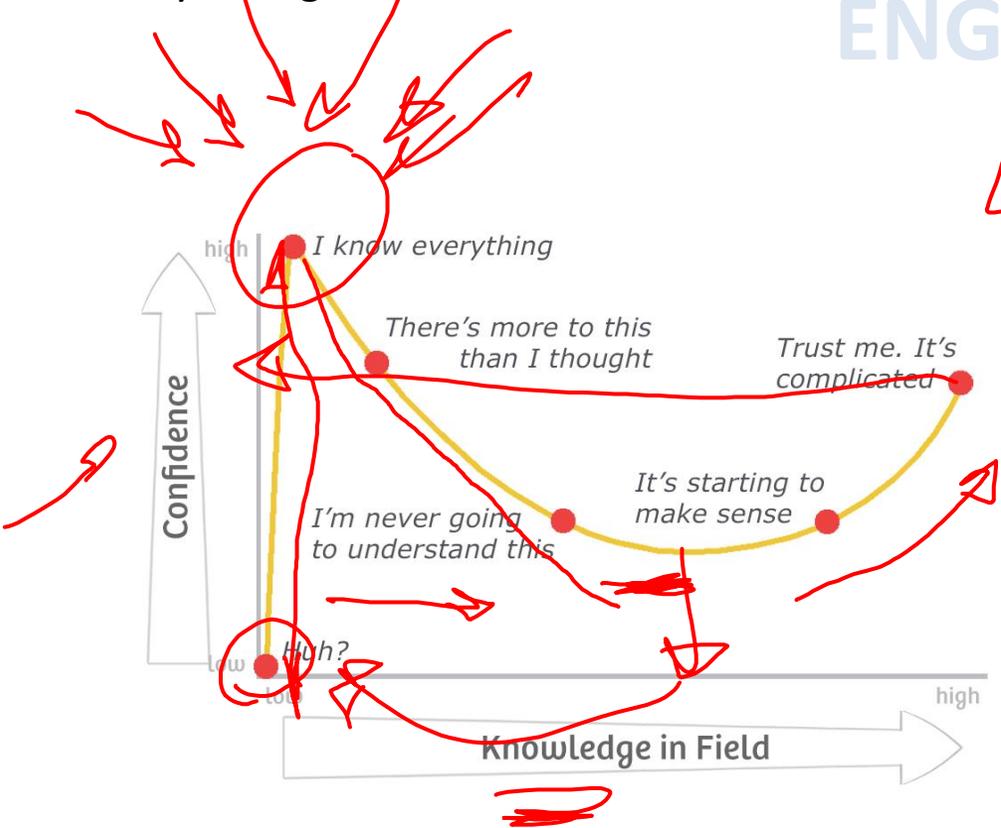
Dunning kruger theory



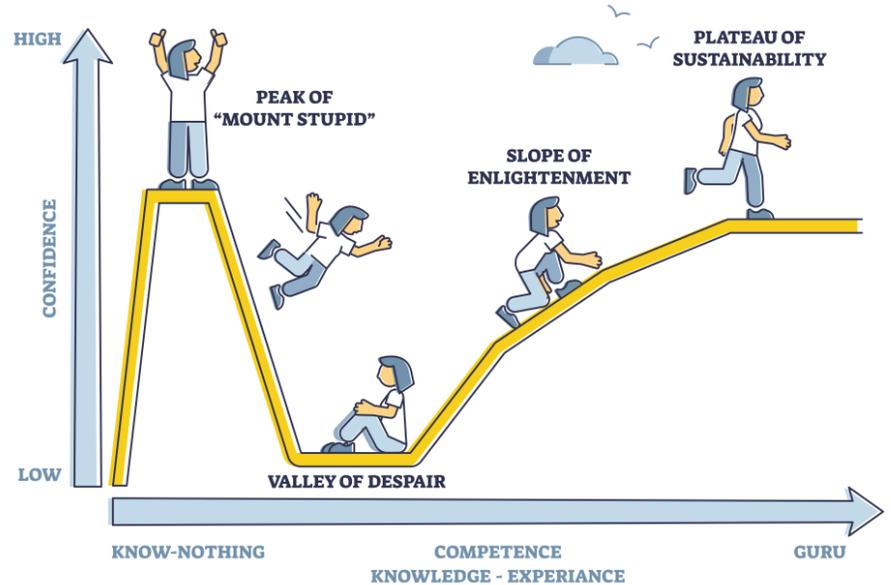
Exam

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Why change resistance exist



DUNNING KRUGER EFFECT

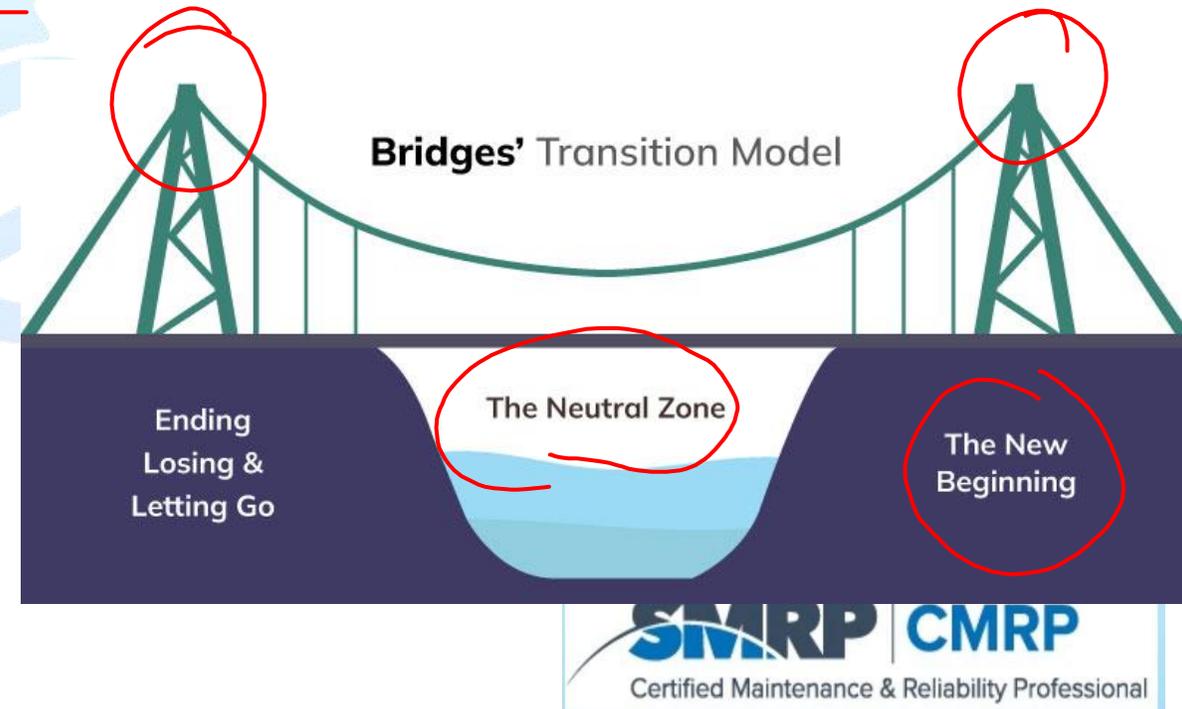


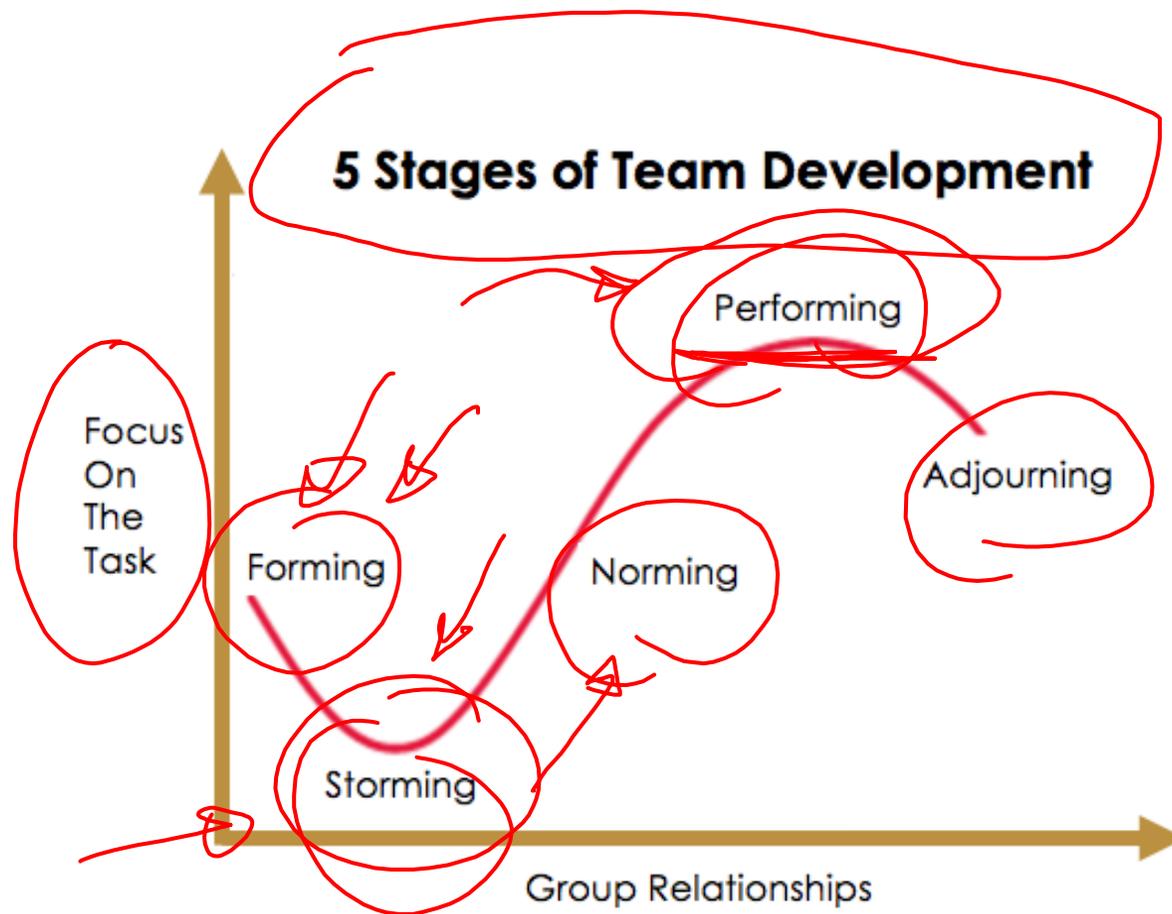


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Bridge transition model

employees are often uncomfortable with change and that discomfort drives them to resist change. Therefore, As per the theories of this model, such understanding of feelings and emotions is essential to help employees accept the change.





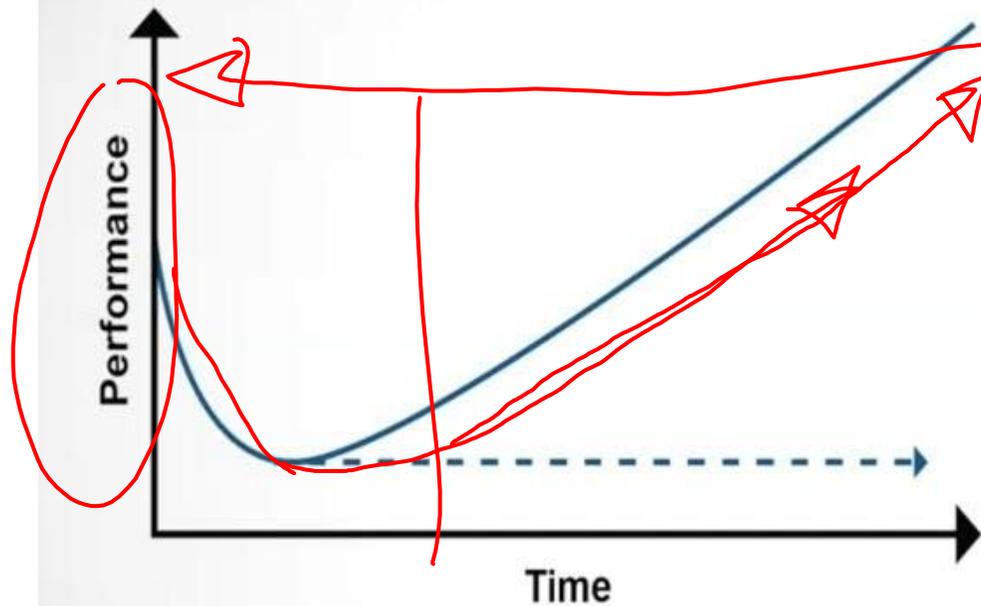
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Why change resistance





The J Curve



The J curve shows the challenge of introducing change into an organization.

Can we return to or exceed previous levels of productivity?

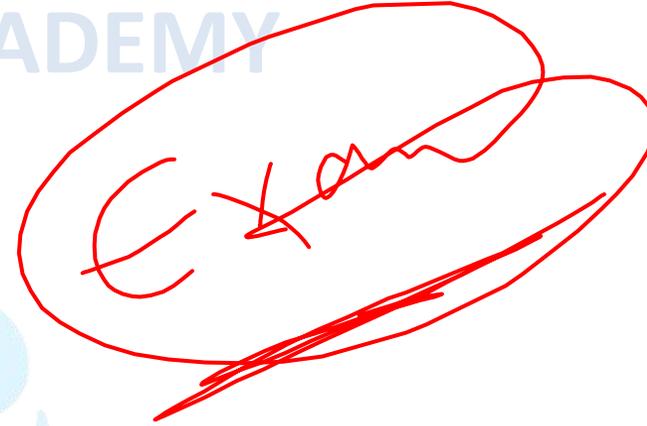
Will we be mired in resistance?

Customer complain process or analysis



- Listen to the customer
- Record details of the complain
- Gat all the facts
- Discuss options for fixing the problem
- Act quickly
- Keep our promises
- Follow up

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Question : how to get customer satisfaction ???

We have to follow the customer complain process or analysis



Progressive discipline



Steps of progressive discipline:

- Step 1: Verbal counseling
- Step 2: Written warning
- Step 3: Performance improvement plan (PIP)
- Step 4: Termination of employment

Exam

Training

Customer delight





Progressive discipline is a disciplinary system that applies:

- a. Penalties
- b. System discipline dispute
- c. Feedback from coworker
- d. Two- way between management and subordinate

Correct answer D





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in a typical Progressive Discipline model, which action immediately follows a formal Written Warning for a recurring performance issue? A. Verbal Counseling
B. Termination of Employment
C. Formal Performance Improvement Plan (PIP) ←
D. Informal conversation with a coworker

Answer C





What is the primary objective of a progressive discipline process in a maintenance and reliability organization?

- ~~A. To immediately dismiss underperforming employees to reduce operational costs.~~
- B. To apply increasingly severe corrective actions after an employee fails to resolve a problem following a reasonable opportunity to do so.**
- ~~C. To establish new performance metrics for maintenance technicians after a major failure.~~
- ~~D. To document and categorize all employee complaints against their supervisors.~~

Answer B





Which of the following is an **essential step** in the formal Management of Change (MOC) process for intentional changes to processes or equipment?

- A. Calculating the new Overall Equipment Effectiveness (OEE) and Total Effective Equipment Performance (TEEP) before implementation.
- B. Creating a permanent cross-functional steering committee to lead all reliability efforts.
- C. Ensuring the change application is reviewed by all affected parties, including Management, Maintenance, Production, and EHS.
- D. Submitting the change request only after the previous Root Cause Analysis (RCA) has been formally closed.

Answer C





To effectively counter an organization's natural resistance to change and ensure a strategic maintenance and reliability plan is sustained, what is the *primary* action required of leadership?

- A. Secure external consultants to manage all new processes.
- B. Apply a counter effort to influence and sustain the change.**
- C. Immediately replace all personnel who express resistance.
- D. Halt all change initiatives until 100% consensus is achieved.

Correct Answer: B





The success of organizational change relies on individual adoption. an employee's ability to change is dependent on their role, personal background, personality, and what fundamental project factor?

- A. The duration of the change cycle.
- B. The financial impact of the change.
- C. The level of operational downtime caused by the change.
- D. The implementation of the change.**

Correct Answer: D





Exam

Which of the following is not a step in the management of change implementation process?

- A. Define the change.
- B. Select the change management team.
- C. Identify management sponsorship and secure commitment.
- D. Obtain the measurements from the failed equipment or component.

Correct answer c





An organization recently implemented a new reliability program. However, after six months, participation from operations remains low, and many operators are unaware of the program's KPIs. What critical step was likely overlooked during implementation?

- A. Designing cross-functional KPIs
- B. Creating a detailed project Gantt chart
- C. Developing a structured change management and communication plan
- D. Initiating pilot programs across maintenance teams only

Correct answer C





Change management steps are

- a. Adjustment , readjustment , freeze
- b. Readjustment , freeze , adjustment
- c. Unfreeze v, adjustment , freeze
- d. None of the above

Answer C



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1.5 Communicate with stakeholders

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Provide management reports

Inform staff

Coordinate with operations



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1.5 Communicate with stakeholders



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Maintenance and Reliability leaders should be capable of creating and executing a :

COMPREHENSIVE COMMUNICATION PLAN

to achieve organizational business goals.



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1.5 Communicate with stakeholders

A communication plan includes:

✓ **“Who”** - the target audiences

✓ **“What”** - the key messages that are trying to be articulated

✓ **“When”** - timing, appropriate time of delivery

✓ **“Why”** - the desired outcomes

✓ **“How”** - how the message will be delivered

✓ **“By whom”** - the sender

Communication Plan



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1.5 Communicate with stakeholders

Performance agreement

How

The primary goal of the agreement is to align maintenance activities with operational needs, ensuring that maintenance resources (time, labor, planning) are focused on the work that provides the greatest value to production and asset availability.

Elements :

- Repair response time
- Machine availability target
- Call - out procedures and guidelines





Which of the following is **not** a typical element of a performance agreement between maintenance and operations?

- A. Repair response time targets
- B. Machine availability targets
- C. Agreed upon staffing levels**
- D. Call-out procedures and guidelines

Answer c





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What is the primary use of a performance agreement between operations and maintenance?

- A. Deploy resources most effectively.
- B. Know who is responsible when a problem occurs.
- C. Clarify operating roles and responsibilities.
- D. Minimize unnecessary call-outs.

Answer A





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To ensure the engagement of stakeholders, an effective communication plan must provide methods for which of the following three essential activities?

- A. Restricting information access, preventing feedback, and minimizing management reports.
- B. Sharing information, developing personal relationships, and reducing all meeting times.
- C. Sharing information, receiving feedback, and providing input to decision-making processes.**
- D. Informing staff, securing new capital, and eliminating all external coordination.

Correct Answer: C





The Maintenance and Reliability leader's ultimate objective in executing a Comprehensive Communication Plan for the strategic direction is to achieve which of the following?

- A. Secure the highest possible capital expenditure for the next quarter.
- B. Limit the flow of information strictly to top management.
- C. Achieve organizational business goals.**
- D. Eliminate all coordination with the Operations department.

Correct Answer: C



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1.6 Manage environmental-health-safety risk



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Conform to applicable regulations

Provide EHS training



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1.6 Manage environmental-health-safety risk

Maintenance and Reliability leaders should promote work practices that achieve:

- Excellence in environmental stewardship.
- Comply with all rules and regulations pertaining to occupational health and safety.
- Security.
- Protect resources.



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1.6 Manage environmental-health-safety risk

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Occupational health and safety and environmental compliance should not be sacrificed to achieve production goals.

The benefits of good EHS practices should be recognized for helping create a better work environment that nurtures improved job satisfaction.



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1.6 Manage environmental-health-safety risk

It is important to:

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- Train and encourage employees to conduct their work in a safe and environmentally responsible manner
- To use proactive programs to identify and eliminate deviation from accepted EHS practices.



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1.6 Manage environmental-health-safety risk

America's Deadliest Jobs

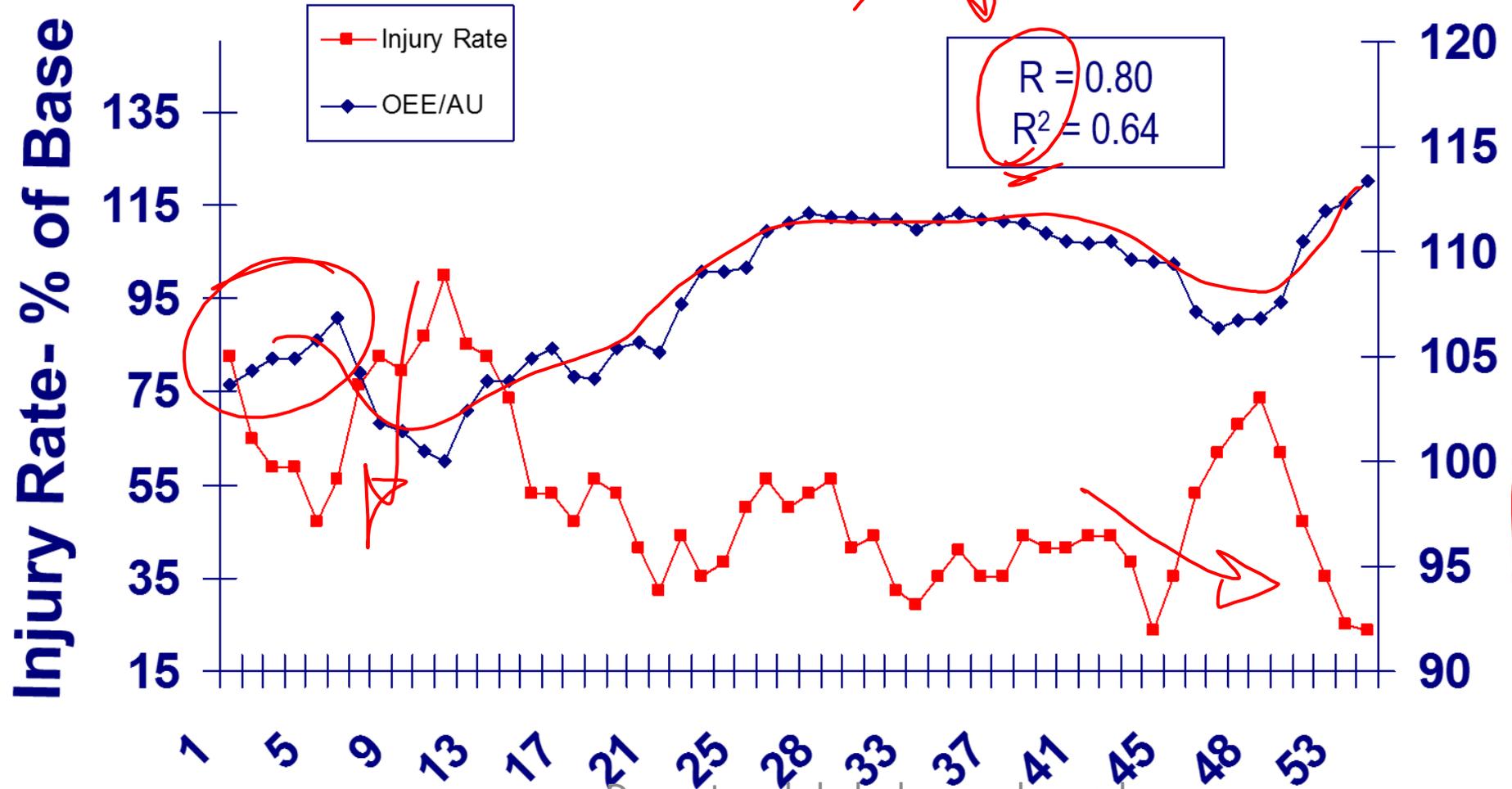
Fatal occupational injuries per 100,000 full-time workers (2013)



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1.6 Manage environmental-health-safety risk



OEE/AU-% of Base





R^2 : the *coefficient of determination*.

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What R^2 Represents

- **Definition:** R^2 is a statistical measure of fit.
- **Range:** Values range from **0 to 1**.
 - $R^2 = 1.0$ → Perfect fit (the model explains all variability).
 - $R^2 = 0.0$ → No fit (the model explains none of the variability).
- **Interpretation:** Higher R^2 means the curve or regression line closely matches the actual data points.

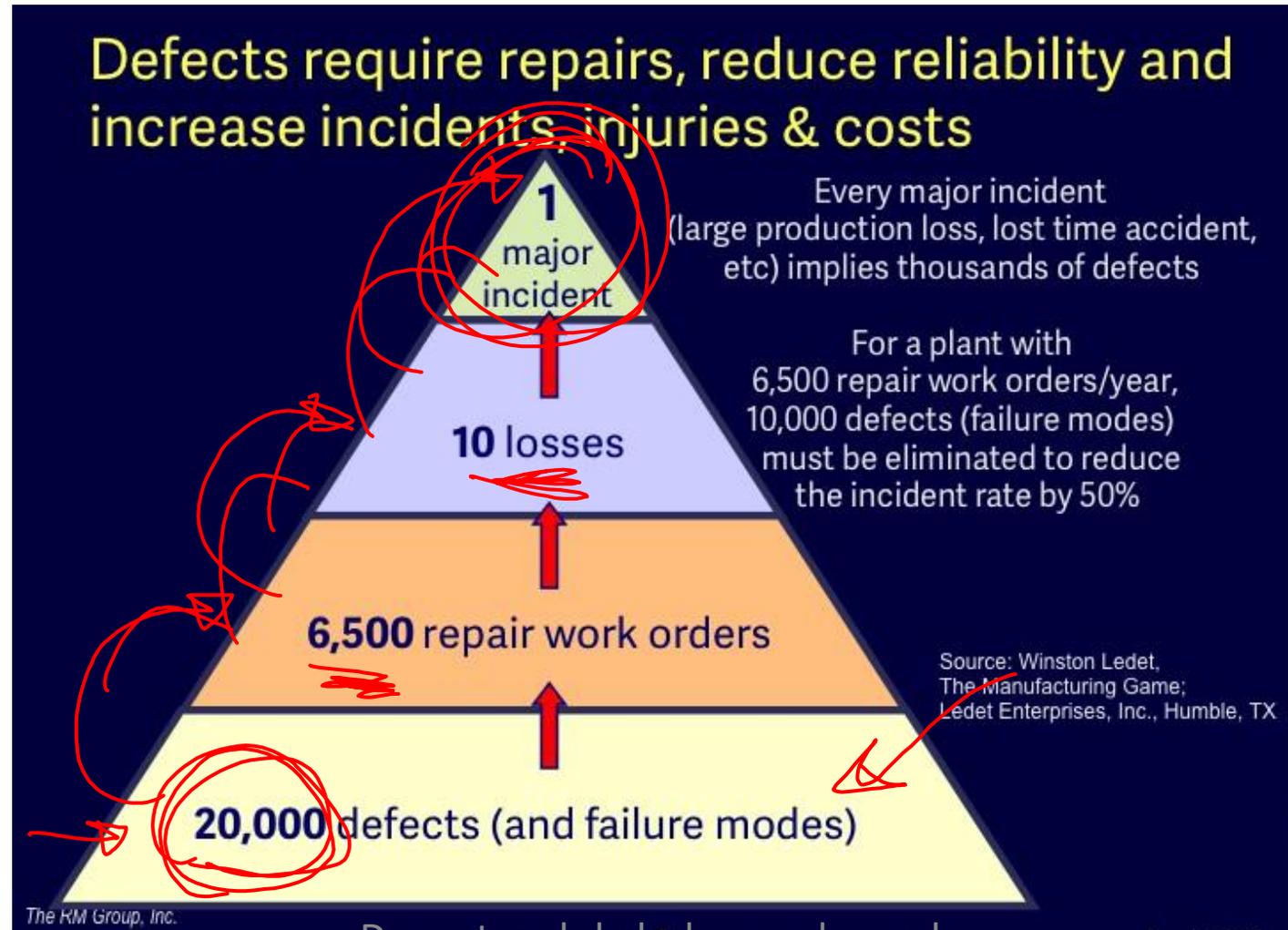
CMRP relevance: This helps reliability professionals validate whether improvements in utilization are truly driving OEE gains, or if other factors are influencing performance.



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1.6 Manage environmental-health-safety risk

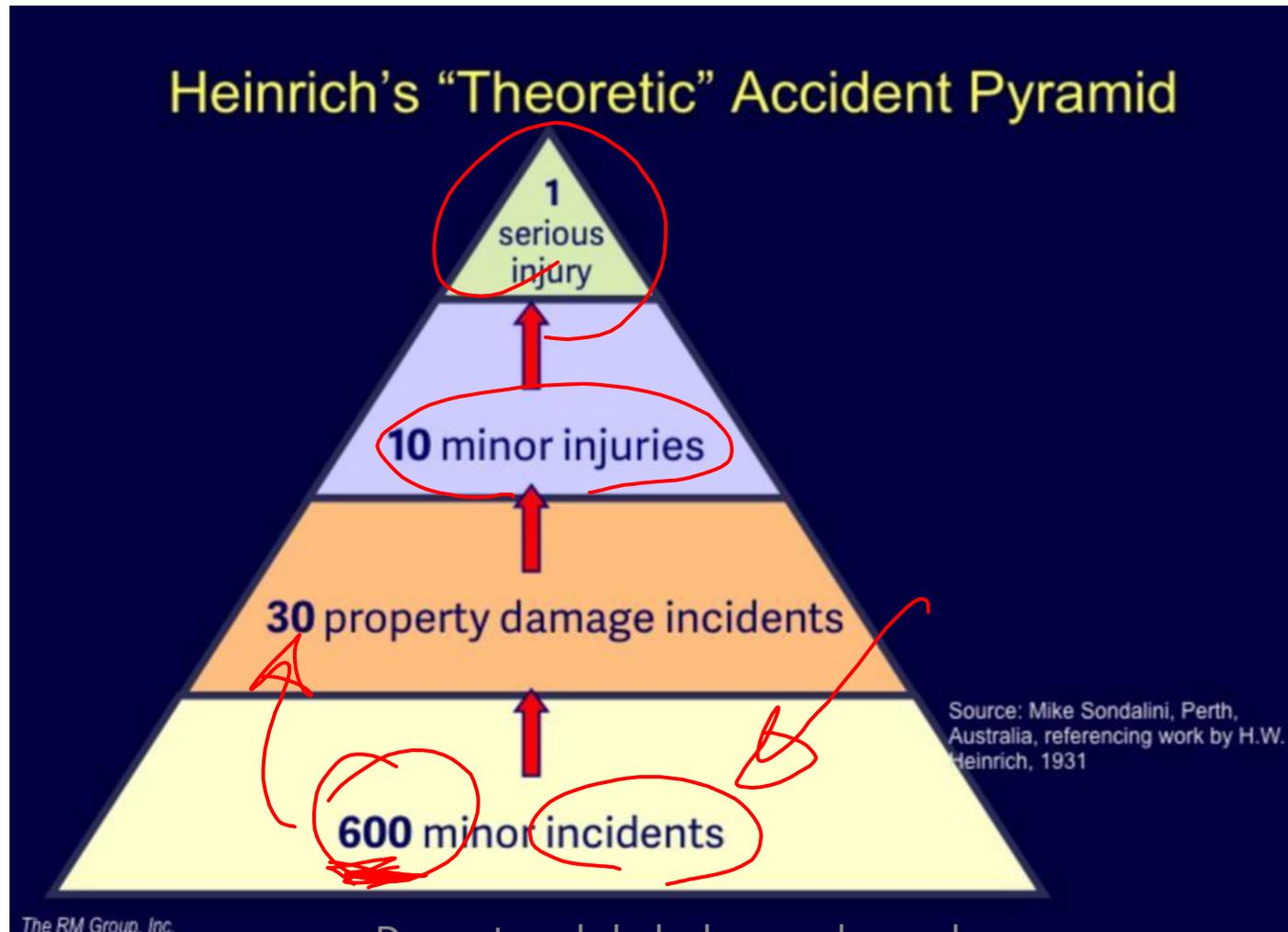


10,000

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1.6 Manage environmental-health-safety risk



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1.6 Manage environmental-health-safety risk

Process Safety Management System:

Process Safety Management System

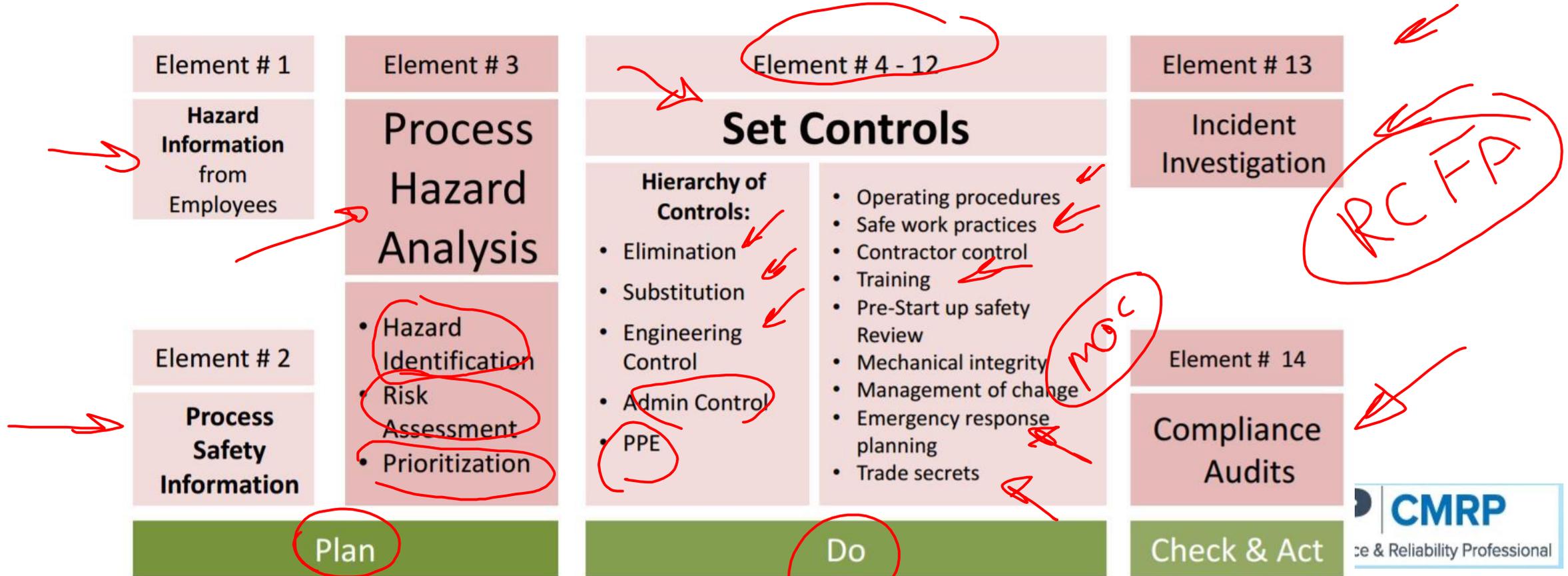


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1.6 Manage environmental-health-safety risk

Elements of Process Safety Management System:



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1.6 Manage environmental-health-safety risk

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OSHA RECORDABLE INCIDENT RATE - a mathematical calculation that describes the number of employees per 100 full-time employees that have been involved in a recordable injury or illness.

→ **TOTAL INCIDENT RATE** - a mathematical calculation that describes the number of recordable incident per 100 full-time employees in any given time frame.

✓ **LOST TIME CASE RATE** - a mathematical calculation that describes the number of lost time cases per 100 full-time employees in any given time frame.



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1.6 Manage environmental-health-safety risk

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LOST WORKDAY RATE - a mathematical calculation that describes the number of lost workdays per 100 full-time employees in any given time frame.

SEVERITY RATE - a mathematical calculation that describes the number of lost days experienced as compared to the number of incidents experienced.

DART RATE (Days Away, Restricted, or Transferred rate)

- a mathematical calculation that describes the number of recordable incidents per 100 full time employees that resulted in lost or restricted days or job transfer due to work related injuries or illnesses.

Exam





Based on the principles of managing environmental-health-safety (EHS) risk, which of the following is the highest-level mandate regarding EHS and production goals?

- A. EHS compliance may be temporarily suspended if critical production goals are at risk.
- B. EHS compliance should be balanced against production needs to find a compromise.
- C. EHS compliance must be prioritized only when a new regulation is introduced.
- D. **Occupational health and safety and environmental compliance should not be sacrificed to achieve production goals.**

Correct Answer: D





The **DART Rate** (Days Away, Restricted, or Transferred) is a key EHS metric. It is a mathematical calculation that describes the number of recordable incidents per **100 full-time employees** that resulted in which of the following outcomes?

- A. Damage to company-owned physical assets.
- B. Voluntary changes in job duties or location.
- C. Lost or restricted days or job transfer due to work-related injuries or illnesses.**
- D. Employee exposure to a hazardous substance without injury.

Correct Answer: C





To effectively manage environmental-health-safety risk and ensure compliance, M&R leaders should use which type of programs to identify and eliminate deviations from accepted EHS practices?

- A. Corrective Maintenance Programs.
- B. Reactive Failure Analysis Programs.
- C. Proactive Programs.**
- D. Management Assessment Programs.

Correct Answer: C



Pillar 1 - Business and Management



Pillar related metrics and KPIs

ENGINEER ACADEMY

- Ratio of Replacement Asset Value (RAV) to Craft-Wage Head Count
- Maintenance Unit Cost
- Stocked Maintenance, Repair, and Operating (MRO) Inventory Value as a Percent of Replacement Value
- Total Maintenance Cost as a Percent of Replacement Asset Value



Pillar 1 - Business and Management



Pillar related metrics and KPIs

- Ratio of Replacement Asset Value (RAV) to Craft-Wage Head Count

Craft-Wage Headcount :

Number of maintenance personnel responsible for executing work assignments pertaining to maintenance activities. Include the number of contractors' personnel who are used to supplement routine maintenance. The headcount is measured in full-time equivalents (FTE).



Pillar 1 - Business and Management



Pillar related metrics and KPIs

- Ratio of Replacement Asset Value (RAV) to Craft-Wage Head Count

Ratio of Replacement Asset Value (\$) to Craft-Wage Head Count =

$$\text{RAV (\$)} \div \text{Craft-Wage Headcount}$$

This metric allows for comparisons of the ratio of craft-wage personnel on a site with other sites, as well as the benchmarking of data.



Pillar 1 - Business and Management



Pillar related metrics and KPIs

- Ratio of Replacement Asset Value (RAV) to Craft-Wage Head Count

SAMPLE CALCULATION :

For a given facility, the Replacement Asset Value (\$) is \$624,500,000 and the Craft Wage Headcount for maintenance employees is 150.

• The Ratio of Replacement Asset Value (\$) to Craft-Wage Headcount = $\frac{\$624,500,000}{150}$ maintenance employees = \$4,160,000 per maintenance employee

* BEST IN CLASS TARGET VALUE \$8,000,000 to \$9,000,000 per Craft Worker



Pillar 1 - Business and Management



Pillar related metrics and KPIs

- Maintenance Unit Cost

ENGINEER ACADEMY

The metric is the measure of the total maintenance cost required for an asset or facility to generate a unit of production.

To quantify the total maintenance cost to produce a standard unit of production over a specified time period (e.g. monthly, quarterly, annually, etc.). This metric provides a period over period trend of maintenance cost per unit produced.



Pillar 1 - Business and Management



Pillar related metrics and KPIs

- Maintenance Unit Cost

$$\text{Maintenance Unit Cost} = \text{Total Maintenance Cost} \div \text{Standard Units Produced}$$

Total Maintenance Cost:

Total expenditures for maintenance labor (including maintenance performed by operators) , materials, contractors, services and resources. Include all maintenance expenses for outages, shutdowns or turnarounds, as well as normal operating times. Include capital expenditures directly related to end-of-life machinery replacement. Do not include capital expenditures for plant expansions or improvements.



Pillar 1 - Business and Management



Pillar related metrics and KPIs

- Maintenance Unit Cost

ENGINEER ACADEMY

SAMPLE CALCULATION :

The total maintenance cost for the year was \$2,585,000. The total output from the manufacturing site in that same year was 12,227,500 kg.

- Maintenance Unit Cost = Total Maintenance Cost ÷ Standard Units Produced
- Maintenance Unit Cost = \$2,585,000 ÷ 12,227,500 kg
- Maintenance Unit Cost = \$0.21 per kg

