RELIABILITY
& MAINTENANCE WEEK

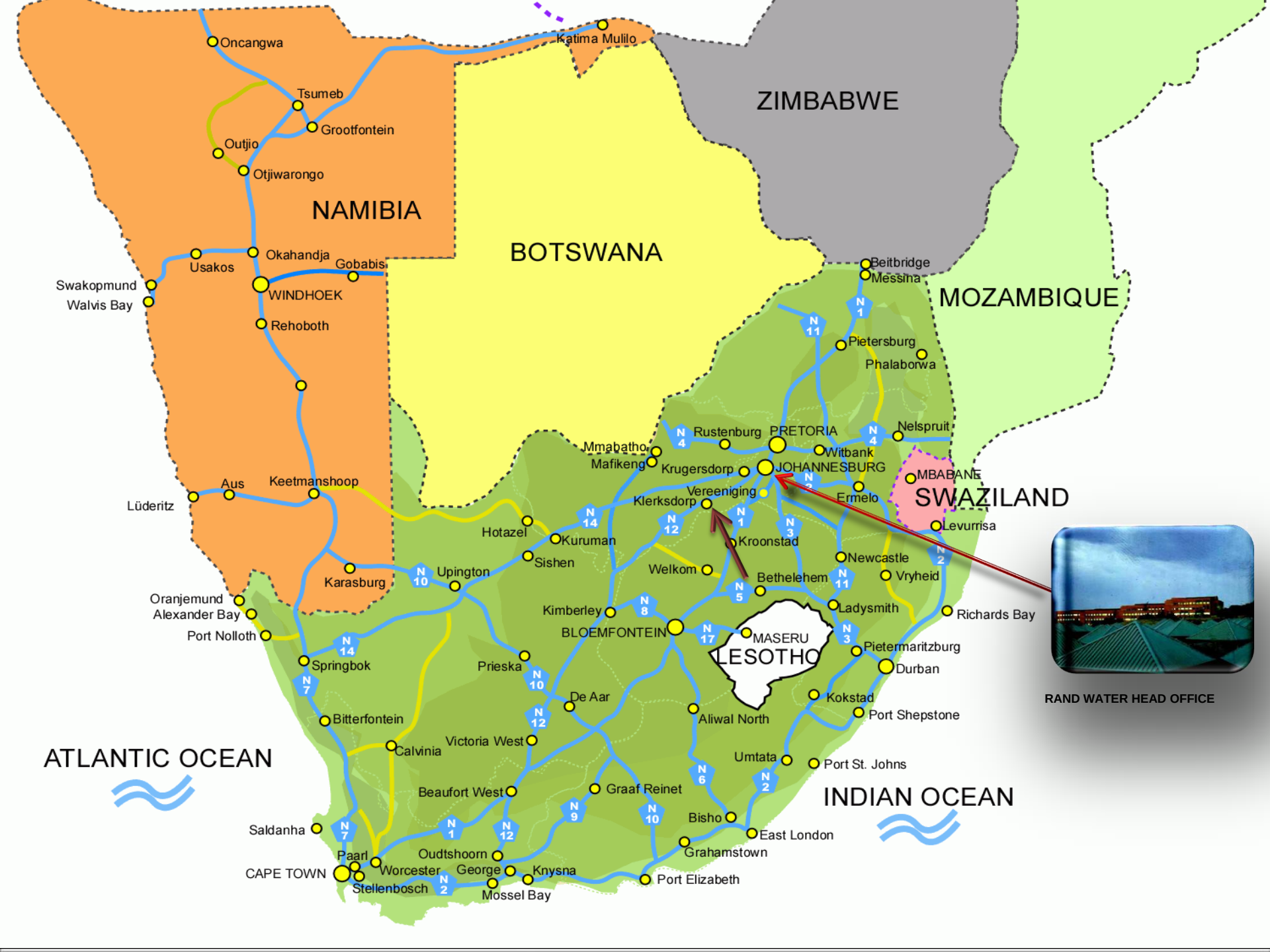
HOW TO INSTITUTE PLANT AND OPERATIONAL KPI'S TO INCREASE PLANT AVAILABILITY

FAROUK KHAN
Maintenance Support Services Manager

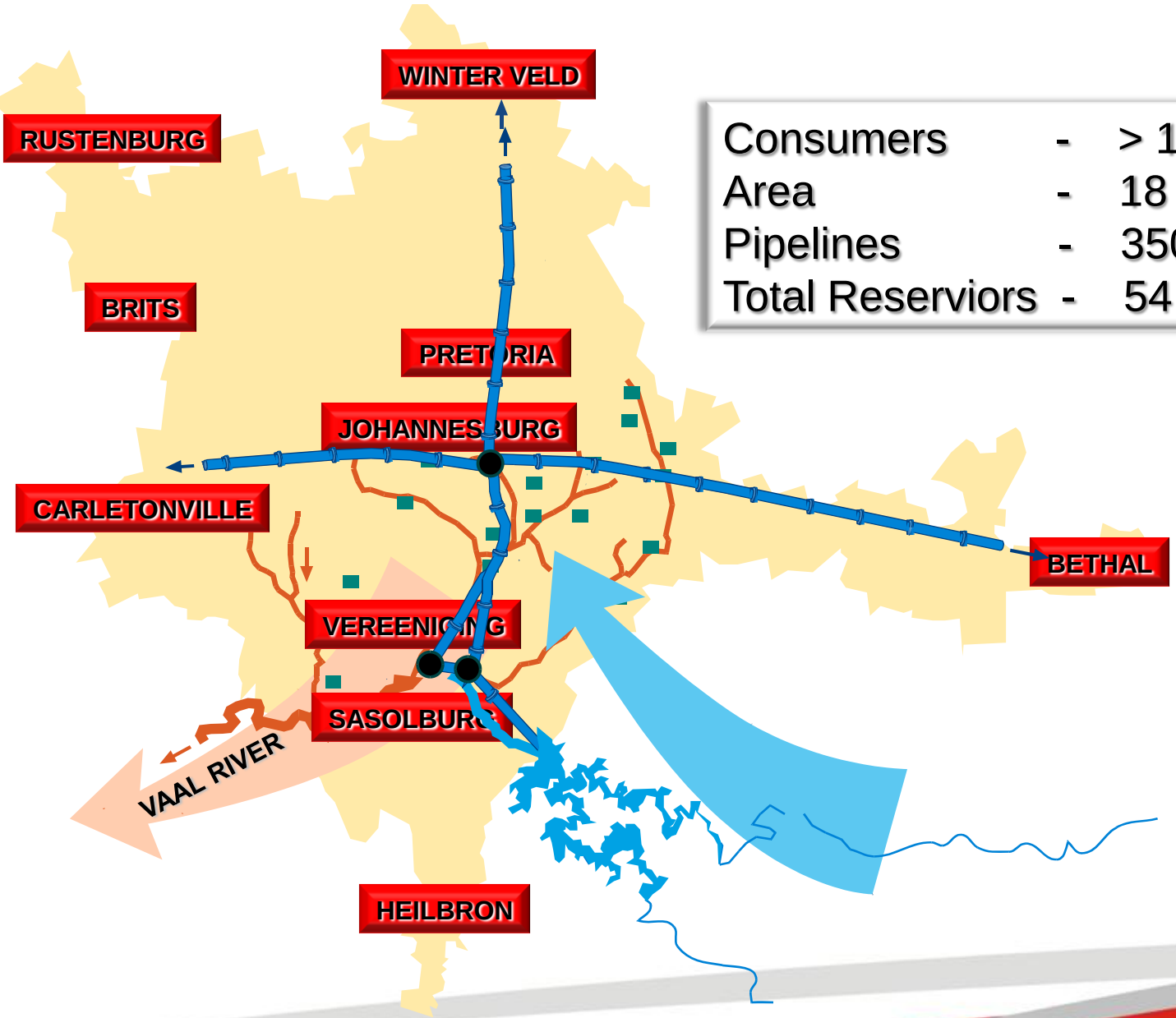
RAND WATER

Rand Water
Gauteng,
South Africa

spintelligent
CLARION


Oncangwa
Katima Mulilo
ZIMBABWE
Tsumeb
Grootfontein
Outjio
Otjiwarongo
NAMIBIA
BOTSWANA
MOZAMBIQUE
Okahandja
Usakos
Gobabis
Swakopmund
Walvis Bay
WINDHOEK
Rehoboth
Beitbridge
Messina
Pietersburg
Phalaborwa
Nelspruit
Rustenburg
PRETORIA
Witbank
Mmabatho
Mafikeng
Krugersdorp
JOHANNESBURG
MBABANE
SWAZILAND
Vereeniging
Ermelo
Klerksdorp
Levurrisa
Aus
Keetmanshoop
Lüderitz
Hotazel
Kuruman
Kroonstad
Newcastle
Upington
Sishen
Welkom
Vryheid
Karasburg
Bethelehem
Oranjemund
Alexander Bay
Kimberley
Ladysmith
Richards Bay
Port Nolloth
BLOEMFONTEIN
MASERU
LESOTHO
Springbok
Pietermaritzburg
Prieska
Durban
De Aar
Kokstad
Bitterfontein
Aliwal North
Port Shepstone
Victoria West
Calvinia
Umtata
Port St. Johns
ATLANTIC OCEAN
INDIAN OCEAN
Beaufort West
Graaf Reinet
Bisho
Saldanha
East London
Oudtshoorn
Grahamstown
Paarl
CAPE TOWN
Worcester
George
Knysna
Port Elizabeth
Stellenbosch
Mossel Bay
RAND WATER HEAD OFFICE

AREAS OF SUPPLY



Consumers	-	> 13 Million
Area	-	18 000 sq km
Pipelines	-	3500 km
Total Reserviors	-	54

- ✓ Potable Water Pumps – 25 to 300 Ml/d
- ✓ Raw Water Pumps – up to 450 Ml/d
- ✓ Motors – 200kw to 6230kw
- ✓ Pump to an elevation of +/- 400m
- ✓ Pipelines – 400mm to 3.5m diameter

AFRICAN STYLE

BUSINESS STRATEGY

Rand Water Vision

To be the industry leader and partner of choice in sustainable water services

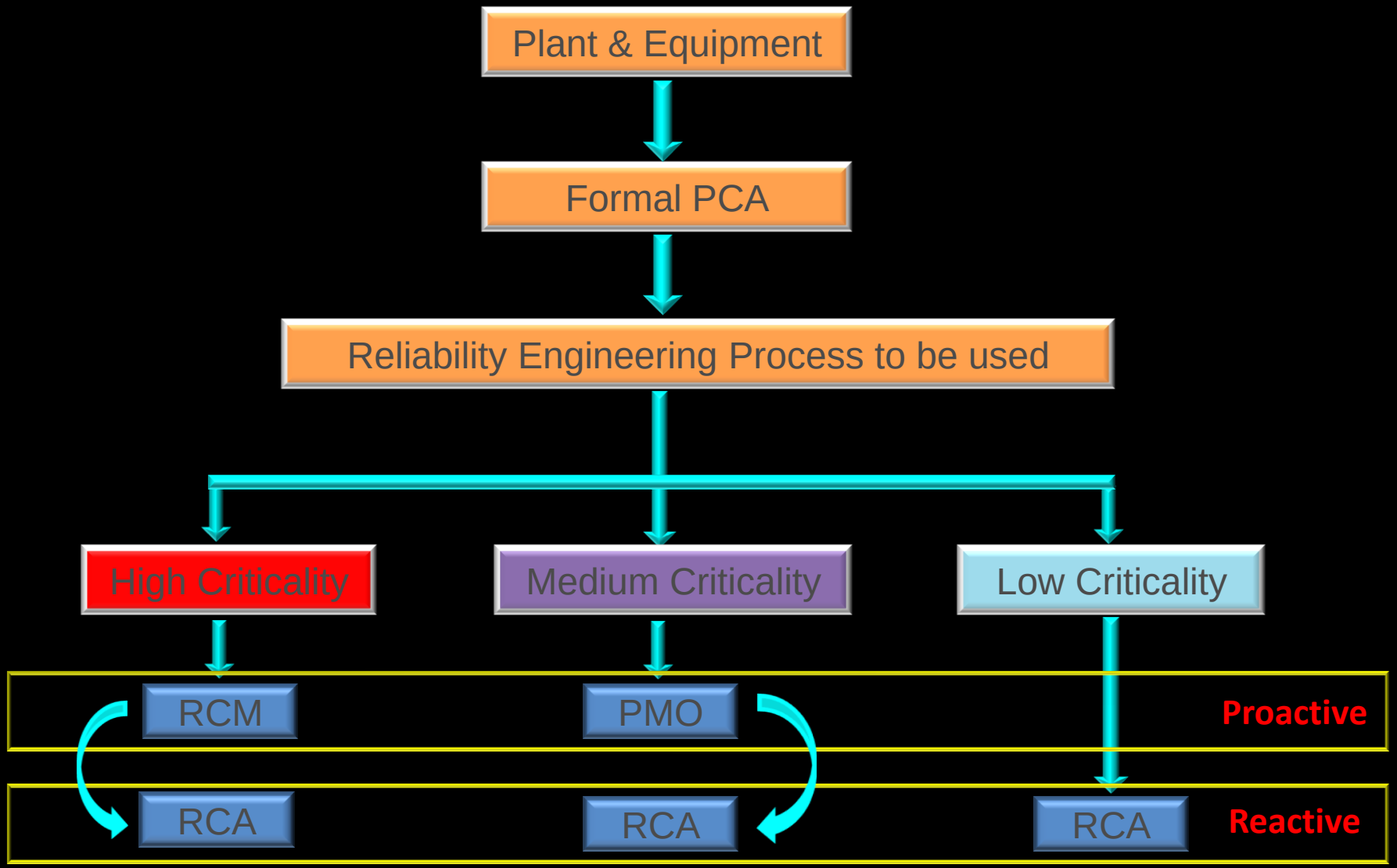
Rand Water Strategic Objectives

- ✓ Position Rand Water as the partner of choice in water services
- ✓ Satisfy all customers
- ✓ Improve efficiencies and quality
- ✓ Achieve transformation
- ✓ Create a dynamic learning organisation

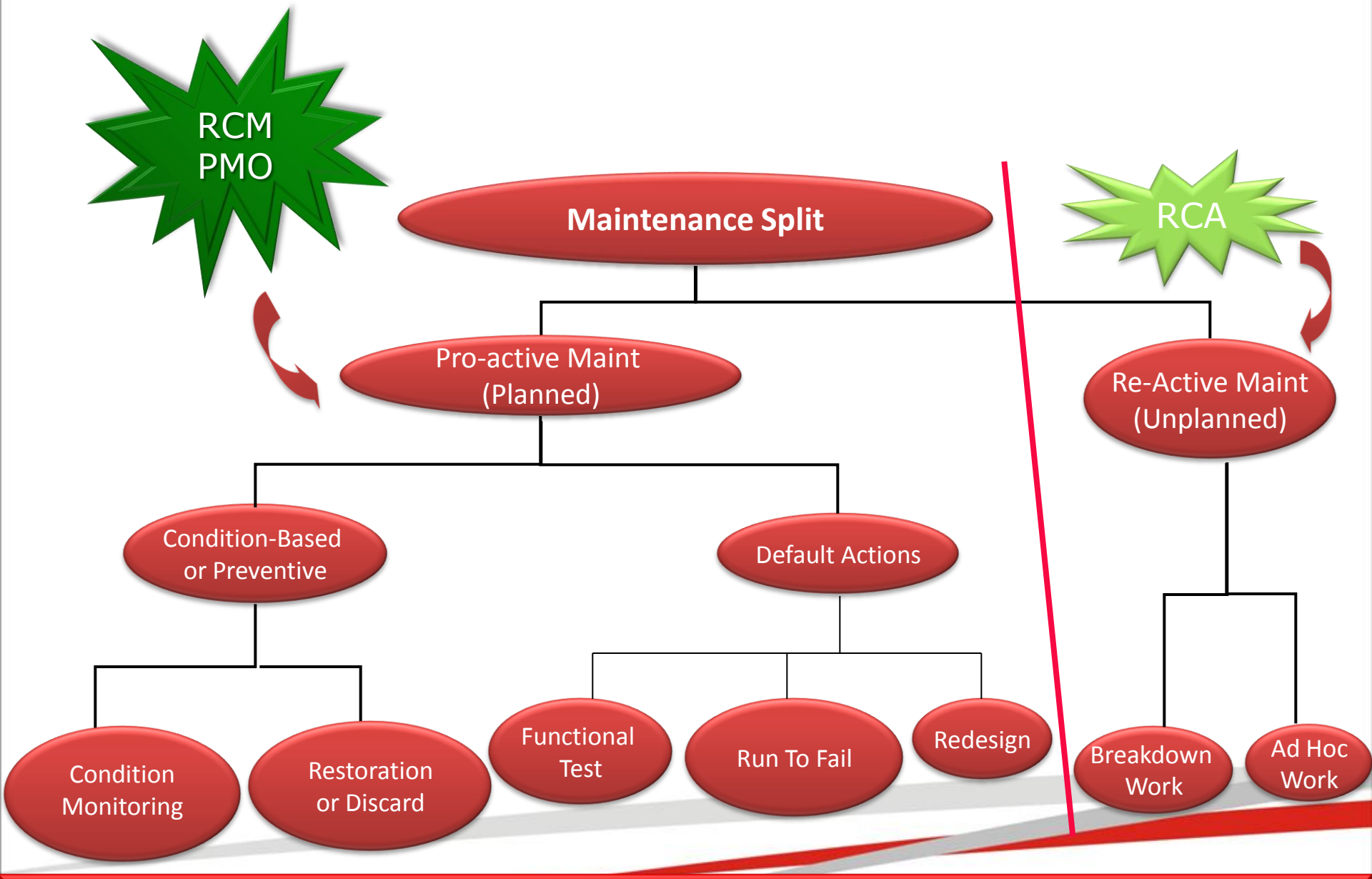
Importance of Assets

- Assets are acquired for their ability to produce the product on which an organisation base its existence.
- They are required to perform specific functions.
- Maintenance should focus on preserving this function.
- RCM looks at preserving primary and secondary functions of equipment based on the consequences of failure.
- Maintenance tactics are determined by the way in which equipment fails:
  - ✓ Failure pattern
  - ✓ Failure development period
  - ✓ Potential failure condition

Maintenance Strategy

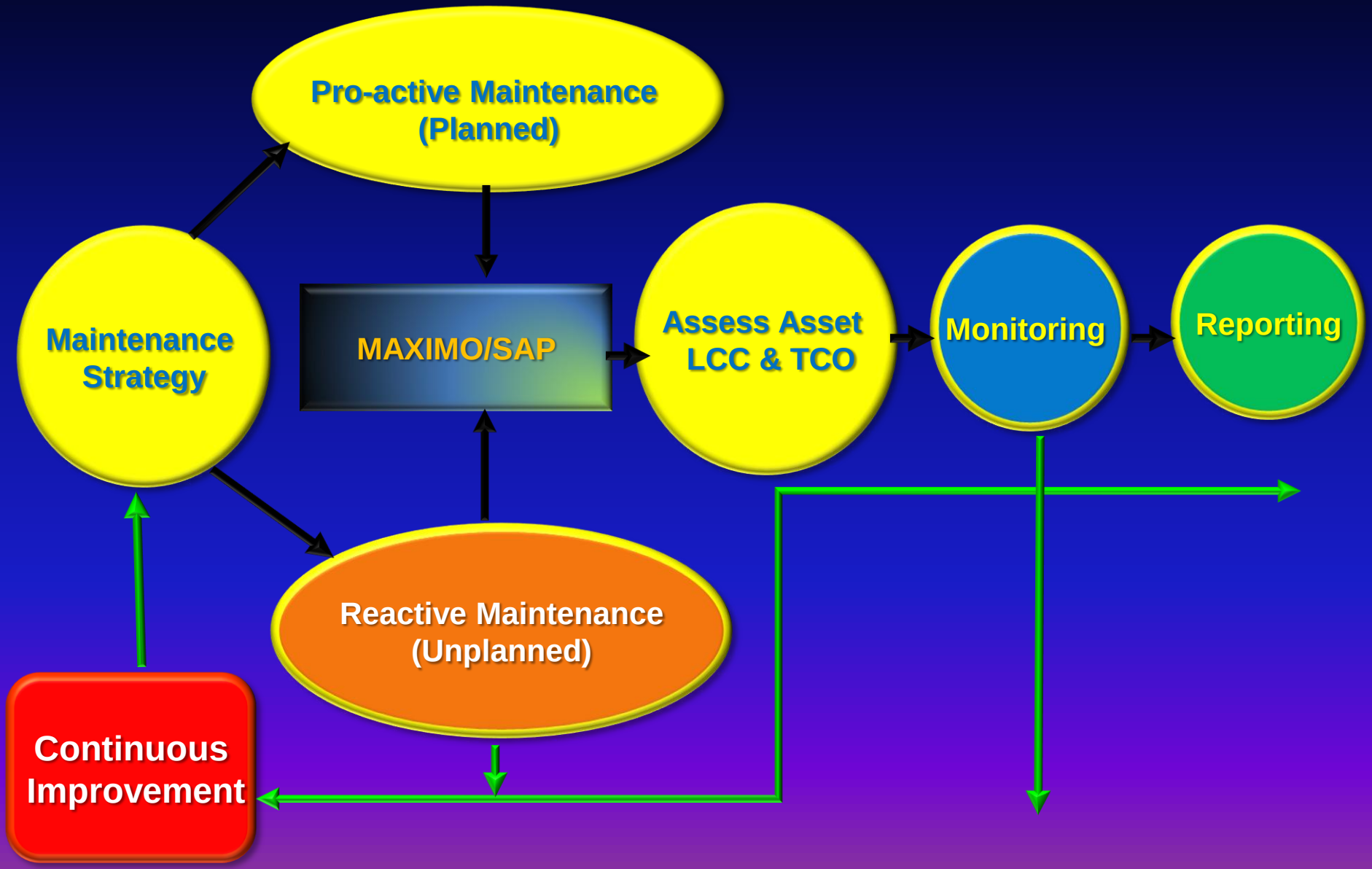


RAND WATER MAINTENANCE STRATEGY



Maintenance Split - Ratio = *70% Planned* :30% *Unplanned - Baseline*

Maintenance Management Process



Purpose of KPI's

KPI PURPOSE	DESCRIPTION	COMMENTS
Focus	Monitor the results of actions	To see if they highlight relevant factors that are truly important to outcomes from actions.
Change	Track the effect of making change	When making a change to a process , how is one to know that it will be a useful change. This is where an appropriate KPI will prove or disprove if change is beneficial.
Score	Act as a means to measure progress towards achievement.	The aim is simply to gradually improve what we do. In this case the performance will be a baseline for improvement and all other future performances aim at being better than the result.

Purpose of KPI's

KPI PURPOSE	DESCRIPTION	COMMENTS
Track	When you must meet set targets.	When a target is set ,it becomes critical to track efforts used to meet targets.
Predict	Proactively warn of future performance	In every organisation ,there are people who are aware of the danger signs" that forewarn of future problems. Put a suitable KPI that purposefully ,track and monitor ,to prevent and reduce the risk of failure.
Improve	Drive Continuous Improvement	Where organisations have several similar operations ,it is valuable to introduce identical KPI's into each group.

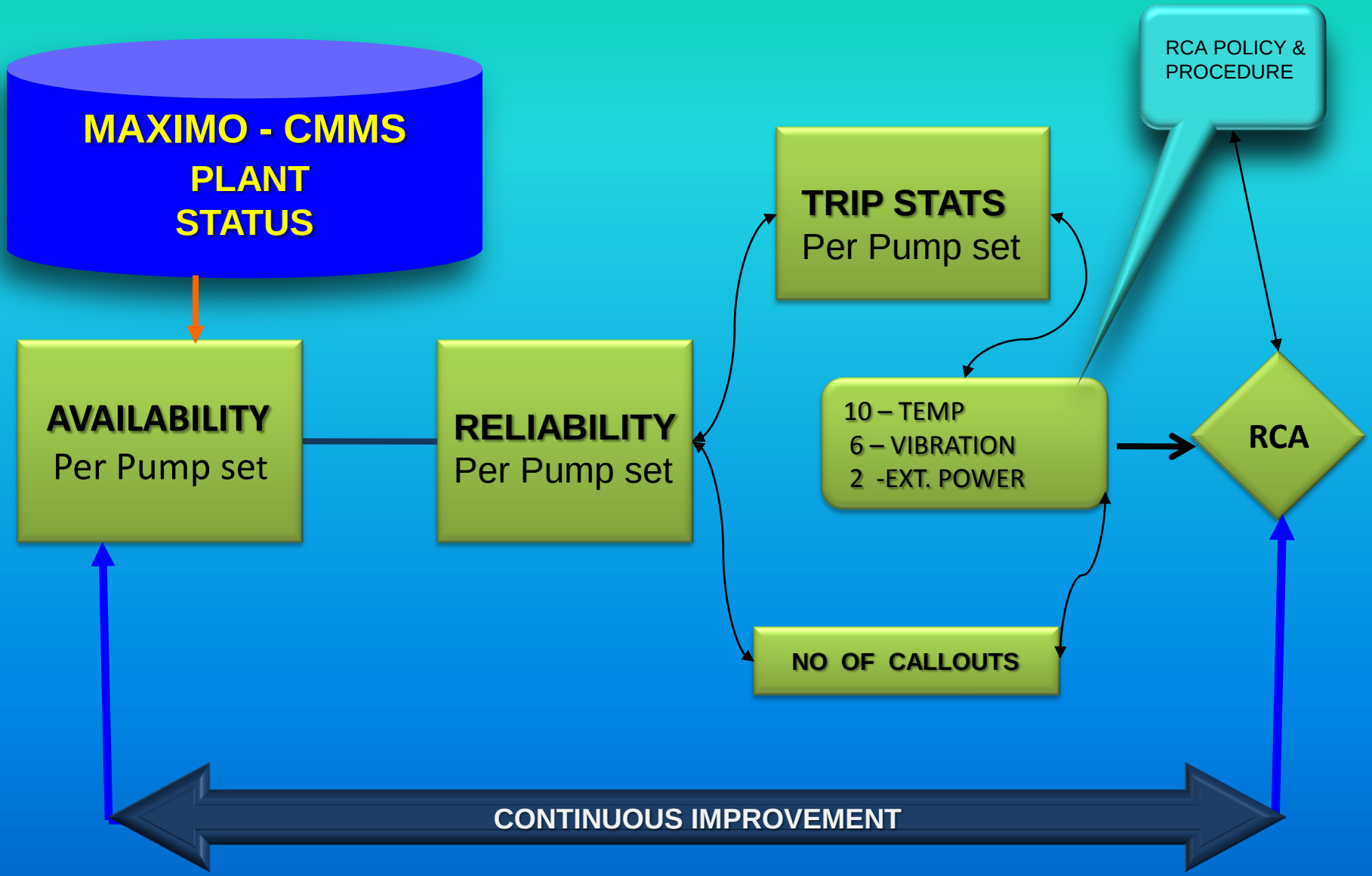
RELIABILITY IMPROVEMENT

•Reliability improvement methods and metrics are being utilized to meet the increasing demands placed on utilities to achieve optimum levels of Plant availability .

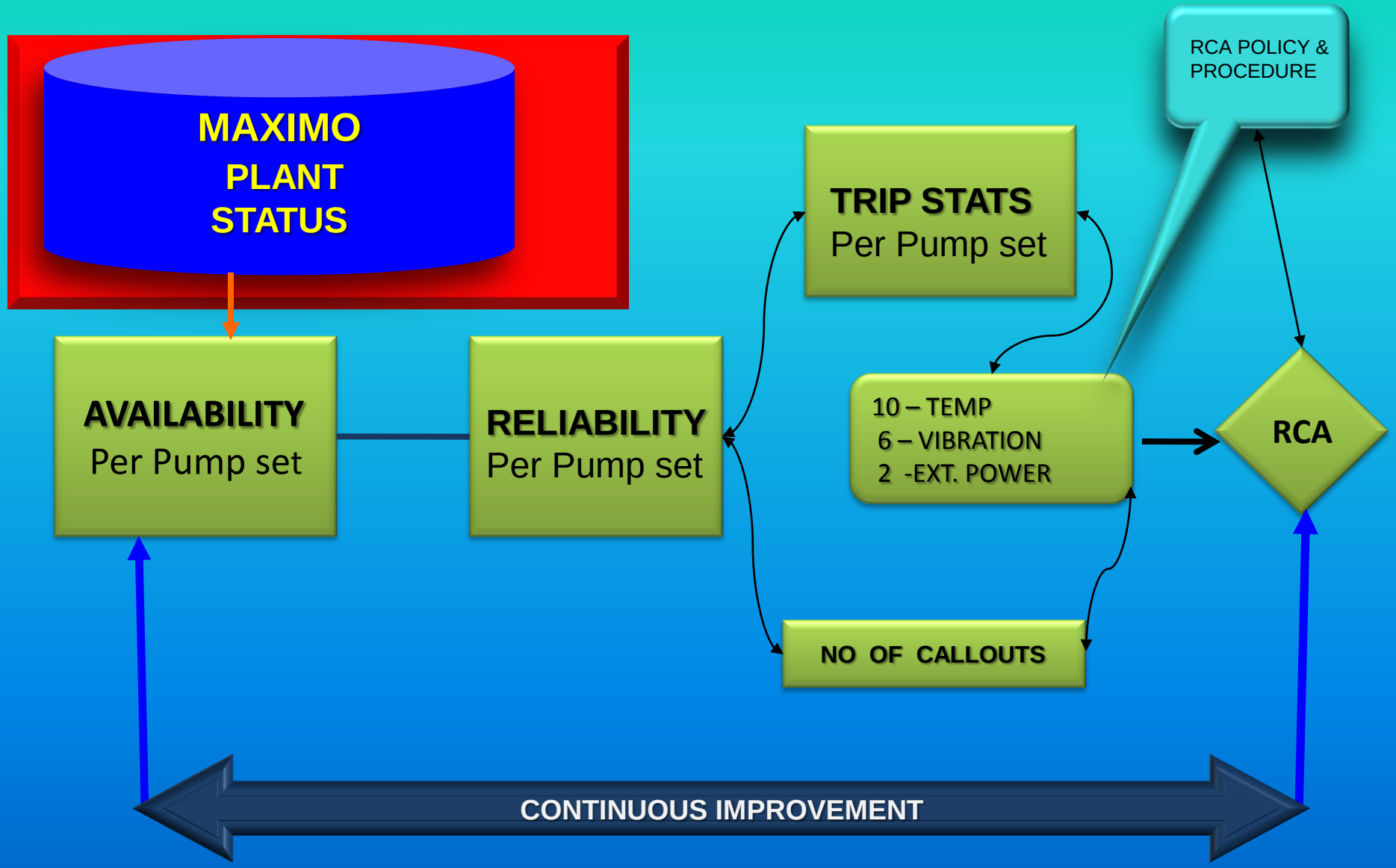
•A key aspect of any reliability improvement program is the comprehensive capture and analysis of actionable, accurate, performance data.

• For years, manufacturing leaders have struggled with the challenge of working with the deficiencies and controversies of manually collected data (i.e. stop watch and clip board and manipulation of data)

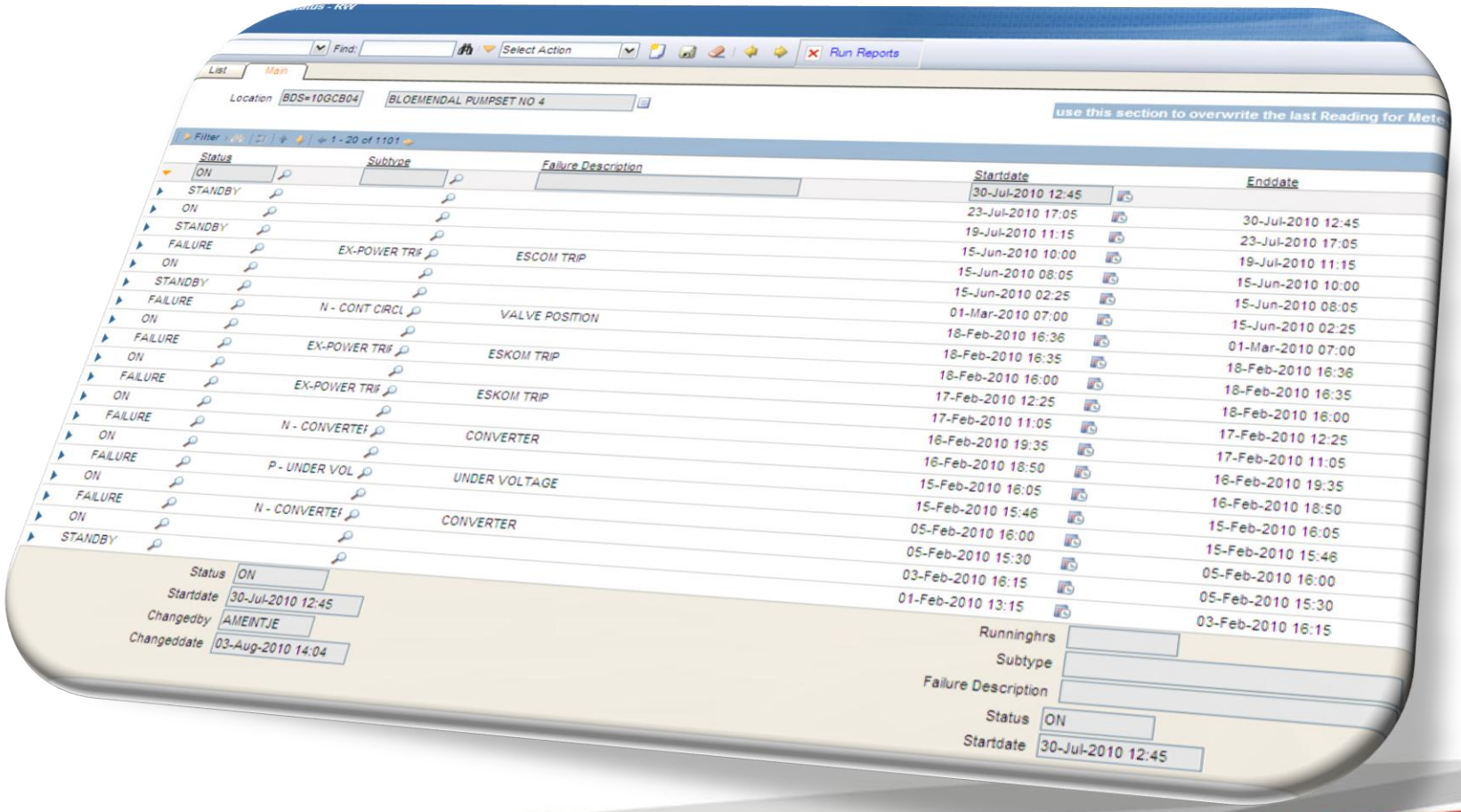
PLANT AVAILABILITY IMPROVEMENT MODEL



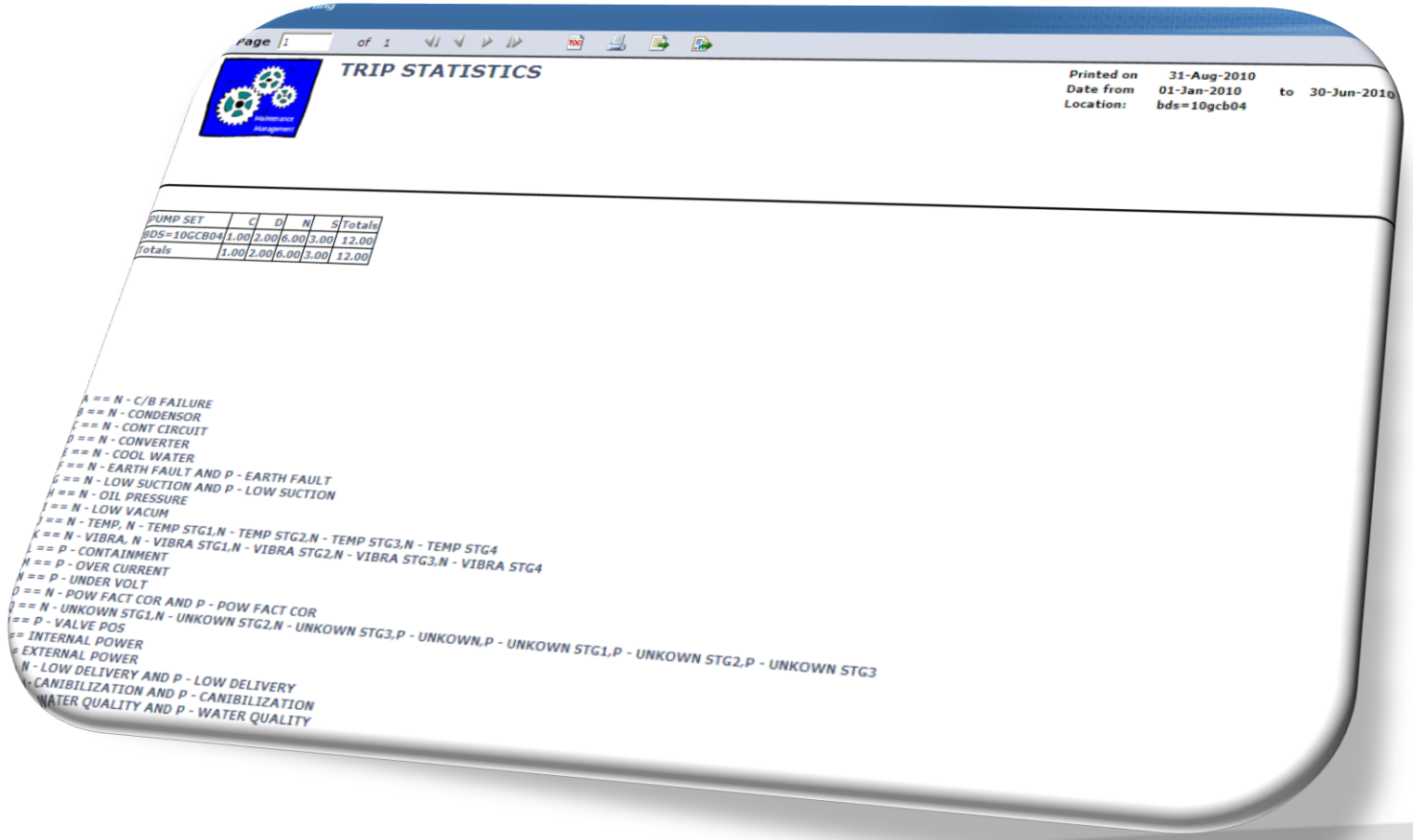
PLANT AVAILABILITY IMPROVEMENT MODEL



PLANT STATUS



TRIP STATISTICS



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TRIP STATISTICS

Printed on 31-Aug-2010
Date from 01-Jan-2010 to 30-Jun-2010
Location: bds=10gcb04

PUMP SET	C	D	N	S	Totals
BDS=10GCB04	1.00	2.00	6.00	3.00	12.00
Totals	1.00	2.00	6.00	3.00	12.00

A == N - C/B FAILURE
B == N - CONDENSOR
C == N - CONT CIRCUIT
D == N - CONVERTER
E == N - COOL WATER
F == N - EARTH FAULT AND P - EARTH FAULT
G == N - LOW SUCTION AND P - LOW SUCTION
H == N - OIL PRESSURE
I == N - LOW VACUM
J == N - TEMP, N - TEMP STG1,N - TEMP STG2,N - TEMP STG3,N - TEMP STG4
K == N - VIBRA, N - VIBRA STG1,N - VIBRA STG2,N - VIBRA STG3,N - VIBRA STG4
L == P - CONTAINMENT
M == P - OVER CURRENT
N == P - UNDER VOLT
O == N - POW FACT COR AND P - POW FACT COR
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S == EXTERNAL POWER
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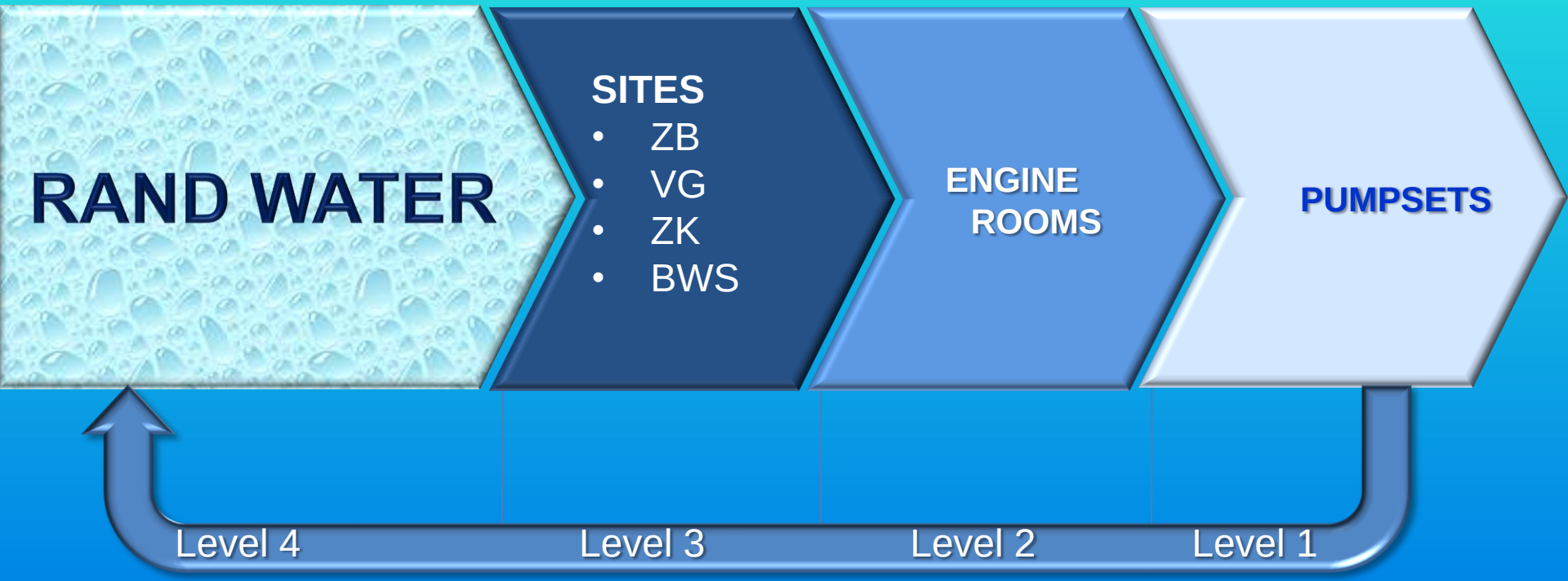
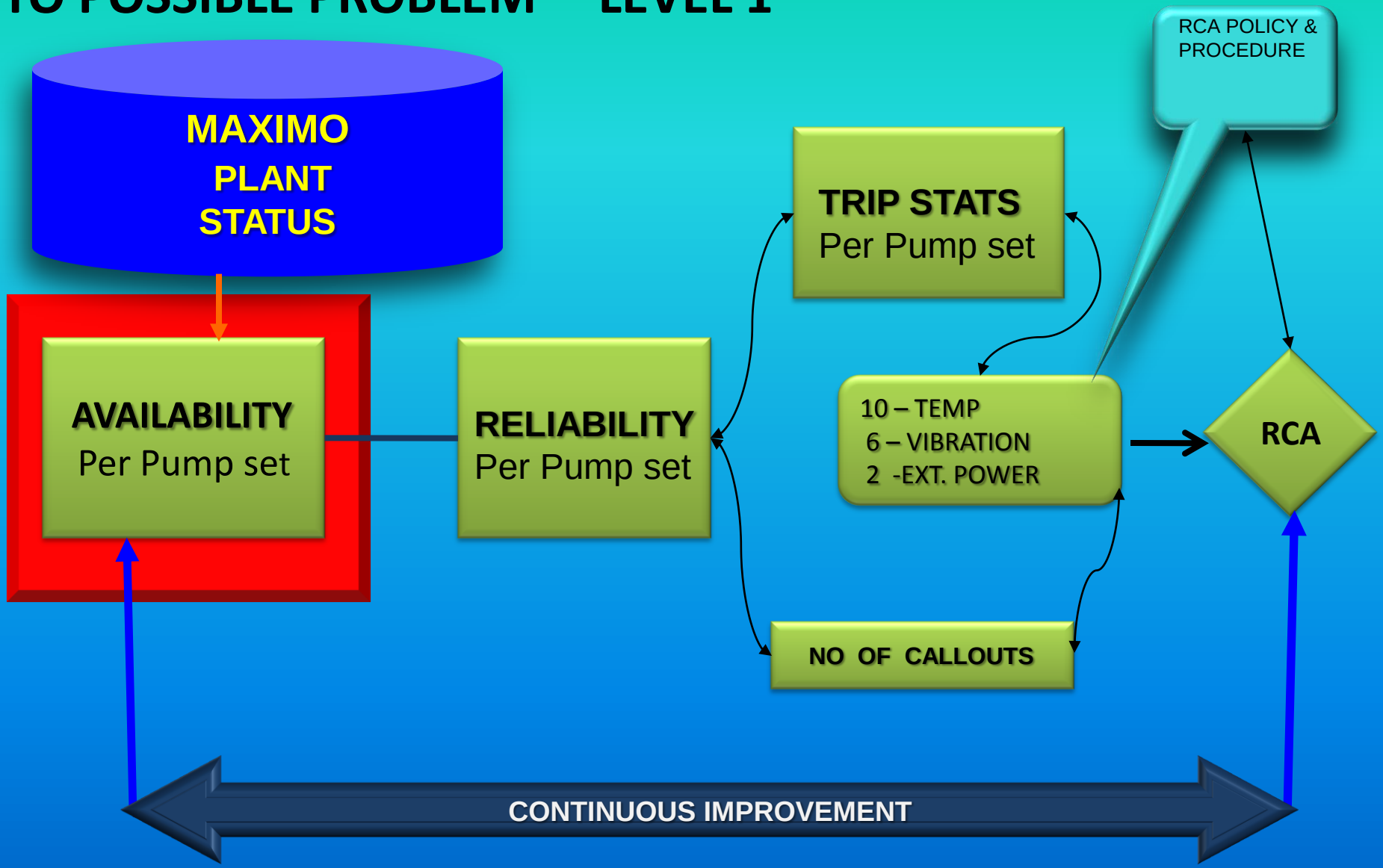
U == CANIBILIZATION AND P - CANIBILIZATION
V == WATER QUALITY AND P - WATER QUALITY

PERFORMANCE REPORT LEVEL



PERFORMANCE REPORT GUIDE TO POSSIBLE PROBLEM – LEVEL 1



AVAILABILITY

DEFINITION

The proportion of total time that an item of equipment is capable of performing its specified functions, normally expressed as a percentage.

FORMULA

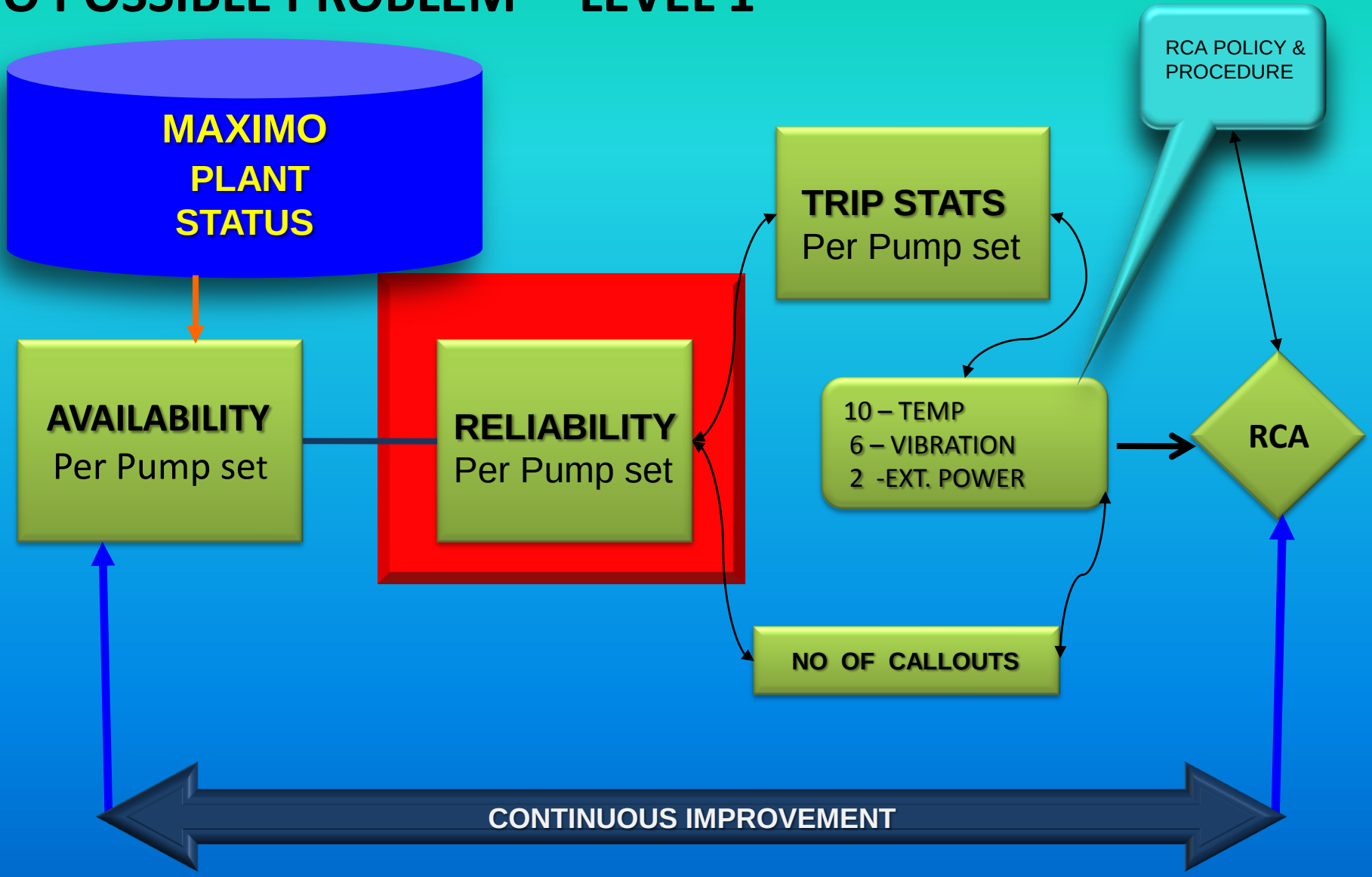
Availability=(Running time + Standby time)/total time.

REMARKS

It is calculated by dividing available hours by the total number of hours in any given period. (Available hours are the total hours in any given period, less the downtime hours) (Downtime hours is the time that an item of equipment is out of service, as a result of equipment failure)

This information is compiled from Plant Status changes, which have to be accurate to be meaningful. All the required information is compiled from accurate plant status reports.

PERFORMANCE REPORT GUIDE TO POSSIBLE PROBLEM – LEVEL 1



PLANT RELIABILITY (MTBF)

DEFINITION

It is the average length of time between one failure and another failure for an asset or component.

- ✓ MTBF is used for repairable assets of a similar type.
- ✓ MTTF is used for non-repairable assets e.g. Light bulbs ,rocket engines etc.
- ✓ Both these terms are used for asset reliability.

OBJECTIVES

This metric is used to assess the reliability of an asset. Reliability is usually expressed as the probability that an asset will perform its intended function without failure for a specified time period under specified function.

AN INCREASING MTBF INDICATES IMPROVED ASSET RELIABILITY.

FORMULA

Operating time (hours) / Number of failures

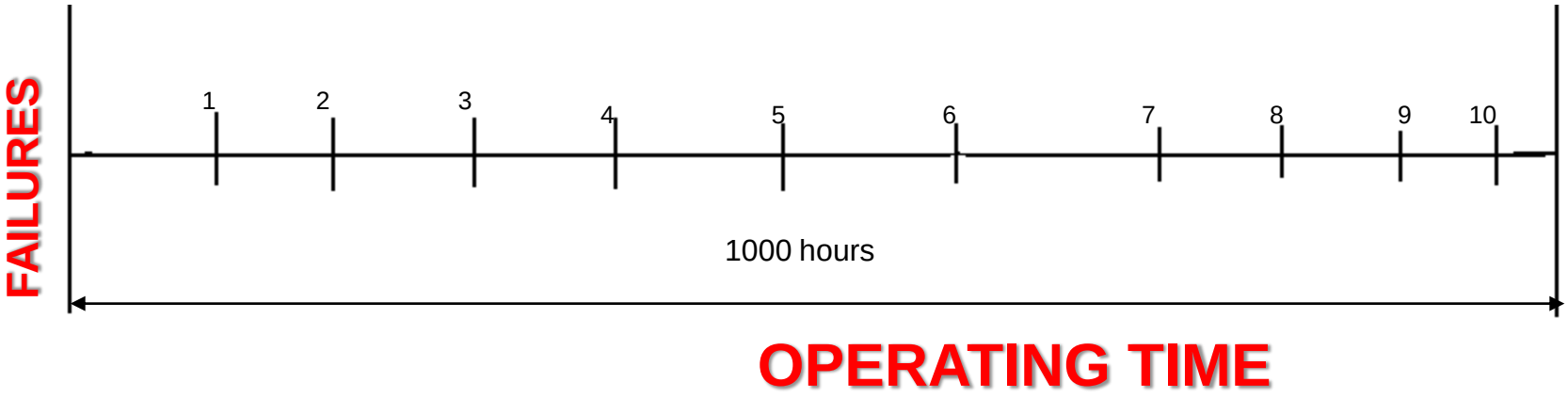
RELIABILITY QUALIFICATION

- Lagging Indicator
- Best used at asset or component level
- To be used by maintenance and reliability team.
- Performed on critical assets and trended over time.
- For low MTBF – RCA ,FMEA analysis must be performed to see how we can improve Reliability.

PLANT RELIABILITY (MTBF)

Sample calculation

If an asset had 10 failures in 1000 hours of operation , as indicated in the diagram below:

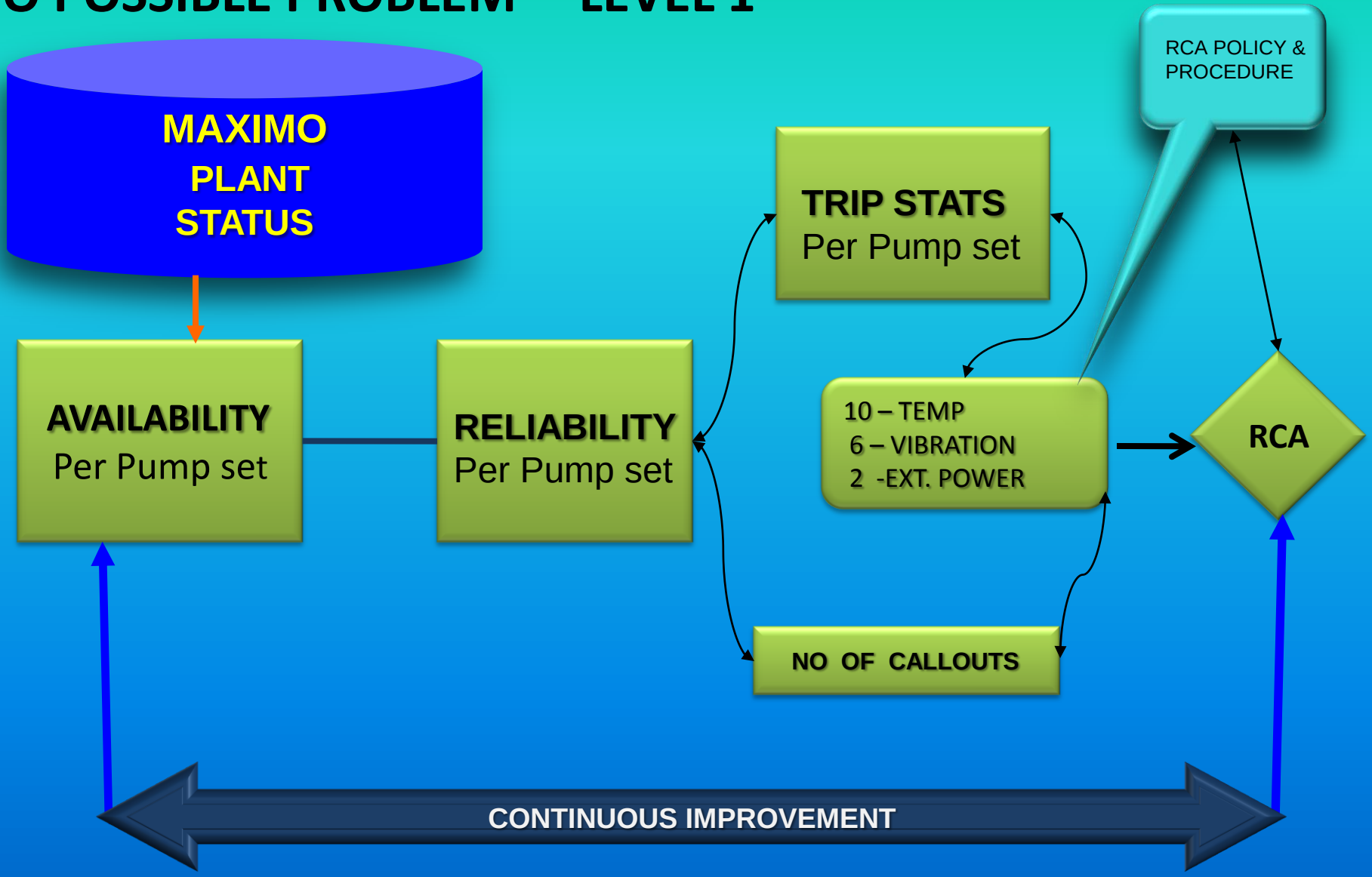


Formula

MTBF = Operating time (hours) / Number of failures
MTBF = 1000 HOURS / 10 FAILURES = 100 HOURS.

CONVERT TO DAYS = 100 / 24 HOURS = 4.16 DAYS

PERFORMANCE REPORT GUIDE
TO POSSIBLE PROBLEM – LEVEL 1



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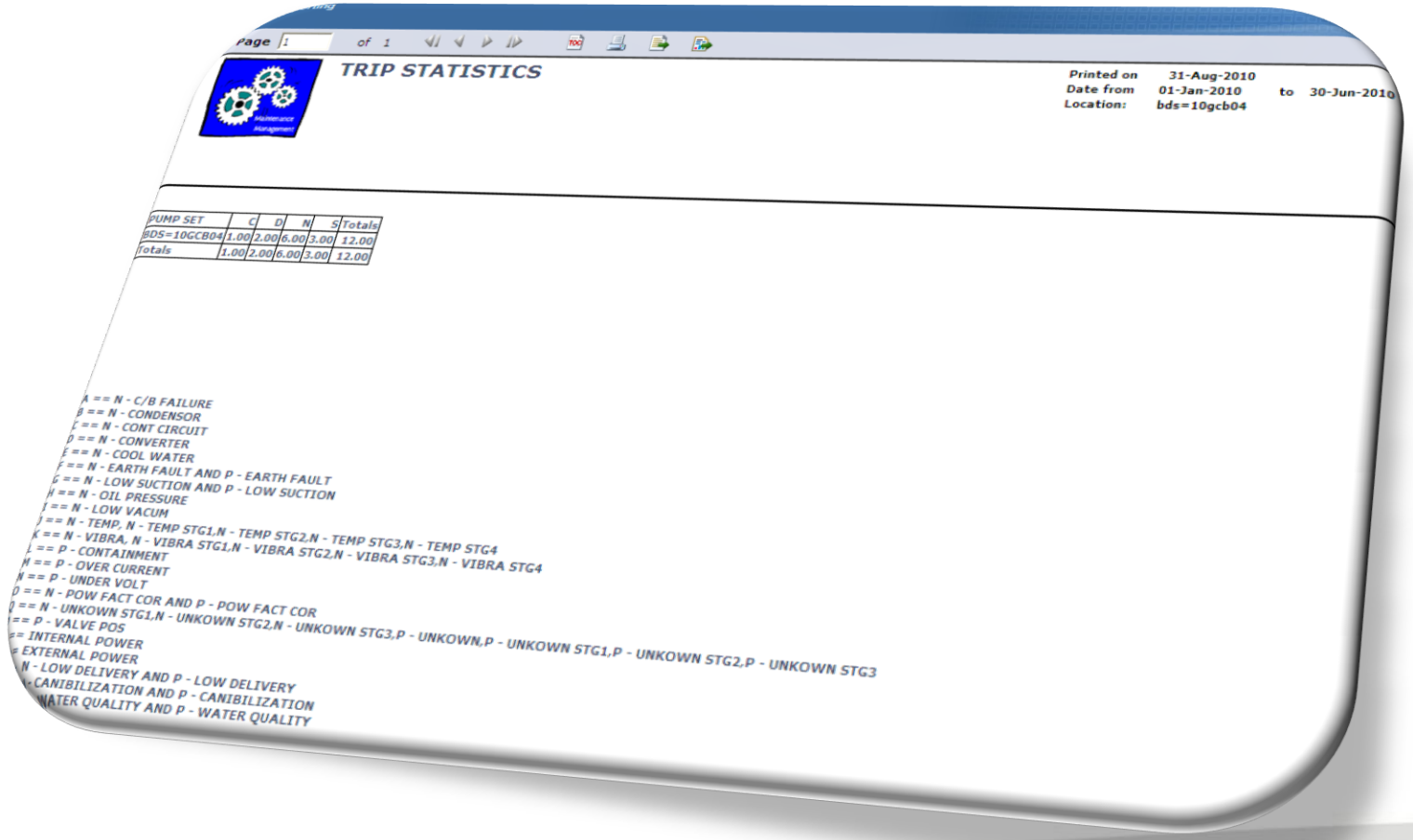

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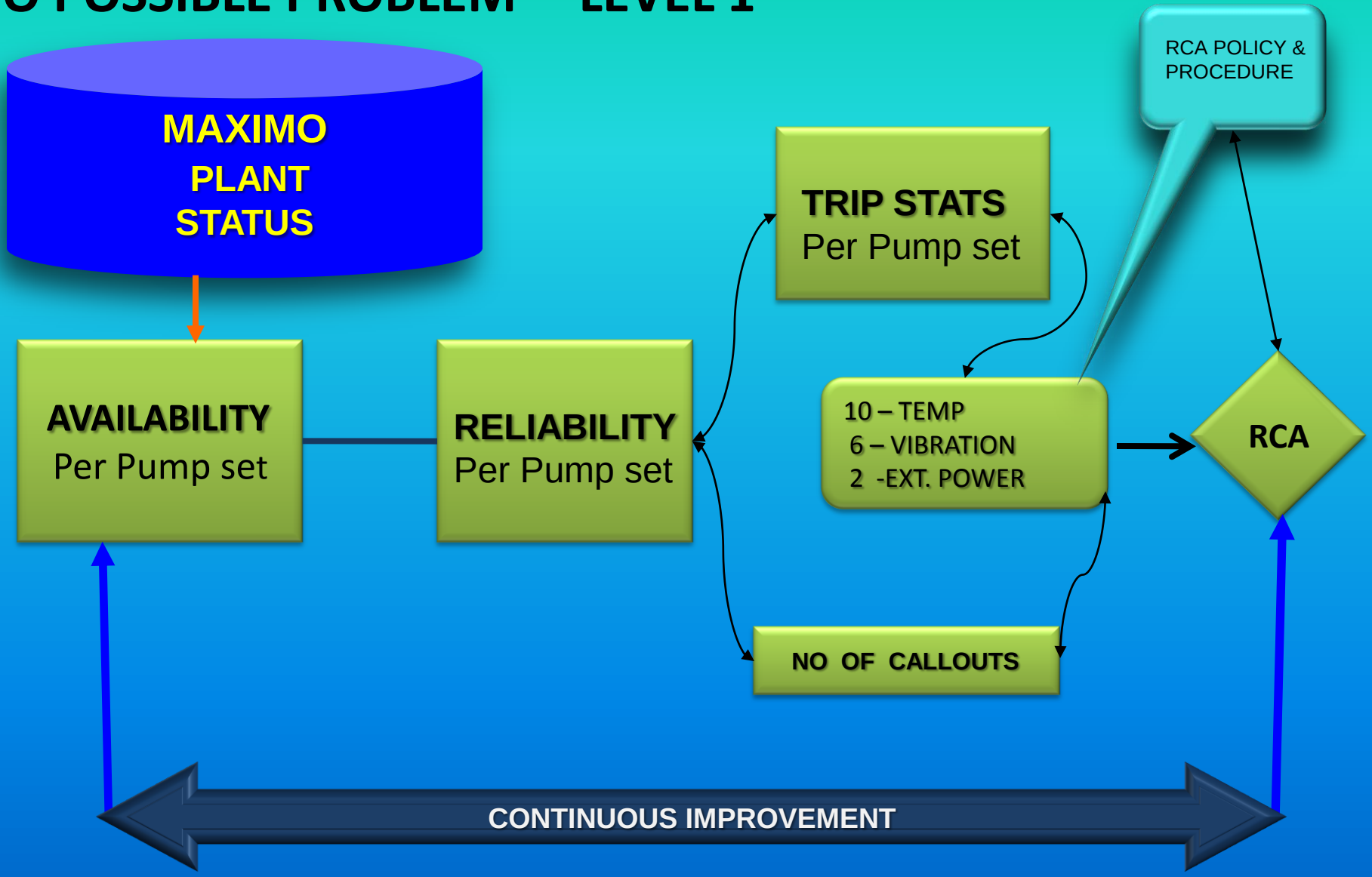


ROOT CAUSE ANALYSIS

Monthly Reliability / weekly report to include a spreadsheet that displays the following info:

No of trips on all main pumps

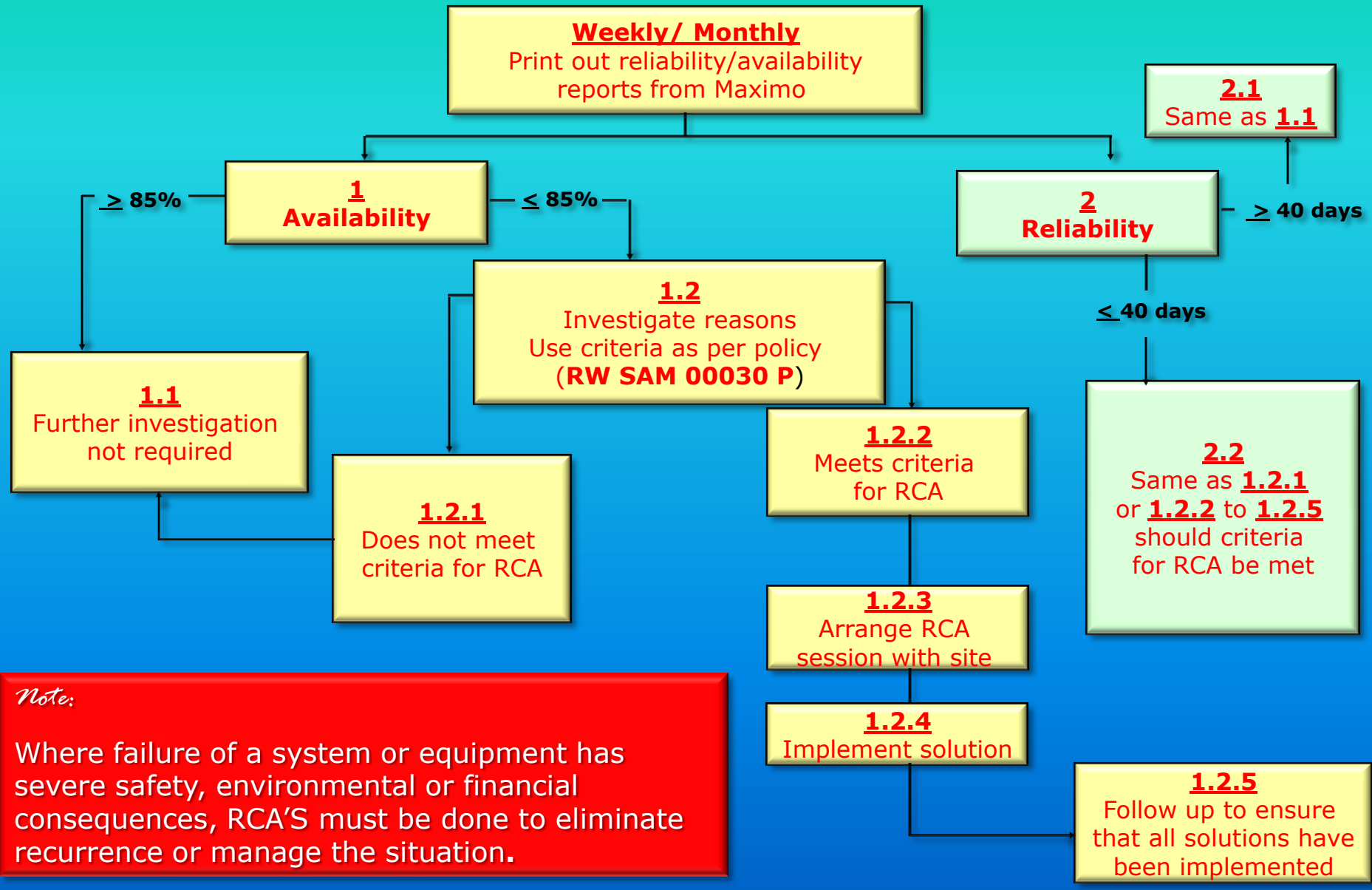
Trip stats of all main pumps

- Temperature
- Vibration
- Low Suction
- Eskom Trips, etc

- ✓ If a main pump trips more than 2 times for the same reason in one month.
- ✓ If reliability for the pump set drops below the 12 month average as per internal target
- ✓ ALL MAJOR FAILURES

Reliability Report to highlight conditions that may require further Investigation using Root Cause Analysis.

CONTINUOUS IMPROVEMENT - RCFA



Note:

Where failure of a system or equipment has severe safety, environmental or financial consequences, RCA'S must be done to eliminate recurrence or manage the situation.

SUMMARY

- ✓ Automate trip /failure recording.
- ✓ Use Reliability KPI;s to manage equipment not Staff.
- ✓ Link improvements to reward scheme.
- ✓ Ensure there are policy and procedure in place for RCA's.
- ✓ For sustainability , management must play an active role to ensure corrective and preventive measures are implemented.
- ✓ Training of staff
- ✓ Form a Reliability improvement team of dedicated stakeholders.
- ✓ Arm workforce with information.

SUMMARY

- ✓ Ensure that the objectives of maintenance and operations is aligned to the Business Strategy
- ✓ Optimize physical asset management using sound AM principles
- ✓ Motivate work force through good working conditions, objective performance management system, fair incentive bonus scheme, suggestion schemes, etc.
- ✓ Ensure competence of work force through continuous assessments and development based on needs
- ✓ Provide resources to perform work
- ✓ Celebrate successes!!!

RELIABILITY IMPROVEMENT GOAL

A LIFETIME OF HIGHLY RELIABLE PRODUCTION PLANT AND EQUIPMENT.

Thank you

References

- Levitt J. Complete guide to preventive and predictive maintenance. 1st ed. New York (USA): Industrial Press; 2003.
- Wireman T. Benchmarking best practices in maintenance management. New York (USA): Industrial Press; 2004.
- Narayan V. Effective maintenance management: risk and reliability strategies for optimising performance. New York (USA): Industrial Press; 2003.
- Mather D. The maintenance score card: creating strategic advantage. 1st ed. New York (USA): Industrial Press; 2005.
- Gulati R. SMRP best practice metrics: revision 4. SMRP 2006 Feb 02.
- Watercare – December 2003 –New Zealand
- Stevenson D. Barta B. Manson N. Asset management for water services sector in South Africa (WRC report).

MEAN TIME TO REPAIR (MTTR)

DEFINITION

Mean Time to Repair (MTTR) is the average time needed to restore an asset to its full operational capabilities after a failure. MTTR is the measure of asset maintainability. Maintainability is usually expressed as the probability that the asset can be restored to its specified operable condition within a specified interval of time, when maintenance is performed in accordance within prescribed procedures

OBJECTIVE

This metric is used to assess the maintainability and effectiveness of plans and procedures.

FORMULA

$$MTTR = D/N$$

MTTR= Mean time to repair

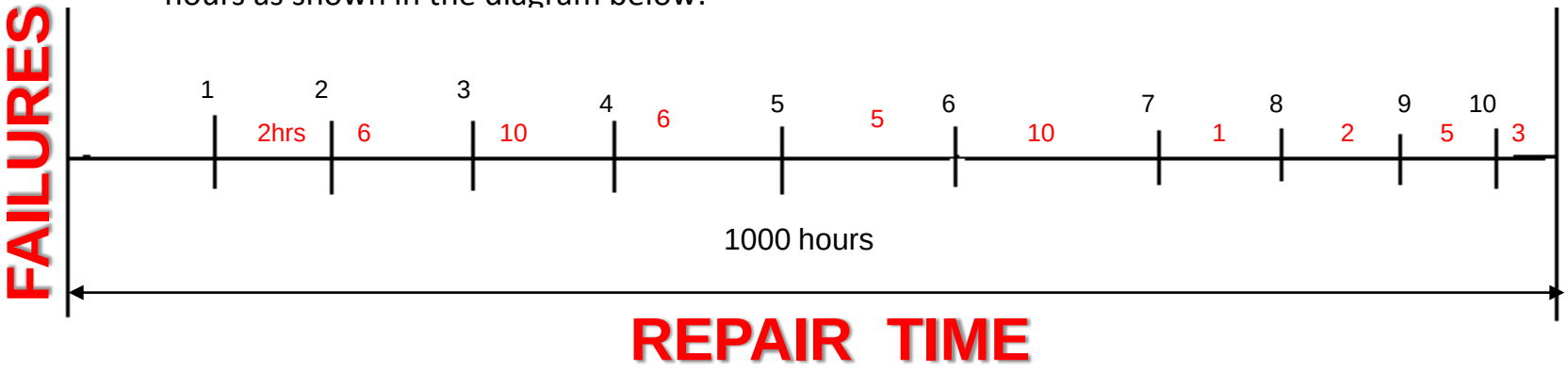
D= Downtime

N= Number of failures

MEAN TO REPAIR (MTTR)

Sample calculation

If an asset had 10 failures in 1000 hours of operation and their repair times were 2, 6,10,6,5,10,1,2,5 and 3 hours as shown in the diagram below:



Then the MTBF is :

Formula

MTTR = Total amount of time expended in a specified period (hours) / number of repair events in a specified period.

MTTR = (2+6+10+6+5+10+1+2+5+3) / 10 = X Hours.

50/10 = 5 Hours

MEAN TIME TO REPAIR (MTTR)

COMPONENT DEFINITION

- ✓ **REPAIR TIME** – The time required to restore the function of an asset after failure or imminent failure. It includes both scheduled and unscheduled repair time.

- ✓ **FAILURE** – The inability of an asset to perform its required function. This excludes proactive repairs.

- ✓ **REPAIR EVENT** – The act of restoring the function of an asset after a failure . This also termed corrective work.

QUALIFICATION

- ✓ To be used by maintenance personnel and reliability engineers.

MEAN TIME TO REPAIR (MTTR)

QUALIFICATION

- ✓ To be used by maintenance personnel and reliability engineers.
- ✓ Repair Time (duration of repair) includes from start of repair to the end of the repair.
- ✓ This includes the time for checking the asset for its functionality prior to handing it over to operations.
- ✓ The Craft workers skill level ,use of proper repair procedures , availability of the correct tools and spares etc. can significantly reduce MTTR.
- ✓ This metric provides the best data when used for the same type of asset/component in a similar operating context.

PROACTIVE WORKORERS

PROACTIVE WORKORDERS

Percentage of work orders generated from PM inspections.

- ✓ How do we know that PM inspections are done ?
- ✓ Are the work order generated from PM's are linked to the PM schedule?
- ✓ How does these W/O's link to the PM?

MANPOWER UTILISATION

- **Definition**

The proportion of available time a person is working.

- **Formula**

$$\text{Utilisation (\%)} = \frac{\text{Hours worked + loss time (RW related)}}{\text{Normal working hours – loss time (Non RW related)}} \times 100$$

Lost lime (RW related)

- Time spend during union activities
- House keeping
- PCP
- Rest time
- Store duties

OVERALL EFFECTIVENESS OF THE MAINTENANCE DEPARTMENT

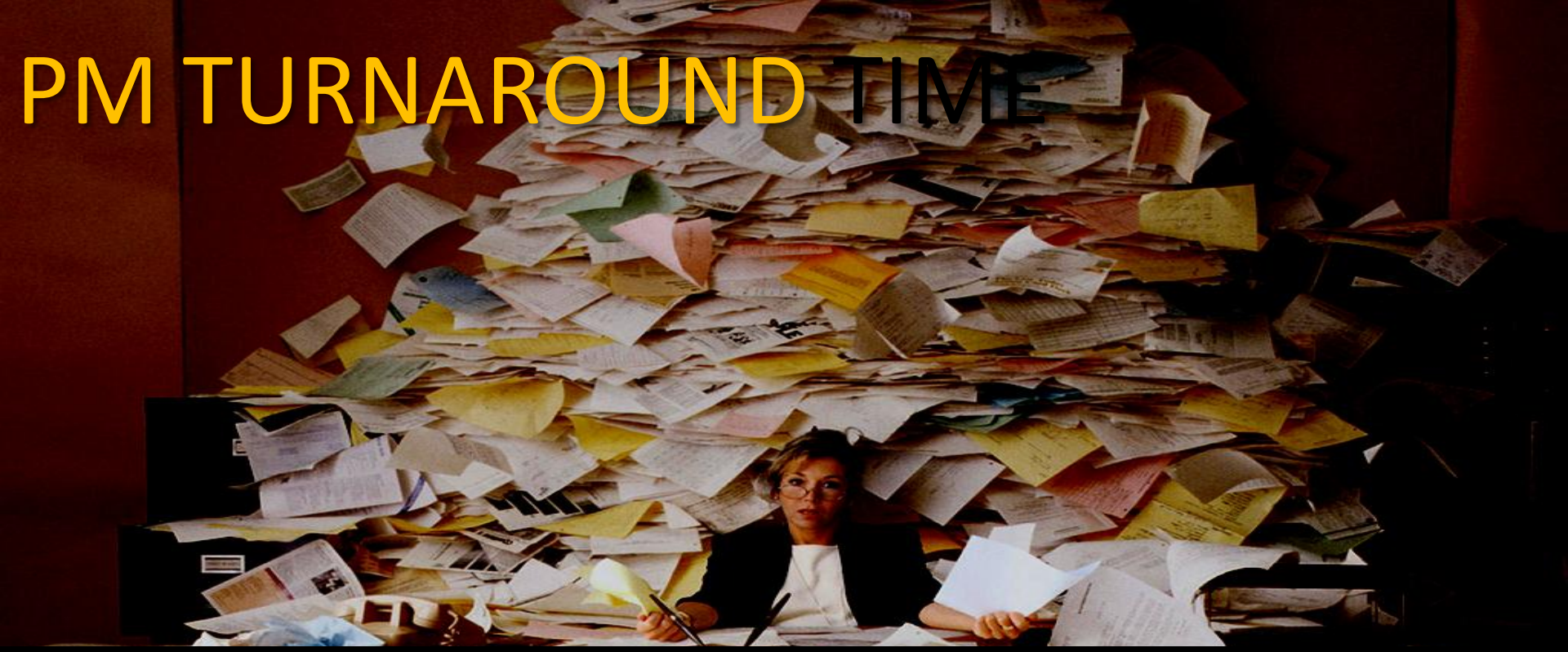
Definition

- ✓ An indication of the level of service the maintenance department provides to their customers.

Formula

- ✓ Overall effectiveness = Time to approve + time to respond + time to repair + time to complete the paperwork.

PM TURNAROUND TIME



Calculate percent of PM/SS Work Orders in the previous month where the PM's were completed on time.

The work is Completed on Time if the Actual Finish Date is less than or equal to Start by Date + 20 % of the PM and SS frequency (up to a maximum of 28 days).

PM TURNAROUND TIME

1 week	grace period (2 days)
2 weeks	grace period (3 days)
1 monthly	grace period (6 days)
2 monthly	grace period (12 days)
3 monthly	grace period (18 days)
6 monthly	grace period (28 days)
1 yearly	grace period (28 days)
2 yearly	grace period (28 days)
5 yearly	grace period (28 days)

PM TURNAROUND TIME

- Daily inspections/ Non core maintenance will be regarded as RM and will not form part of this measure.
- Only Electrical, Mechanical and Instrumentation Crafts will be measured.
- This measurement will include traveling time.
- Material reliant PM’s should have lead-time activated for the Procurement or sourcing of materials

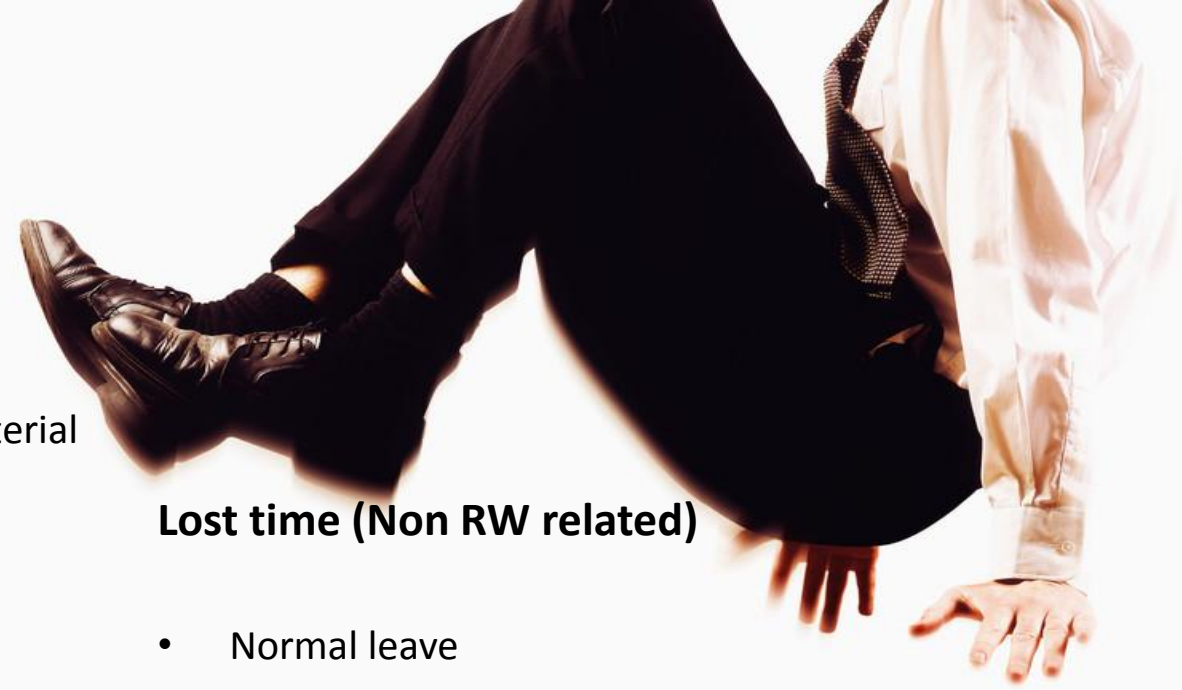
REMARKS

- ✓ Time to approve is measured from reported time to approved time.
- ✓ Time to respond is measured from approved time to Start time of job.
- ✓ Time to repair is measured from Start time to Completion time of job.
- ✓ Time to complete paperwork is measured from completion time of job to
- ✓ the time the work order status is “Complete”
- ✓ The total is expressed in days and fractions of a day.

REMARKS

Lost lime (RW related)

- Supervisory duties
- Waiting for spares/material
- WCA
- Acting foreman
- Driving duties
- ABET
- Evacuation drill
- Fire fighting drill
- Meetings
- Training
- Travelling
- Inclement weather
- Workplace meeting
- Medical
- Sports meetings



Lost time (Non RW related)

- Normal leave
- Special leave
- Sick leave
- Absent