Maintenance Management

Evolution

Key Performance Indicators

MTBF – MTTR

Improvements

My Proposal

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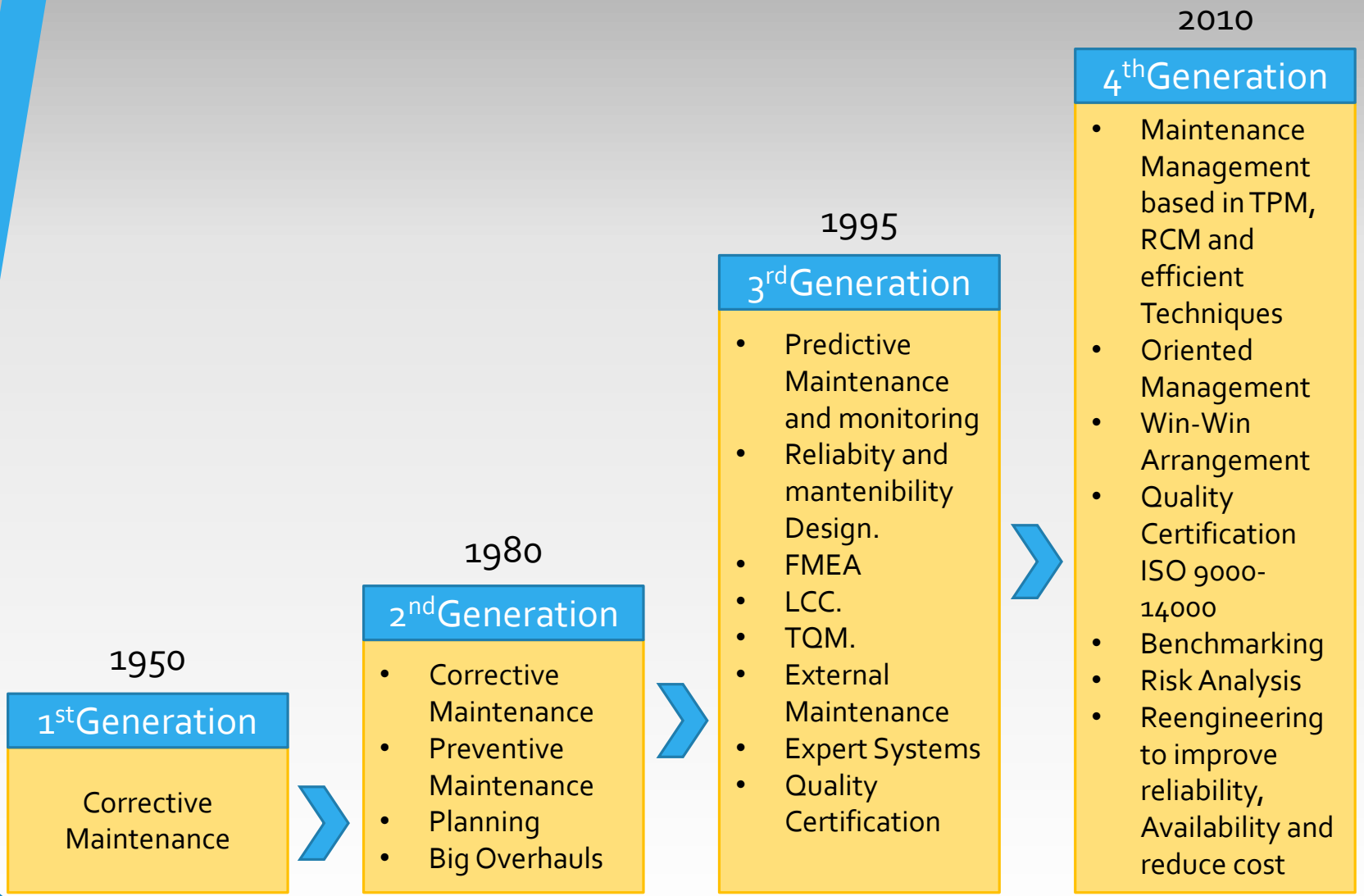
Maintenance Evolution



Key Performance Indicators

Lord Kelvin (Siglo XIX):

"When you can measure, something and expressing it in numbers, you can say that you know something about it; But, when You cannot measure or you cannot express it In numbers, your knowledge is deficient and unsatisfying."

Key Performance Indicators

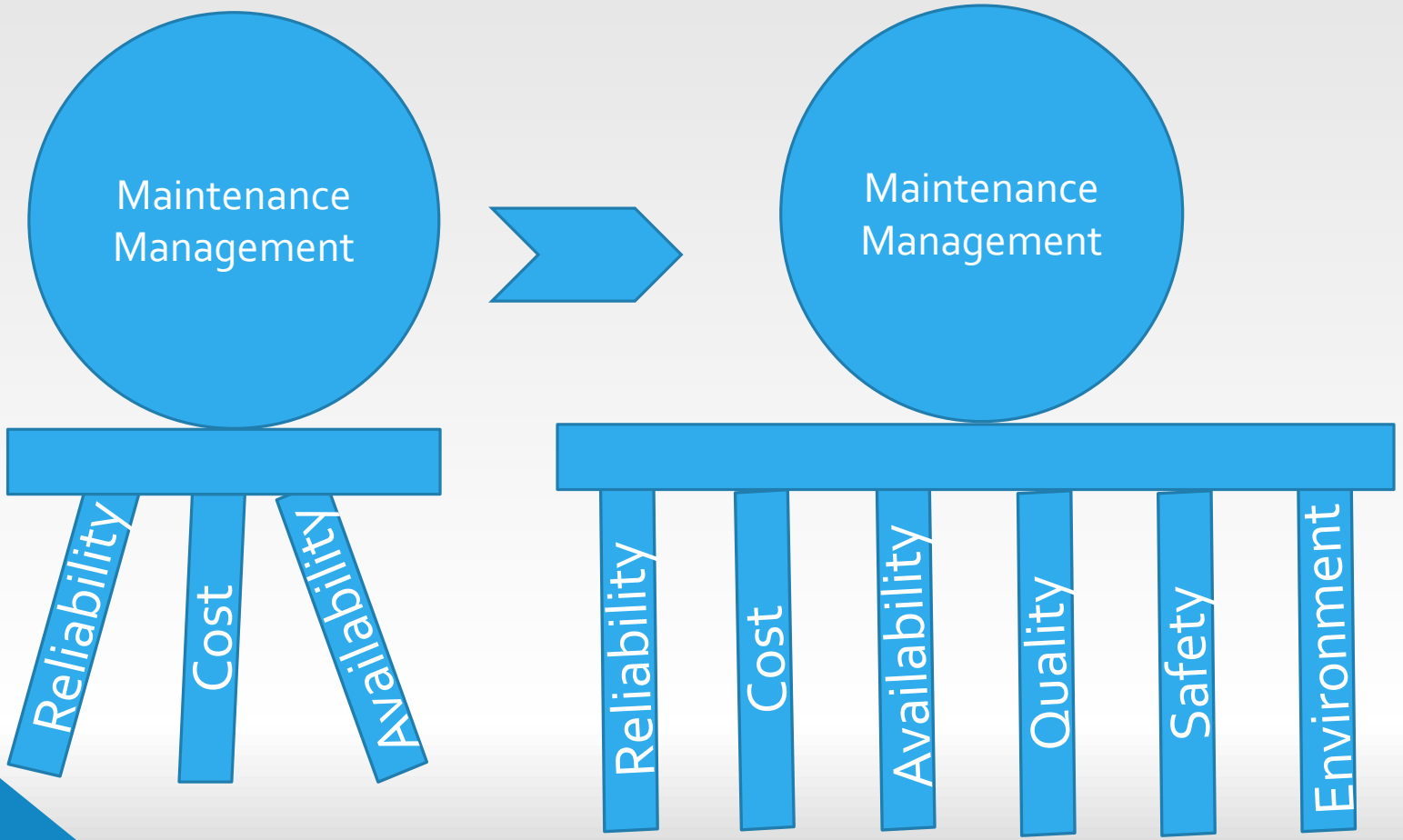
Key Performance Indicators (KPIs) are quantitative and qualitative measures used to review an organization's progress against its goals.

These are broken down and set as targets, in order to get desired achievements.

The achievement of these targets must be reviewed at regular intervals.

Key Performance Indicators

Every maintenance plan must be based in at least 3 pillars and it can evolve.



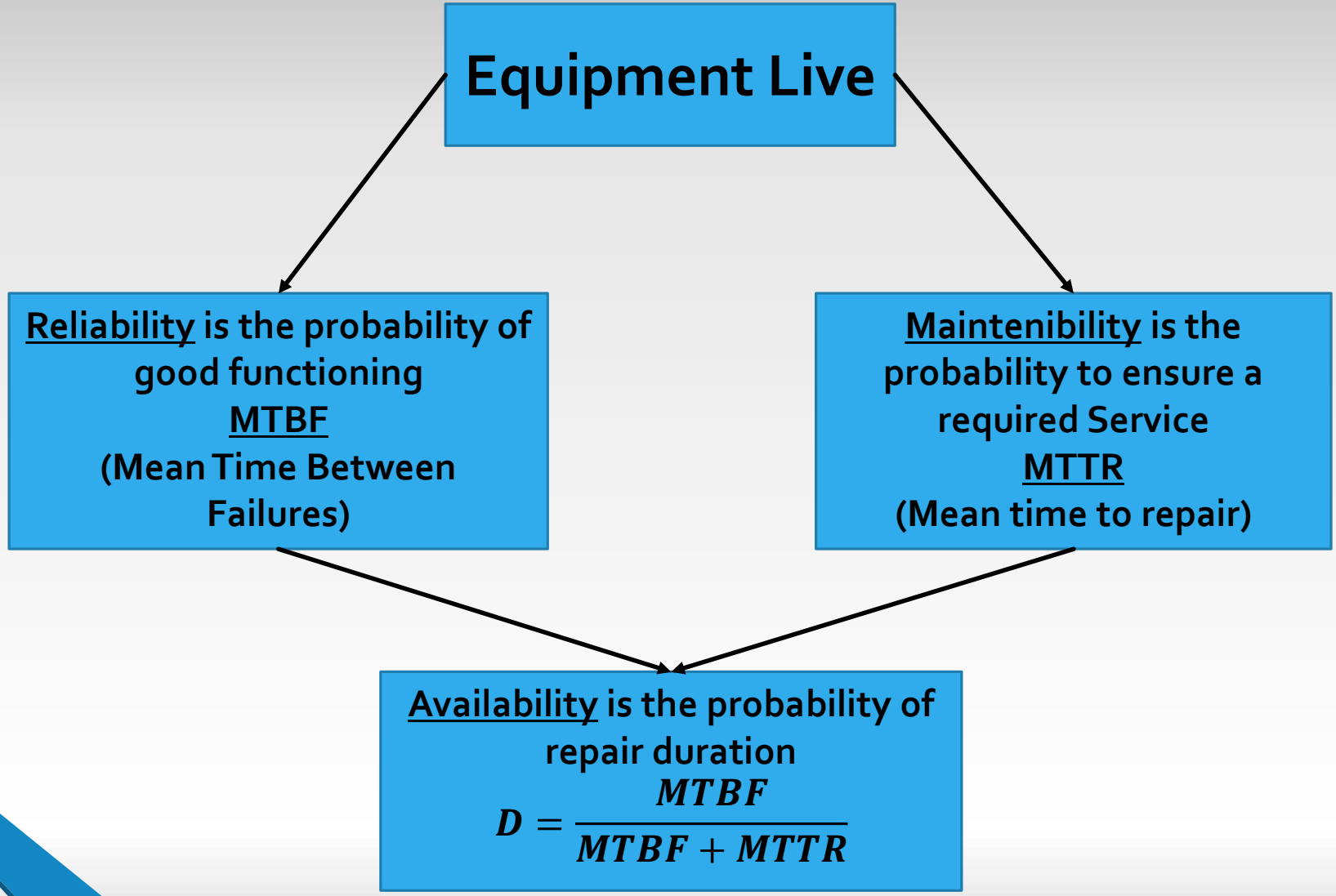
Basic Key Performance Indicators

Reliability: The probability of failure-free a specified timeframe, under specified environmental and duty-cycle conditions. Often expressed as mean time between failures (MTBF) or reliability coefficient.

Availability: Ability of an item to perform its designated function, whenever required.

Cost: The money used to perform the maintenance.

Key Performance Indicators



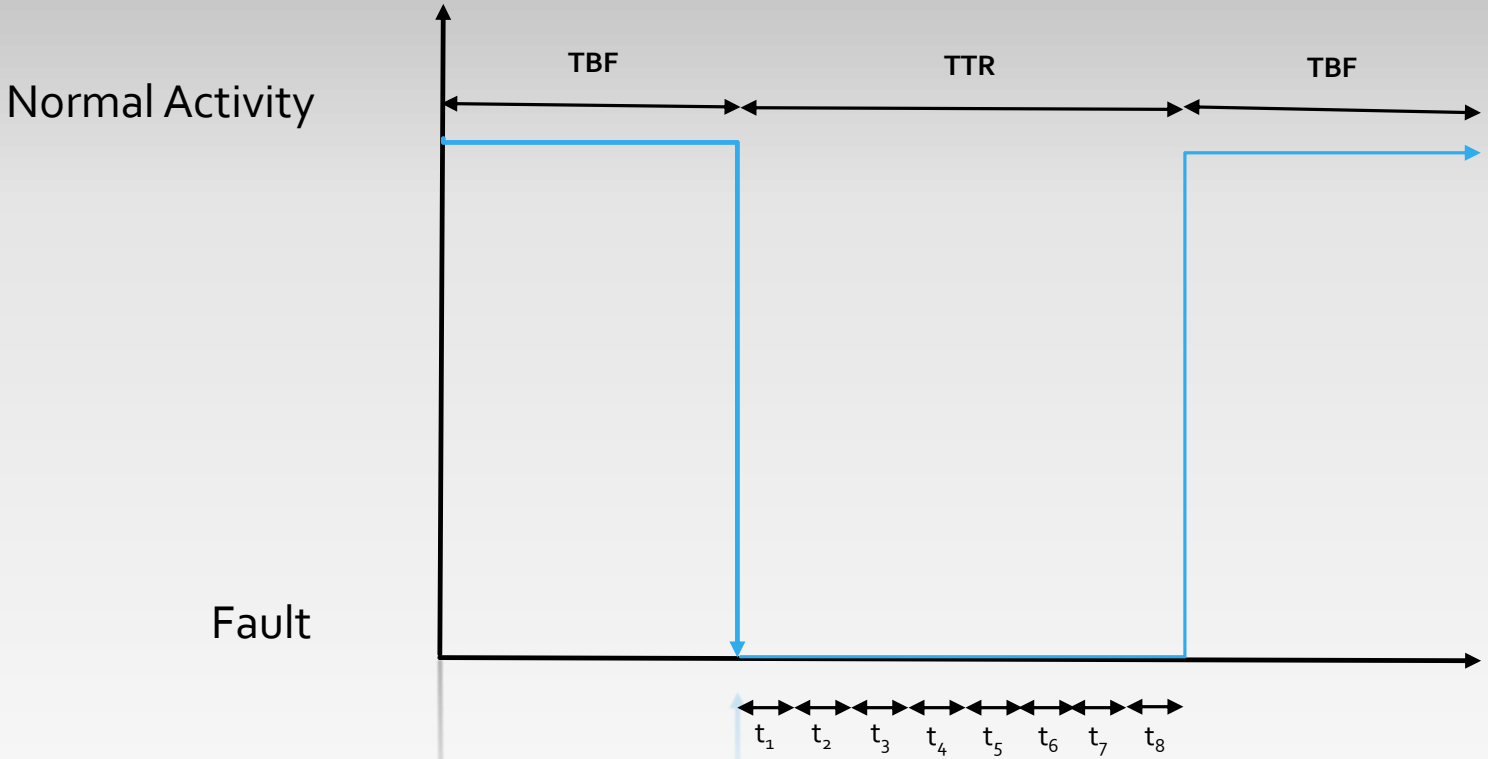
MTBF - MTTR

Mean Time Between Failure (MTBF) is a reliability term used to provide the amount of available time . When special equipment must be installed into critical applications, MTBF becomes very important.

Mean Time To Repair (MTTR) is the time needed to repair a failure. Taking too long to repair a product drives up the cost of the installation. To avoid MTTR, the companies should have a special policies (spare parts, Training, etc.).

Mean Time to Failure (MTTF) is the time that a system is not failed, or is available.

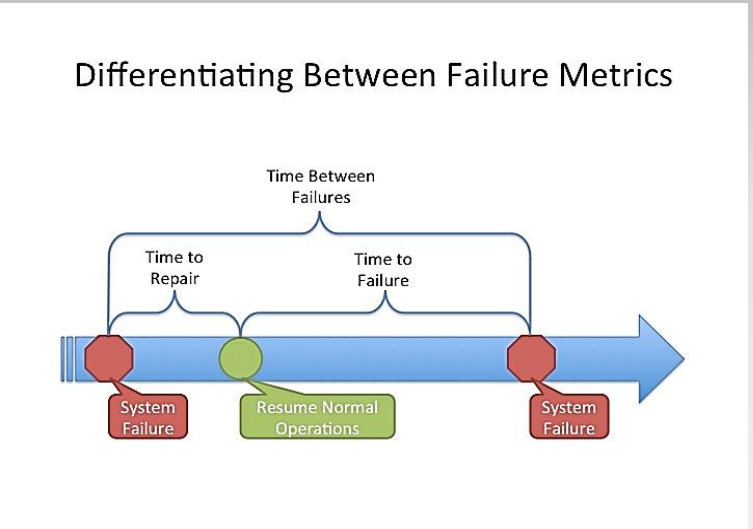
MTBF - MTTR

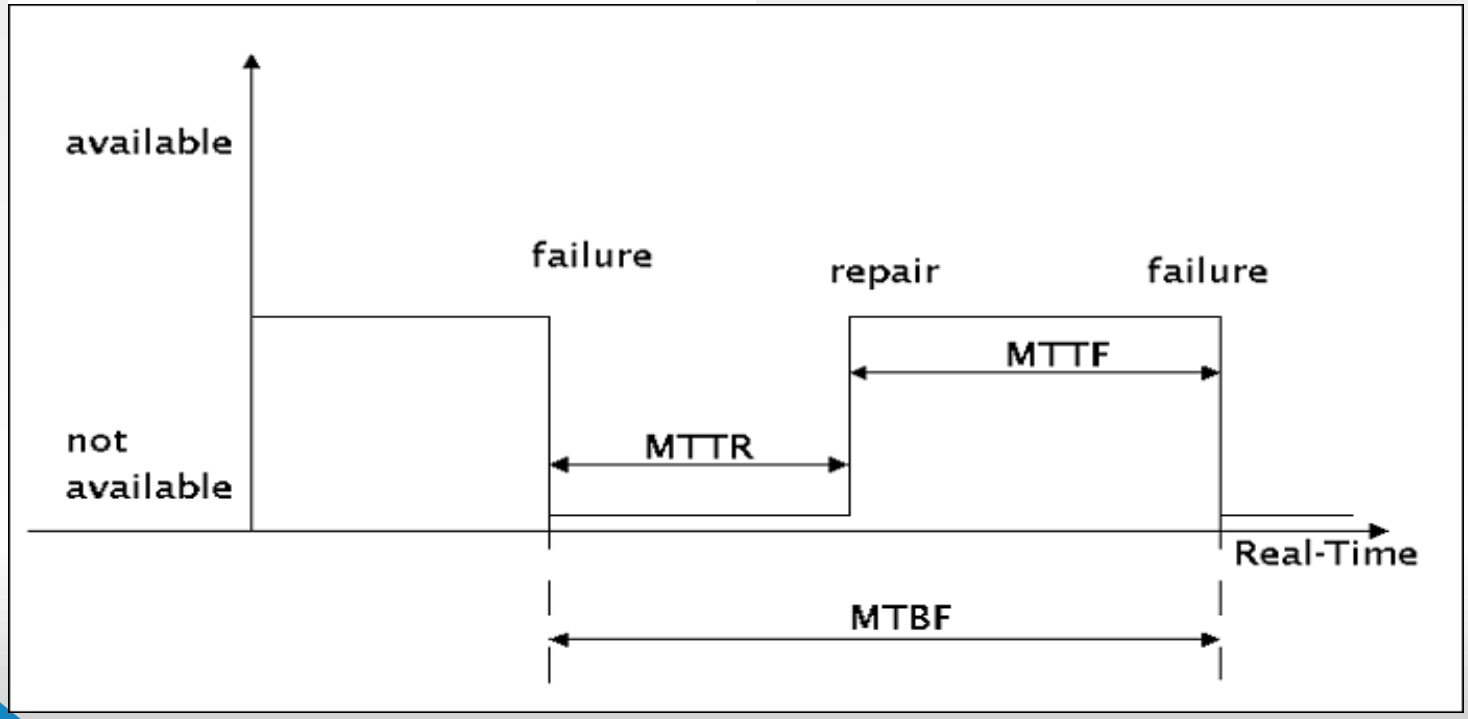


t_1= Communication of the fault time
t_1= Order launching time
t_1= Preparation of the repairing time
t_1= Trouble shooting time
t_1= Spare part collection time
t_1= Repairing time
t_1= Test of repaired equipment
t_1= Communication time to return to functioning

$$TTR = \sum_{n=1}^{8} t$$

MTBF - MTTR


Differentiating Between Failure Metrics
Time Between Failures
Time to Repair
Time to Failure
System Failure
Resume Normal Operations
System Failure


available
not available
failure
repair
failure
MTTF
MTTR
Real-Time
MTBF

MTBF – MTTR (Calculations)

$$MTBF = \frac{\sum_{I=1}^{n} TBF}{n} = \frac{TBF_1 + \cdots + TBF_n}{n}$$

$$MTTR = \frac{\sum_{I=1}^{n} TTR}{n} = \frac{TTR_1 + \cdots + TTR_n}{n}$$

MTBF – MTTR (Calculations)

$$\boldsymbol{\lambda} = \frac{1}{MTBF}\ Failure\ Rate$$

$$\eta = \frac{1}{MTTR}\ Repair\ Rate$$

$$D_1 = \frac{MTBF}{MTBF + MTTR_1}\ Failure\ Related$$

$$D_2 = \frac{MTBF}{MTBF + MTTR_2}\ Preventive\ Related$$

Maintenance Improvements

1. Audit the status of the equipment in order keep or replace.
2. Repair and maintain to leave them in their reference state
3. Analyze the information, about the previous reliability and availability data.

Its is important analyze the effectiveness of the maintenance system before us to develop the new rules, protocols and techniques in order to improve availability, reliability and cost.

Developed indicators

These indicators are recommended by EN 15341.

They are defined as measured phenomenon characteristic, which evaluate the evolution and are directly related with the objectives to be reached.

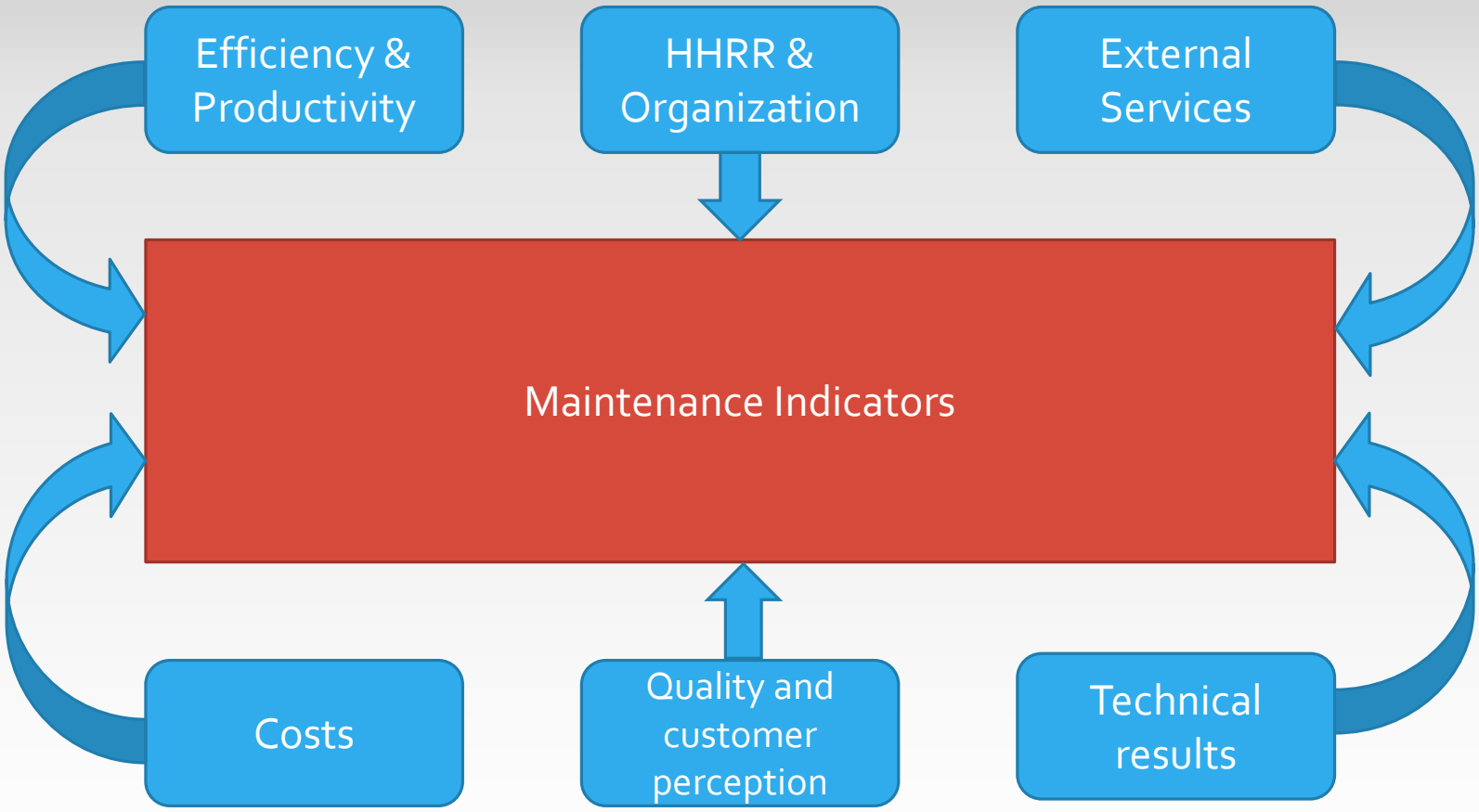
The objectives are:

a) Measure the State
b) Evaluate the performance.
c) Identify weaknesses and strengths.
d) Control de development and changes across the time.
e) the development control and changes across the time.

The analysis of these indicators will help to:

1. Establish and improve objectives.
2. Plan strategies and actions.
3. And share the results to inform and motivate the team.

Developed indicators



Dashboard

Display key performance indicators (KPIs) on a reporting dashboard.
it is used, by the company, to determine how successful the maintenance system is.

An optimal Dashboard allows a company to visualize its performance across the board.

	Total	Worked	Delayed	%		
Predictive Maintenance	260	245	15	5,77		
Preventive Maintenance	520	470	50	9,62		
Corrective Maintenance	400	370	30	7,50		

The KPI´s used are separated in 4 blocks

Dashboard- Overall efficiency of the department

Overall efficiency of the department A	
Total Fautls	10,00
Theoric Production Time	24,00
Toal Work order	15,00
Production stops due Fault	1,00
Repetitive faults	1,00
Fault with no failure	5,00
Fault after preventive maintenance	4,00
Corrective orders generated by Preventive	9,00

Quality of repairs	A1		0,10
	A2		0,50
Damage caused in production	A3		0,04
Technical efficiency of repairs	A4		0,40
Quality of preventive maintenance	A5		0,60

Dashboard - Technological advancement and resource utilization

Technological advancement and resource utilization B	
Preventive maintenance hours	1,00
Production stops due preventive Maintenance	1,00
Corrective Maintenance hours	1,00
Predictive Maintenance hours	1,00
Systematic Maintenance hours	1,00
Justified hours (preventive-corrective)	1,00
Total worker presence hours	1,00
Repetitive orders	1,00
$MTTR_2$ B1	
Relation between Preventive and corrective B2	
Quality of preventive-Predictive versus systematic B3	
Use of human resources B4	
Effectiveness of repairs B5	

Dashboard - Economic Management

Economic Management C	
Total Operative cost	250000,00
Production industrial cost	10000,00
Accumulated costs	10000,00
Budgeted costs	150000,00
Production stop cost	1000,00
total workers cost	50000,00
total maintenace workers cost	25000,00
Shutdown order costs	0,00
Total Maintenance cost	60000,00

Cost of Maintenan versus Industrial cost C1		25,00
Accumulative cost versus budget C2		0,07
Cost of Maintenance versus prduction cost C3		25,10
Grade of indirect workers C4		2,00
Stoppage of orders due to lack of spare part C5		0,00

Dashboard - Quality and human resources development

Quality and human resources development D	
Production Claims	5,00
Preventive and corrective operations	15,00
Level of claims	0,50
Mean Time of stops	15,00
Total Training hours	25,00
Planned Training hpurs	30,00
defective pieces	0,00
Used Pieces (Spare parts)	15,00
Proposals and improvements	10,00
Satisfaction level D1	0,33
Level of Claims D2	0,03
Time used in trainings D3	0,83
Quality of 2nd Level Maintenance D4	0,00
Level of staff motivation D5	0,40

Dashboard

MTBF and MTTR Calculator

Month	February, 2009
Name of Machine	GTE GE LM 2500
Operation availability (min/mo)	40.320
Frequence	13
MTBF (min)	3.073
MTTR (min)	29

Fail Rate 0,03%

Repair Rate 3,47%

5:04:37

No.	Date	Time Start	Time Finish	Down (min)	Replacement
1	01-feb	10:00 AM	11:00 AM	60	Parts 56
2	03-feb	10:00 AM	12:00 PM	120	Parts 98
3	04-feb	10:00 AM	11:30 AM	90	Parts 33
4	05-feb	10:00 AM	11:00 AM	60	Parts 11
5	06-feb	11:30 AM	11:35 AM	5	Parts 12
6	07-feb	12:30 PM	12:35 PM	5	Parts 98
7	15-feb	1:30 PM	1:35 PM	5	Parts 09
8	22-feb	2:30 PM	2:35 PM	5	Parts 12
9	25-feb	3:30 PM	3:35 PM	5	Parts 98
10	25-feb	4:30 PM	4:35 PM	5	Parts 09
11	26-feb	5:30 PM	5:35 PM	5	Parts 12
12	27-feb	6:30 PM	6:35 PM	5	Parts 13
13	28-feb	7:30 PM	7:35 PM	5	Parts 14
14					
15					
16					
17					
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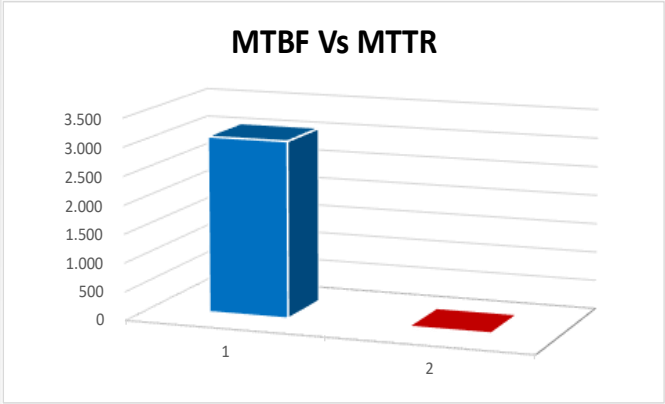
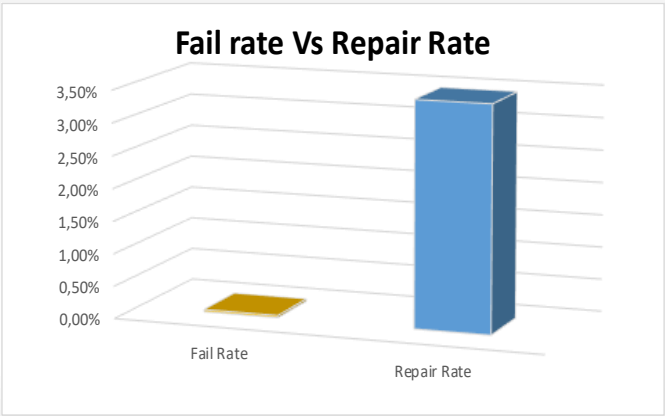
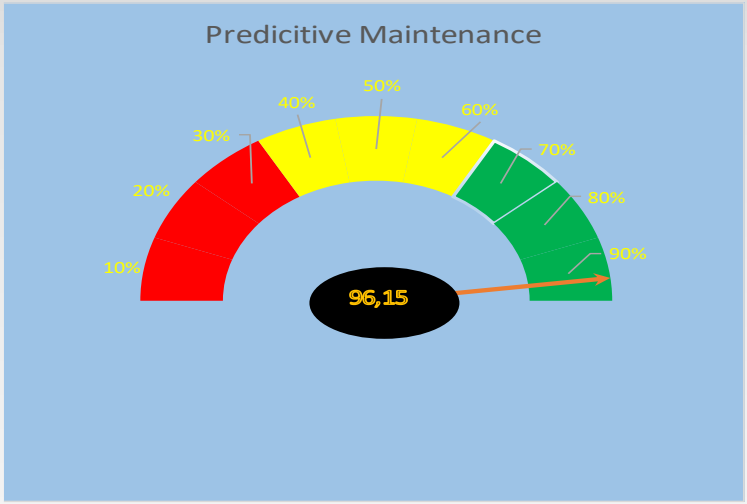
25					
Total down time (min)				375	

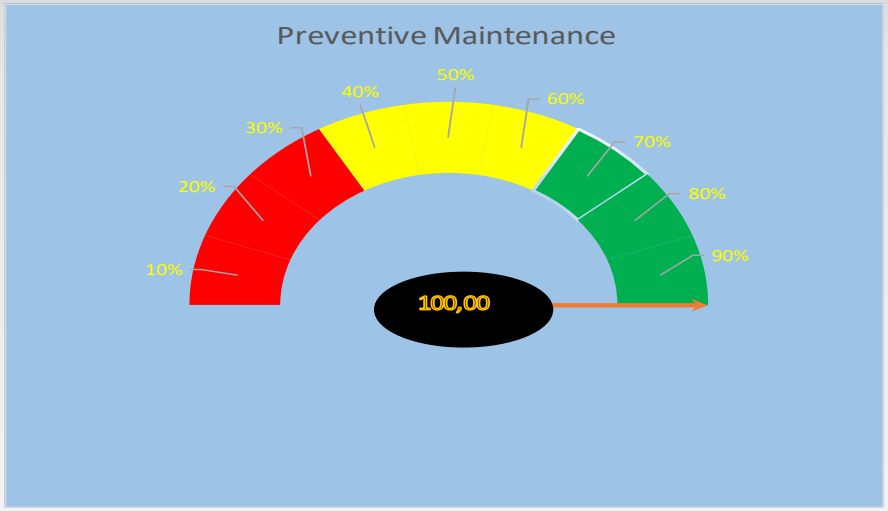


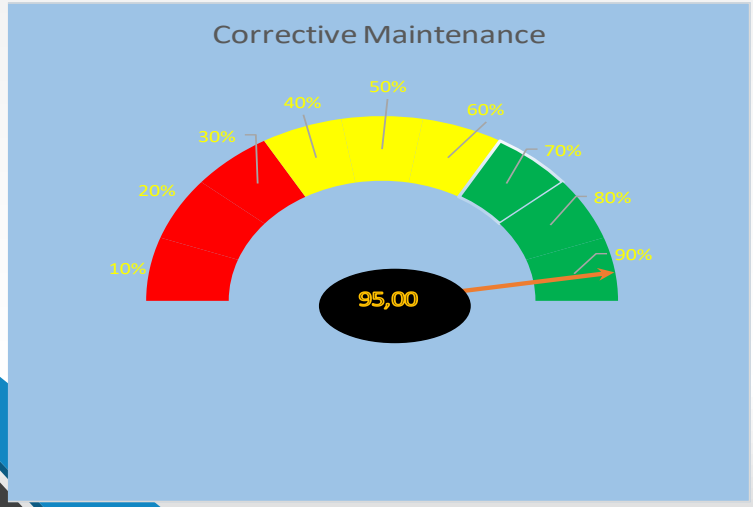


Dashboard

	Total	Worked	Delayed	% Finalized	% Delayed
Predictive Maintenance	260	250	10	96,15%	3,85
Preventive Maintenance	520	520	0	100,00%	0,00
Corrective Maintenance	100	95	5	95,00%	5,00







Type of Maintenance -TPM or RCM

Total Productive Maintenance (TPM) is a system of maintaining and improving the integrity of production and quality systems through the machines, equipment, processes, and employees that add business value to an organization.

The main objective of TPM is to increase the Overall Equipment Effectiveness (OEE) of plant equipment. OEE has three factors which are multiplied to give one measure called OEE

Performance x Availability x Quality = OEE

Each factor has two associated losses making 6 in total, these 6 losses are as follows:

Performance = running at reduced speed - Minor Stops
Availability = Breakdowns - Product changeover
Quality = Startup rejects - Running rejects

The objective finally is to identify then prioritize and eliminate the causes of the losses. This is done by self-managing teams that problem solve. Employing consultants to create this culture is common practice.

OEE Calculation Example

Planning	40320 minutes - 10000 pieces	100%
Availability	40320 – 375= 39945 minutes	99%
Performance	8465 pieces	84%
Quality	8465 – 8215 = 250 defective pieces	97%
OEE	Availability * Performance * Quality	80,66%

Type of Maintenance -TPM or RCM

Reliability Centered Maintenance (RCM) it ensures that the equipments continue working on their reference state.

It is used to achieve improvements in fields such as the establishment of safe minimum levels of maintenance.

Successful implementation of RCM will lead to increase in cost effectiveness, reliability, machine uptime, etc. It is defined Society of Automotive Engineering JA1011 and EN 60300-3-11.

The main objective of RCM in an industrial plant is to increase its availability and reduce its maintenance costs.

The analysis of an industrial plant according to this methodology provides a set of results:

1. It improves the understanding of how equipment and systems operate
2. It analyzes all possible failures of a system and develops mechanisms that try to avoid them.
3. It determines a series of actions which ensure high plant availability.

My Proposal

TPM and RCM support different ways to perform the maintenance, but both have weak points .

RCM: It needs experienced workers; the success of the process depend on the leader and the motivation of the team; in rigid organizations the improvements could be Minimal or null; the predictive technics must be implemented instead of the preventive plans.

TPM: Its implementation will fail if:

- Lack of planning and development strategies.
- Need for immediate results, which can lead to miss important steps.
- Not having a firm base in terms of improvement methodologies.
- Misunderstanding with unions.
- Geographically separated production plants.
- Incompatible production systems.
- Nonconformity due to the growth of tasks of production personnel, who were previously doing maintenance.

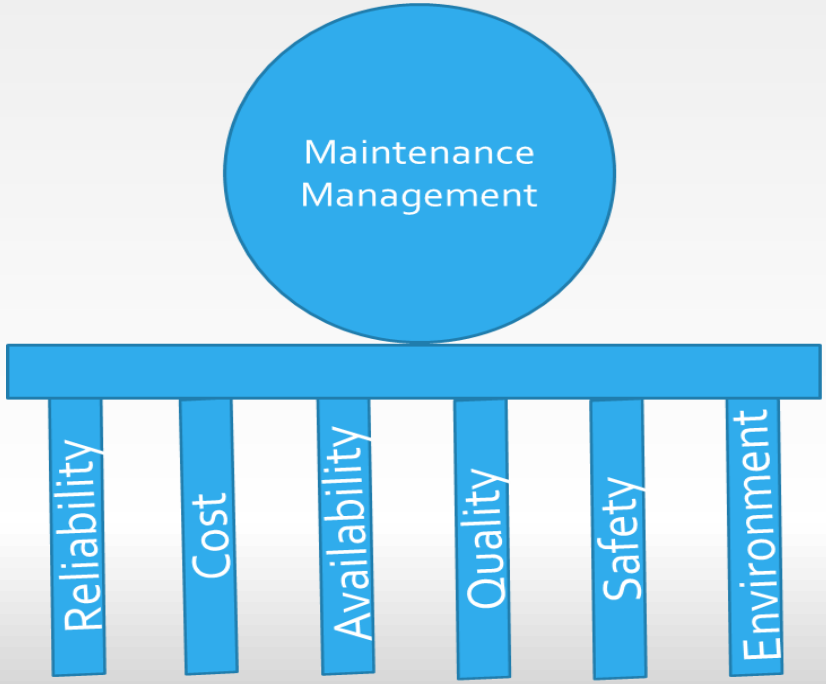
My Proposal

The Idea is extract the best of both to create a system where the important points are directly connected with targets of the company:

1. Reliability
2. Availability
3. Quality
4. Cost

If we want to go more far away we can extend our Maintenance plan to:

1. Environment
2. Safety
3. Customer Satisfaction
4. Legal



My Proposal

1. **Reliability and Availability** : these indicators will became very important and its calculation depend on the work orders, data registered, etc, therefore the maintenance plan must be accurate and register all the parameters that we will need and the KPI´s must be only the necessary.

2. **Quality**: It will be the response of our customer, internal or external and the KPI´s used to measure it must collect all the information about items produced, rejected or lost, delays, nonconformities, etc…

3. **Cost:** Almost the most important, our trend must be reduce the cost of maintenance but in a logical manner In order to comply with the above.

My Proposal- The tools

To perform them we will use some techniques:

1. **Reliability and Availability** : We will use Predictive Maintenance and it can be implemented with Scada System. Also we will use techniques like:
    1. **Tribology**: Real time Analysis of the lubricants (Autonomous and Intelligent System IK4-Tekniker), based on optical particle detector and Vis-NIR sensor (Visible Near Infrared).
    2. **Thermography**: The best tool to diagnose and control the machine without stops.
    3. **Vibration Analysis**: It could be implement in Scada system to analyze the trend and solve problems before they appear.
    4. **The preventive** maintenance must be minimum and reduced to visual check, level check (hydraulic systems, lubricants, fuel, etc.), small measures, etc.
2. **Quality**: We will analyze the data from our customer and production department and we involve the machine operators in the cleaning, preparation, change of format, since they are the ones that have more experience in this field, and those who know best when the machine begins to fail.
3. **Cost:** We have to implement a protocol for spare parts and warehouse in order to reduce the stop time for waiting a spare parts, it includes win-win contracts with supplies, and organizations of warehouse.

THAT´S ALL
Many thanks for your attention