

MAINTENANCE MANAGEMENT SYSTEM DIAGNOSIS AT COLOMBIAN SUGAR INDUSTRY: A FIRST APPROACH



Diego Cobo

dcobo@cenicana.org

Adolfo L. Gómez

Nicolás J. Gil

Santiago Orduz

Factory Processes Program

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Overview

- Introduction
- Initial activities
- Maintenance indicator analysis for Colombian mills
- Diagnostic activities
- Technical issue
- Conclusion

Introduction

- Colombian sugar mills can crush cane almost all year (average of thirteen mills 297 days for 2013). It means that less time is available for maintenance activities.
- It is required to adopt/adapt world class maintenance management practices which allow achieving the production goals in a sustainable way.
- Cenicaña (Colombian Sugar Cane Research Center) has recently begun a new project about Maintenance Management. To propose the characteristics of a World Class Maintenance Management System that impact favorably the principal KPI's (Key Process Indicator), is the main objective.

Typical trend on Mill Maintenance (example 8800 TPD Mill)...

- Scheduled crushing days: 330
- Scheduled short breakdown (4 hour) for heavy duty shredder maintenance and minor repairs, approximately each 15 days in dry weather and around 8 days when is rainy.
- Two main 10 day maintenance breakdown for crushing mill maintenance (in the more rainy months, May and November). Crushing rate planned to be reduced ~ **27%** in rainy months.
- Evaporator cleaning while crushing using switching valves with redundant vessels always with 5 effect configuration...
- 2013 lost time: 11% Harvest + Factory

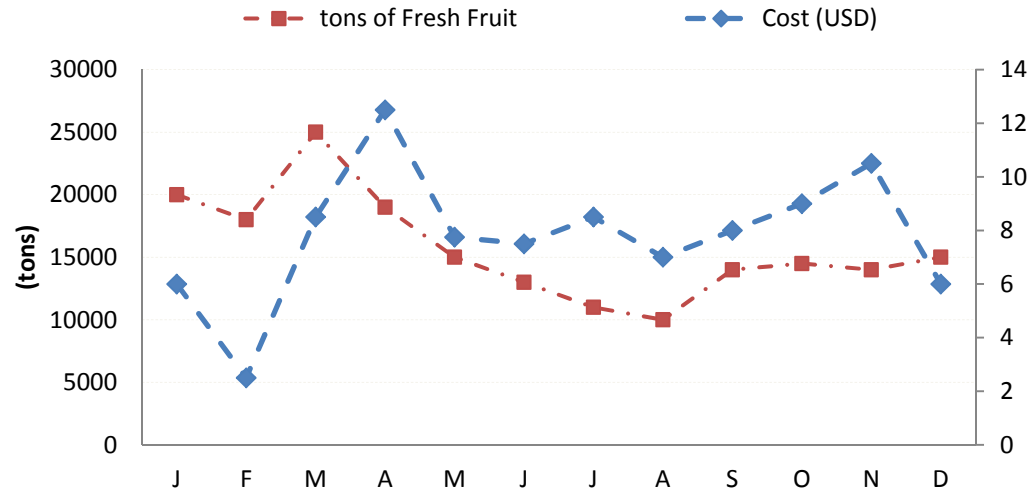
CENICAÑA's Maintenance Management Project: Initial Activities



- Visits to similar industries: Palm oil plants
- Asset Management was chosen as general route to follow.
- Asset Management Training: 80 hours, 50 participants from the mills and CENICAÑA
- PAS-055 Asset Management standard used as a guide to develop diagnosis tools
- Asset Management Seminar with SKF held during June 2013
- Basic capacitation for maintenance group at Colombian mill (december 2013)

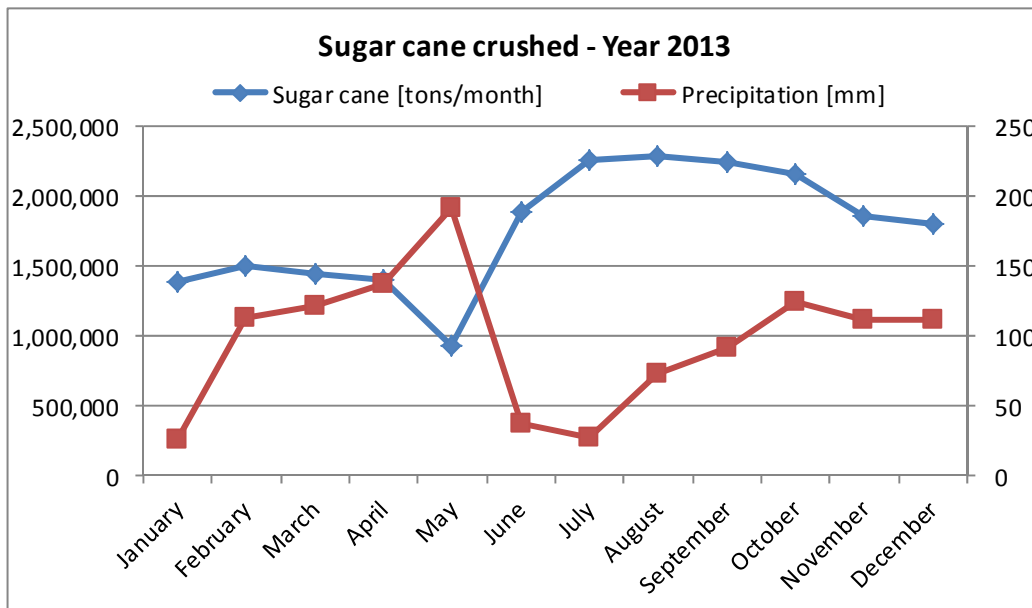
Comparison with Palm oil industry

Palm Oil Extraction plant



- Palm oil processed is also related to rainy season.
- Maintenance cost depends on production:
 - 5 to 10 USD/t FF

Sugar cane crushed - Year 2013



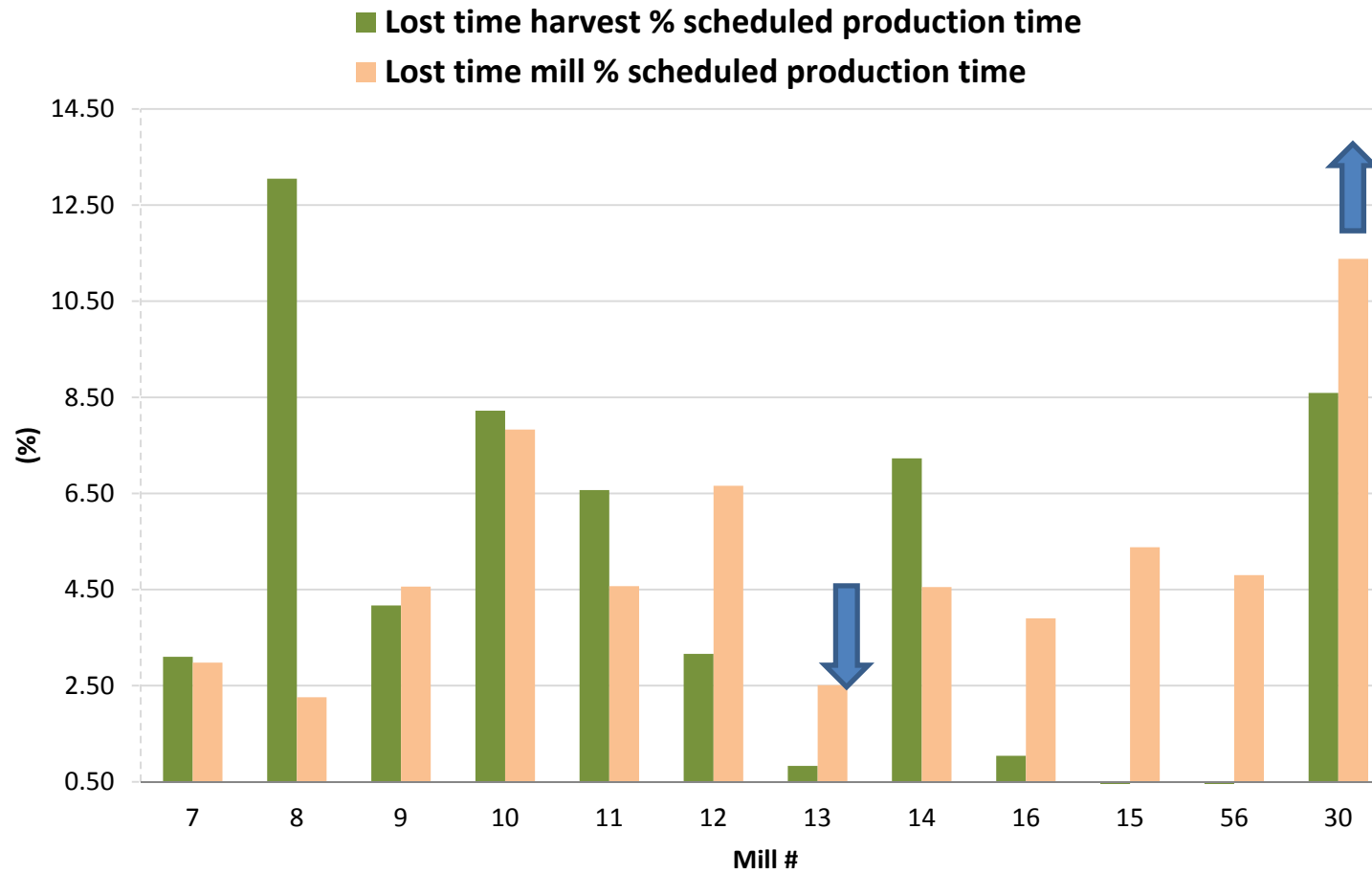
- Sugar cane processed is related to rain season.
- Average specific maintenance cost for a pilot mill is:
 - 5.9 USD/t cane

Maintenance Indicator Analysis for Colombian mills

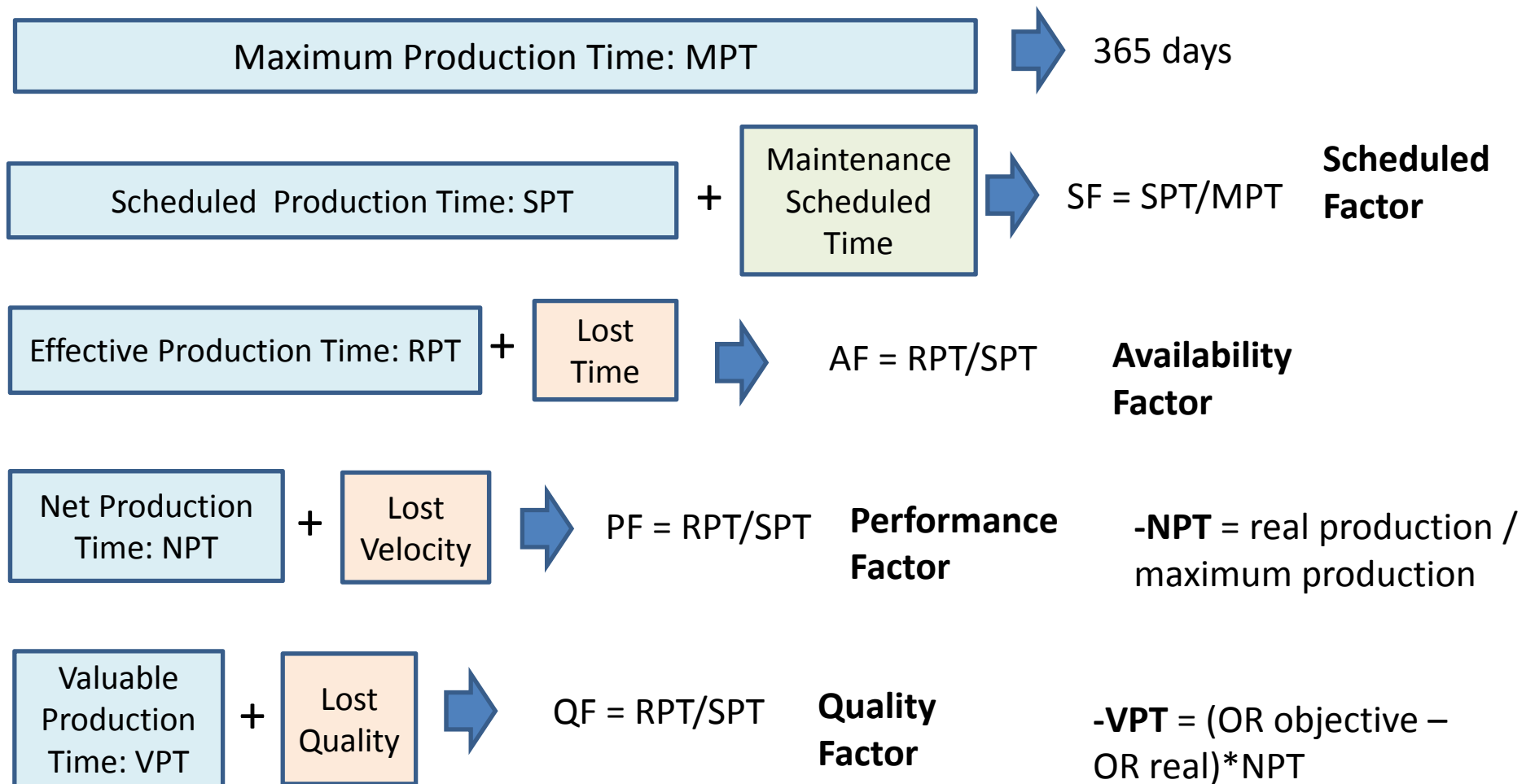
- Initially, an analysis of global maintenance management indicators for the Colombian sugar mills was conducted.
- A correlation between OEE (Overall Equipment Efficiency) indicator and the conventional Lost Time indicator was found.

Typical Indicators (2013)

- Lost time / Scheduled production time



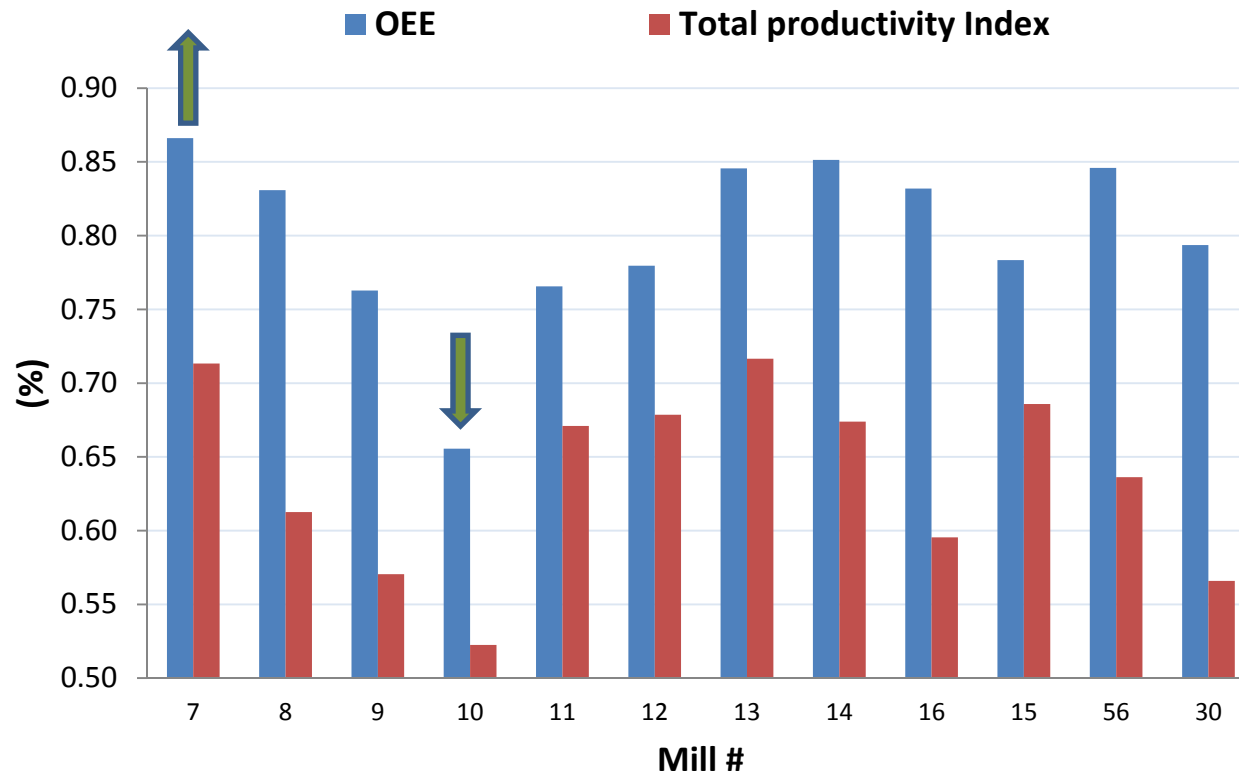
Global Maintenance Indicator



O.E.E. (Overall Equipment Efficiency) = AF * PF * QF

Total Productivity Index = O.E.E. * SF

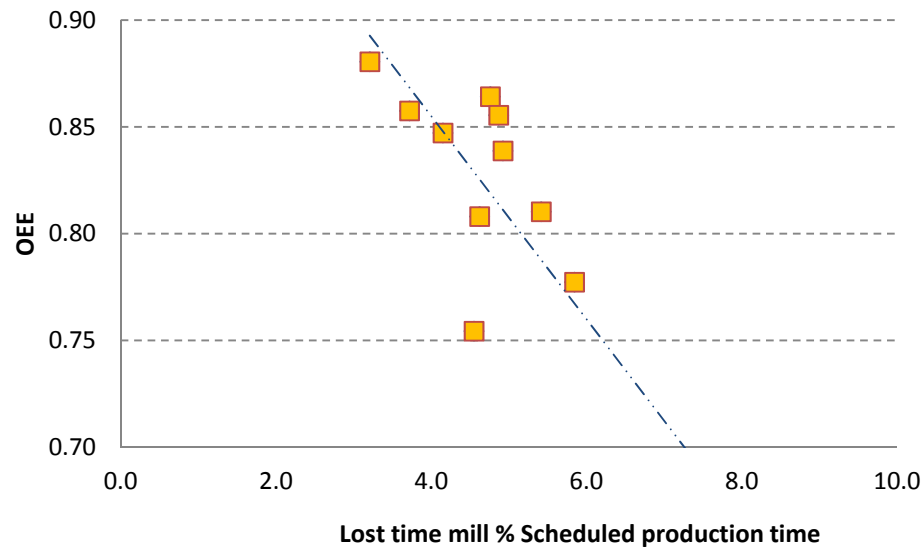
OEE & Total productivity Index at Colombian Sugar Mills (2013)



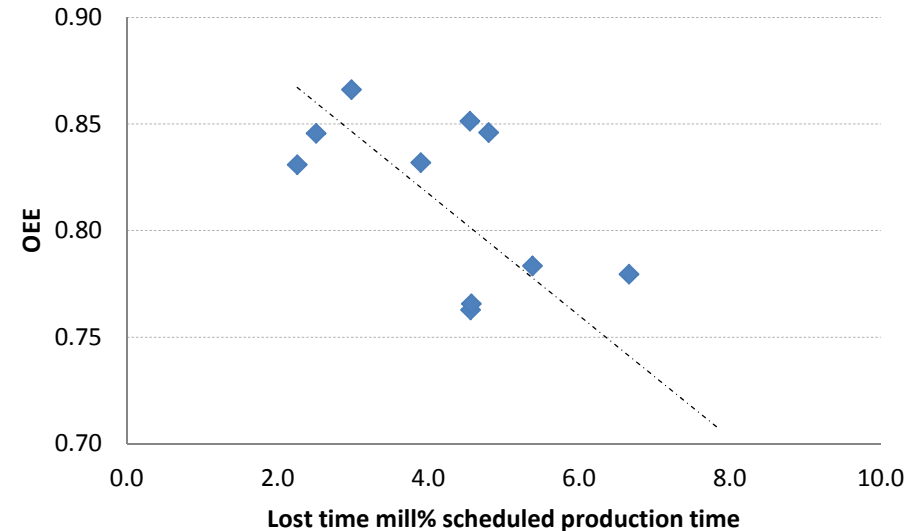
- Mills with less lost time are not always the mills with higher OEE

Relation between OEE and Lost time indicator

2012



2013



	2012	2013
Crushed cane:	20' 699.179 t	21' 374.196 t
Sugar production:	2' 462.883 t	2' 485.689 t
Average Annual Precipitation	1202 mmH ₂ O	1166 mmH ₂ O
Mechanized harvesting area	31%	39%
Average Season days	292	298
Average Mill Lost time	5.4% +/- 1.7	5.3% +/- 2.5
Average Harvest Lost time	5.8% +/- 6.9	6.4% +/- 7.3
Average OEE	0.81 +/- 0.06	0.80 +/- 0.06

- Relation between OEE and Lost time indicator decrease because second was more variable.

Mills groups by weather conditions

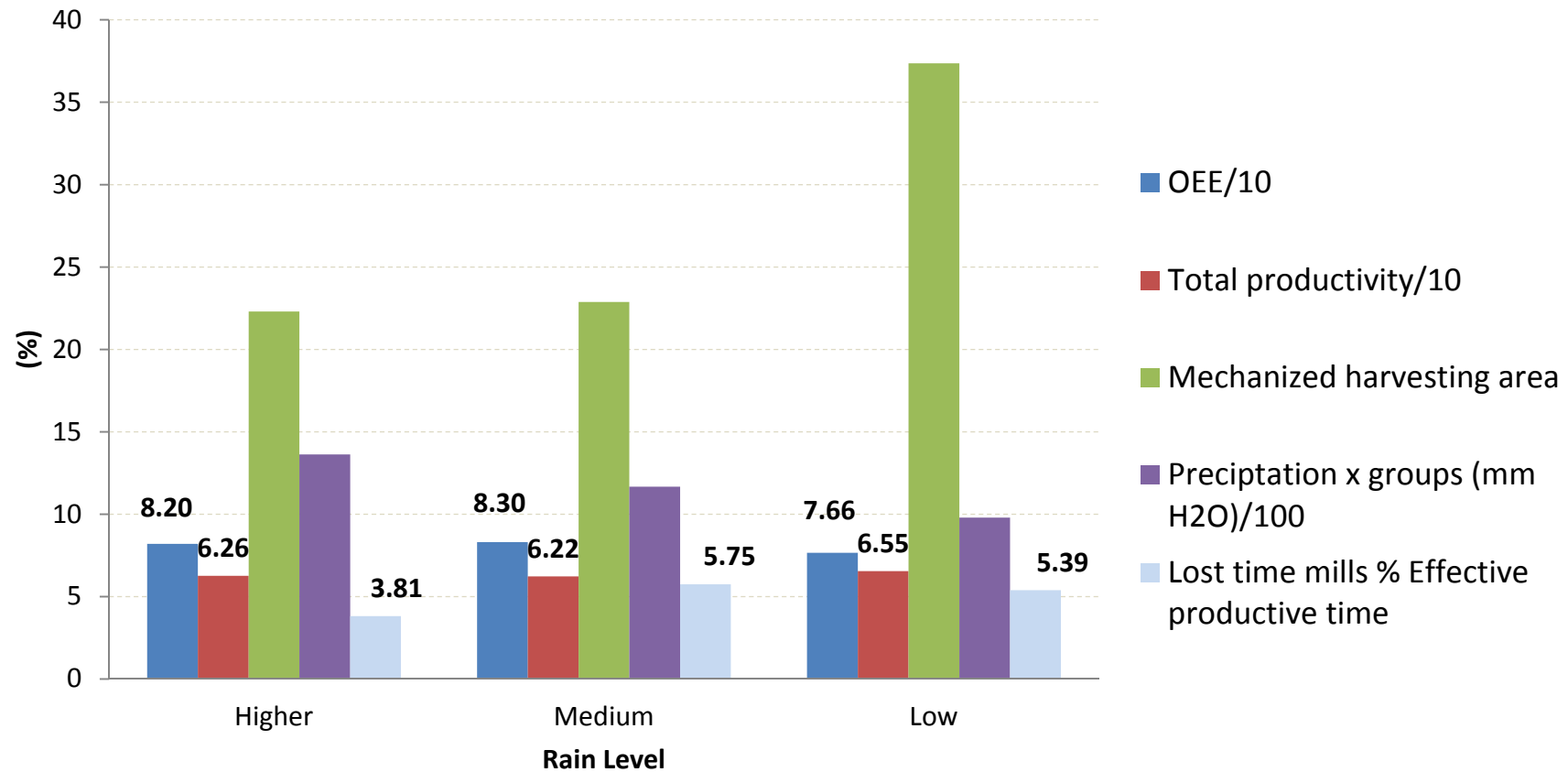
Precipitation

- **High precipitation group : Mills # 7, 9, 016**
 - Average Annual precipitation (2012): **1363 mmH₂O**
 - Average mechanized harvesting area: **22%**

- **Medium precipitation group: Mills # 8, 14, 30, 56**
 - Average Annual precipitation (2012): **1167 mmH₂O**
 - Average mechanized harvesting area: **23%**

- **Low precipitation group: Mills # 1, 10, 11, 13, 15**
 - Average Annual precipitation (2012): **979 mmH₂O**
 - Average mechanized harvesting area: **37%**

Groups by rain level



- Mills with Higher rainy level have to be ready to crush cane incoming the mill.

Diagnostic Activities

- Diagnostics activities (still running) have been developed, principal maintenance structures at Colombian sugar mills were identified.
- A simple diagnostic interview was applied to four (4) mills.
- A diagnostic survey according to PASS -55 was applied to one pilot mill. A solid strategy focused into equipment and process reliability has to be adopted by the pilot mill, in order to achieve world class maintenance indicators.

Kinds of Asset Management Survey

- **MQM** (*Matrix Qualitative Maintenance*):

- 7 maintenance factors



Factor	Uncertainty	Awareness	Understanding	Ripeness	Excellency
Ability management					
Importance					
Unitary cost					
Methods to solve problems					
Staff competence					
Information management					
Organization position					

- **MES** (*Maintenance Effectiveness Survey*): The purpose is to determine where the maintenance organization's strengths are to leverage improvements and identify areas of opportunity to correct.

- This survey addresses questions in five key maintenance areas:


- Resource management,
- Information management,
- Preventative maintenance and equipment technology,
- Planning and scheduling,
- Maintenance support




Resource Management

1. Do you feel maintenance is staffed to do its job?	①	②	③
2. Does the overall structure of the maintenance organization seem to be logical and helpful in accomplishing the work?	①	②	③
3. Does the organization help to remove barriers maintenance craftspeople encounter in their jobs that they have no control over, which prevents them from doing a good job?	①	②	③
4. Does management encourage maintenance to meet the needs of production?	①	②	③
5. Does management encourage production to help maintenance in doing its job?	①	②	③
6. Are cross-functional (production and maintenance) teams used to identify and resolve issues that affect both departments?	①	②	③
7. Does management encourage maintenance craftspeople and production operators to work together on issues?	①	②	③
8. Have craftsmen received training to help them do their jobs?	①	②	③
9. Are maintenance craftspeople in your plant properly skilled to do their jobs?	①	②	③
10. Are maintenance craftspeople in your plant properly motivated to do the best possible job?	①	②	③
11. Do maintenance craftspeople follow safety policies and procedures?	①	②	③
12. Does management follow-up and review housekeeping with craftspeople?	①	②	③
Comments:			

Kinds of Asset Management Survey

- **MQS** (*Maintenance Qualification Survey*) questionnaire with 386 questions for 12 areas of maintenance, multiple answer. 

Area	# Questions	Importance
Links between production and maintenance	34	8.8
Perception of maintenance by management	31	8.0
Perception of the maintenance department	26	6.7
Availability	22	5.7
Maintenance Costs	20	5.2
Methods of preparation	66	17.1
Planning	23	5.9
Warehouse Management and Parts	56	14.5
Distribution of roles in the organization	29	7.5
Human Resources	34	8.8
Material Resources	27	7.0
Training	18	4.3

- **CMMS** (*Computerized Maintenance Management Software*) Benchmarking evaluation: specific audit to evaluate the basic system information and maintenance management (PM module of SAP in the mills) 

CMMS BENCHMARK EVALUATION CATEGORIES	EVALUATION ITEMS
1. CMMS Data Integrity	6
2. CMMS Education and Training	4
3. Work Control	5
4. Budget and Cost Control	5
5. Planning and Scheduling	7
6. MRO Materials Management	7
7. Preventive and Predictive Maintenance	6
8. Maintenance Performance Measurement	4
9. Other Uses of CMMS	6
TOTAL CMMS EVALUATION ITEMS	50

Diagnostic Interview by Cenicaña

	#	Questions
Maintenance Indicators	1	What indicators would be appropriate for benchmarking between the sugar mills in the field of maintenance management?
	2	What kind of indicators currently used in the area of maintenance management? Some internal handled?
	3	¿Pareto analysis (80-20 rule) is conducted? For what type of indicators?
	4	Are maintenance indicators related to production and / or energy indicators?
Maintenance planning	5	What CMMS (Computerized Maintenance Management System) platform is used in the maintenance management work? Indicators are obtained?
	6	What is the number and profile of people responsible for managing the CMMS?
	7	How is the maintenance management system described in the mill? And the Working Group? Flowchart
External relationship	8	Outsourcing for maintenance is used? At that level and intensity?
	9	What is the role of contractors in the planning, implementation, maintenance and auditing wit?
Reliability	10	Root cause analysis are conducted? Examples
	11	How many cases can you refer related to redesigns based on reliability improvement?
	12	What Condition Maintenance techniques are applied?, The reliability group exist?, What about structure and resources?
	13	Have been you conducted risk analysis for the production lines?
	14	How the Project Area is related to the performance of Maintenance
Cost Issue	15	Could you describe the cost structure in the maintenance area?
	16	What is the reasonable period that allows a proper "Benchmarking" on the issue of maintenance for Colombian sugar mills?
	17	If you plan to migrate to a new maintenance management system, as you describe it?

Results from Diagnostic Interview applied for 4 mills

Common Topics:

1) Maintenance Indicators:

- Lost time % scheduled production time
- Degree of compliance with maintenance orders.

2) CMMS (Computerized Maintenance Management Software): SAP-PM

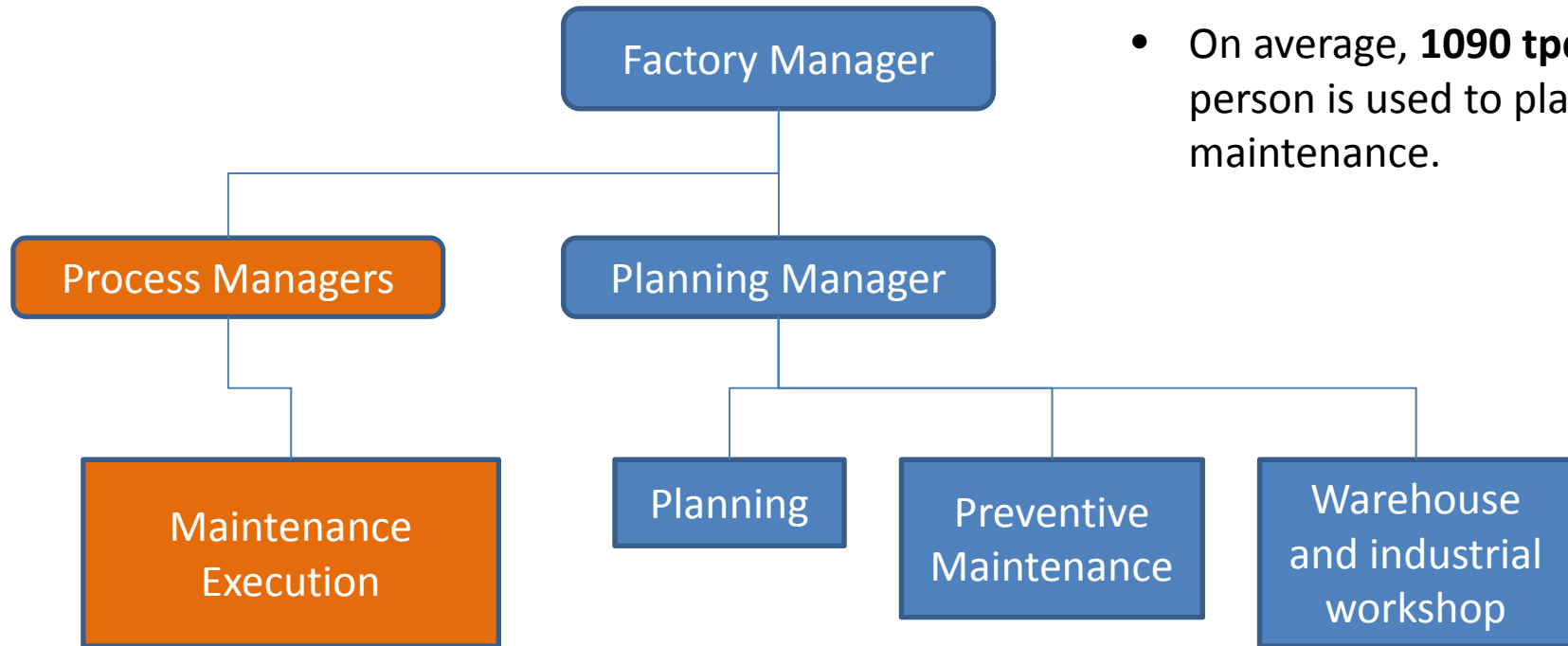
3) Pareto analysis is applied in order to identify the major lost time causes. «Root Causes Analysis» is then conducted.

4) Vibration analysis, thermography routes are used as predicted maintenance work

Indicator (2012)	Mill # 1	Mill # 2	Mill # 3	Mill # 4
Lost time (%) real production time	4.62	4.76	5.42	3.21
OEE	0.808	0.864	0.810	0.880

Composition of Maintenance Planning Group

Mill # 1 (4400 tpd)	Mill # 2 (7800 tpd)	Mill # 3 (4100 tpd)	Mill # 4 (8800 tpd)
4 Engineers	7 workers: <ul style="list-style-type: none"> • 3 Mechanical Engineers • 2 Mechanical technologist • 2 Electrical technologist 	4 workers: <ul style="list-style-type: none"> • 2 Engineers • 2 Technologist 	8 workers: <ul style="list-style-type: none"> • 1 Engineer • 7 Technologist



- On average, **1090 tpd** per person is used to planning maintenance.

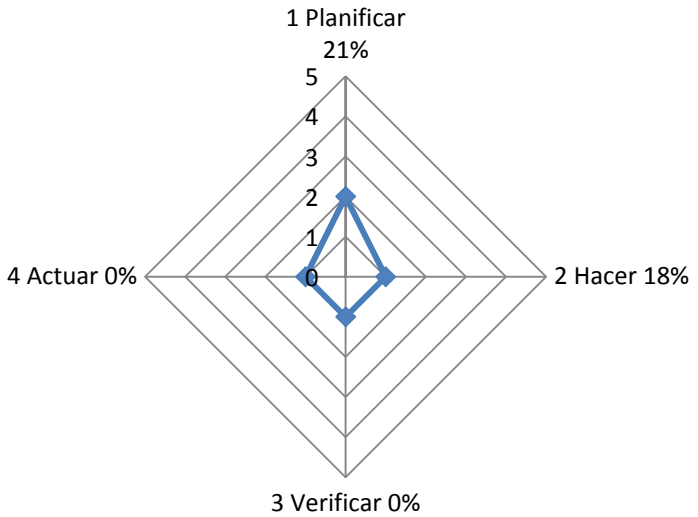
Diagnostic Survey Design:

- Tool designed for Excel®
- Total questions: 145
- Time execution: 3 days
- Survey has been applied to one pilot mill

Qualification					
PASS -55 (2008)	Process unpredictable, out of control with high variability and reagent	There are basic management processes according to general policies.	Documented and standardized process. There is an understanding of the interrelationships of the process activities and measures.	There quantitative targets and indicators supported the needs of internal and external customers. The causes of the variation of the process are identified.	The process is continuously improved based on a quantitative understanding of the causes of variation.
	1	2	3	4	World Class

Diagnostic survey topics for a pilot mill

No.	Maintenance Topics	
1	General	Planning
2	Strategy	
3	Planning	
4	Management	Do
5	Learning	
6	Information	
7	Risk	
8	Process analysis	
9	Reliability	Check
10	Execution	
11	Overview	Act

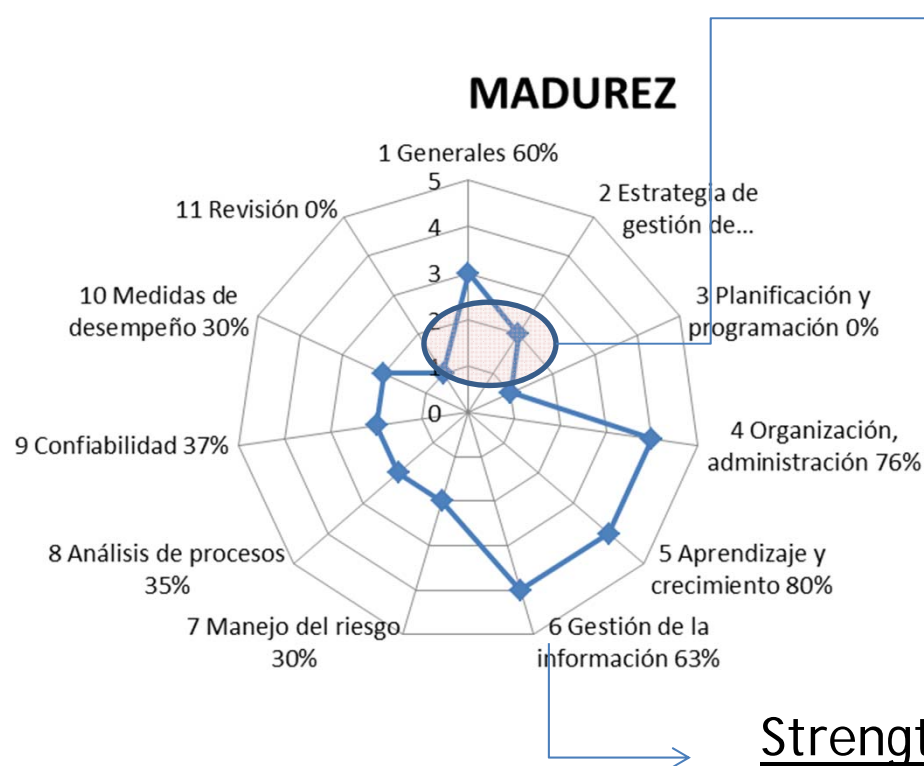


We don't check and don't act



Reliability Centered Maintenance

Results from The Diagnostic Survey for A pilot mill



Opportunities for Improvement:

- Strategies
- Planned programs
- Reliability and risk analysis

Reliability Centered Maintenance

Strengths:

- Documentation and standardization of processes
- Systemic relationship with other organizational processes (ISO Standards)

Technical subjects

- In the more technical subjects, activities are oriented to identify research requirements related to critical maintenance areas and processes, to plan strategies which help main objective achievement.
 - Root Causes Analysis (RCA) methodology has been applied in order to identify potential research areas for maintenance.
 - Using the Pilot Mill approach, CENICAÑA is budgeting for 2015 a second phase of Maintenance Project

Root Causes Analysis (RCA) Methodology

1. Get information:

- Persons in charge
- Meeting with all workers involved
- Review information : CMMS, catalogue, drawings, etc.
- Check damaged pieces: dimensions, geometry, chemical composition, metallography, etc.
- Analyze products involved

2. Diagram of failure event

3. Failure hypothesis formulation

4. Identify real failure causes

5. Diagram causes/root failure

6. Solution

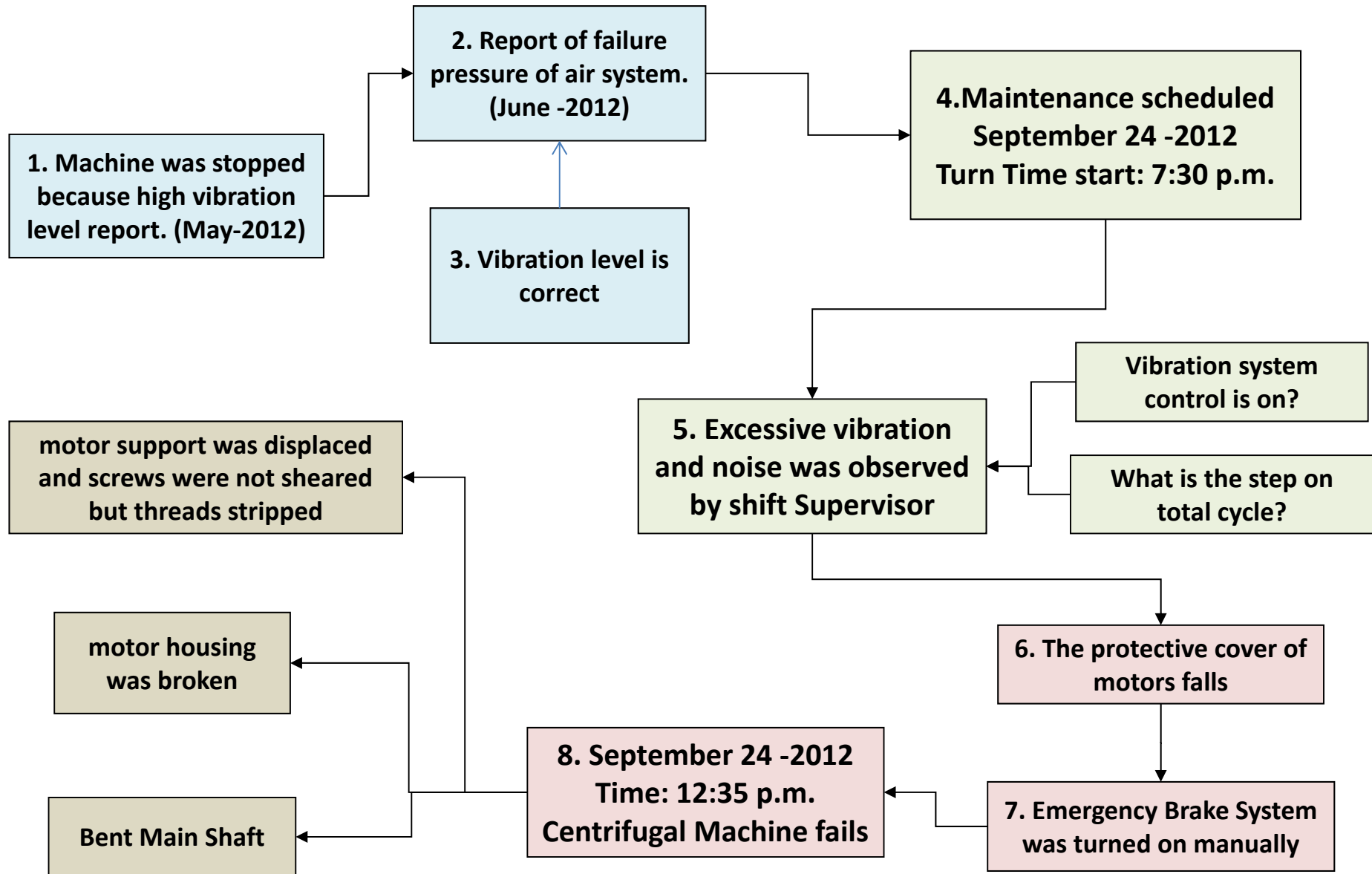
7. Socializing the results

RCA for Centrifuge Batch Equipment: Example of applications

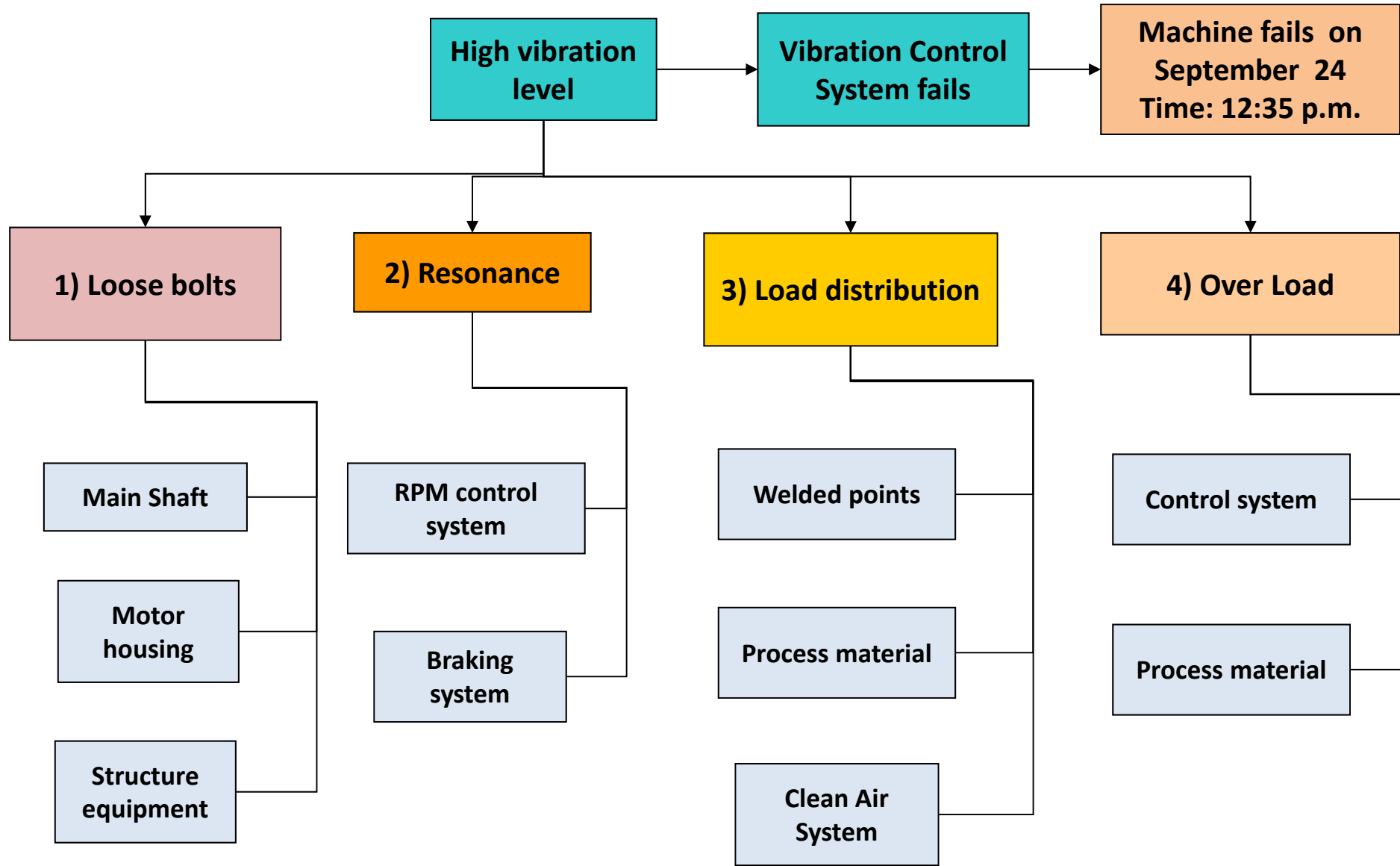


- Previously, on May (2012) Centrifuge was stopped because high vibration levels.
- Predictive Maintenance group didn't report abnormal condition, before this event.
- Equipment stopped because of damage on September 24 (2012), first shift after scheduled maintenance.

Step 2: Diagram of Failure event



Step 5: Diagram causes/root failure



Step 6: Solutions recommended

1. Structure fixation screw should be the originally recommended by manufacturer.
2. Practice to preload screw joints must be taken to avoid premature failure, either too much or too tight.
3. The emergency stop procedure should be reviewed.
4. It is suggested to ask the manufacturer the natural frequencies of the complete centrifuge rotor, with rated load and 80% load.
5. the instructions in the manual calibration of the proximity sensor rotor should be checked again.



Conclusion

- Global maintenance Indicators like OEE, could match traditionally indicator.
- New strategies for maintenance management and execution have be applied to mills, in order to improve the global maintenance indicator.
- Reliability Centered Maintenance (RCM) is one alternative to improve maintenance and reduce costs.

Acknowledgement

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