

Troubleshooting:

Integrated tool for fast and automatic failure diagnosis and solution

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Introduction : scenario

Maintenance world is a “mature” world:

- Methodologies: RAM, RCM,...
- Techniques: Vibrational Analysis, Oil Analysis, Thermography, ...

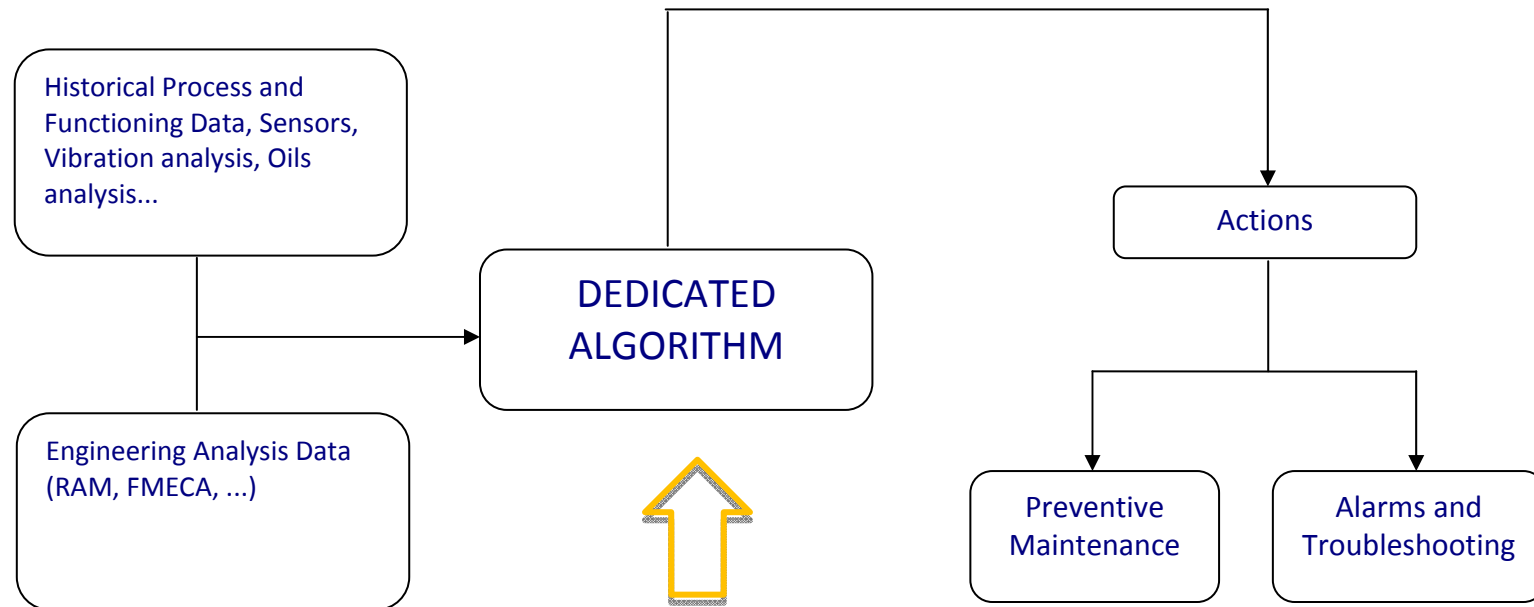
What's the problem with CMMS?

Perception of “something to be done”

INTRODUCE BENEFITS

- Personal
- Company

The Tool: Structure



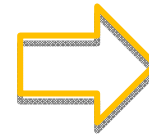
RULES

- Qualitative
- Quantitative

Introduction : BENEFITS

•OPERATIVE BENEFITS

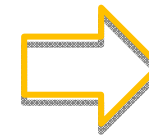
- ✓Quickly identify the cause of an anomaly
- ✓Get immediately the indication to solve a problem
- ✓Gather documentation
- ✓Have all the information to schedule and execute an intervention



Daily Work
Activities



•STRATEGIC BENEFITS

- ✓Have a self-feeding system that optimizes continuously
- ✓Draw a true scenario of Company's maintenance performance
- ✓Have always under control the functioning of the assets
- ✓Data for Re-engineering assets





Continuous
Improvement

What is Troubleshooting

trou·ble·shoot  [truhb-uhl-shoot]  [Show IPA](#) *verb*, -shoot-ed or -shot, -shoot-ing.

Origin:

1930–35; back formation from troubleshooter

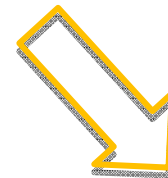
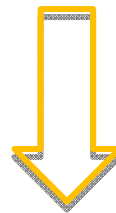
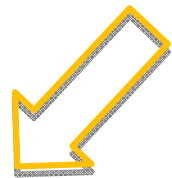
trou·ble·shoot·er  [truhb-uhl-shoo-ter]  [Show IPA](#)

-noun

1. a person with special skill in resolving disputes, impasses, etc., as in **business**, national, or international affairs: *a diplomatic troubleshooter in the Middle East.*
2. an expert in discovering and eliminating the cause of trouble in mechanical equipment, power lines, etc.

Troubleshooting is not ONLY Question and Answers for a specific problem

Troubleshooting should find problem and suggest solutions



OEM/
Plants Producers


Customers

Maintenance Services



Mindstorms for your Business

What is a Trouble

Main Entry: **trou·ble** 

Pronunciation: \ˈtrə-bəl\

t : a state or condition of distress, annoyance, or difficulty <in trouble with the law> <heading for trouble> <got into financial trouble>: as **a** : a condition of physical distress or ill health : AILMENT <back trouble> <heart trouble> **b** : a condition of mechanical malfunction <engine trouble> **c** : a condition of doing something badly or only with great difficulty <has trouble reading> <has trouble breathing> **d** : pregnancy out of wedlock <got a girl in trouble>

Definitions:

- Failure.
- Set of Conditions leading to abnormal status.
With and w/o compromising functionalities.

Any game needs RULES

SINGLE CAUSE



Real World: POLY-CAUSE



RULES TO DEFINE THE TROUBLE

Any game needs RULES

Qualitative and
Quantitative



FMECA*, engineering and field data.


* **F**ailure **M**ode **E**ffects and **C**riticalities **A**nalysis

Rules are not only for detection but also to forecast.



PREDICTIVE MAINTENANCE.

What is a solution

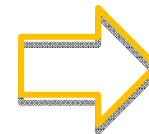
so·lu·tion  /səˈluʃən/

Easier to define:

- The absence of a trouble. (but this is the effect)
- The restoring of a non trouble situation. (but this is limitative)
- The maintenance of a non-trouble situation.


Speaking of a Machine: it's maintaining its availability at a given value with a certain value of reliability.

3 kind of Troubleshooting are identified



- Fully automatic
- Semiautomatic
- Manual

What is a solution

so·lu·tion  /sə'luʃən/

Fully automatic Troubleshooting

Condition:

It is possible to identify a single cause of the detected effect in an automated way

How:


Sensors, asset's parameters and working conditions. (RULES)

Results:

the tool will display the only coherent cause.

What the tool is performing is an automatic troubleshooting that allows the operators/maintenance team to get automatically information on what to do, with all data about spare parts and all related documentation. The tool is also able to originate a complete work order to be sent to maintenance service/maintenance manager.

What is a solution

so·lu·tion  /sə'luʃən/

Semiautomatic Troubleshooting

Conditions:

When the available data are not enough for the software to define in a unique way the cause of an observed effect/anomaly

Results:


System prompts an alarm and advises the operator to perform troubleshooting.

Showing only causes consistent with the observed effects, the software suggests a list of checks to be done.

Answering Yes/No to this checklist the possible causes are filtered to point out the solution.

The possible causes are listed ordered by relevance, according to engineering and historical data

What is a solution

so·lu·tion  /sə'luʃən/

Semiautomatic Troubleshooting

Benefits:


People who perform the checklist are not required to know deeply the engineering aspects of the assets, but are able to solve problems just following guidelines.

FLEXIBILITY:

If the problem is too complex to be managed by the machine operator, he can send the result of the troubleshooting to the maintenance service as a request for intervention, adding notes and observations.

The maintenance operator himself can use troubleshooting to manage new situations, reporting new failure modes and the activities done to handle them.

What is a solution

so·lu·tion  /sə'luʃən/

Manual Troubleshooting

When:

To diagnose a failure even if no alarm is active.

To examine documents and procedures.

Troubleshooting tool acts as the **natural interface** between machines and man, where all the information, documents and related procedures are stored.

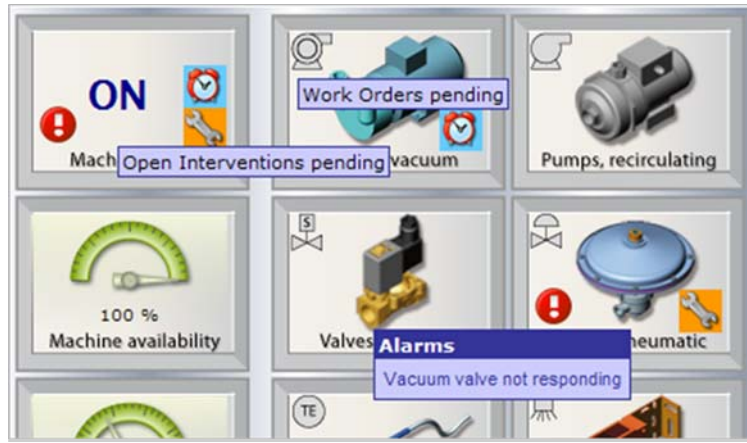
It's clear that the basis of the troubleshooting is an engineering analysis enriched with data coming from the field .

This finally reflects in giving a **daily, concrete use to FMECA** data that, crossed with functioning parameters start an improvement cycle: data from the field can be used to tune the analysis, adding failure modes, finding criticalities and refining procedures.

Gathering these data, Companies can improve and have under control their assets utilization.

Real Case

OEM world leader in Autoclaves for Pharma.



- Visual Interface with subgroups
- Customizable icons for each subgroup
- Direct link with on-board software

Troubleshooting Configuration

- ✓ Defined on machines or selected sub-systems
- ✓ Failure data can be imported from catalogues or FMECA Analysis
- ✓ Automatic diagnosis using rules and alarms
- ✓ Manual diagnosis through checklists
- ✓ Solutions made up of text, digital documents, pre-filled work orders
- ✓ Causes relevance depending on actual failure history

Troubleshooting settings

Code	PV03.6		
Subset	PV01	Failure	
Failure Effect	E023 Impeller in rotation - Vacuum ta		
Failure Cause	FM026.6 Insufficient operating liquid		
MTTF (h)	5116.0		
MTTR (h)	2.0		
Solution	Remove lime-scale or foreign matter from the piping		Solution
Document	Maintenance sheet - Vacuum Pump		
Planned work order	ODLP_PV_A Remove obstructions o		Diagnosis
Related alarm	VACUUM_ALARM Vacuum target nc		
Launch WO	<input type="checkbox"/>		
Diagnose rule	test PRESSURE_HIGH High pressure		

Checklist

	Position	Code	Description	Yes	No	
<input type="checkbox"/>				<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
<input type="checkbox"/>	1	CK03	Is hand valve open?	<input checked="" type="radio"/>	<input type="radio"/>	<input type="checkbox"/>
<input type="checkbox"/>	4	CK01	Is hand valve damaged?	<input type="radio"/>	<input checked="" type="radio"/>	<input type="checkbox"/>
<input type="checkbox"/>	5	CK05	Is there a high contemporary request for operating liquid?	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="checkbox"/>

Troubleshooting Execution

Step-by-step procedure:

1. Choose sub-system and noticed effect
2. Evaluate provided checks
3. Choose failure cause
4. Evaluate provided solution

or

5. Request for assistance

Troubleshooting for Autoclave : DEMO

➔ Select failure cause, using the provided checklist

Code	Description	Subset
Pumps / Vacuum / PV01	Main Vacuum Pump	

Observed effect	
Code	Description
E023	Pump running - Vacuum target not reached

Select the result of the following checks		
Description	Yes	No
Is chiller working?	<input type="radio"/>	<input type="radio"/>
Is root valve open?	<input type="radio"/>	<input type="radio"/>
Is pin tap open?	<input type="radio"/>	<input type="radio"/>
Is pin tap broken?	<input type="radio"/>	<input type="radio"/>
Is there a high water utilization?	<input type="radio"/>	<input type="radio"/>

Possible failure causes			
Code	Relevance	Description	Select
FM026.6	100%	Low water pressure due to obstructed pipes	<input type="button" value="➔"/>
FM026.4	50%	Low water pressure due to broken pin tap	<input type="button" value="➔"/>
FM026.1	33%	Low water pressure due to closed root valve	<input type="button" value="➔"/>
FM026.3	25%	Low water pressure due to closed pin tap	<input type="button" value="➔"/>
FM026.2	20%	Low water pressure due to root valve failure	<input type="button" value="➔"/>
FM026.5	16%	Low water pressure due to high utilization	<input type="button" value="➔"/>
FM024.1	14%	High water temperature due to warm environment	<input type="button" value="➔"/>
FM024.2	12%	High water temperature due to chiller problems	<input type="button" value="➔"/>

Other options	
<input type="button" value="Request for Intervention"/>	<input type="button" value="Insert a new Intervention Card"/>

Effects

- ✓ Only effects consistent with chosen subset and machine status are shown
- ✓ The operator selects detected effect
- ✓ During any step, a request for intervention can be sent to maintenance service

Troubleshooting for Machine : TS001

No failure detected. Please proceed manually.

- ➡ If known, select failed element
- ➡ Select detected effect

Nr of solutions: 24

Code	Description	Subset	Selection
Pumps			⇒
Fans			⇒
Valves			⇒

Code	Description	Noticed effects	Selection
E023	Impeller in rotation - Vacuum target not performed		⇒
E042	Fan not in rotation - Thermal uniformity in chamber not performed		⇒
E037	Fan in rotation - High noise level and vibrations		⇒
E015	Drain valve leaking		⇒
E035	Impeller in rotation - Vacuum performance decreasing		⇒
E034	Impeller in rotation - Power consumption too high		⇒
E014	Steam valve leaking		⇒
E033	Impeller in rotation - High noise level / vibrations		⇒

Other options

Request for Intervention Insert Intervention Card manually

Checklist and causes

- ✓ The system shows the list of causes consistent with selected effect and machine status (if available)
- ✓ A series of manual checks is proposed, in order to identify the right cause
- ✓ Check by check, inconsistent causes are discarded
- ✓ The operator selects a cause or asks for intervention

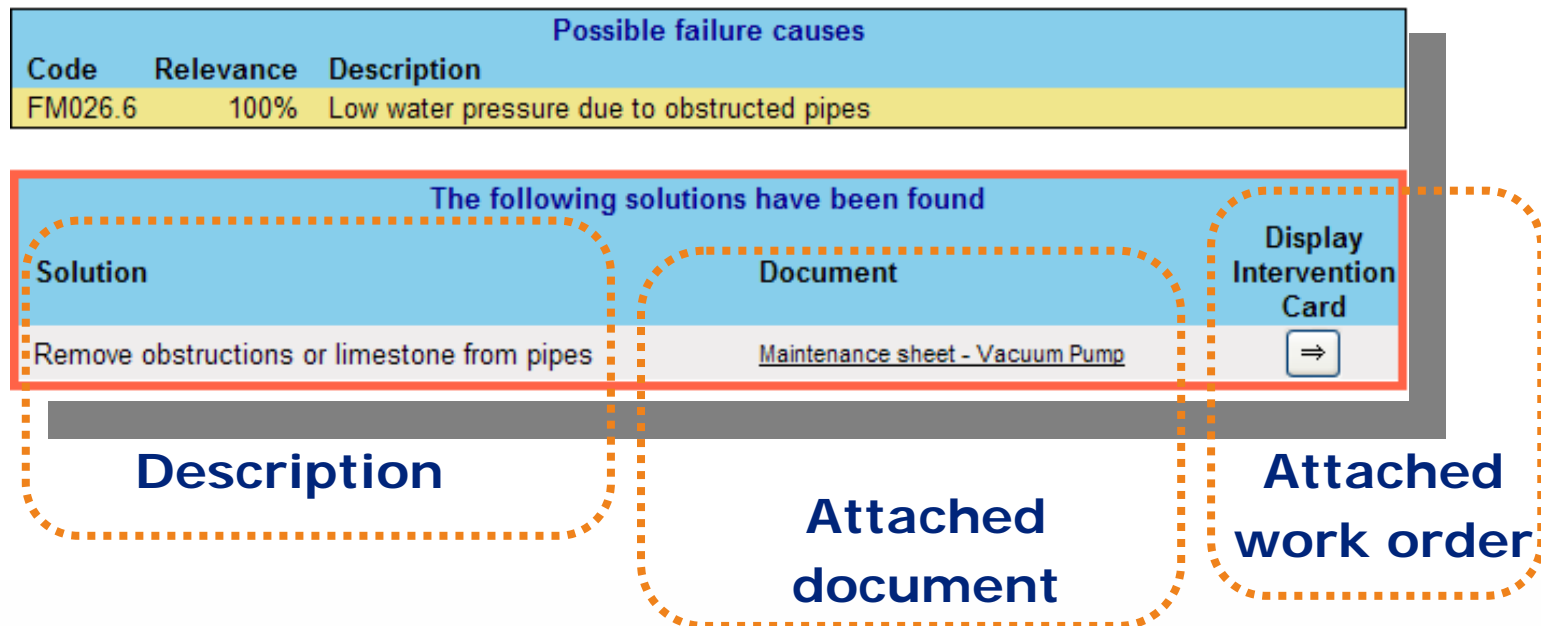
Select the result of the following checks		
Description	Yes	No
Is chiller working?	<input type="radio"/>	<input type="radio"/>
Is root valve open?	<input type="radio"/>	<input type="radio"/>
Is pin tap open?	<input type="radio"/>	<input type="radio"/>
Is pin tap broken?	<input type="radio"/>	<input type="radio"/>
Is there a high water utilization?	<input type="radio"/>	<input type="radio"/>

Possible failure causes			
Code	Relevance	Description	Select
FM026.6	100%	Low water pressure due to obstructed pipes	<input type="button" value="⇒"/>
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Other options	
<input type="button" value="Request for Intervention"/>	<input type="button" value="Insert a new Intervention Card"/>

Solutions

- ✓ Troubleshooting proposes the solution defined for selected cause
- ✓ The solution can consist of a descriptive text, a digital document (manuals, datasheets, diagrams, internet links...) and a pre-filled work order



Request for Intervention

- ✓ If the operator is not able to solve the failure, he can send a request to the maintenance service
- ✓ The request contains all the choices and checks made up to that moment

Element name : PV01			
Description : Main Vacuum Pump			
Warning's Code	AVV_201017121517		
Following	Damage	Inspection	Other
Emission date	2010-01-07 12:15		
Applying	OP001		
Priority	None		
Job type	None		
From planned WO	None		
Description	Noticed effects: Impeller in rotation - Vacuum target not performed Performed checks: Is chiller working?: Yes		

Work Order

- ✓ Prefilled work orders can be attached to solutions
- ✓ The work order is launched manually or automatically according to Troubleshooting mode
- ✓ Completing the work order, failure statistics are updated

Main

Asset path: Fedegari → Albuzzano → LAB001 → DEMO → Pneumatic → VP7

Card Code: ODLP_VP7_A_1

Description: Replace diaphragm and O-ring

Failure Effect: Vacuum phase - Bad sealing

Failure Cause: Broken diaphragm

Fault detection: 2009-04-27 15:35

Intervention Start: []

Intervention End: []

Job Type: Substitution

Intervention closed: Password []

Notes: []

Operations

Linked activity

Position	Code	Description	Executed		Notes
			Yes	No	
1	VPA01	Feed compressed air into the actuator by activating the corresponding solenoid valve	<input type="radio"/>	<input checked="" type="radio"/>	
2	VPA02	Using the hook wrench, unscrew the ring and separate the valve from the lower body	<input type="radio"/>	<input checked="" type="radio"/>	
3	VPA03	Vent the compressed air from the actuator by activating the corresponding solenoid valve	<input type="radio"/>	<input checked="" type="radio"/>	
4	VPA04	Unscrew the diaphragm	<input type="radio"/>	<input checked="" type="radio"/>	
5	VPA05	Remove the O-ring and the ring	<input type="radio"/>	<input checked="" type="radio"/>	
6	VPA06	Clean all the disassembled parts and check for damage to the parts	<input type="radio"/>	<input checked="" type="radio"/>	
7	VPA07	Replace the diaphragm and the O-ring	<input type="radio"/>	<input checked="" type="radio"/>	
8	VPA08	Reassemble the valve by performing the operations described above in reverse order	<input type="radio"/>	<input checked="" type="radio"/>	
			<input type="radio"/>	<input checked="" type="radio"/>	

Updating Troubleshooting

- ✓ The list of causes is ordered by their actual occurrence, so that frequent causes are shown first. This relevance is updated at every maintenance intervention

Code	Relevance	Description	Select
FM026.6	100%	Low water pressure due to obstructed pipes	⇒
FM026.4	50%	Low water pressure due to broken pin tap	⇒
FM026.1	33%	Low water pressure due to closed root valve	⇒
FM026.3	25%	Low water pressure due to closed pin tap	⇒
FM026.2	20%	Low water pressure due to root valve failure	⇒
FM026.5	16%	Low water pressure due to high utilization	⇒
FM024.1	14%	High water temperature due to warm environment	⇒
FM024.2	12%	High water temperature due to chiller problems	⇒

Relevance

- ✓ Completing an intervention, new effects and causes can be reported. This information is recorded and will be evaluated during Troubleshooting revisions

Conclusion

HIGH LEVEL BENEFIT

- ✓ Troubleshooting “gives life” to FMECA data
- ✓ Troubleshooting allows people to be easily trained on maintenance
- ✓ For OEM troubleshooting gives feedback on what is happening on the field
- ✓ Shorten the response time: LESS DOWN TIME, INCREASE AVAILABILITY

Troubleshooting helps in daily activity, very friendly machine interface.

Troubleshooting tool seems to be the natural evolution of CMMS interface.

Thanks for your attention

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