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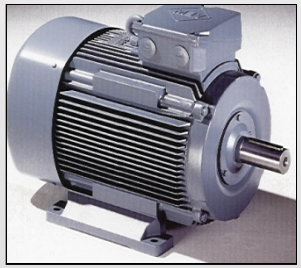


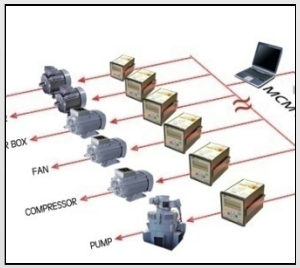

Simple Predictive Maintenance and Energy Efficiency

Anglian Water Discussions 23rd October 2009

Simplified approach to predictive diagnostics

From this ….

…. to this

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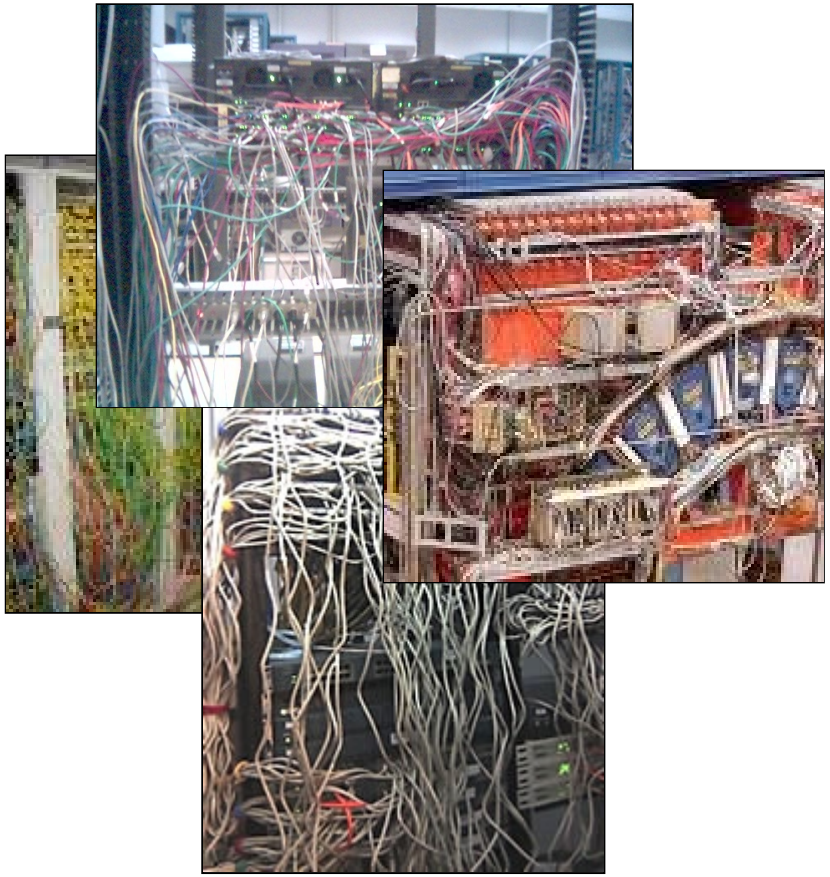
Simplified installation

From this ….



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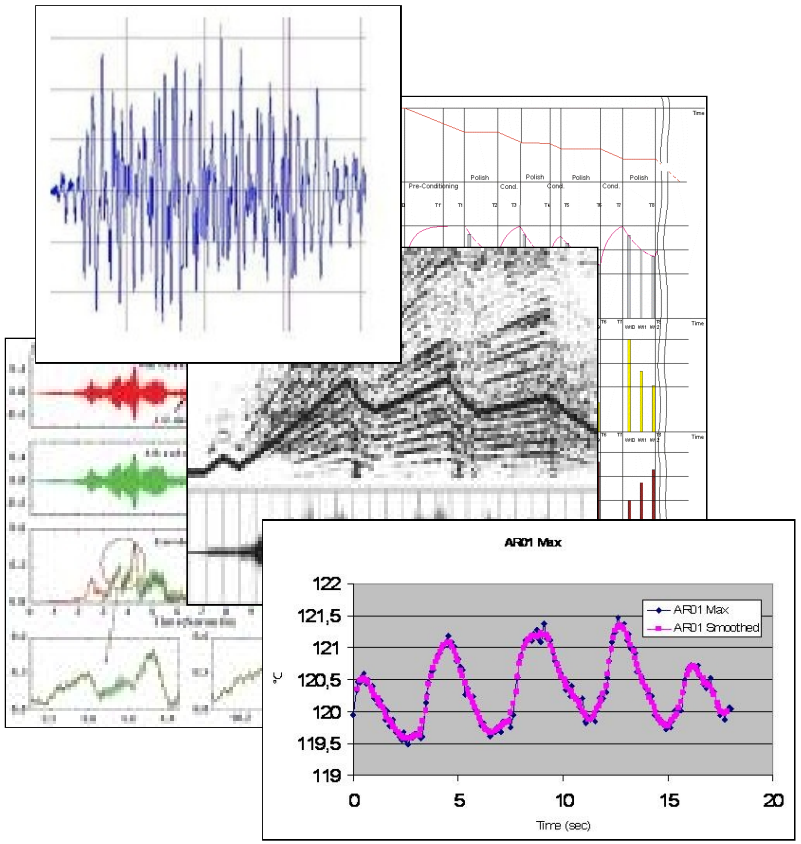
MCM just gives you the answers

From this ….



…. to this

Diagnostic

EQUIPMENT STATUS	
OK	Loose Foundation / Components
OK	Unbalance/Misalignment/Coupling/Bearing
OK	Transmission Element / Driven Equipment
OK	Bearing
OK	Rotor
OK	Loose Windings / Stator / Short Circuit
OK	Internal Electrical Fault
OK	External Electrical Fault
OK	Other
OK	Line Status
Watch	Load Status

ELECTRICAL VALUES		
Watch	Power Factor	0.76
OK	Active Power [kW]	2524
OK	Reactive Power [kVar]	2158
OK	Vrms [V]	8066
OK	Irms [A]	137
OK	V Imbalance[%]	0.67
OK	I Imbalance[%]	0.48
OK	Frequency [Hz]	60
OK	THD [%]	0.64
OK	3th Harmonic [%]	0.26
OK	5th Harmonic [%]	0.32
OK	7th Harmonic [%]	0.11
OK	9th Harmonic [%]	0.02
OK	11th Harmonic [%]	0.04
OK	13th Harmonic [%]	0.02

WATCH LOAD	If the process load has not been altered deliberately, check for leakage, valve & vane adjustment, pressure gauge faults, manometer, dirty filters (fans, compressors). If the process is altered deliberately, MCM/PCM should be updated.
WATCH ELECTRICAL VALUES	Electrical values are outside of their expected range. They should be noted and watched to identify the cause

WORK REQUESTS

WATCH LOAD: If the process load has not been altered deliberately, check for leakage, valve & vane adjustment, pressure gauge faults, manometer, dirty filters (fans, compressors). If the process is altered deliberately, MCM/PCM should be updated.

WATCH ELECTRICAL VALUES: Electrical values are outside of their expected range. They should be noted and watched to identify the cause

EQUIPMENT INFORMATION	
Equipment Name	CM0501X
Equipment Type	Other
Nominal Voltage [V]	7967
Nominal Current [A]	206
Rotation Spd. [rpm]	1785
MCM Address	1

DATABASE (Last Five Hours)	
Start Date	05/10/2009 17:23:05
End Date	05/10/2009 22:23:05
Number of Data Points	182
DATABASE (Full)	
Database Range	01/15/2009 - 05/13/2009
Number of Data Points	40000 (39200/40000)

Plot | Report | Clear Selection | PSD | Auto

Load | Advanced | Help | Close | Step 800 | Goto 40000 | Go

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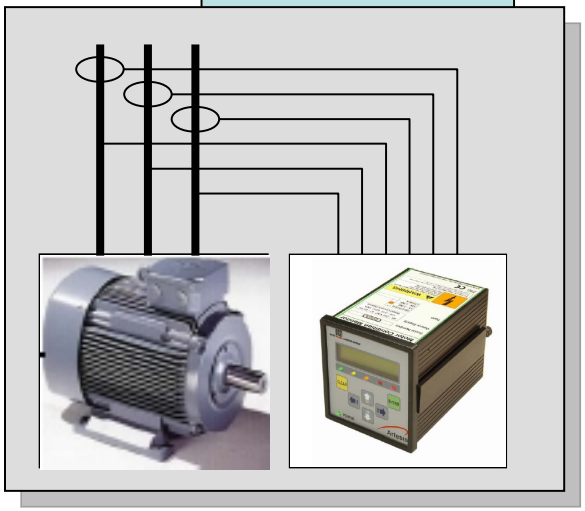
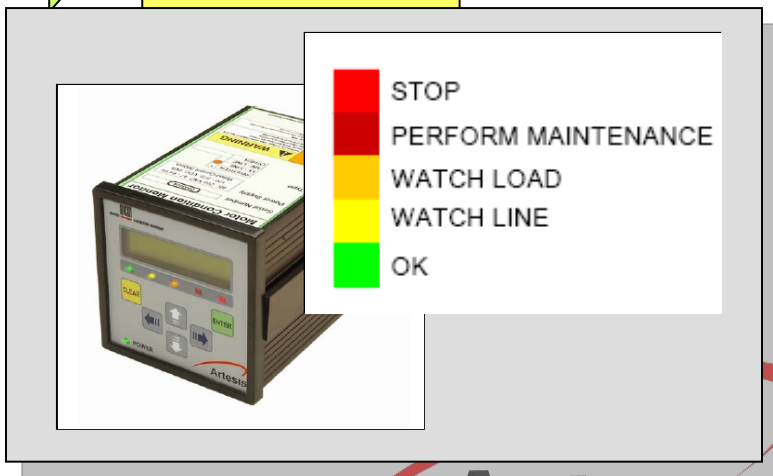
Simple to ins

Install

Train

Run





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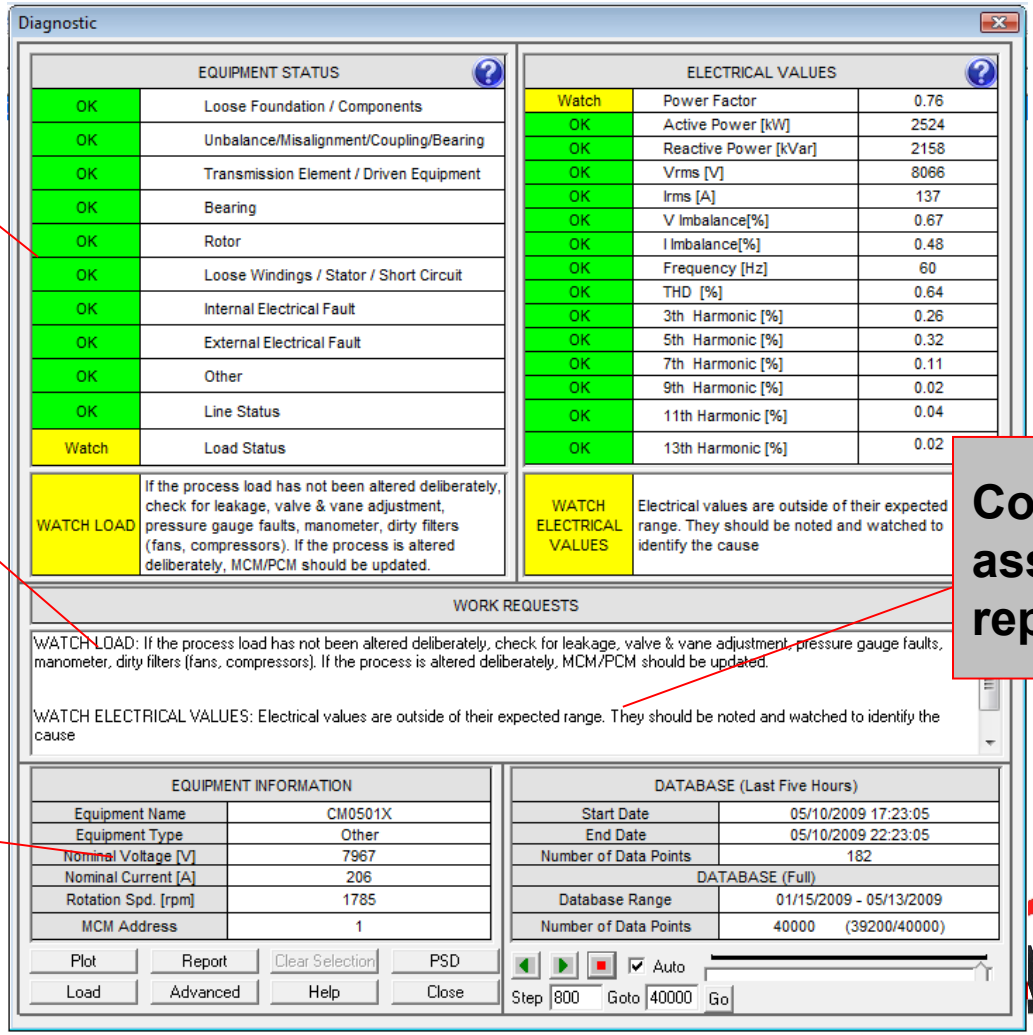
Concise, reliable fault diagnosis

Fault diagnosis and severity level

Action urgency

Motor or generator data



Condition assessment report

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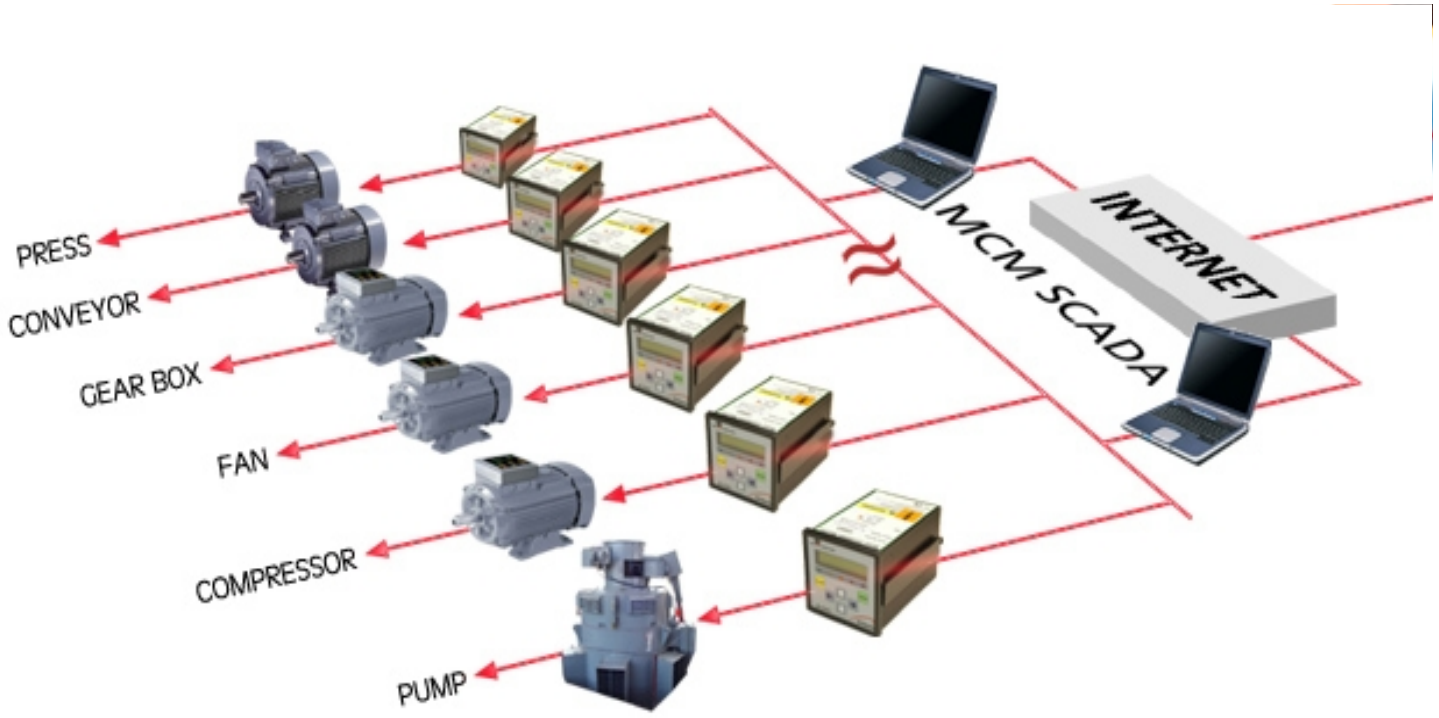
Connects with other systems



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Benefits

- Can connect to existing SCADA systems
- Centralised automated fault diagnosis
- Enables better resource planning
- Located in motor control centre so ideal for boreholes and submersible pumps, mixers etc
- Minimal complexity of diagnosis

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Case Study

- A typical water site example located in the south west.
- 6 MCMs installed on 2 relift pumps, 2 boreholes and two honeycombe pumps.
- Installed in Spring 2008
- GPRS communications back to Artesis.net server
- Remote access to diagnostics from both Artesis and the customer

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Diagnosis 1: Relift Pump #1

- This example is from the time immediately following installation in Spring 2008.
- 6 MCMs on the site monitoring 2 borehole, 2 relift and 2 honeycombe pumps.
- The initial condition assessment from relift #1 showed signs of looseness, coupling and rotor bar problems. These got worse and corrective action was taken.

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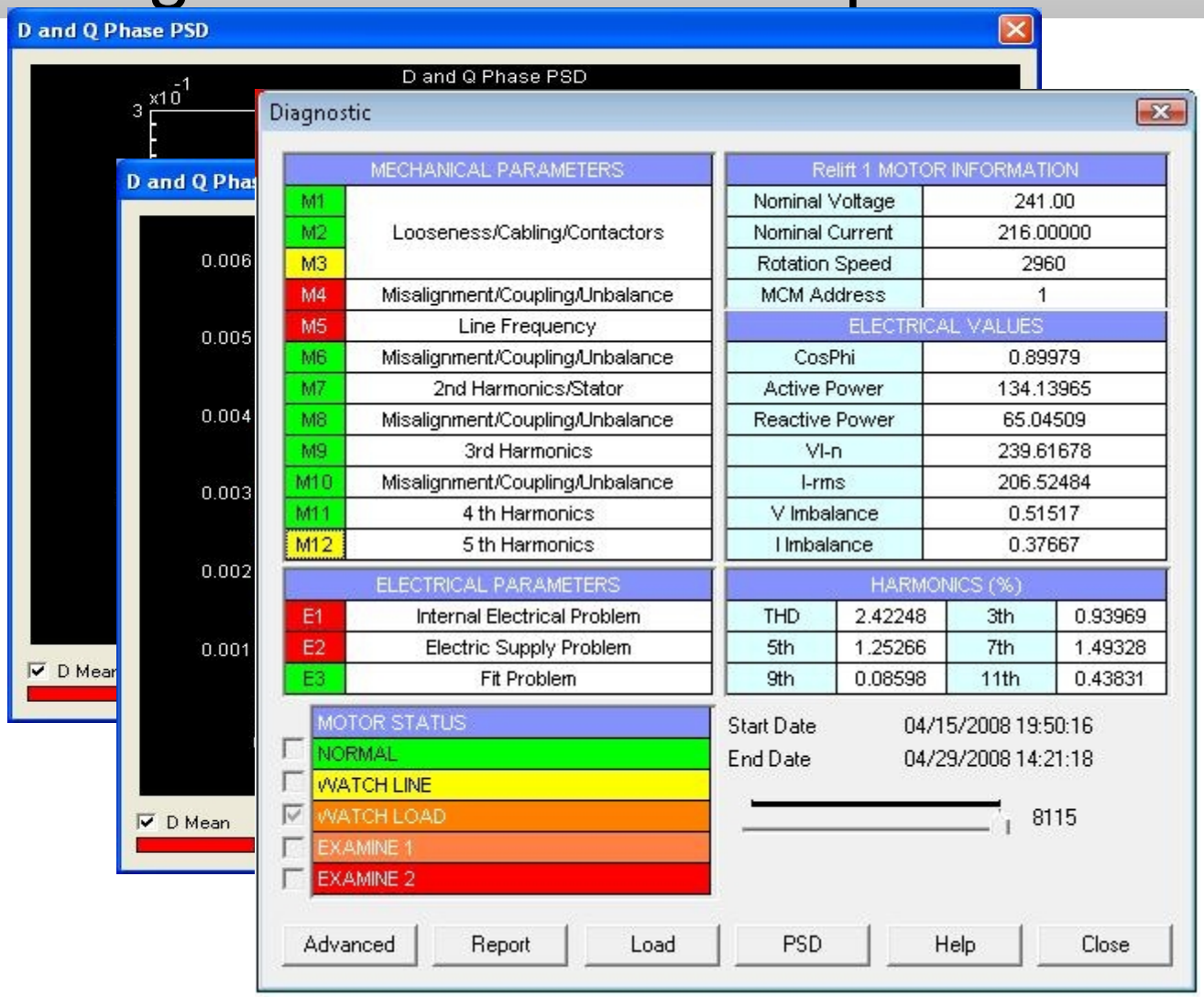
Diagnosis 1: Relift Pump #1



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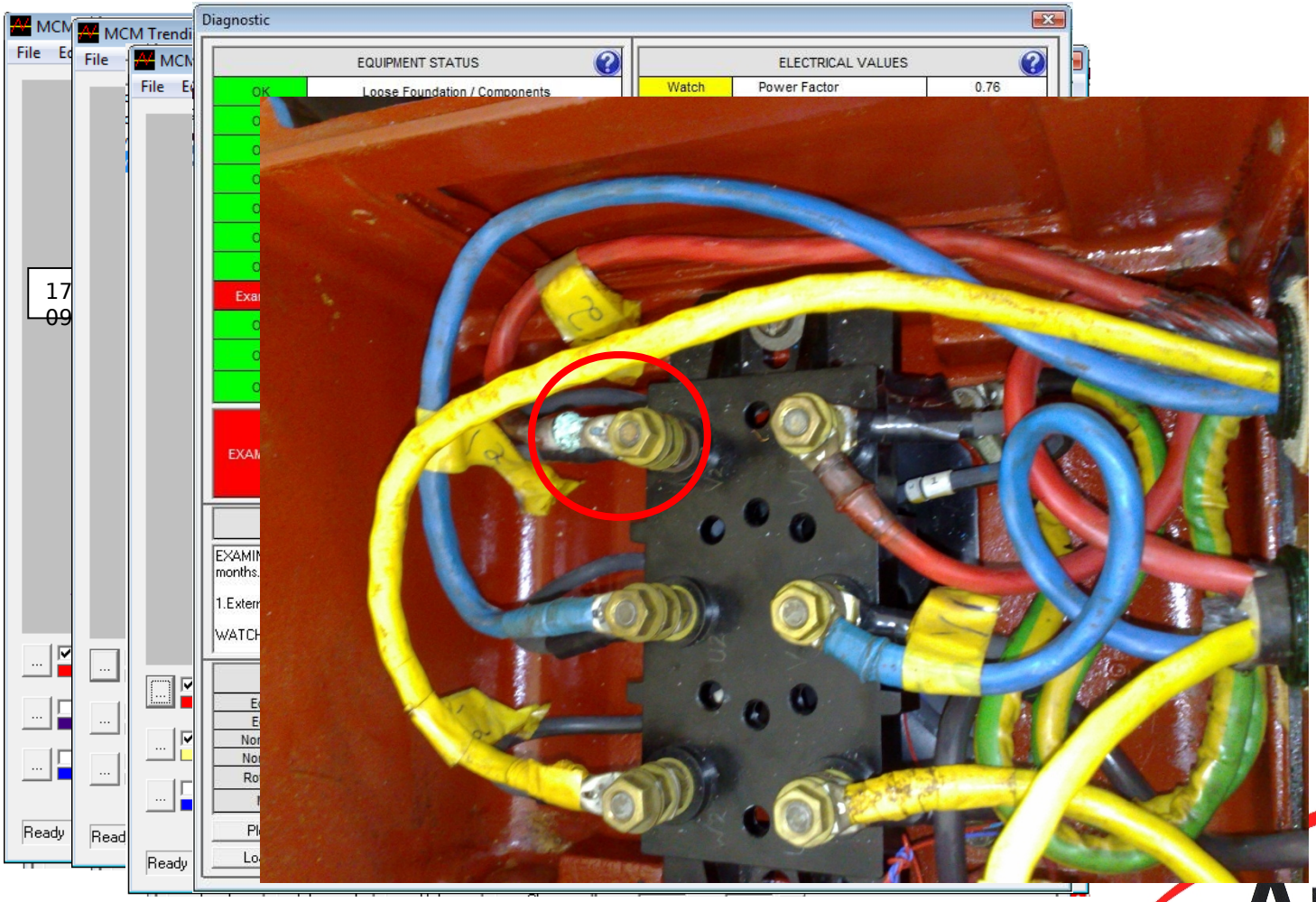
Diagnosis 2: Honeycomb Pump 1 and 2



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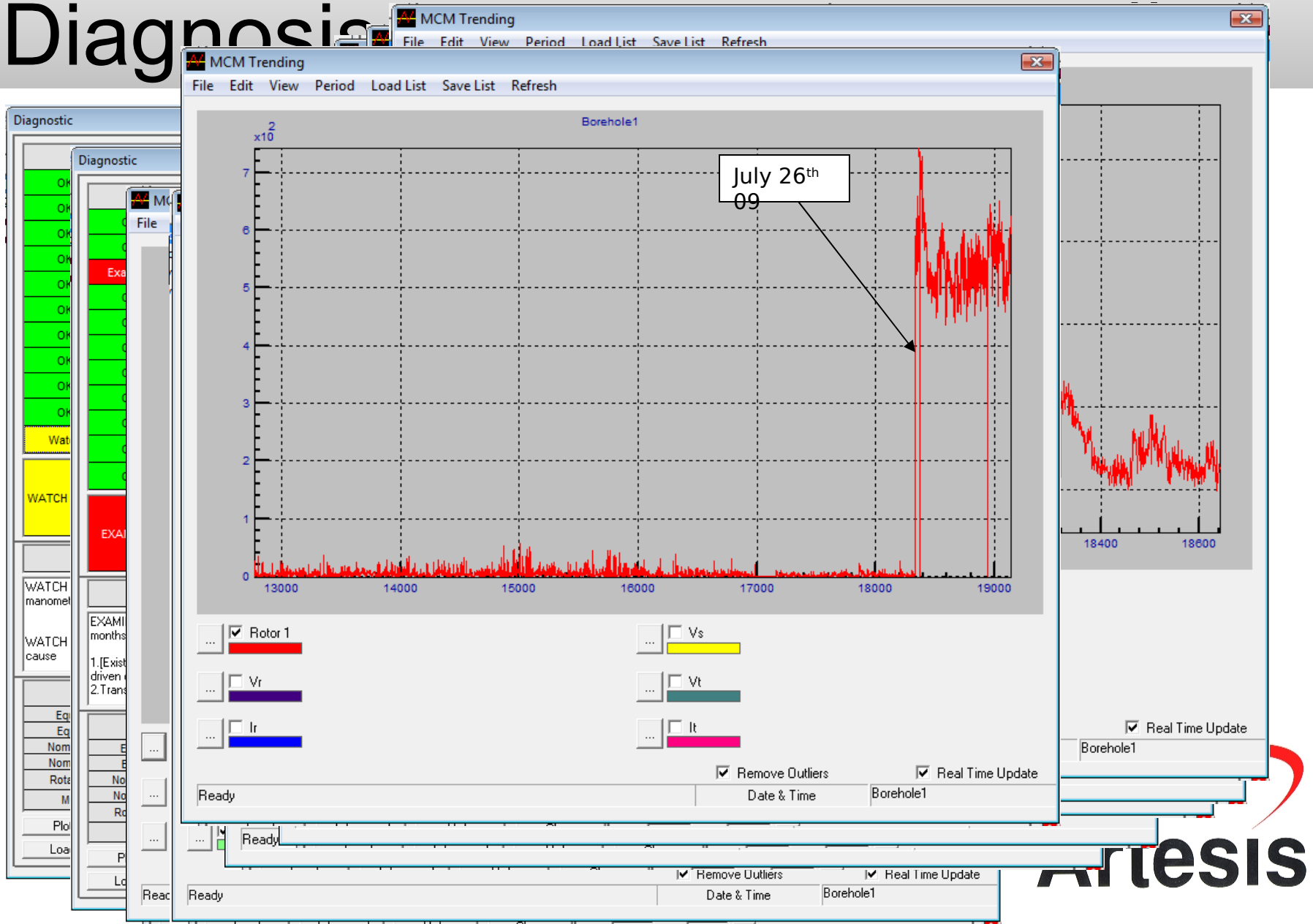
Diagnosis


MCM Trending
File Edit View Period Load List Save List Refresh
Borehole1
x10 2
July 26th 09
Rotor 1
Vs
Vr
Vt
Ir
It
Remove Outliers
Real Time Update
Ready
Date & Time
Borehole1
Diagnostic
WATCH
EXAMI
months
1.[Exist
driven
2.Trans
WATCH
manomet
WATCH
cause

Site summary

- Technically demonstrated MCM's performance through a range of diagnoses including:
  - Bad connections
  - Coupling unbalance
  - Borehole pump failure
  - Poor rotor bar condition
  - Foundation looseness
- Achieved payback several times
  - Lost energy
  - Prevented failures
  - Planned removal of pumps

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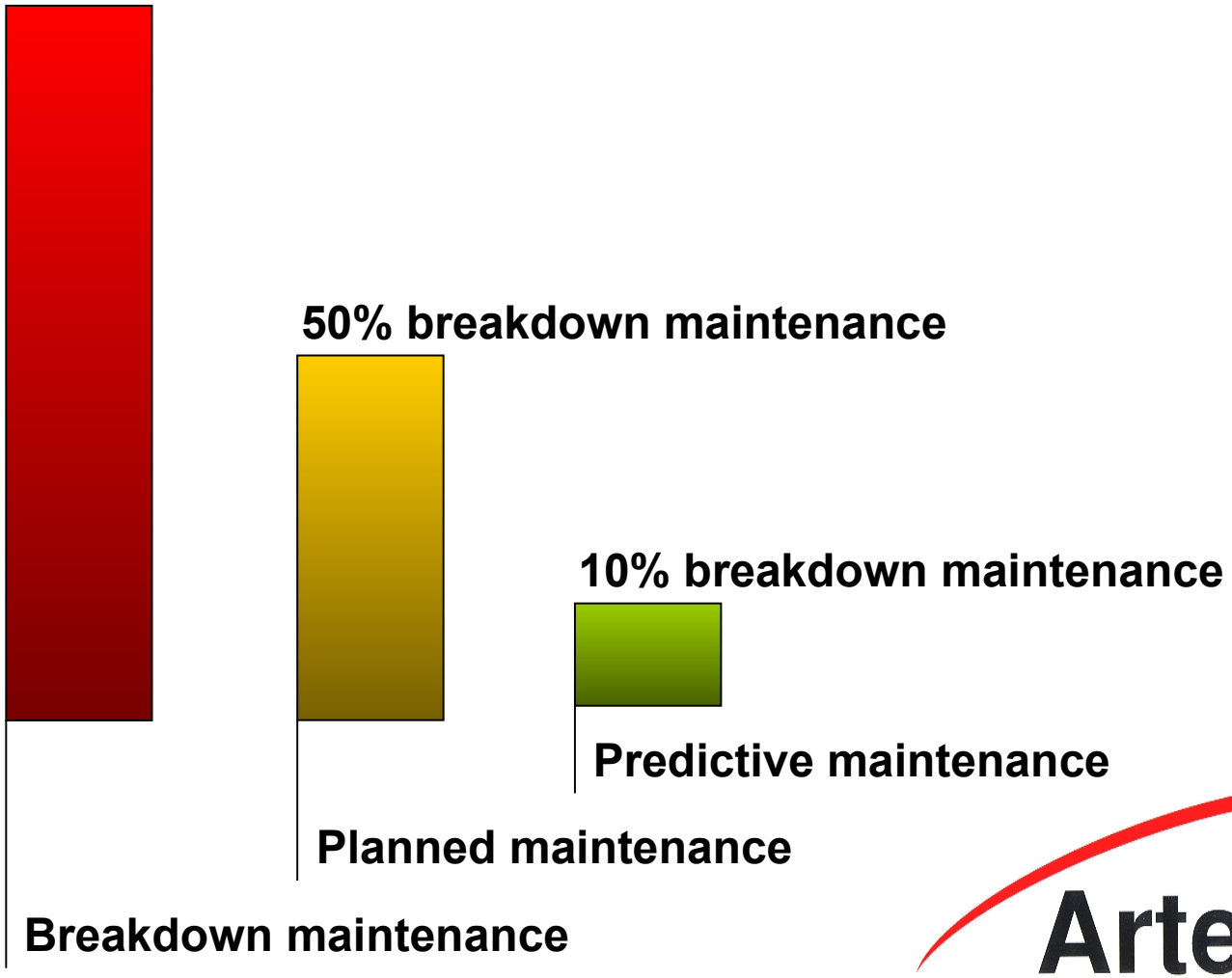
Predictive maintenance benefits



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Energy efficiency benefits

For a typical 75kW motor:

- **Replacing EFF3 motor with EFF1 motor gains 1.1% increase in efficiency**
- **2.5% voltage unbalance loses 1.3% in efficiency***
- **mechanical imbalance & misalignment can lose between 2-10%+ efficiency.**

* US Department of Energy, Energy Efficiency and Renewable Energy

Motor Power [kW]	Minimum Efficiency		
	EFF3 [%]	EFF1 [%]	(EFF1 – EFF3) [%]
1,1	<76,2	>83,8	7,6
1,5	<78,5	>85,0	6,5
2,2	<81,0	>86,4	5,4
3	<82,6	>87,4	4,8
5,5	<85,7	>89,2	3,5
7,5	<87,0	>90,1	3,1
15	<89,4	>91,8	2,4
22	<90,5	>92,2	1,7
30	<91,4	>93,2	1,8
37	<92,0	>93,6	1,6
45	<92,5	>93,9	1,4
55	<93,0	>94,2	1,2
75	<93,6	>94,7	1,1
90	<93,9	>95,0	1,1

The efficiency gains from replacing old motors with high efficiency ones can be completely wasted if plant is not installed and adjusted ***correctly***.

The potential for **benefit** from ***correct, optimised plant care is greater than*** the benefit of installing higher efficiency motors

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Ofwat pressures for AMP5

- Reduced OPEX
- Reduced CAPEX
- Improved customer SERVICEABILITY
- Reduced Climate Change impact

How far can we help address each of these?

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Reduced OPEX

- Predictive Maintenance savings compared to Preventive or Breakdown (10% - 50% - 100%)
  - Avoidance of catastrophic failure
  - Avoidance of secondary damage
  - Avoidance of emergency call outs & overtime
  - Avoidance of emergency spares expediting
  - Avoidance of disruption on other priority work

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Cost and Time of Breakdown Strategy

Do no planned work

Yr 1	£0
Yr 2	£0
Yr 3	£0
Yr 4	£100k, out of action for 38 weeks
Yr 5	£?

With no preventative care or monitoring, gradual pump impellor erosion / damage resulted in imbalance, overloading bearings, thence damage to casing requiring welding and re-machining, and detected only when motor failed by burning out, requiring new motor, as well as shaft, bearings, impellor, emergency overtime, etc.

Probably not the best business strategy – but we were OK because there were three other pumps we could use.

Cost and Time of Preventive Strategy

Do "all" planned work

Yr 1	£5k – one week
Yr 2	£5k – one week
Yr 3	£10k – two weeks
Yr 4	£5k – one week
Yr 5	£5k – one week

Routine overhaul every year, team of two guys for a week.

In year 3, they discover the beginnings of a problem, and replace impellor before serious damage that would have become catastrophic in year 4

Looks like a better business strategy – but we still spent 30k and 6 weeks outage.

Cost and Time of Condition Based Strategy (Walkaround)

Do routine walkaround patrols

Yr 1	£1k – no downtime
Yr 2	£1k – no downtime
Yr 3	£9k – one & half weeks
Yr 4	£1k – no downtime
Yr 5	£50k – four weeks

Routine patrol readings monthly – one guy, drive to site. No routine PM, no downtime

In year 3, they discover the beginnings of a problem, and replace impellor before serious damage that would have become catastrophic in year 4. By planning, it is less downtime than in PM case.

In Yr 5, an obstruction passes through the pump between measurements, resulting in a burned out motor.

Looks like a better business strategy still – but we are still vulnerable to damage with short P-F time failure modes

Cost and Time of Condition Based Strategy (Online – permanently installed)

Wait until alerted automatically

Yr 1	£500 – no downtime
Yr 2	£500 – no downtime
Yr 3	£9k – one & half weeks
Yr 4	£500 – no downtime
Yr 5	£10k – two weeks

Readings taken continuously and any alerts fed direct to relevant staff / managers. No site visits required.

In year 3, the beginnings of a problem is detected, and impellor replaced before serious damage that would have become catastrophic in year 4. By planning, it is less downtime than in PM case.

In Yr 5, an obstruction passes through the pump. The alert is raised and the pump impellor and shaft is replaced without further damage

Looks like the best business strategy yet – but there may be more...

Energy Consumption

Electricity Costs

(100kw, 8,000hr / yr, 6.25p/kWHr = £50,000 pa)

Year 1	£50k
Year 2	£50k
Year 3	£50k
Year 4	£50k
Year 5	£50k

So in 5 years, we spend more on electricity than the replacement value of the pump.

This is a significant cash cost – and is also a major contributor to **Climate Change**.

Industry uses approx 60% of electricity driving electric motors.

Some large water companies are spending >£30m pa on electricity bill for pumping water. Even 1% of this is significant.

So installing efficient motors is essential, but it is not sufficient...

Opex comparison – 5 yr figures

- Breakdown strategy: £100k+, 38wks down
- PM strategy: £30k, 6 wks downtime
- On-line CBM strategy: £20k, 3.5 wks downtime
- Saving £80k & 30+wks uptime

- Energy saving potential: £10 – 25k (4-10%)

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Capital Efficiency

Capital Efficiency

Year 1	£?
Year 2	£?
Year 3	£?
Year 4	£?
Year 5	£?

Through confidence in both **reliability** and ***detectability***, redundancy can be safely reduced.

Do you really need 4 pumps?

How much could you save if you only had 3?

Given all-up installation cost is a multiple of the equipment cost, the potential benefit is significant.

Potential - £500k

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Ofwat pressures for AMP5

- Reduced OPEX ✓
- Reduced CAPEX ✓
- Improved customer SERVICEABILITY ✓
- Reduced Climate Change impact ✓

- Payback many times over in the 5 year period

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Suggested serving

- Implement MCM on your most critical assets (300 pumping stations?)
- Initial condition assessment and energy saving potential assessment
- Ongoing energy monitoring service for 5 yr period
- Ongoing fault prediction / identification service and corrective advice for 5 yr period
- Bundled as a single Capex transaction

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Next Steps?

- Agree scope
- Who would need to be involved in
  - Defining?
  - Approving?
- How should we engage with them
- How soon? (start of AMP period is pressing)

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For further help

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