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Optimisation Of Gas Turbine Compressor Trains By Online Monitoring

Holger Berghaus

Brussels, October 2016

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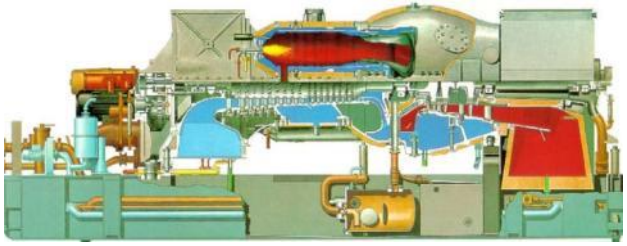
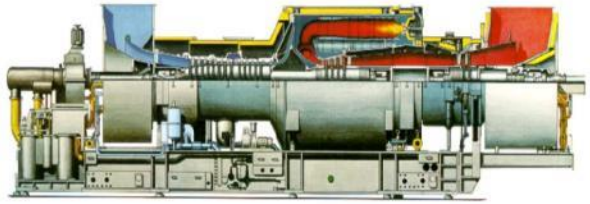
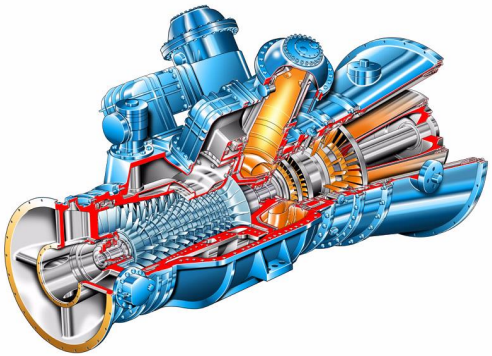
MDT GT‘s - Overview

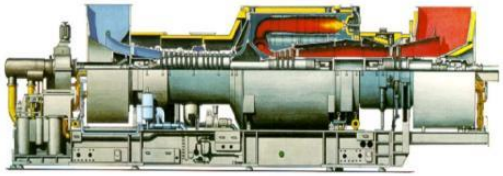


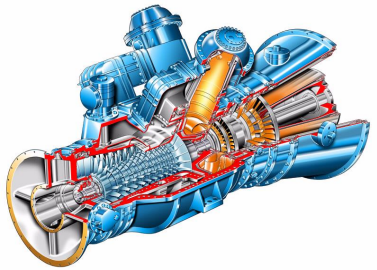


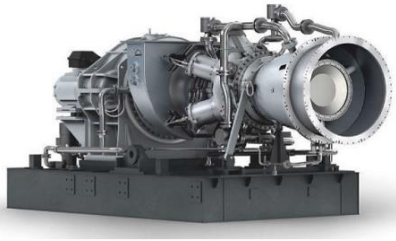


Oldest one from 1968
Power 3-25MW

MDT GT‘s - Overview







Some

Always

Since 1999

Always

Data Collector

Installations save cost!

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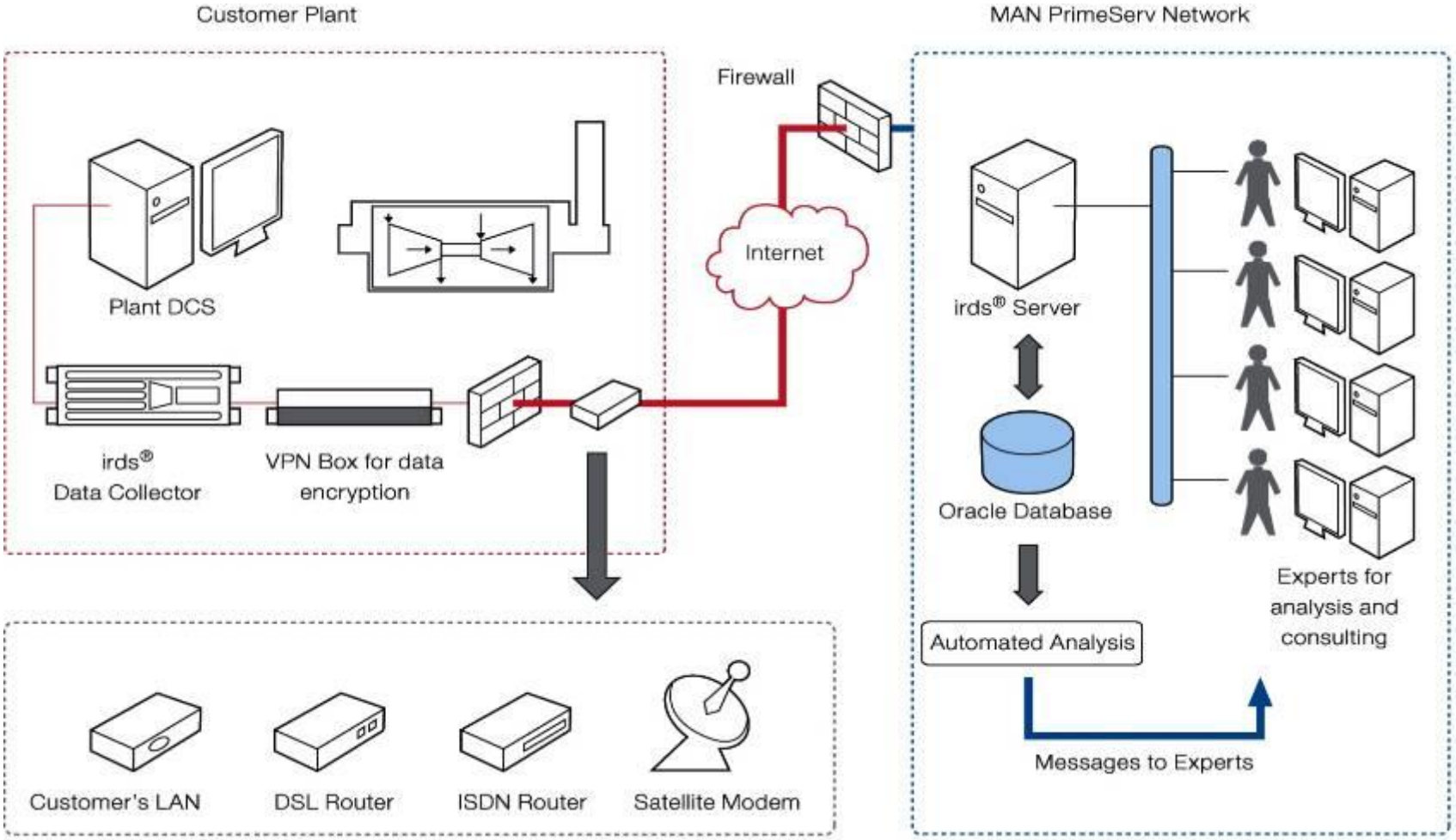
Monitoring System



Source: PrimeServ Turbo project team

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Monitoring System – Capabilities

irds® Basic Parameters

Machine Data
- Speed & VGV position
- Shaft vibration & axial displacement
- Bearing-, casing- and differential temperatures
- Voltage, current, power and winding temperatures of motor

Process Data
- Pressures, temperatures and mass flow at inlet & outlet of each stage group
- Ambient conditions

Auxilliaries Data
- Pressures and temperatures
- Differential pressure at filter elements
- Coolant temperature and pressure
- Controller inputs and outputs
- Position feedback

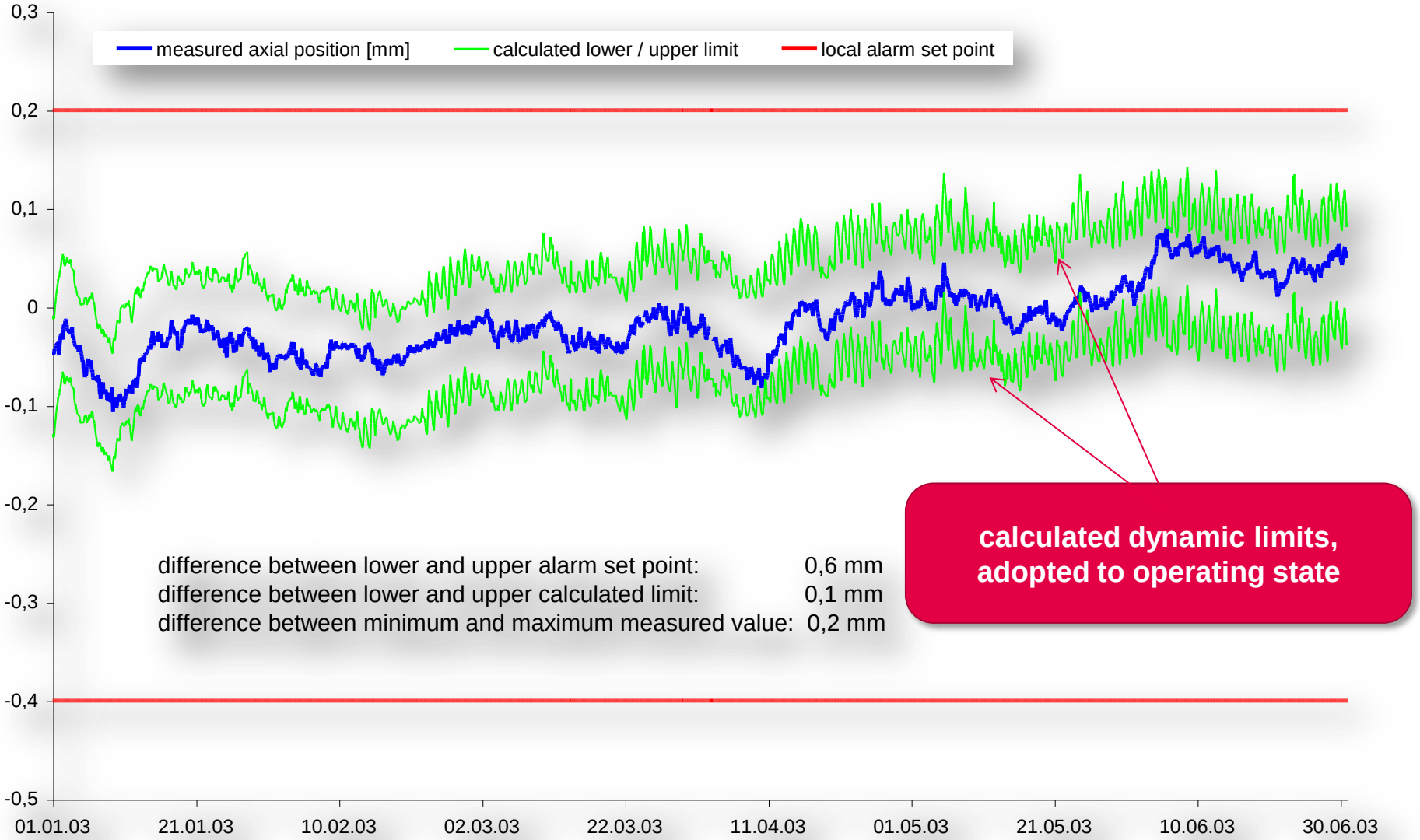
Resulting analysis

- Mechanical condition of each machine
- Operating point in characteristic curve
- Efficiency

- Operating point in characteristic curve
- Degradation of internals
- Efficiency

- Mechanical condition of coolers and filters
- Degradation of coolers and filters
- Efficiency of auxilliaries
- Control logic

Monitoring System – Data Analysis



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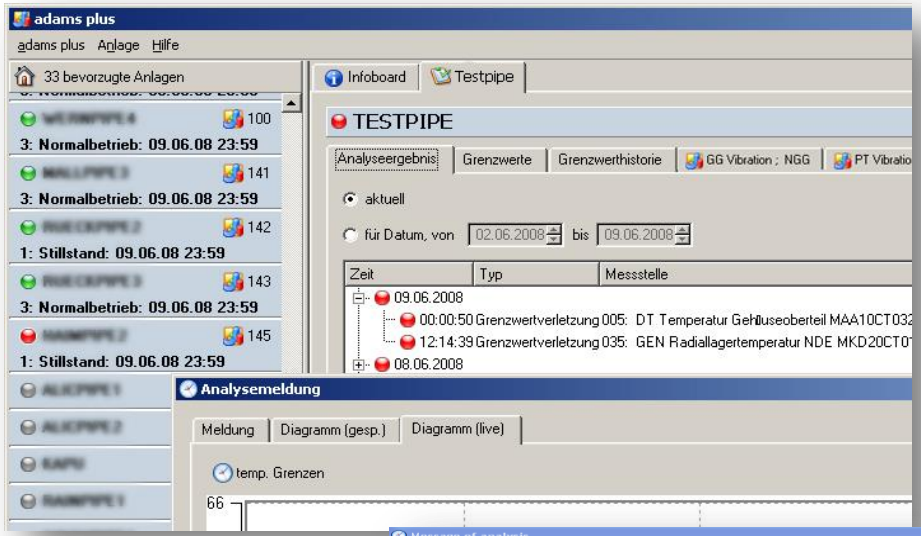
Monitoring System – Data Analysis Remote



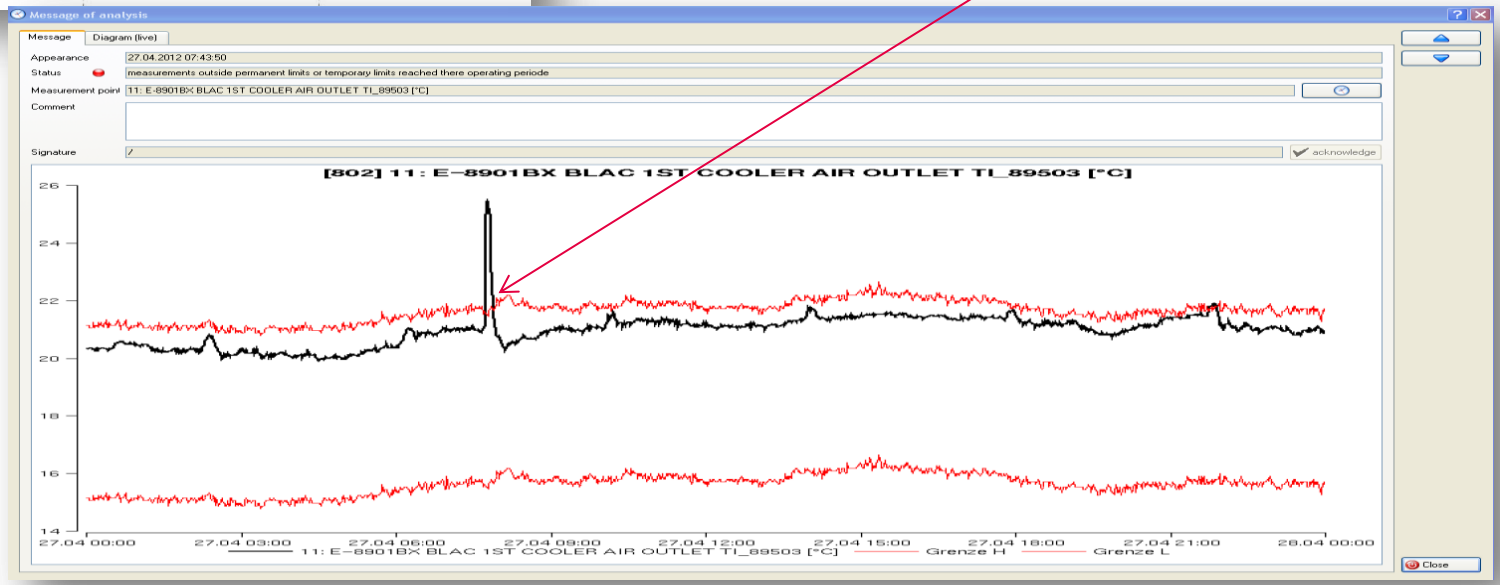
Message of limit violations to nominated PrimeServ engineer

& trending of deviations

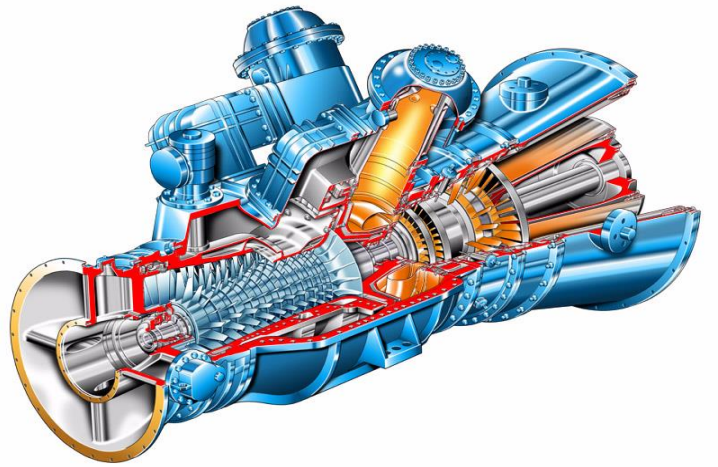
with adams plus

(automatic data analysis and message system)

Operating value exceeds dynamic limit



Monitoring System – Examples

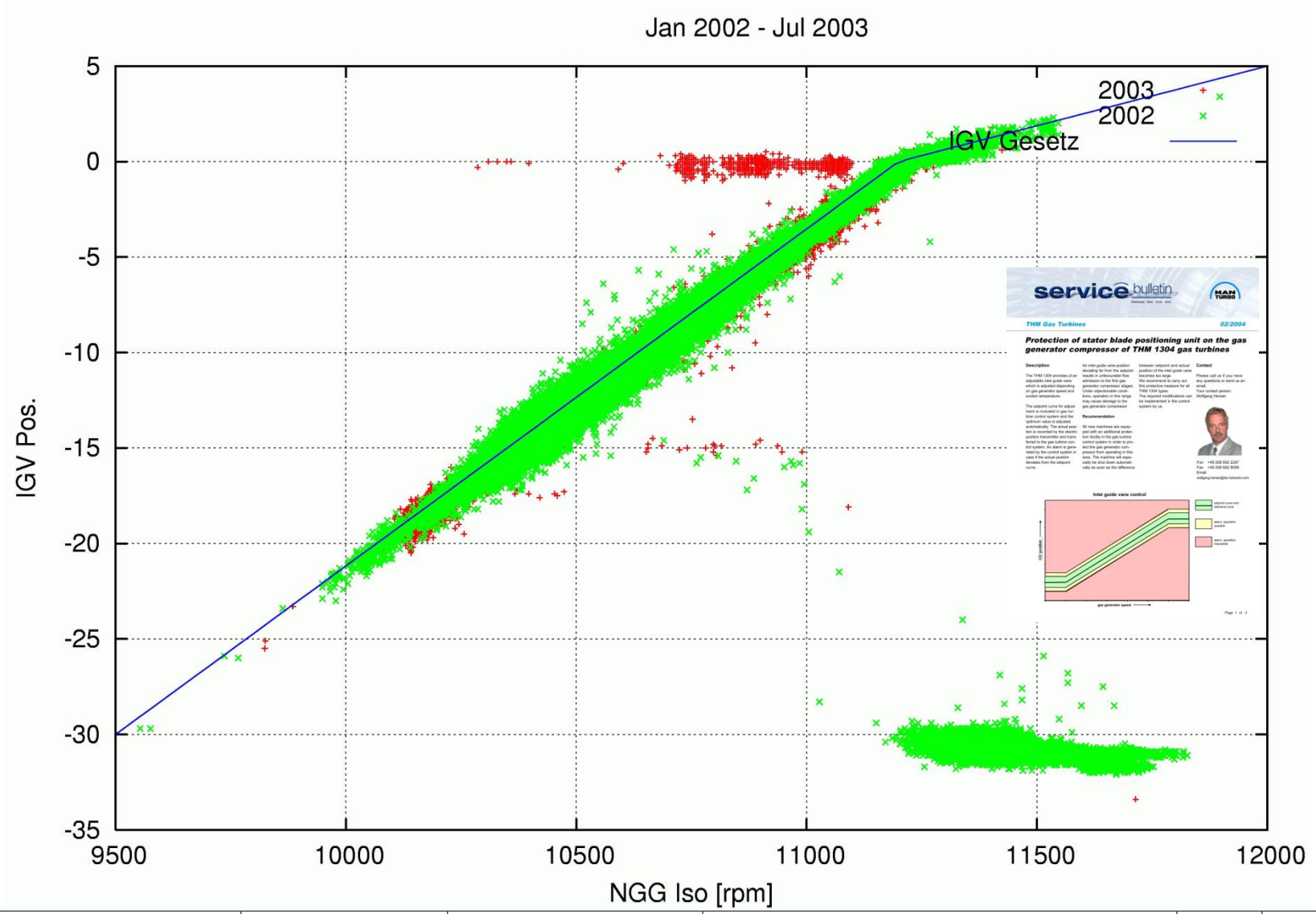


Libya 2003: Customer informs about vibration trip, site inspection reveals GG compressor damage.

Fleet: Compressor blading with more than 2 billion operating hours.

Analysis of operating data shows frequent message of GG-speed being on upper limit – unusual for this climate.

Monitoring System – Examples



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Monitoring System – Examples

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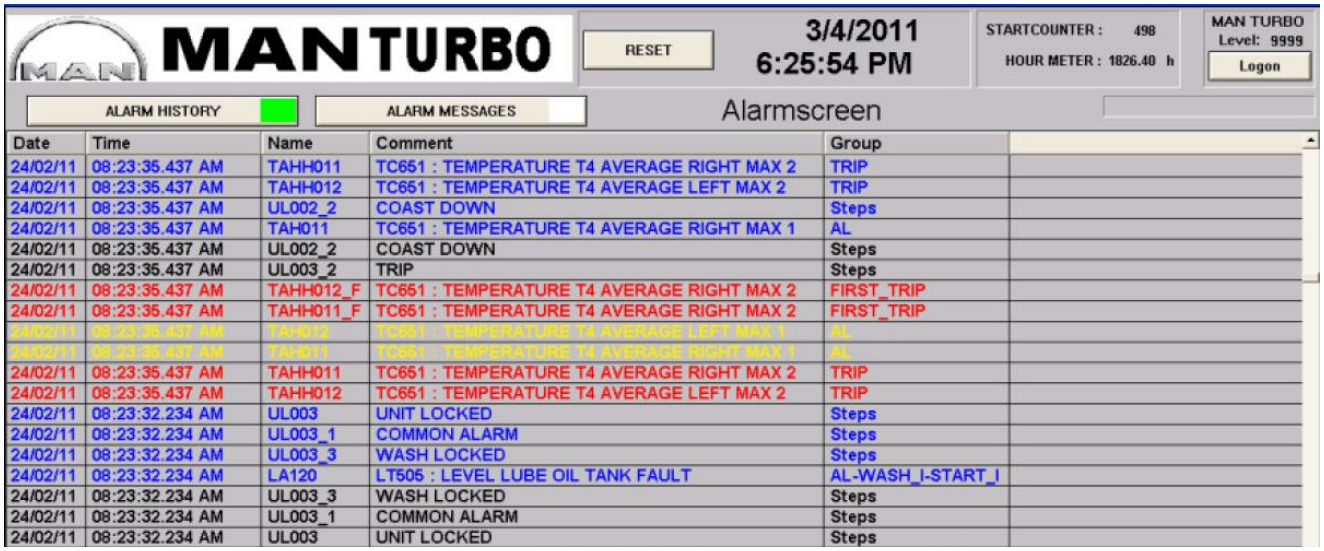
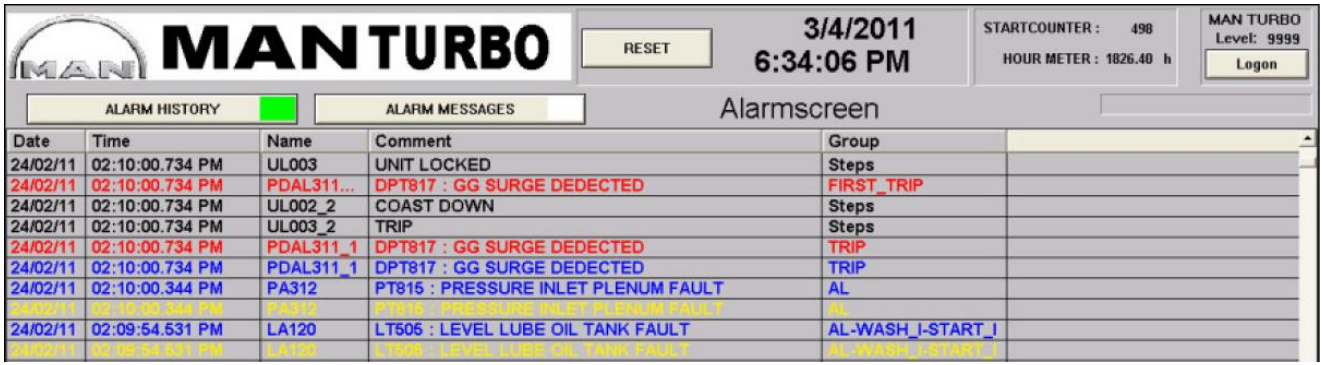


Date	Time	Name	Comment	Group
24/02/11	08:23:35.437 AM	TAHH011	TC651 : TEMPERATURE T4 AVERAGE RIGHT MAX 2	TRIP
24/02/11	08:23:35.437 AM	TAHH012	TC651 : TEMPERATURE T4 AVERAGE LEFT MAX 2	TRIP
24/02/11	08:23:35.437 AM	UL002_2	COAST DOWN	Steps
24/02/11	08:23:35.437 AM	TAH011	TC651 : TEMPERATURE T4 AVERAGE RIGHT MAX 1	AL
24/02/11	08:23:35.437 AM	UL002_2	COAST DOWN	Steps
24/02/11	08:23:35.437 AM	UL003_2	TRIP	Steps
24/02/11	08:23:35.437 AM	TAHH012_F	TC651 : TEMPERATURE T4 AVERAGE RIGHT MAX 2	FIRST_TRIP
24/02/11	08:23:35.437 AM	TAHH011_F	TC651 : TEMPERATURE T4 AVERAGE RIGHT MAX 2	FIRST_TRIP
24/02/11	08:23:35.437 AM	TAH012	TC651 : TEMPERATURE T4 AVERAGE LEFT MAX 1	AL
24/02/11	08:23:35.437 AM	TAH011	TC651 : TEMPERATURE T4 AVERAGE RIGHT MAX 1	AL
24/02/11	08:23:35.437 AM	TAHH011	TC651 : TEMPERATURE T4 AVERAGE RIGHT MAX 2	TRIP
24/02/11	08:23:35.437 AM	TAHH012	TC651 : TEMPERATURE T4 AVERAGE LEFT MAX 2	TRIP
24/02/11	08:23:32.234 AM	UL003	UNIT LOCKED	Steps
24/02/11	08:23:32.234 AM	UL003_1	COMMON ALARM	Steps
24/02/11	08:23:32.234 AM	UL003_3	WASH LOCKED	Steps
24/02/11	08:23:32.234 AM	LA120	LT505 : LEVEL LUBE OIL TANK FAULT	AL-WASH_I-START_I
24/02/11	08:23:32.234 AM	UL003_3	WASH LOCKED	Steps
24/02/11	08:23:32.234 AM	UL003_1	COMMON ALARM	Steps
24/02/11	08:23:32.234 AM	UL003	UNIT LOCKED	Steps

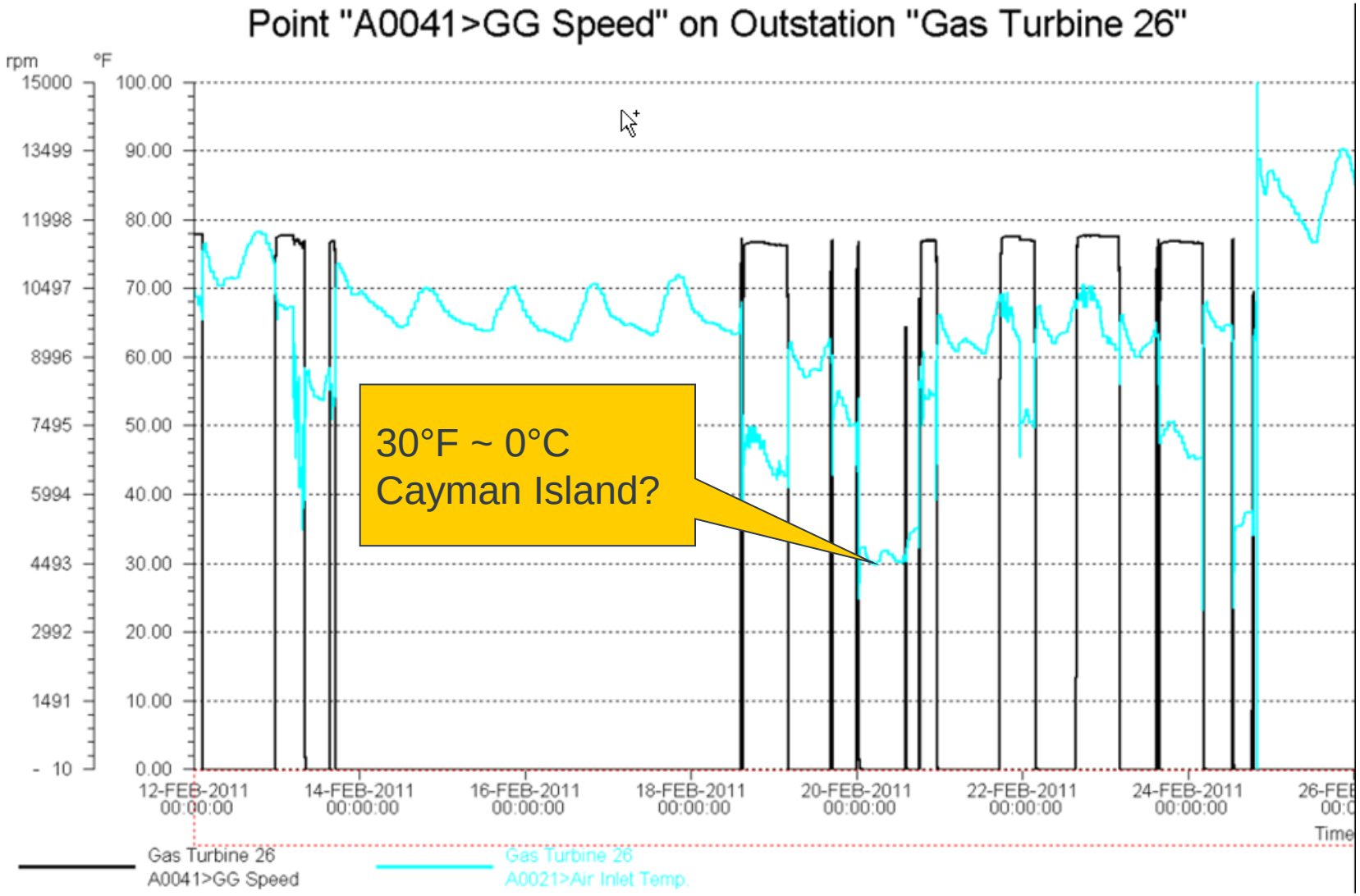


Date	Time	Name	Comment	Group
24/02/11	02:10:00.734 PM	UL003	UNIT LOCKED	Steps
24/02/11	02:10:00.734 PM	PDAL311...	DPT817 : GG SURGE DEDECTED	FIRST_TRIP
24/02/11	02:10:00.734 PM	UL002_2	COAST DOWN	Steps
24/02/11	02:10:00.734 PM	UL003_2	TRIP	Steps
24/02/11	02:10:00.734 PM	PDAL311_1	DPT817 : GG SURGE DEDECTED	TRIP
24/02/11	02:10:00.734 PM	PDAL311_1	DPT817 : GG SURGE DEDECTED	TRIP
24/02/11	02:10:00.344 PM	PA312	PT815 : PRESSURE INLET PLENUM FAULT	AL
24/02/11	02:10:00.344 PM	PA312	PT815 : PRESSURE INLET PLENUM FAULT	AL
24/02/11	02:09:54.531 PM	LA120	LT505 : LEVEL LUBE OIL TANK FAULT	AL-WASH_I-START_I
24/02/11	02:09:54.531 PM	LA120	LT505 : LEVEL LUBE OIL TANK FAULT	AL-WASH_I-START_I

Gas Turbine (peaking genset) trips via surge detection or overtemperature.

Data conncection not available => 2 engineers fly out.

Monitoring System – Examples



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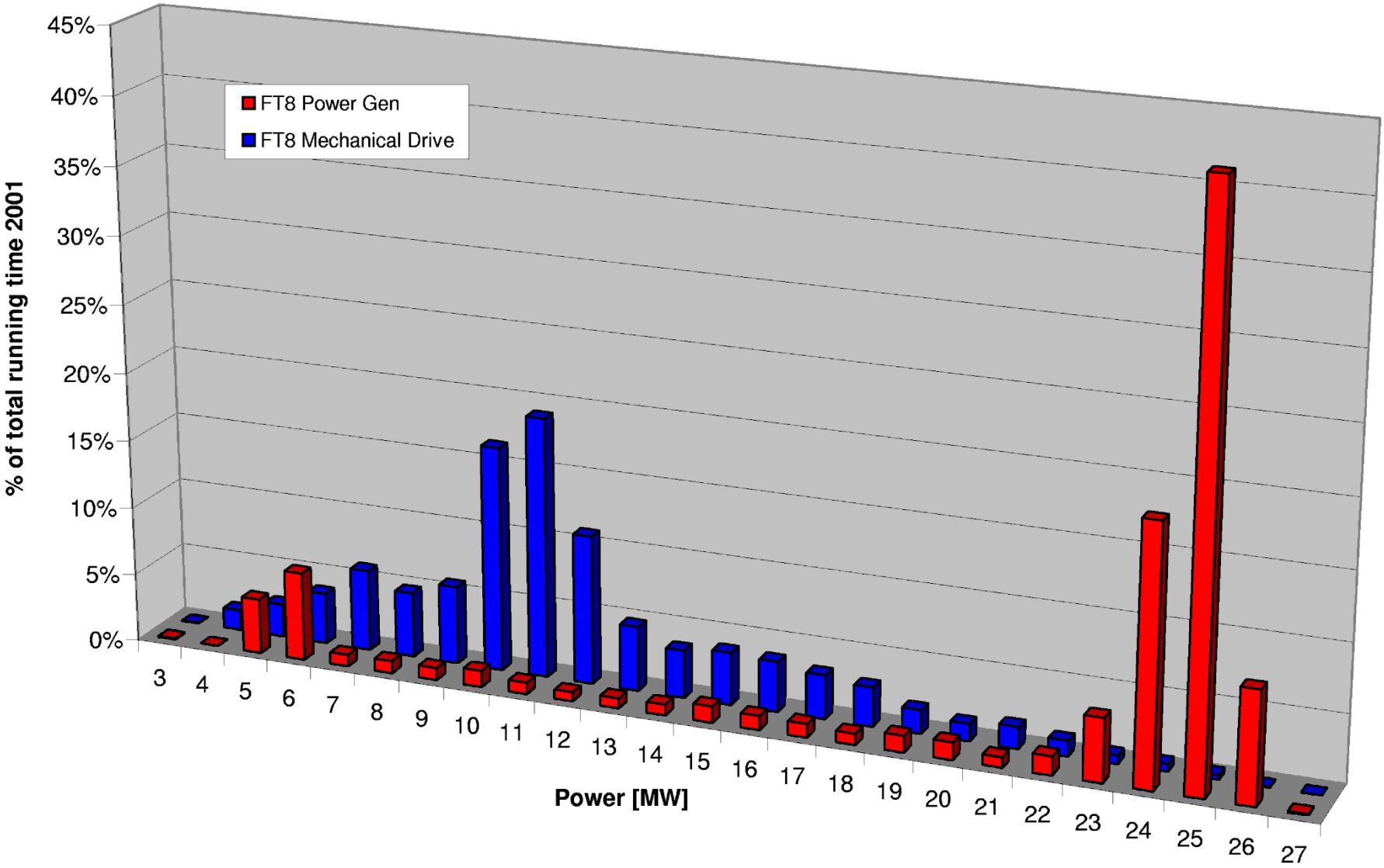
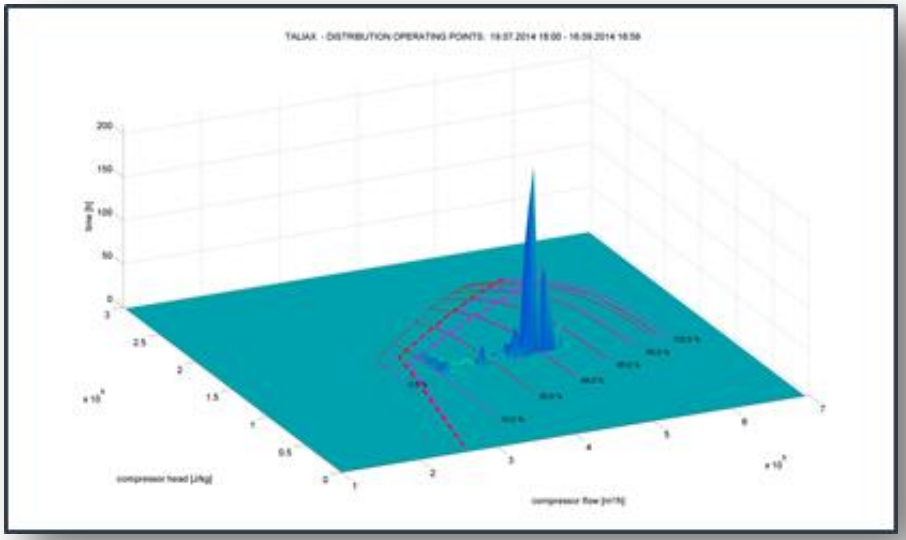
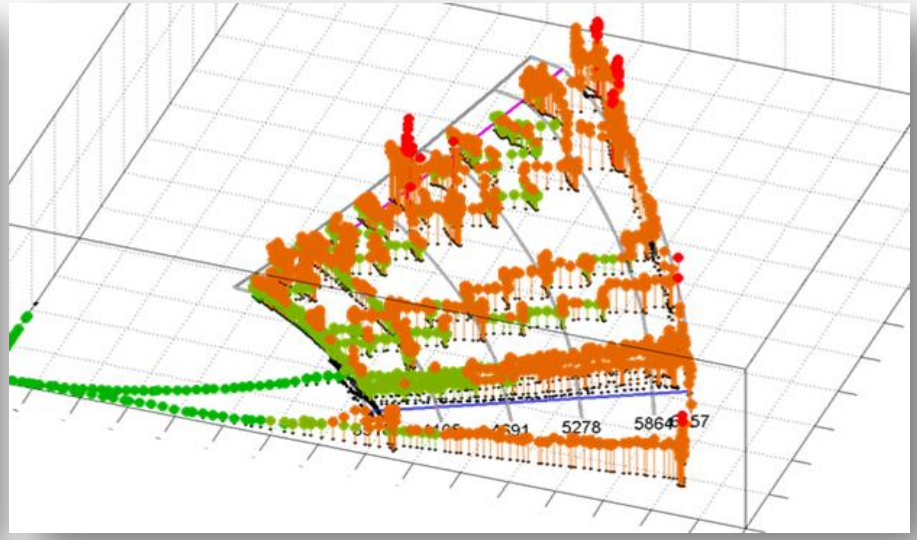
Monitoring System – Examples



Monitoring System – Examples

Enhanced analysis with further tools





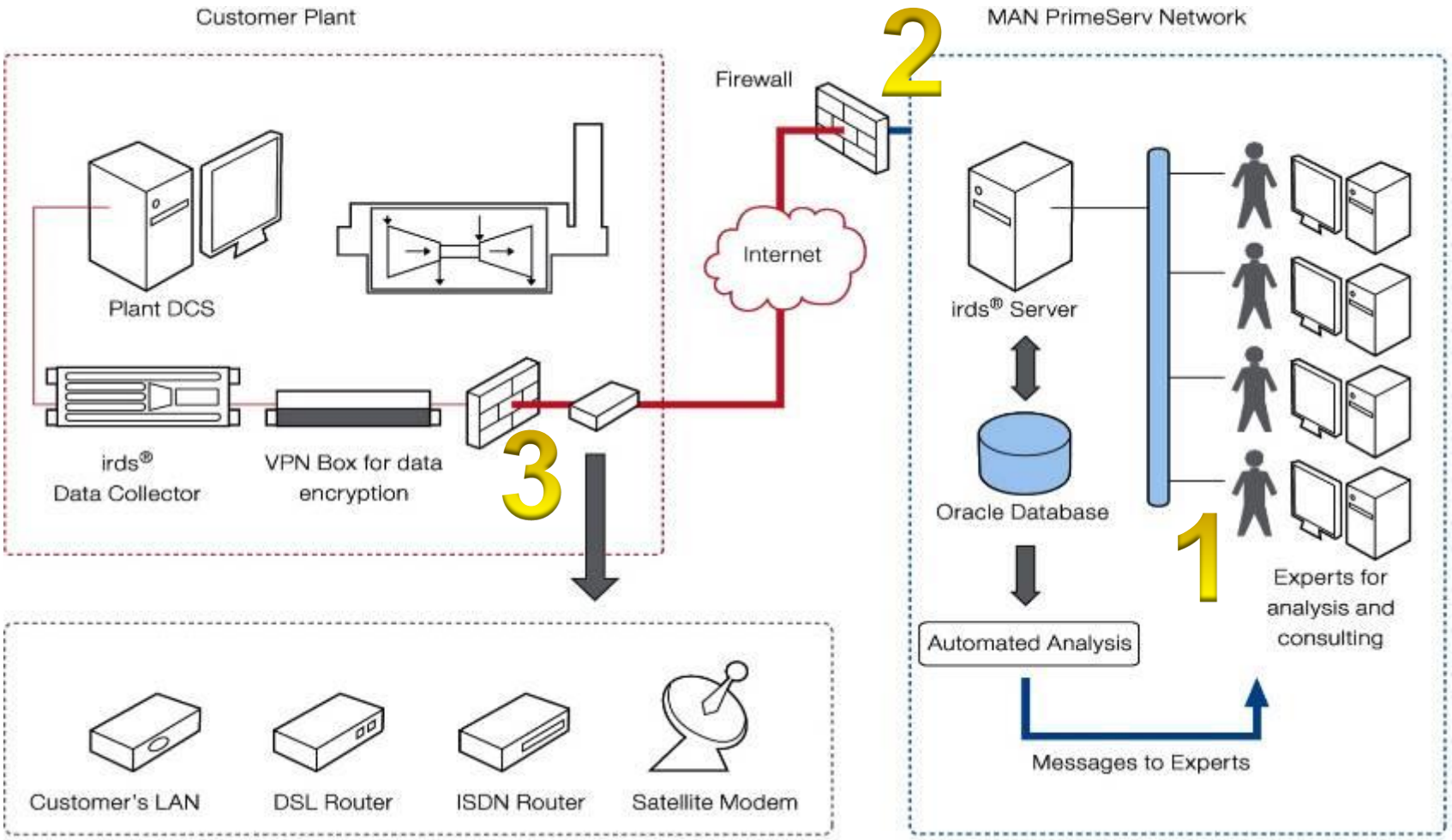
statistical analysis:

rate of operating time within curve

analysis of properties:

efficiency, vibration, etc. versus curve

Monitoring System – Overview & Areas of Development

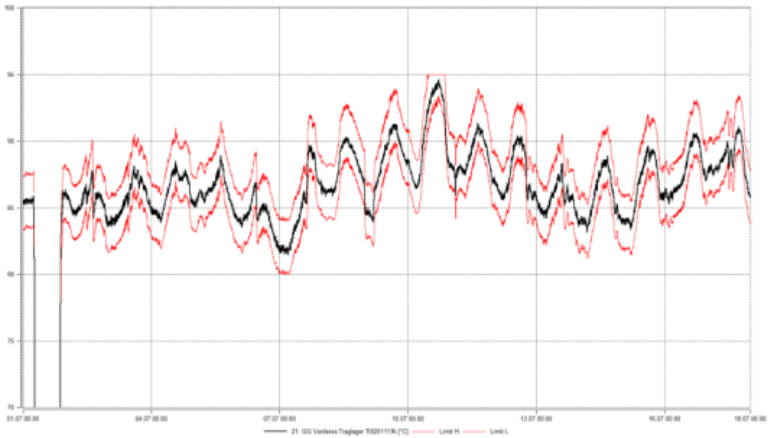


Source: PrimeServ Turbo project team

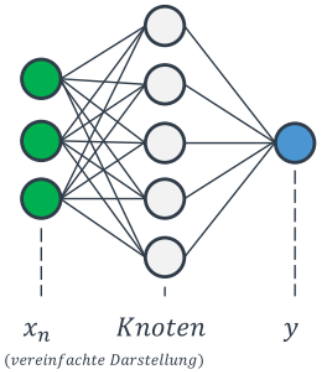
Current developments – 1 – Improving Monitoring

Dynamic Limits currently:

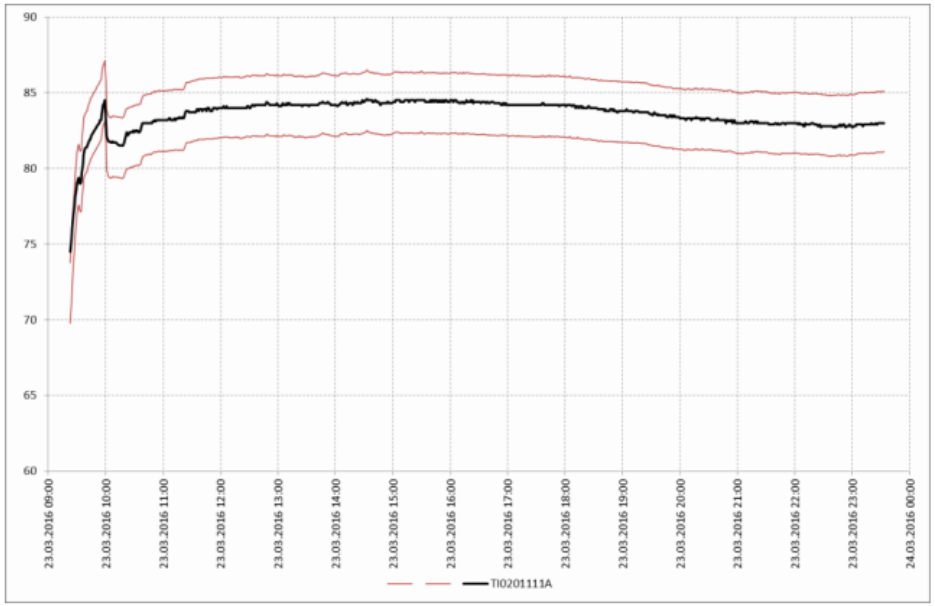
$$S = \sum_{i=1}^{n} (a \cdot x_i + b \cdot y_i + c \cdot x_i y_i + d - z_i)^2 = 0$$



Neural Networks:



$$y = \bar{B} \cdot \tanh\left(\bar{A} \cdot \vec{x} + \vec{b}\right) + \vec{c}$$



Current developments – 2 – Always the Server?

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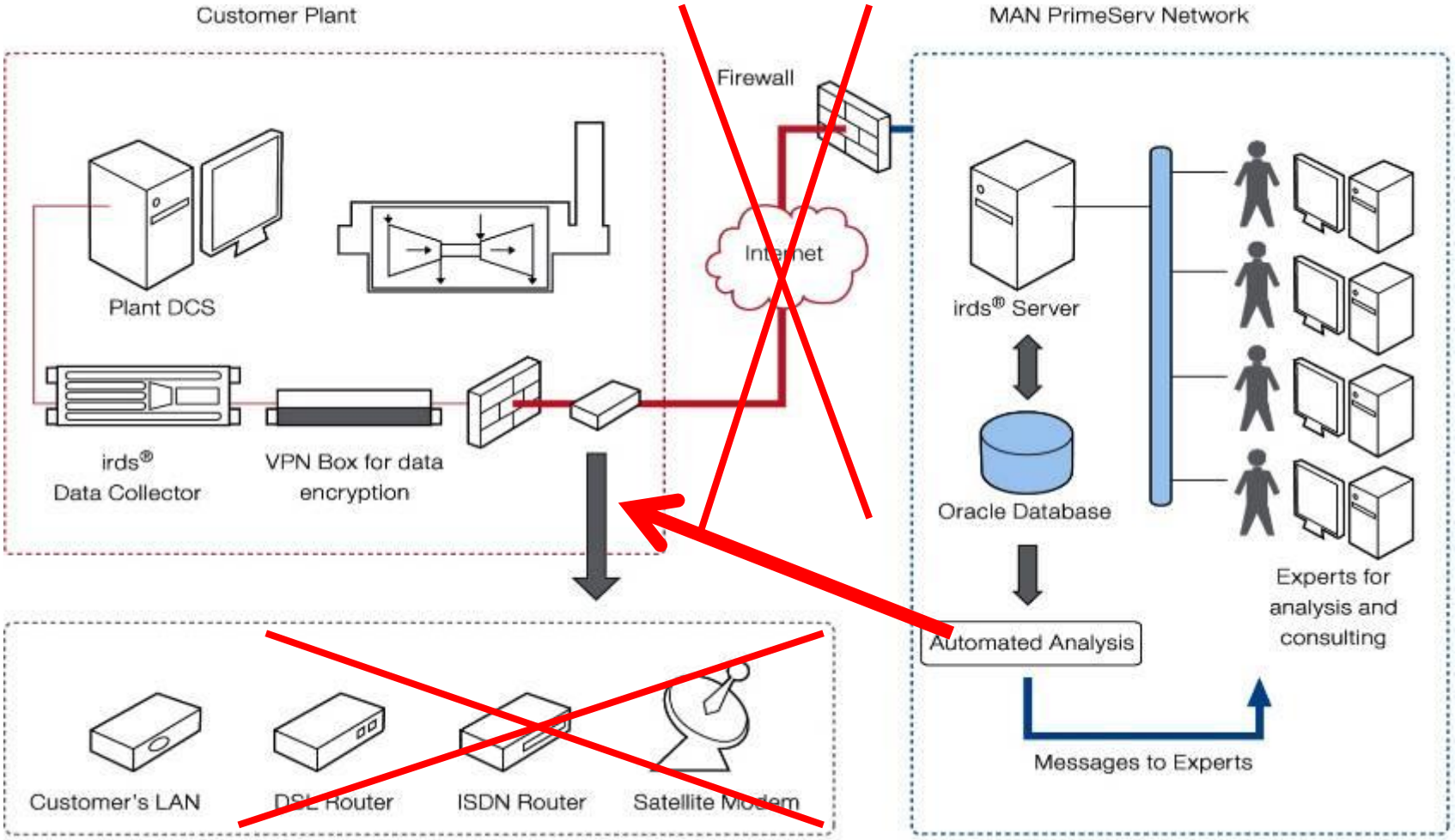
Current developments – 3 – No Data Outside



Summary

1. The installation of a data collecting system saves more than it costs. This is why MAN Diesel & Turbo does it since 1999 for all gas turbines.
2. Flexibility is key, gas turbine & driven machine may be only part of an installation.
3. In our experience, central analysis is a “must have” but analysis capabilities will have to be expanded for direct at site availability.

All data provided in this document is non-binding.

This data serves informational purposes only and is especially not guaranteed in any way. Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.

Thank You For Your Attention