Maintenance and Diagnostics of GT’s

27/03/2018 Giacomo Tirone

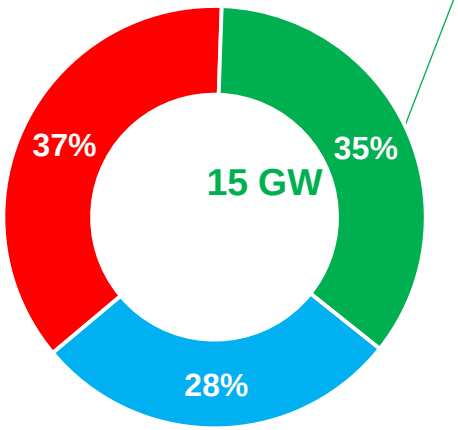
Outline

- Presentation of Enel Fleet
- Hystoric Overview of Enel strategies
- Standardized approach to maintenance
- Organization of Maintenance Service
- Internal Capabilities and Know How
- Examples of On-Condition Maintenance
- Transition to Advanced Monitoring and Diagnostics
- Examples of Advanced M&D capabilities

Enel CCGT Fleet

Key elements(1)

Installed Capacity



Net Generation

38 TWh

Power Plants

24

	# PPs*	# BLOCK	Installed Capacity [GW]	Net Generation [TWh]
Baseload	9	10	4,4	24,8
Intermediate – Peak Load	18	28	11,1	12,9

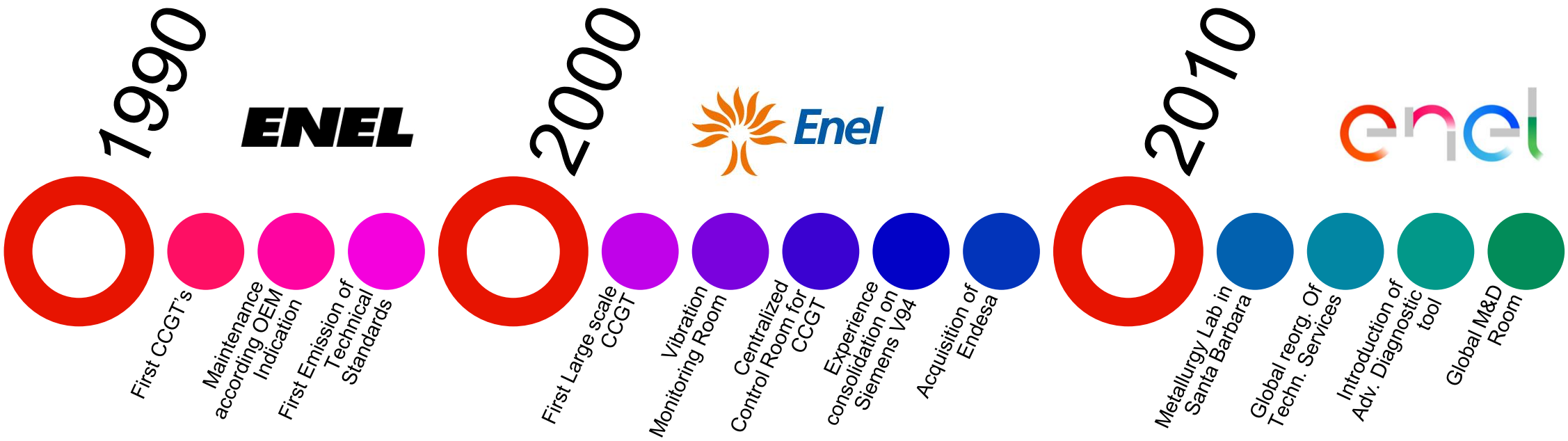
VENTANILLA

- » **Baseload**
- » **#1 unit, 470 MW**
- » **51% efficiency**
- » **90% avalaibility**

(1) FCST 2016

* Plants that belong to two or more load service units are counted one for each load service cluster

Evolution of Enel GT Maintenance



Enel GT Maintenance approach

The standardized approach to maintenance

Basic Principle

- Standardize frequency and scope of Maintenance in GT
- Standardize inspection and checks during overhauls

Drivers

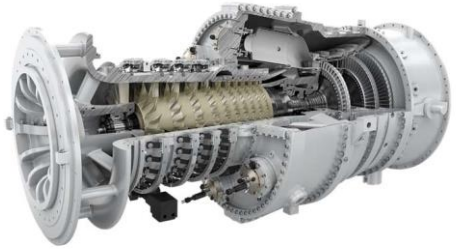
- Operating hours and startups (EOH)
- Company experience in machines operation
- Evidences from Operation, past maintenances and inspections
- Evidences from Online Diagnostic Tools

Typical Intervals

- Combustion inspection: 8.000 EOH
- Hot Gas Path Inspection: 25.000 EOH
- Major Inspection: 50.000 EOH

Organization of Maintenance Activities

Power Plant



- Management of Operation & Maintenance
- Management of Health, Safety and Environment issues

Local Units

HSEQ

- Implementation of Quality in Maintenance
- Support to safety in outages

Global M&D Room

- Management of predictive diagnostics

Centralized service Units

Technical Support

- Inspections and on line monitoring
- Technical Guidelines
- Machine Know how

Global TL

- Recirculation of Experiences
- Maintenance Monitoring at global level

OPO

- Optimization of Supply/Services strategies
- Strategic spare parts management

In House Capabilities

Examples of internal know how

Vibration Monitoring Center

NDT

Boresonic Inspections

Metallurgy Lab

Maintenance Engineering

Global M&D Room

Engineering & Construction

Unmanned Vehicles

Example of On-Condition Maintenance

TI22 Failure

Event

Unit Trip due to high unbalance in outlet temperature

Sequence of Events

- Unit trip
- Preliminary inspection from outlet duct
- Boroscopy

Actions

- Machine Opening
- Extended fact finding
- Replacement of several components

Root Cause

- Pressure pulsation (humming) damaged a flame tube
- Unwanted air flow into the CC caused improper flame development
- Damages to the adjacent burners
- High humming operation damaged several other components

Lesson Learned

Improving Humming monitoring is crucial for machine safety

Example of On-Condition Maintenance

PG22 Failure

Event

Unit Trip due to high vibration

Sequence of Events

- End of MO with rotor RI/RO
- First variation of vibration behavior after restart
- Second step variation of vibrations after 8 months
- Third event of step variation after 6 days
- Stop of the unit for further investigation

Actions

- Boroscopy
- Machine Reopening
- Rotor Replacement

Root Cause

2nd Turbine disc damage with material detachment

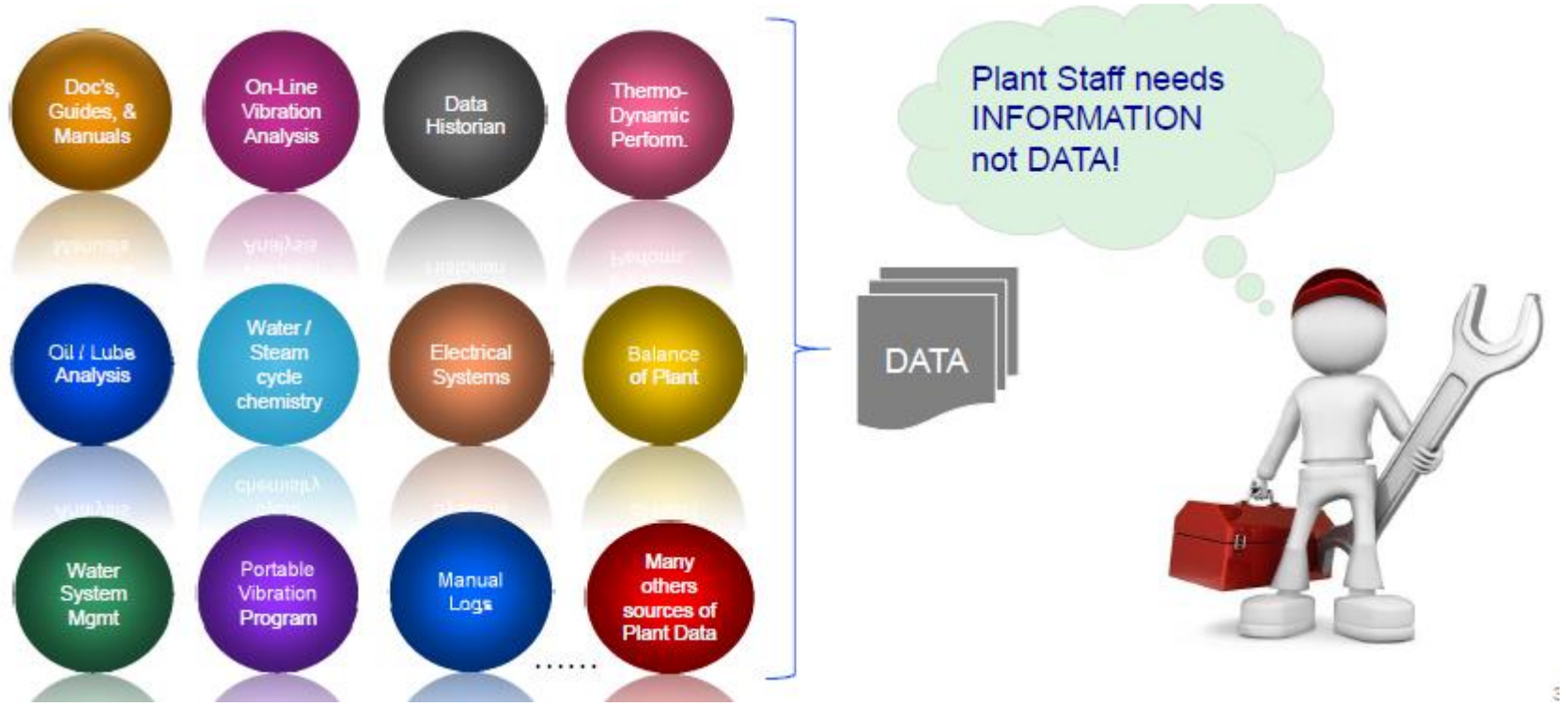
Lesson Learned

A proper vibration monitoring really helps in preventing catastrophic failures

Transition to Advanced M&D

As Control Systems and IT System evolve, more and more data are available.

- More data doesn't mean more Information



M&D: From Data to Information

Data + Knowledge = Information

Data collection

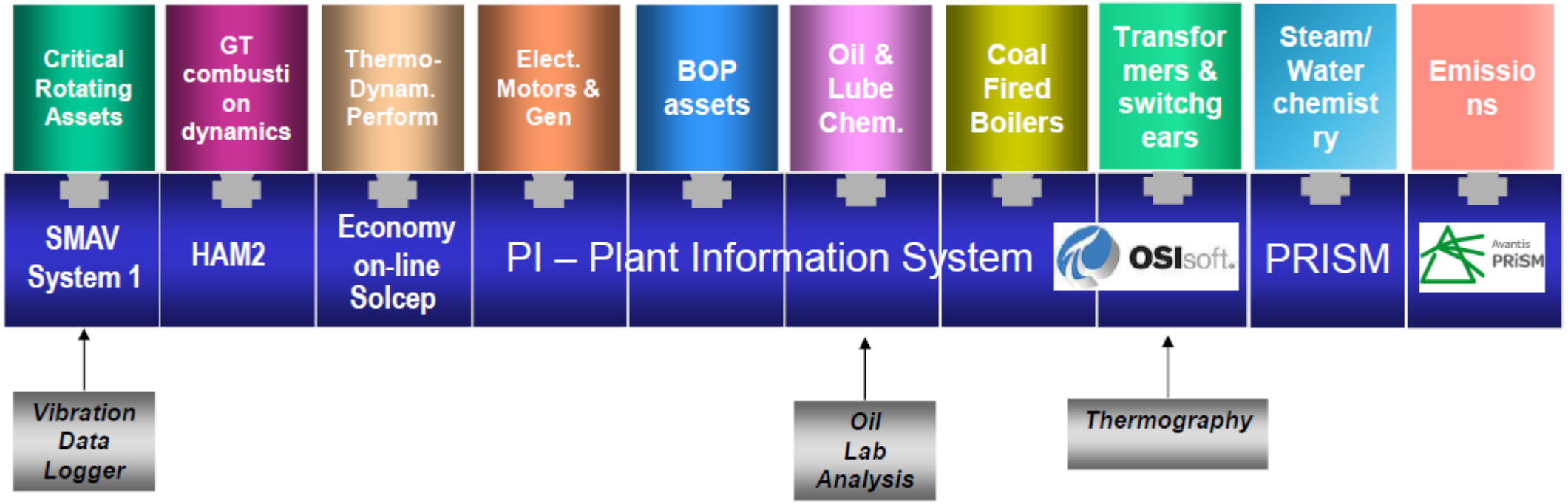
Data fusión and validation

Data analisis and alarming

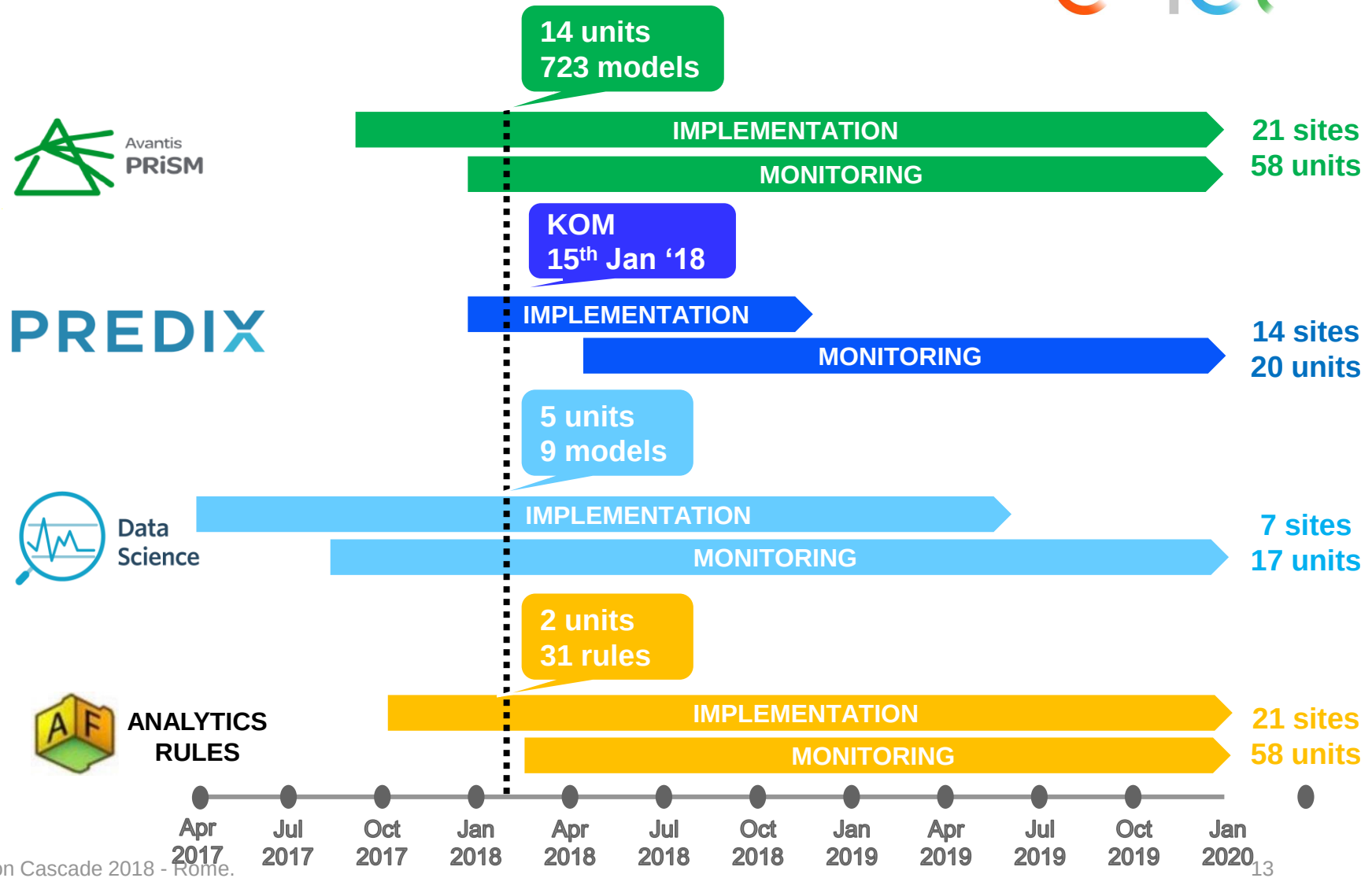
Actionable information and O&M recomendations

- Severity 0 (normal)
- Severity 1
- Severity 2
- Severity 3
- Severity 4 (danger)

Enel State of the art on M&D

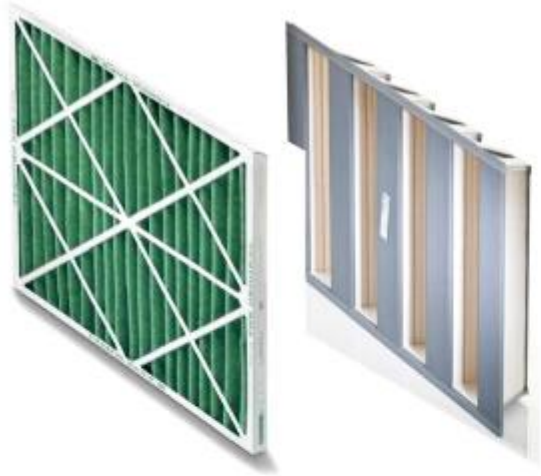


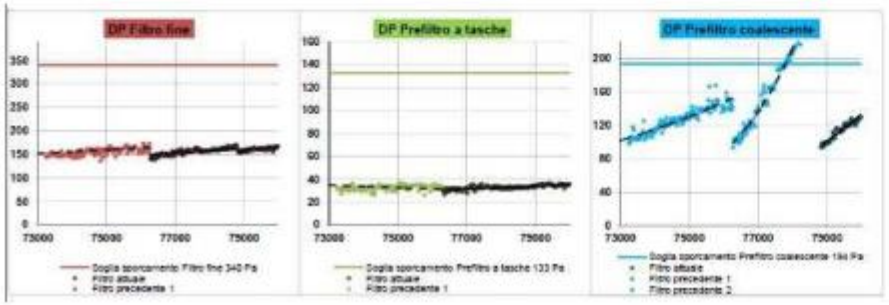
Advanced M&D Deployment plan



@2020
~ 70.000 tag
~ 3.700 models
~ 1.200 equipment

Advanced M&D examples





Preventive maintenance based on operational hours (4.000 for filters and 2.000 for pre-filters)

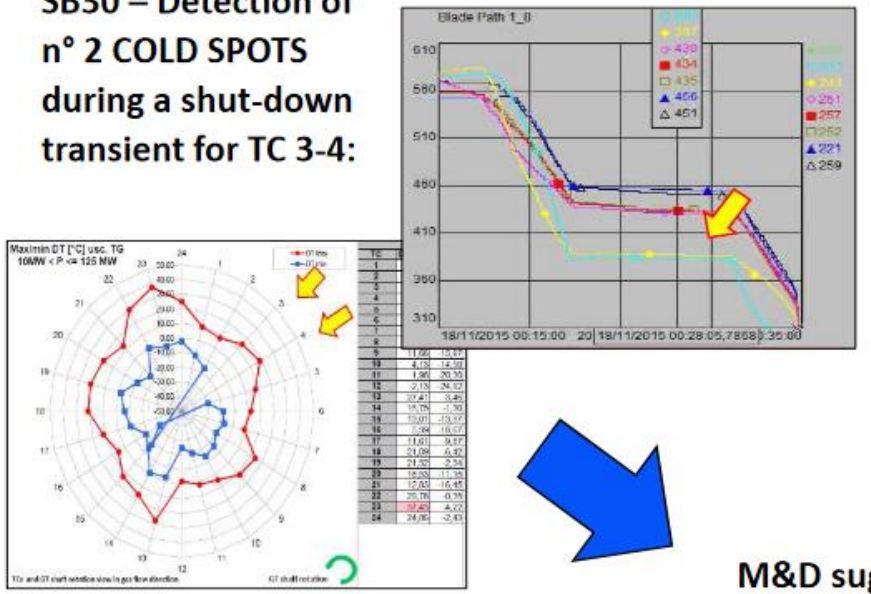
Optimization of their replacement with an economic balance between maintenance costs and gas turbine heat rate.

With these new approach we have doubled the life of the filters.

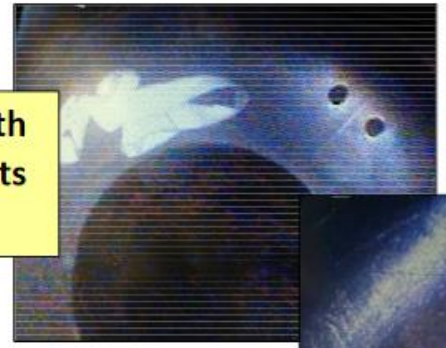
Advanced M&D examples

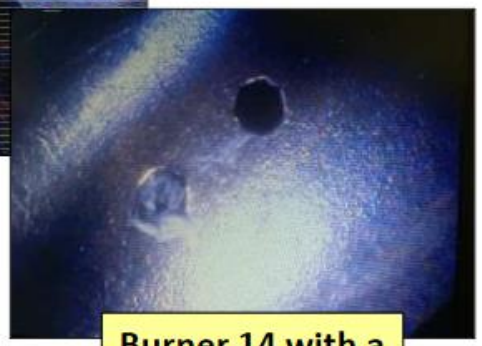
HAM2: Humming analysis to diagnose GT

SB30 – Detection of n° 2 COLD SPOTS during a shut-down transient for TC 3-4:



Burner 13 with foreign objects inside





Burner 14 with a clogged hole

M&D suggestion to Santa Barbara PP to check burners n° 12-13-14

Advanced M&D example

Training result of Machine Learning

DETECTION TEST

Prism model built internally (INN+M&D) using pump historical data *(considering 2015 operation):*

First model warnings since Jan'16

REAL EVENT

Circulation water pump TVN 3 showed flow rate problems:

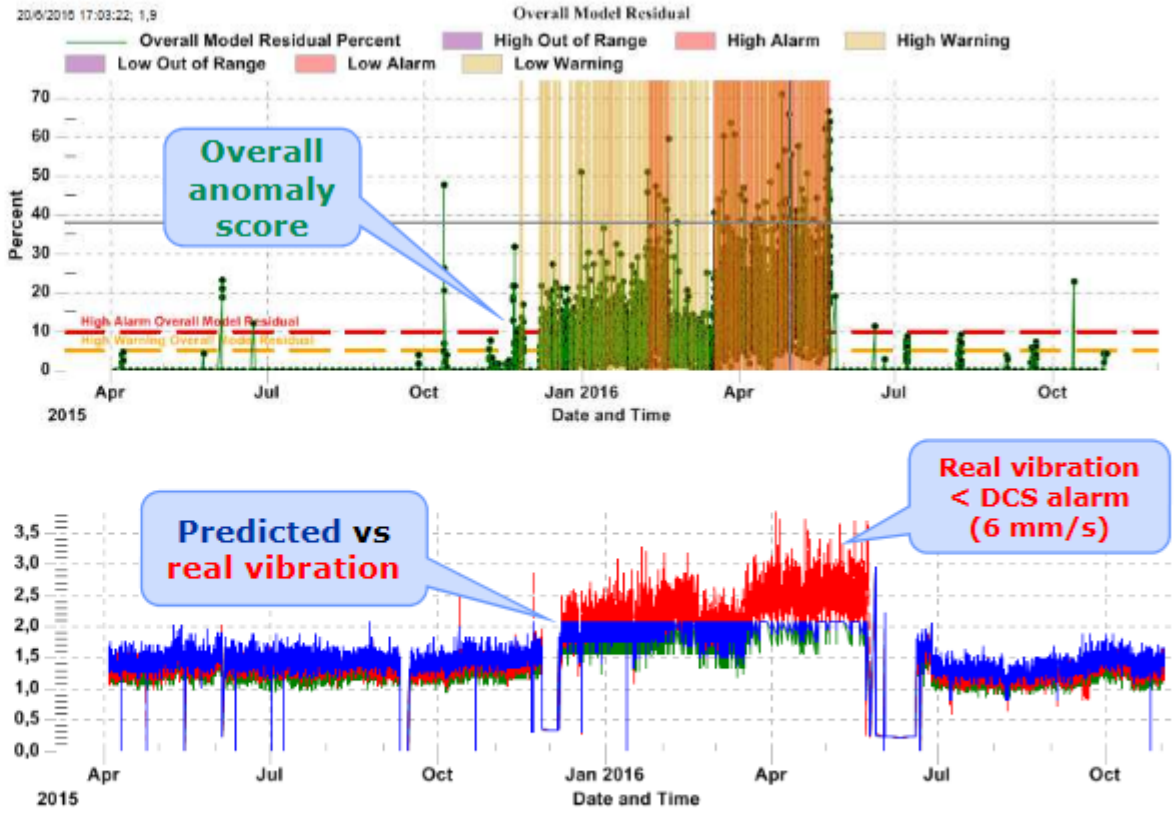
Partial unavailability: 27/5 to 18/6

IMPACT

TVN 3 Unit load limited at 530 MW:

Lost Margin ~ 350 k€

The early warning about pump status would have led to the identification and solution of the problem before the forced derating



Model showed continuative warnings from Jan'16 and alarms from Mar'16

Conclusion

- A more competitive market requires operators to **optimize all parts of the process**
- Keeping **operational excellence** inside organization is a key point
- Relationship with suppliers is necessary, but a strong know helps
- The new opportunities from **digitalization and data** exploitation open new opportunities
- In the next future Operational Excellence will also pas through a deep knowledge of advanced M&D tools

Thank you