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Predictive On-Line Monitoring of Cogeneration Plants

AVEVA World, San Francisco 2022

Vance Seeley, P.Eng
Dr. David Smith

Speaker Introduction

Vance Seeley, P.Eng, Senior Analyst, APM Specialist, Canada:

Mr. Seeley is a Mechanical Engineer with over fifteen years of direct experience in the Power Generation industry. He has worked with many forms of generation including Cogeneration, Thermal, Hydro, and Wind.

He is the Cogeneration Specialist in Suncor's remote monitoring and advanced analytics team where he supports over 2,000MW of generation.

Dr. David Smith, Senior Analytical Solutions Engineer, AI Center of Excellence, United Kingdom:

Dr. Smith is a Chartered Mechanical Engineer and holds a Ph.D. in Fluid Mechanics from Imperial College London. Until 2018 he worked in the industry mainly for EPC companies, leading design, development, and commissioning of Power Plant processes and combustion systems.

Moving to AVEVA, Dr. Smith joined the AI Center of Excellence where his main activities are the integration of AI technologies with AVEVA's first principles simulation products as well as being an SME for Power.

Suncor Energy
An overview

SUNCOR

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SAN FRANCISCO 2022

- A globally competitive integrated energy company with a team of over 30,000 people, headquartered in Calgary, Alberta, Canada.
- Our operations include oil sands development, production and upgrading; offshore oil and gas; petroleum refining in Canada and the US; and our national Petro-Canada™ retail distribution network (now including our Electric Highway network of fast-charging EV stations).
- We care about responsibly developing our petroleum resources, while profitably growing a renewable energy portfolio and advancing the transition to a low-emissions future.

To provide trusted energy that enhances people's lives, while caring for each other and the earth.

Asset Performance Management
Remote Monitoring, Advanced Analytics, & Remote Monitoring
(APM RAW)

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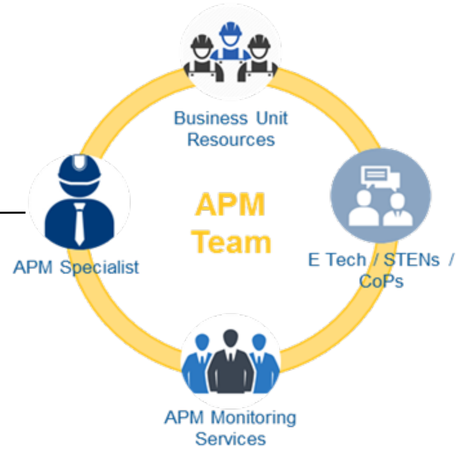
APM (RAW) Overview

Asset Performance Management (APM) (RAW) is part of the overall Reliability Enablement journey. It leverages **R**emote monitoring, **A**dvanced analytics, and a collaborative **W**orkflow (RAW) to enable predictive asset maintenance and identification of risks to future asset performance.

Once analytical models are developed and deployed, the **APM Specialists** monitor these models and work with sites to triage, investigate and action any advanced alerts.



Working as a collaborative unit, the APM Team will monitor Suncor's assets, focusing on the window of 6 weeks and out

Benefits

Time to Plan	Damage Reduction	Asset Strategy Optimization	Institutionalized Knowledge	Collaborative Work Environment
Reduce LOV, reduce planned maintenance costs	*Catch anomalies before secondary damage occurs*	*Do the right work at the right time via early detection*	*Shared learning and centralized expertise across the enterprise*	*Access to expertise (i.e. STENs, Enterprise Tech etc.)*

Asset Performance Management – “RAW” Explained

The **R**emote monitoring, **A**dvanced analytics, and collaborative **W**orkflow (RAW) components of the APM program ***enable*** predictive asset maintenance and identification of risks to future asset performance

*R*emote monitoring

- **Enterprise APM IOC with Functional Specialists**
- **Improved Connectivity to Stranded Field Data**
- **New APM Sensor Deployment**
- **Enterprise Software and APM Data Centralization**

*A*nalytics

Diagnostics/Predictive Analytics | *Performance Models*

Single Variable

D — Rules-Based Diagnostics

- Instrumentation AMS Analytics
- Asset Run-Time Tracking
- PeakVue Vibration Diagnostics
- T&D Asset Health Index

A — Principle Performance Models

- Pump Head / Efficiency Ratio
- Compressor Polytropic Efficiency
- Exchanger HTC / Fouling Factor
- Ctrl Valve Cv Ratio, etc.

Multi-Variable

B — APM Data Analytics

- Machine Learning / Anomaly Detection
- End of Run / Life Prediction
- T&D Dynamic Health Index

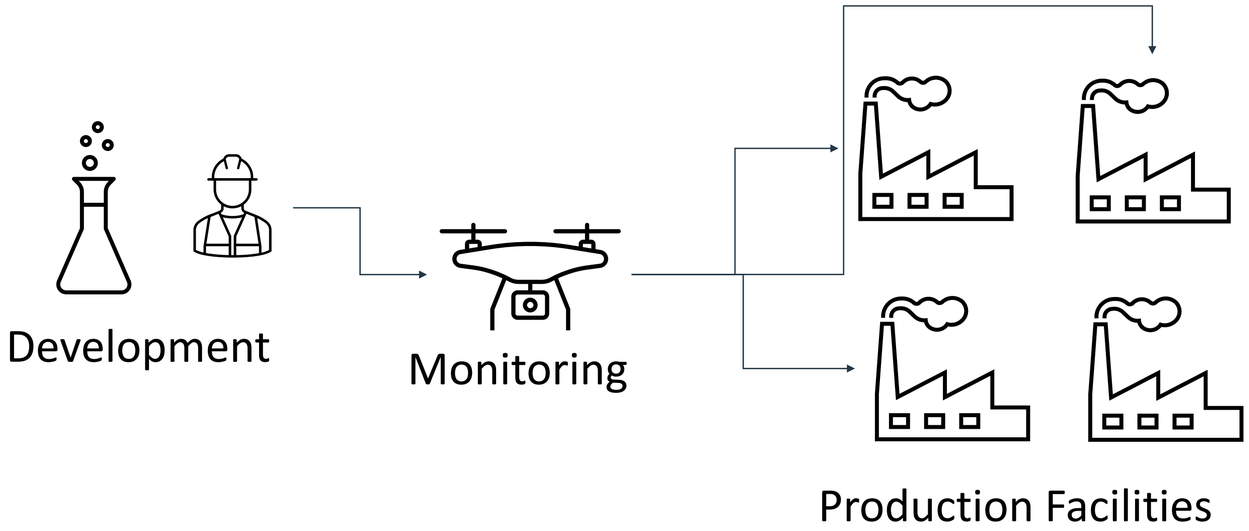
C — System Performance Models

- Power Generation Forecasting
- Heat Integration Optimization
- Asset/System Impact Simulation

*W*orkflow

- **Proactive Health Case Management**
- **SME Support Integrated with Site Way of Working**
- **Situational Awareness Dashboards**
- **Asset Strategy Optimization**

Centralized Monitoring Team



Monitoring team consists of:

- (4) Rotation Specialists
- (1) Cogeneration Specialist
- (1) Process Specialist
- (1) Instrumentation Specialist

Multiple software platforms

AVEVA Process Optimization

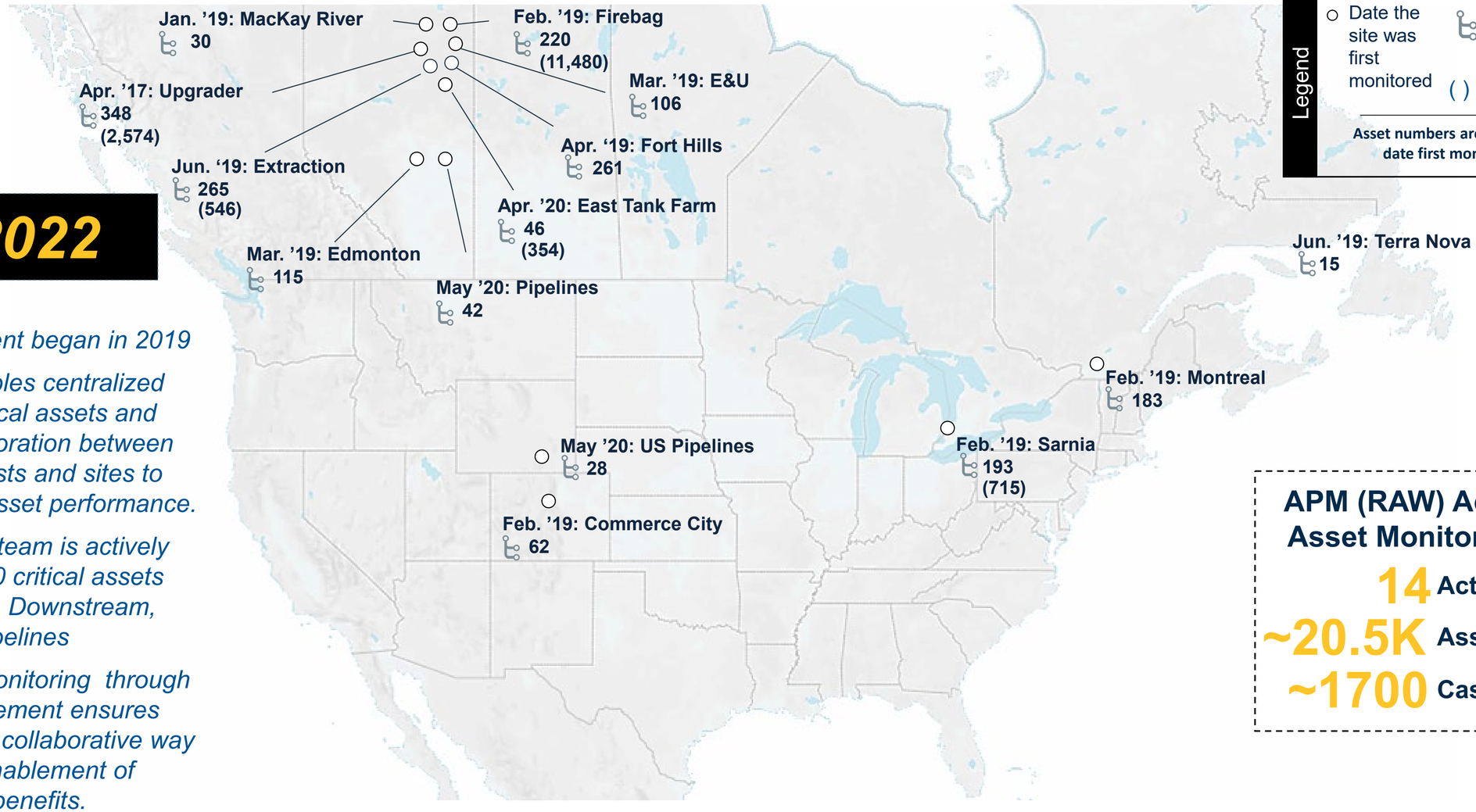
Asset Framework

AVEVA™ PI Vision™

AVEVA™ Predictive Analytics

APM (RAW) Deployments and Monitoring

The APM (RAW) program has expanded its asset monitoring capabilities across the enterprise and is currently active at 14 sites ***optimizing overall asset performance*** management



July 2022

- *Model development began in 2019*
- *APM (RAW) enables centralized monitoring of critical assets and enhanced collaboration between the APM Specialists and sites to improve overall asset performance.*
- *The APM (RAW) team is actively monitoring 20,500 critical assets across Oil Sands, Downstream, ETF, E&P and Pipelines*
- *Deployment of monitoring through active site engagement ensures alignment, a new collaborative way of working and enablement of transformational benefits.*

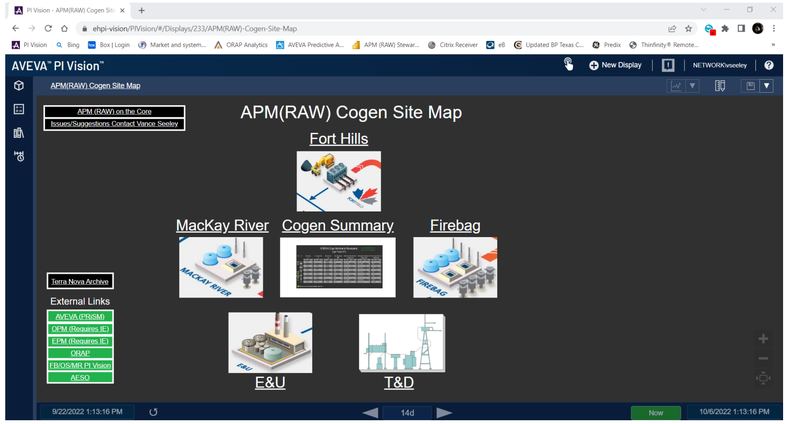
APM (RAW) Active Asset Monitoring:

14 Active sites

~20.5K Assets

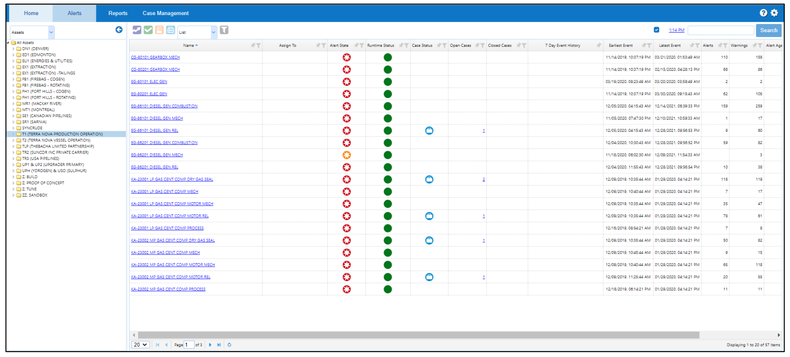
~1700 Cases

Predictive Asset Optimization with AVEVA



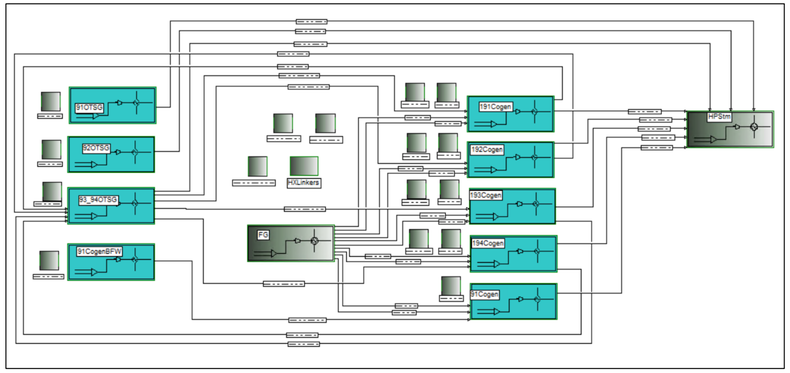
PI Vision & Asset Framework

- Digital Twin with AF Templates
- Provides dashboards & Adhoc Analysis
- KPI Calculated in Real Time



AVEVA Predictive Analytics (PRiSM)

- Anomaly Detection with Machine Learning
- Improve Reliability and Reduce Maintenance



AVEVA Process Optimizer (ROMeo)

- Process Simulation and Optimization
- Equipment Condition Monitoring
- Soft Sensors

Benchmarking Gas Turbine Performance with Predictive Analytics

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Problem Statement

Gas Turbine Performance Degradation

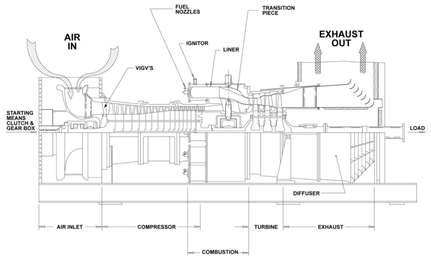
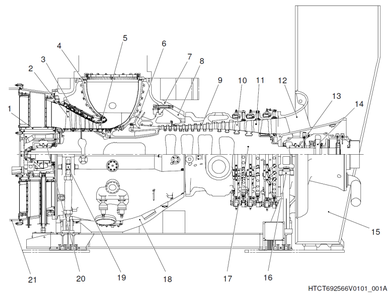


Figure 3. Major Sections of the MS– 7001 Gas Turbine Assembly.

Firebag GT7 Frame 7 GT

PGT: 2007



E&U Frame 11 GT

GT5 PGT: 2000

GT6 PGT: 2000

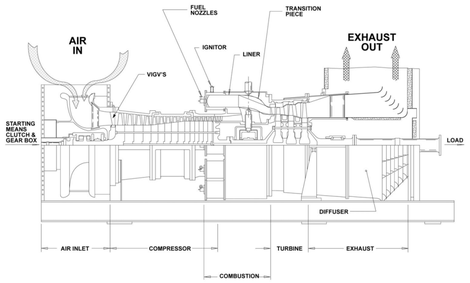


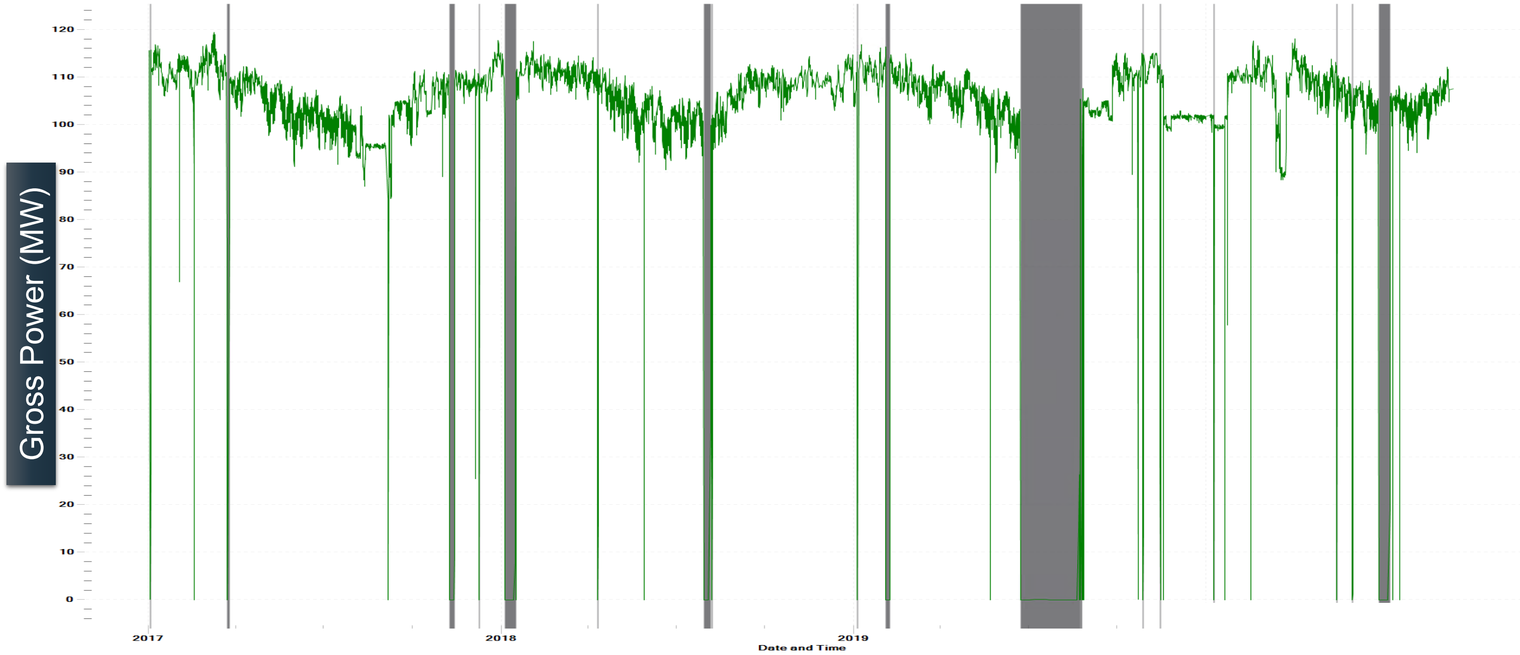
Figure 3. Major Sections of the MS– 7001 Gas Turbine Assembly.

Fort Hills Frame 7 GT

GT 1 PGT: 2017

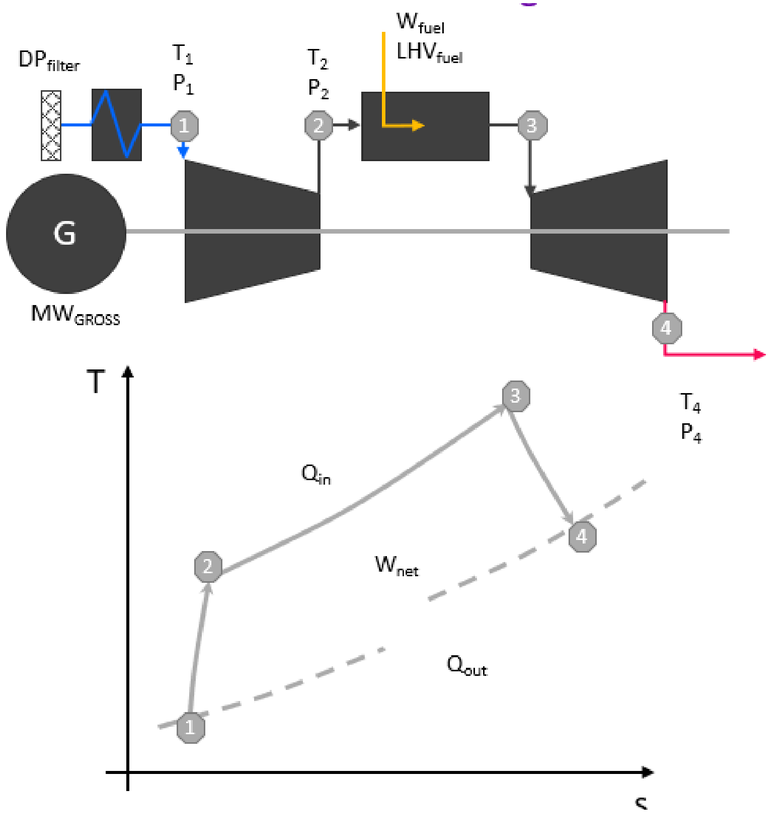
GT 2 PGT: 2017

- Degradation monitoring of gas turbine performance allows Suncor to guide operational time and risk based decisions about routine or emergency maintenance and evaluate the performance / economic benefit of maintenance and upgrades once it is completed.
- Isolation of degradation is challenging due to continuous and large operating point changes; both external (ambient pressure, temperature and humidity) and imposed (load point and inlet heating for example).
- We want a combined first principles and machine learning PAO approach to be able to give accurate measurement of performance degradation.



Gas Turbine Degradation

First Principles Based KPIs



- Power Output
- Heat Rate
- Compressor Efficiency
- Compressor Pressure Ratio
- Turbine Efficiency
- Exhaust Temperature

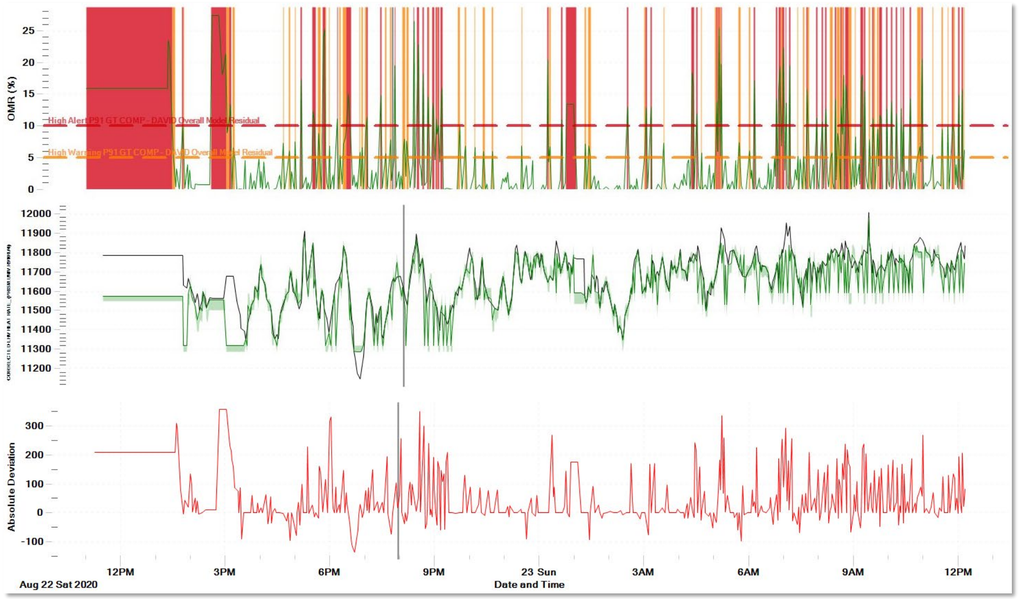
Challenge is to configure models which measure degradation through changes in KPIs in isolation of day to day operating point changes

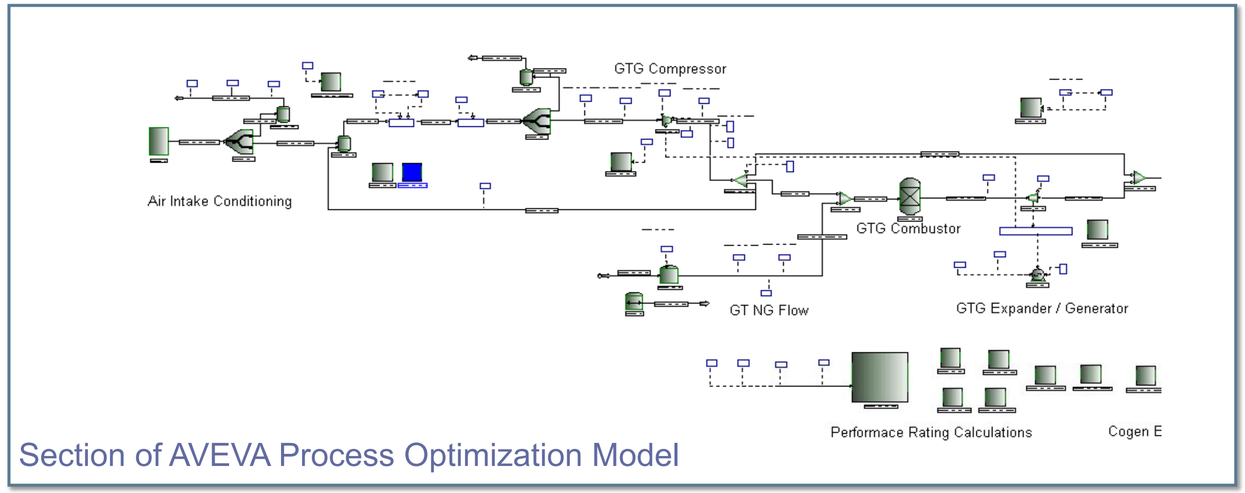
Degradation Mechanisms

- Air Inlet Degradation:
  - Filter blockage
  - Air leakage
- Compressor degradation:
  - Fouling
  - Guide vane position error
  - Blade erosion
  - Tip rubs / clearance
- Combustion section degradation:
  - Fuel nozzle plugging or wear
  - Combustion instability
  - Combustion liner fatigue cracking
- Turbine section degradation:
  - Blade erosion
  - Seal degradation
  - Blade tip rubs
  - Deposits

Model Baseline

Corrected Heat Rate (kJ/kWh)



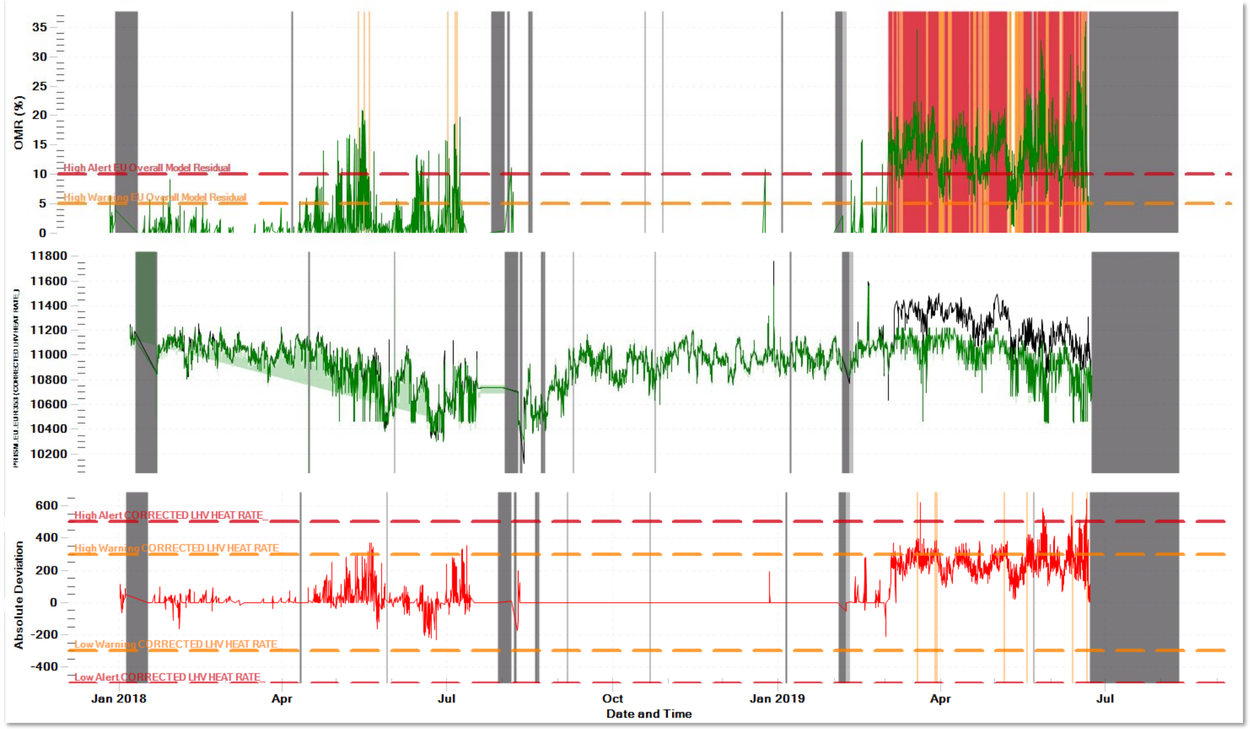


Section of AVEVA Process Optimization Model

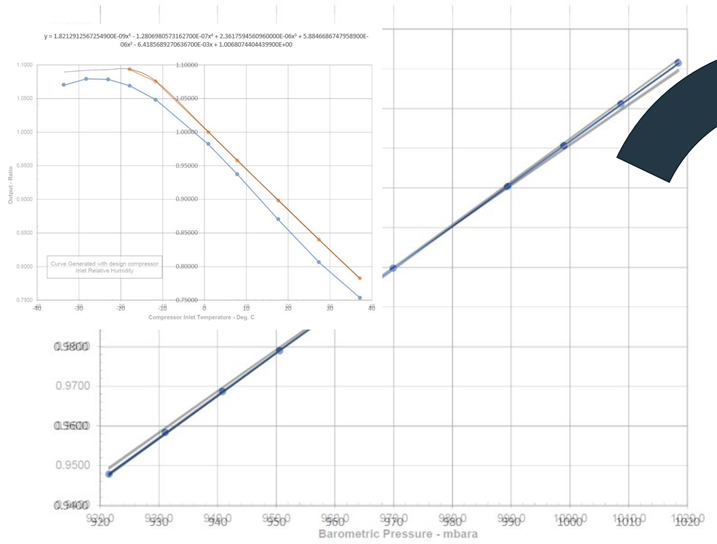
- First attempt had limited success:
  - Noisy results
  - Training data self-polluted by degradation
  - Sometimes frustrated by bad instruments
  - Model tolerance masks small changes in the data

  → ***Conclusion: Better approach needed!***

Corrected Heat Rate (kJ/kWh)



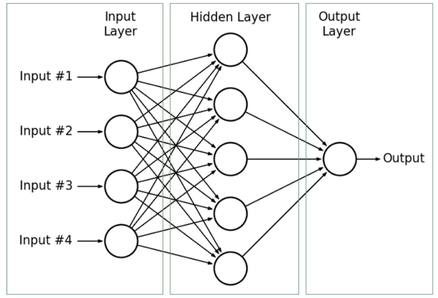
PAO High Dynamic Range Model: Rated Performance Approach



OEM PERFORMANCE CURVES / CURVE FITS
PGT REPORT

	A	B	C	D	E	G	H	I	J	K	L
1	PointID	PRISM.FH	PRISM.FH	PRISM.FH	PRISM.FH	SM.FH	PRISM.FH	PRISM.FH	PRISM.FH	PRISM.FH	PRISM.
2	Descriptic	GT1 HUMI	GT1 BARO	GT1 GT IN	GT1 COMP	MEGA	GT1 AIR DI	GT1 AIR DI	GT1 AIR DI	GT1 IN DE	GT1 IN
3	Extended	FH1_637A	FH1_637P	FH1_637P	FH1_	_637JI	FH1_637TI	FH1_637TI	FH1_637TI	FH1_637TI	FH1_63
4	Extended	GT1 HUMI	GT1 BARO	GT1 GT IN	GT1 CO	MEGA	GT1 AIR DI	GT1 AIR DI	GT1 AIR DI	GT1 IN DE	GT1 IN
5	Units	%	KPA	MMH2O	C		C	C	C	C	C
6	01/29/202	0	94.5	0	-20	0	7194	0	0	0	0
7	01/29/202	0	94.6	0	-20	0	100.1289	0	0	0	0
8	01/29/202	0	94.7	0	-20	0	100.2385	0	0	0	0
9	01/29/202	0	94.8	0	-20	0	100.3481	0	0	0	0
10	01/29/202	0	94.9	0	-20	0	100.4577	0	0	0	0
11	01/29/202	0	95	0	-20	0	100.5672	0	0	0	0
12	01/29/202	0	95.1	0	-20	0	100.6768	0	0	0	0
13	01/29/202	0	95.2	0	-20	0	100.7864	0	0	0	0
14	01/29/202	0	95.3	0	-20	0	100.896	0	0	0	0
15	01/29/202	0	95.4	0	-20	0	101.0056	0	0	0	0
16	01/29/202	0	95.5	0	-20	0	101.1151	0	0	0	0
17	01/29/202	0	95.6	0	-20	0	101.2247	0	0	0	0
18	01/29/202	0	95.7	0	-20	0	101.3343	0	0	0	0
19	01/29/202	0	95.8	0	-20	0	101.4439	0	0	0	0

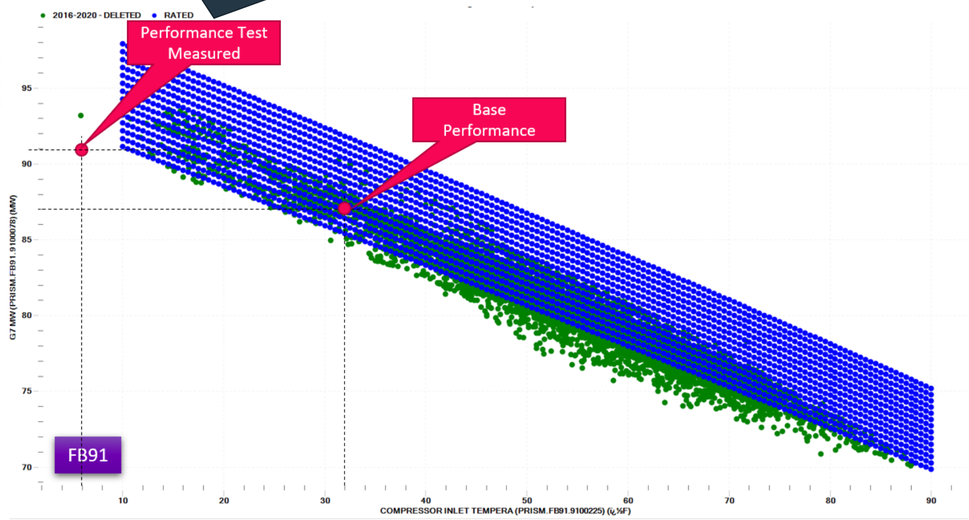
Compressor Inlet Temperature
Ambient Pressure
Humidity



Mathematical description of each operational mode

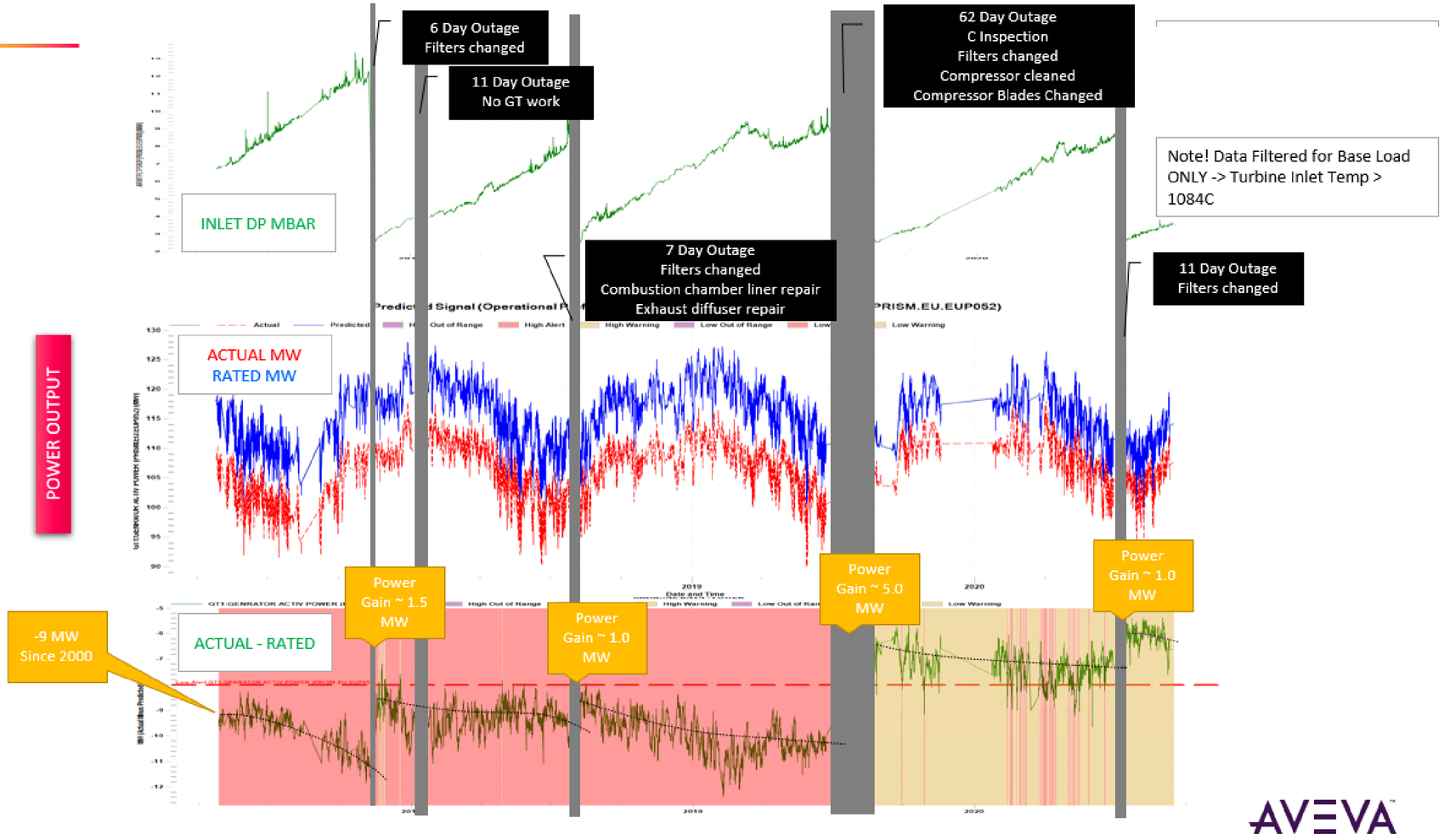
SURROGATE RATED PERFORMANCE DATA SET AND MODEL TRAINING

Powe
Heat R
Compressor
etc



RATED PERFORMANCE PREDICTIVE ANALYTICS MODEL

Results



- Rated Performance approach gives insights into performance degradation which was not possible via traditional anomaly detection Predictive Analytics.
- The traditional approach was unable to convincingly identify degradation behaviour whereas the Rated Performance Approach reveals changes in performance, distinct from operating point changes.

AVEVA

Takeaways

Challenge

20,500 critical assets across 14 sites including Oil Sands, Downstream, ETF, E&P and Pipelines

Solution

SUNCOR APM(RAW) Program leveraging AVEVA Predictive Asset Optimization

Simulation +

Machine Learning +

Data Contextualization & Visualization

Benefits

Lower Risk – Detect issues early with greater clarity

Improved Performance – Assess and quantify the impact of issues

Optimized Maintenance Strategy – forecast to determine urgency / Intervention window

Maximized Availability and Profitability – Maximize payback on maintenance investment

Questions?

Thank you