System 1 Decision Support Analytic for gas turbines

Bently Nevada
a Baker Hughes business
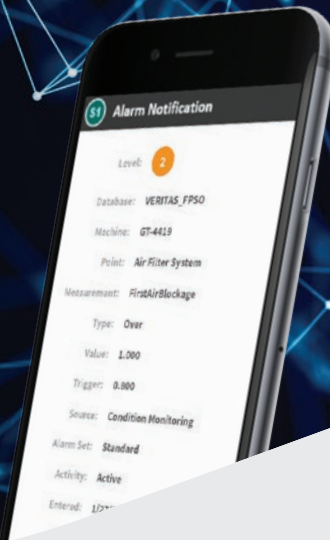
Gas turbines are used as prime movers for a variety of driven equipment including compressors, pumps, electric generators, and others. Because these machine trains are frequently critical to the process, understanding the health of the gas turbine is fundamental to reliable, profitable, and emissions-compliant operations. This analytic covers both industrial and aeroderivative gas turbines and is designed to automatically detect more than 40 different problems and provide corresponding insights across the gas turbine and its subsystems. This affords a truly holistic view of the gas turbine's health and performance. When coupled with additional analytics, the health of the entire machine train can be assessed.

Comprehensive yet scalable

Decision Support Analytics are designed to use whatever available data exists and scale the insights they provide appropriately. For example, when only process data is available, insights for the gas turbine's auxiliary systems such as lube, fuel, exhaust, and inlet filtration can be generated because they rely exclusively on process data. Conversely, when only static and dynamic vibration data is available, insights relying exclusively on vibration data are provided, but not those relying on process data. When both vibration and process data are available, the most comprehensive level of insights are provided, covering the full capabilities of the analytic. For this reason, users are encouraged to ensure that process data is available in System 1 through connection to the DCS, process historian, or other control/automation platform using the various open protocols and interfaces we support.
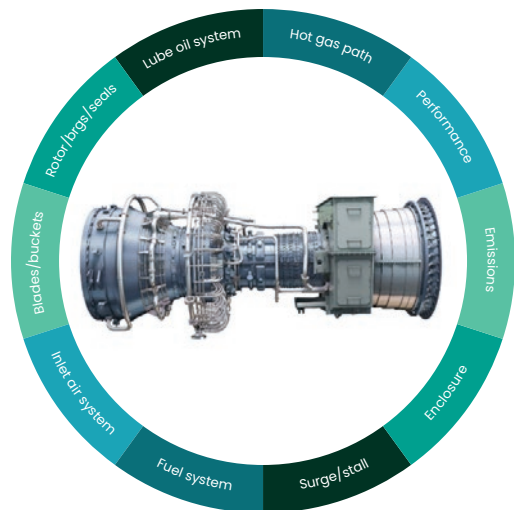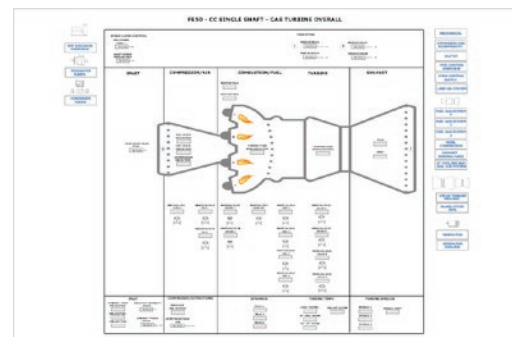

42 insights / 10 subsystems

Benefits

- Eliminates tedious manual review of data to identify problems for better use of personnel

- Reduces the need for resident machinery expertise at each site and/or travel to diagnose problems

- Delivers 60+ years of embedded Bently Nevada machinery diagnostics expertise

- Allows the knowledge of your own experts to be embedded, retained, and disseminated

- Ensures anomalies do not go unnoticed through continuous and automated review of data

- Facilitates your own company processes and practices in responding to machinery problems through fully customizable notifications

- Removes guesswork; first principles approach delivers actionable information to operators and personnel rather than statistical probabilities and indeterminate results

- Enables faster and easier commissioning because the system does not require database "training" of the AI engine via extensive historical data ingestion

- Provides holistic asset coverage; not limited to vibration data and rotordynamic issues and instead covers all major subsystems of the gas turbine, allowing greater confidence in O&M decisions

- Supplies insights in minutes or less—not hours/days; allows rapid intervention for incipient problems
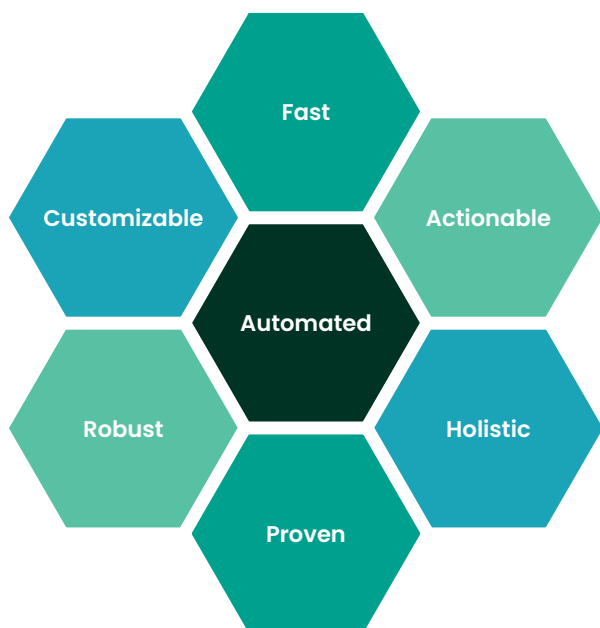
Customized insight saves an estimated €2.2M

An offshore platform without resident machinery or instrumentation expertise was experiencing repeated trips of an aeroderivative gas turbine, necessitating costly inspections and production disruptions representing 35 MBOE* per day. Root cause was found to be intermittent noise from high-temperature accelerometers mounted on the machine. The extremely high g-levels on the casing of many aeroderivatives due to blade passage tends to result in a short lifespan for accelerometers and cable connectors for even the most robust sensor systems. The System 1 Decision Support environment was used to examine spectral components associated with the sensor failure mode, thereby eliminating spurious trips by instructing operators to bypass the sensor channel when early signs of degradation began to appear, until the offending sensor/cable could be replaced. Operation was able to continue uninterrupted during such events with the assurance that the turbine was indeed mechanically sound. Each time this insight was triggered, it eliminated an estimated €2.2M in losses due to unnecessary mechanical inspection and associated loss of production.

* Million Barrels of Oil Equivalent

Capabilities

A holistic approach for the entire asset

Decision Support Analytics embed a substantial body of machinery and process expertise gained by Bently Nevada over the last six decades. Through more than 15,000 machinery diagnostic projects in dozens of industries, our field engineers perform the same data review and analysis that is now contained in our analytics. We place this same Bently Nevada intelligence right into your System 1 installation where it can be extended to every asset in your operations, automatically and continuously.

We extract 75 different attributes from the data to deliver 42 powerful insights across the turbine and its subsystems.

Rotors | Bearings | Seals | Blades | Buckets | Couplings

Lube oil system | Cooling system | Performance

IGVs | Inlet filters | Enclosure | Fuel system

Suge | Stall | Emissions

14 mechanical insights

12 auxilliary insights

9 lube system insights

7 process insights

Mechanical insights	
Fluid-induced instability whirl/whip	I
General radial preload	I
High synchronous vibration	I
Rotor 1X runout	I
Sub-synchronous rub	I
Super-synchronous rub	I
Misalignment	I
Rotor bow	I
Compressor near surge	I
Compressor surge and stall	I
High exhaust temperature	B
High differential exhaust temperature	B
Blade pass	B
Combustor rumble	B

Process insights	
Bleed valve position control issue	B
Inlet guide vane position control issue	B
Liquid fuel supply pressure low	B
Possible combustor issue	B
Turbine inner barrel cooling problem	B
Gas generator possible performance loss	A
Power turbine possible performance loss	A

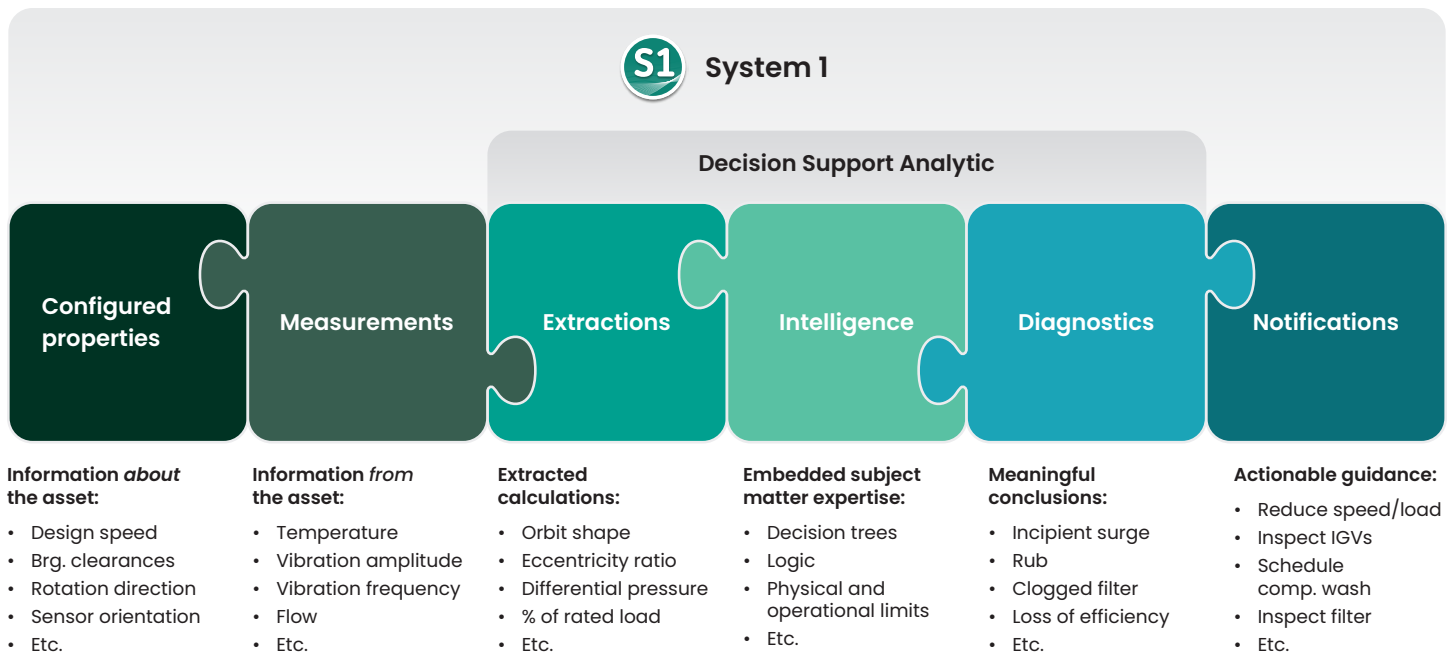| Lube system insights	
2oo2 temp1 validity check	B
LO 2oo2 temp2 validity check	B
2oo3 header pressure validity check	B
Cooler oil leak	B
Cooler oil-side fouling	B
Cooling system problem	B
Heater problem	B
Filter clogging	B
Pump problem	B

Auxiliary system insights	
Air filter system air filter rupture or blockage	B
Combustor issue	B
Compartment air temperature high and sensor failure	B
Compressor Inlet air filter clogging/icing	B
Enclosure cooling issue	B
Flame detector failure	B
Gas fuel valve position control issue	B
Gas leak detection and sensor failure	B
Gas valve comp air temp high and sensor fault	B
Liquid fuel filter filter clogging	B
Liquid fuel filter position control issue	B
NOx control issue	B

A – Aeroderivative gas turbines only (rolling element bearings)

B – Both aeroderivative and industrial gas turbines

I – Industrial gas turbines only (fluid-film bearings)

Methodology

A proven method for robust, reliable decision support

S1 System 1

Decision Support Analytic

Configured properties	Measurements	Extractions	Intelligence	Diagnostics	Notifications

Information *about* the asset:
- Design speed
- Brg. clearances
- Rotation direction
- Sensor orientation
- Etc.

Information *from* the asset:
- Temperature
- Vibration amplitude
- Vibration frequency
- Flow
- Etc.

Extracted calculations:
- Orbit shape
- Eccentricity ratio
- Differential pressure
- % of rated load
- Etc.

Embedded subject matter expertise:
- Decision trees
- Logic
- Physical and operational limits
- Etc.

Meaningful conclusions:
- Incipient surge
- Rub
- Clogged filter
- Loss of efficiency
- Etc.

Actionable guidance:
- Reduce speed/load
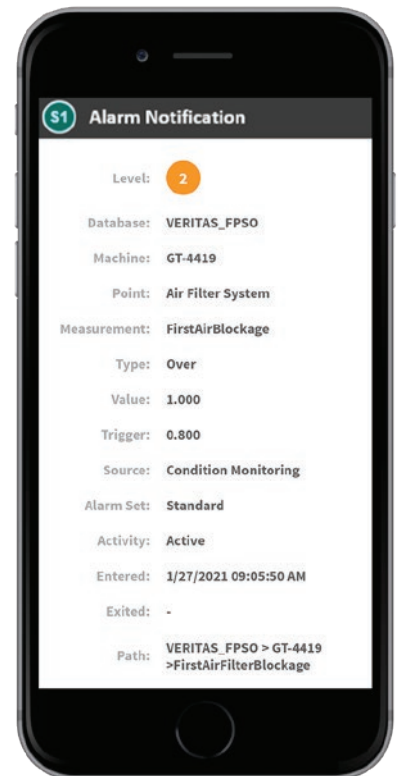- Inspect IGVs
- Schedule comp. wash
- Inspect filter
- Etc.

Decision Support Analytics use Bently Nevada's proven diagnostic methodology that combines configured properties with measurements to generate extractions. It mimics the approach used by our own machinery diagnostic experts to collect the available data from the asset and the process, and then convert it to useful parameters and ratios used in the analysis process. It then applies the same intelligence to these extractions that a human expert would use to arrive at diagnostic findings. These findings can then be sent to relevant personnel using System 1's notification features.

Flexibility

Transparent and customizable

The intelligence we embed is fully accessible to you. No black boxes, no secret recipes. Using Decision Support Developer, you can edit Decision Support Analytics to meet specific goals. In addition, users may write custom extractions and diagnostic rules to address asset needs which are not yet covered by our inventory of analytics. In fact, Decision Support Developer is what we use to create our analytics. Decision Support Developer is a powerful way to capture the accumulated experience and knowledge of your own experts, ensuring it isn't lost, and deploying it across your entire enterprise.

S1 Alarm Notification

Level:	2
Database:	VERITAS_FPSO
Machine:	GT-4419
Point:	Air Filter System
Measurement:	FirstAirBlockage
Type:	Over
Value:	1.000
Trigger:	0.800
Source:	Condition Monitoring
Alarm Set:	Standard
Activity:	Active
Entered:	1/27/2021 09:05:50 AM
Exited:	-
Path:	VERITAS_FPSO > GT-4419 >FirstAirFilterBlockage

Decision Support Analytics are also available for:

Driven machinery
- Pumps
- Blowers/fans
- Generators
- Centrifugal/axial compressors
- Integrally geared compressors
- Reciprocating compressors

Specialty components
- Dry gas seals

Prime movers
- Steam turbines
- Electric motors

Power transmission
- Gearboxes
- Power turbines

When the gas turbine analytic is coupled with analytics for its driven machinery (power transmission components such as gearboxes, specialty components such as dry gas seals, generators, etc.) end users will gain insights into the health of the full machine train and identified subsystems. Bently Nevada continues to enhance Decision Support Analytics and expand System 1's analytics library to cover new machines and equipment types.

Complementary services

Decision Support Analytics deliver the best value when all parts of your condition monitoring ecosystem are working properly. Our service capabilities cover the entire spectrum of your needs and our global footprint ensures our expertise is available wherever and whenever you need it.

- Installation and configuration
- Training
- System tuning and optimization
- Supporting service agreements
- Remote and onsite diagnostics
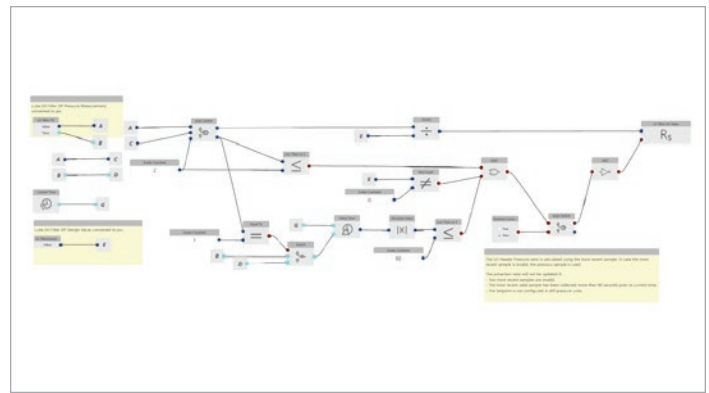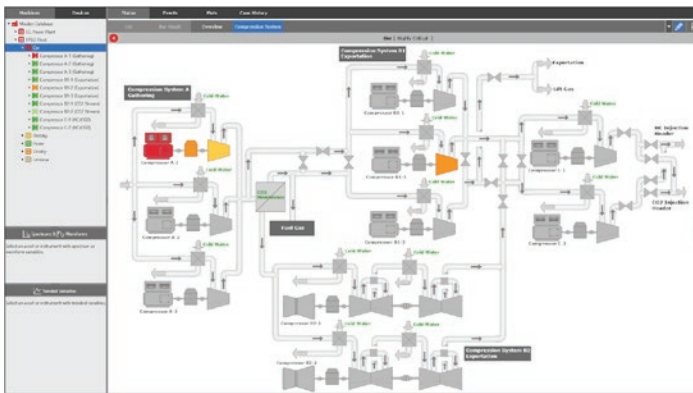
Customized Human Machine Interfaces (HMIs)

Looking for a clearer view of your operations?

We can create fully customized diagnostic HMIs for individual assets or even your entire plant. These HMIs allow operators and others to quickly drill down to specific assets and subsystems to understand the nature and severity of problems and the precise actions to take for mitigation.

Customized insights

While the Decision Support Developer's capabilities allow you to build and customize your own insights, many customers turn to us for these services. We can tailor existing insights to the specifics of your operations, or we can develop entirely new insights—whether to augment the capabilities on an existing asset or to address entirely new assets, both rotating and fixed.

Baker Hughes ⧽

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