Paris Session 2022

How the industrial internet of things is driving the asset management digitalization: the implementation of an interconnected asset performance management system in the electrical power distribution sector

C1 PS1

Q 1.3.1- Have others used chaos theory, artificial intelligence, or similar advanced methods to set standards for resilience?

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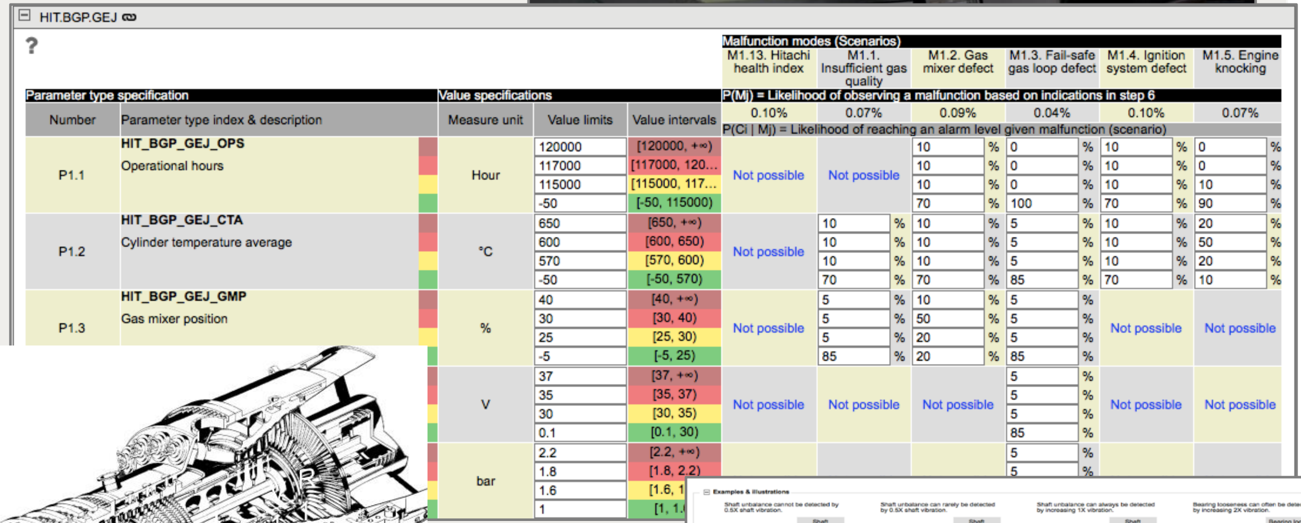
Turning FMECA into a Stochastic model through ML techniques

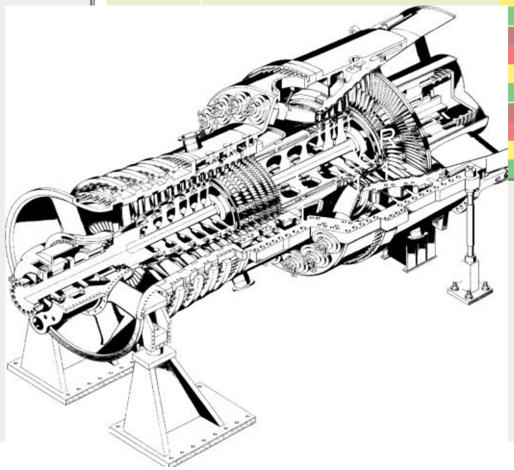
- The most robust and consolidated methodology for reliability engineers to implement an **effective maintenance strategy** is **FMECA** (***Failure Modes, Effects and Criticality Analysis***)

- Running a FMECA means retrieving all the **best expertise and experience** within an organization's **operations and maintenance** departments, formalized in a **structured framework** thanks to the contribution of a moderator

- Once this analisys is used to feed a Machine Learning algorithm, a «static» FMECA becomes a **dynamic model** which enables to run **what-if scenario symulations**, supporting a **robust decision making process** based on **quantitative results**.


HIT.BGP.GEJ

Number	Parameter type index & description	Measure unit	Value limits	Value intervals	M1.13. Hitachi health index	M1.1. Insufficient gas quality	M1.2. Gas mixer defect	M1.3. Fail-safe gas loop defect	M1.4. Ignition system defect	M1.5. Engine knocking
				P(Mj) = Likelihood of observing a malfunction based on indications in step 6	0.10%	0.07%	0.09%	0.04%	0.10%	0.07%
				P(Ci | Mj) = Likelihood of reaching an alarm level given malfunction (scenario)						
P1.1	HIT_BGP_GEJ_OPS Operational hours	Hour	120000	[120000, +∞)	Not possible	Not possible	10 %	0 %	10 %	0 %
			117000	[117000, 120...			10 %	0 %	10 %	0 %
			115000	[115000, 117...			10 %	0 %	10 %	10 %
			-50	[-50, 115000)			70 %	100 %	70 %	90 %
P1.2	HIT_BGP_GEJ_CTA Cylinder temperature average	°C	650	[650, +∞)	Not possible	10 %	10 %	5 %	10 %	20 %
			600	[600, 650)		10 %	10 %	5 %	10 %	50 %
			570	[570, 600)		10 %	10 %	5 %	10 %	20 %
			-50	[-50, 570)		70 %	70 %	85 %	70 %	10 %
P1.3	HIT_BGP_GEJ_GMP Gas mixer position	%	40	[40, +∞)	Not possible	5 %	10 %	5 %	Not possible	Not possible
			30	[30, 40)		5 %	50 %	5 %		
			25	[25, 30)		5 %	20 %	5 %		
			-5	[-5, 25)		85 %	20 %	85 %		
		V	37	[37, +∞)	Not possible	Not possible	Not possible	5 %	Not possible	Not possible
			35	[35, 37)				5 %		
			30	[30, 35)				5 %		
			0.1	[0.1, 30)				85 %		
		bar	2.2	[2.2, +∞)				5 %		
			1.8	[1.8, 2.2)				5 %		
			1.6	[1.6, 1						
			1	[1, 1.						



Turning FMECA into a Stochastic model through ML techniques

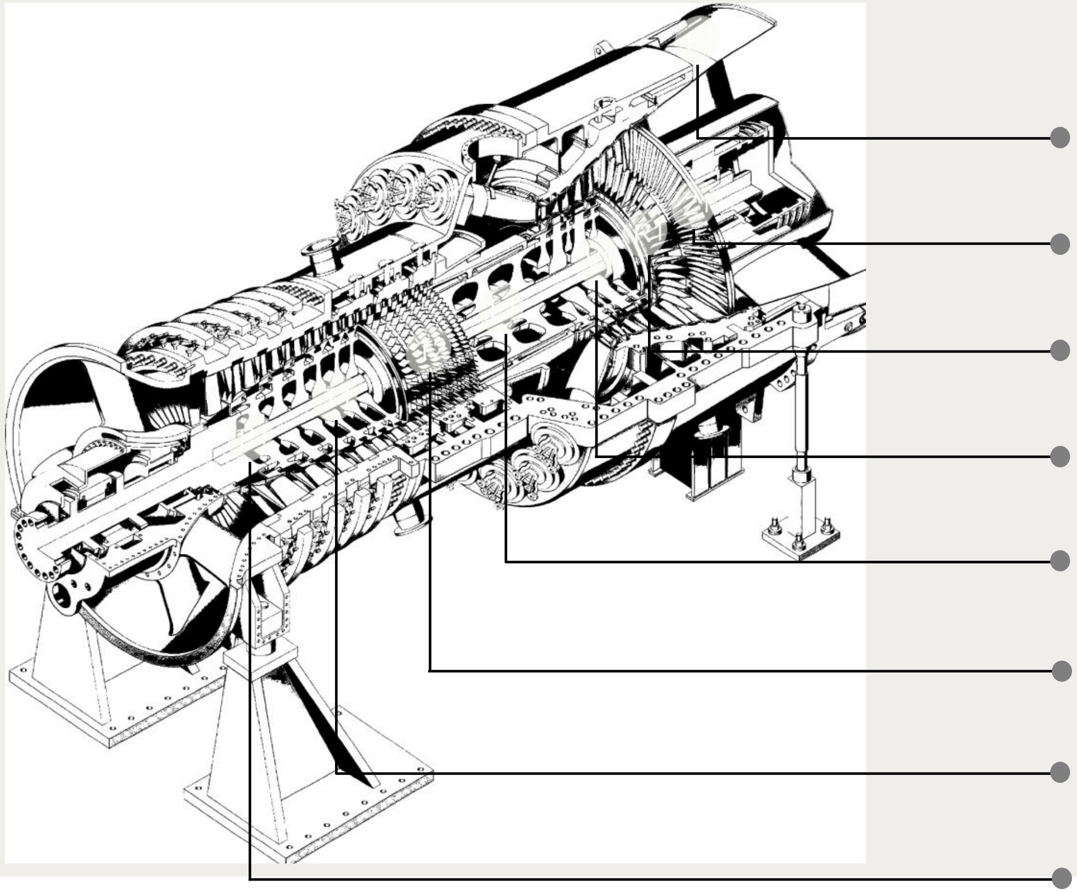
25 plus proven malfunction mode templates

15 Temperature measurements
7 Vibration measurements
2 Lubrication Oil analysis at various points
1 Fuel and GT exhaust Flow
2 Speed Sensors at various points

Stochastic process model (Markov)
Stochastic inference model (Bayes)

150 Plus Raw and Calculated Parameters

Malfunction Modes	Data Source		
Radial Bearing malfunction	T2		V1
Axial Bearing malfunction	T2		V1
Combustion Chamber temperature deviation	T1		Z1
Compressor Fouling	P1	T1	Z1
Turbine Unbalance	V1		
Varnish Build-up	T2		L1
Cooling air valve defect	Z1		
Combustion process instability	T1		Z2



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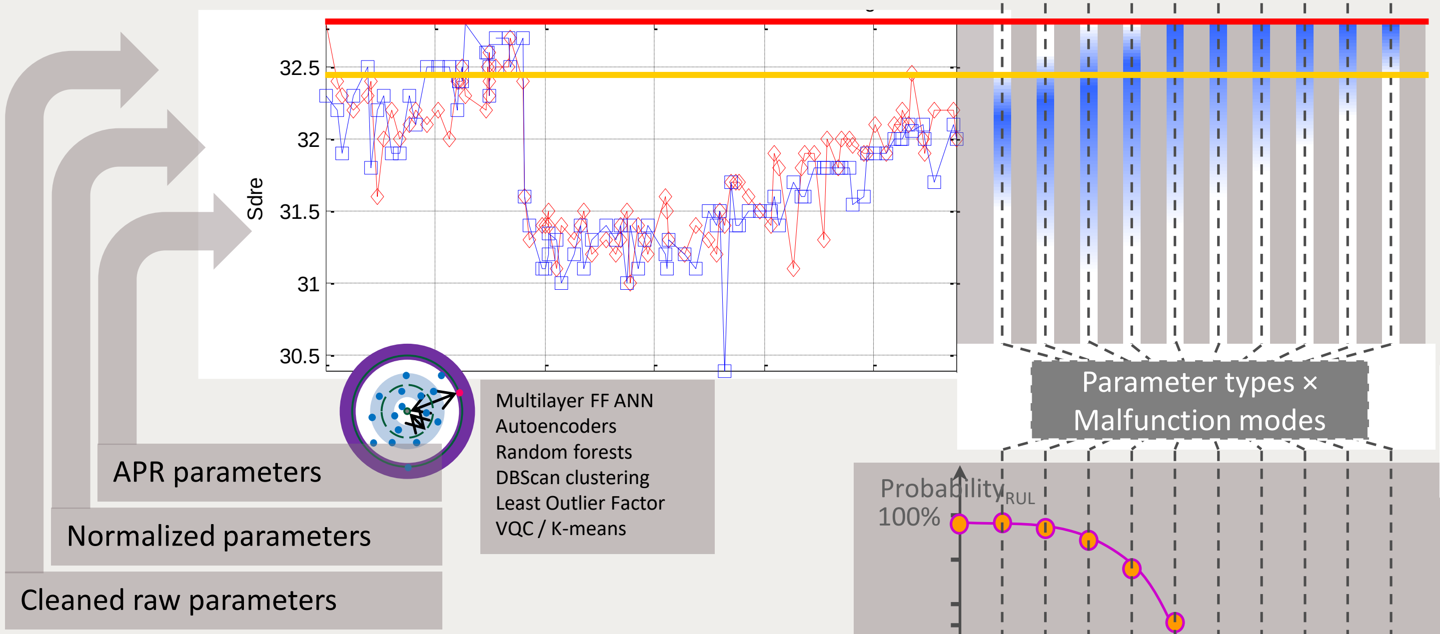

Stochastic process model (Markov): Computation of…

- …Transition probabilities per parameter
  (Cloud of possible future values)
- …Probability of reaching value limits per parameter
- …Probability of reaching limits per component, unit, etc.

Stochastic inference model (Bayes): Computation of…

- …Probability of malfunction, given parameter value range

Remaining useful life (RUL) distribution: Probability of…

- …a parameter staying in feasible value range
- …a component, unit, etc. staying in feasible value range