GE Oil&Gas

On line Condition Based Maintenance

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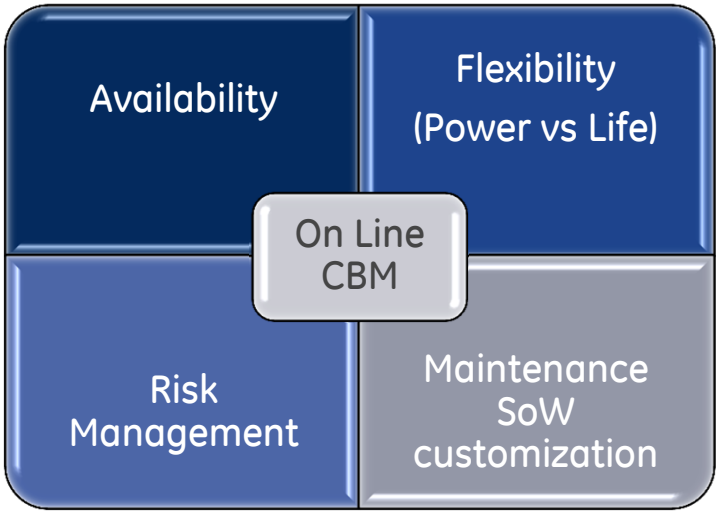
Imagination at work.

On line Condition Based Maintenance

Scope of work	An on-line cockpit that, getting input from lifing models, analytics and advanced sensors, provides a combined picture of part/unit degradation, unit maintenance planning and SoW forecasting
Accurate Life Odometers	Models dedicated to estimate residual life of the machine, based on how it is operating. They can be used to inform customers about maintenance outage distance or to optimize the operation increasing maintenance intervals. Life odometers consider the overall machine life and operate locally influencing the operation behavior
Risk Management	CBM on-line continuously computes the risk @ Failure Modes, section and unit level and provides a picture on how the unit is approaching the maintenance period, evaluating if it can be postponed based on runtime risk calculation
Maintenance Optimizer	A tool that allows to move from a fixed intervals maintenance to dynamic intervals one. Base on risk output the maintenance optimizer represents an instrument to compare different and potential scenarios guiding the maintenance strategy decisions

On Line CBM is a Customer value...



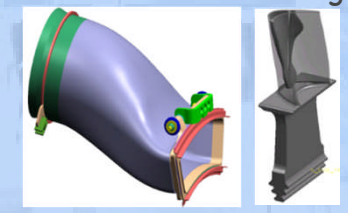
On line CBM..how it works – General Overview

INPUTS

Running Unit

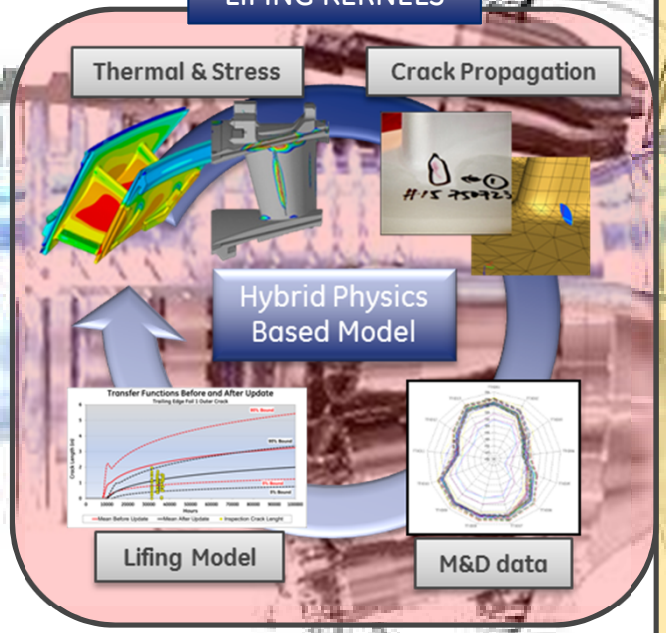
RMD

Asset Configuration and Part Life Tracking



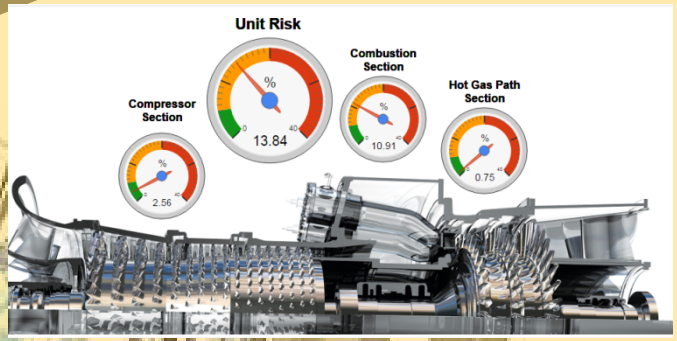
Failure and damage experience

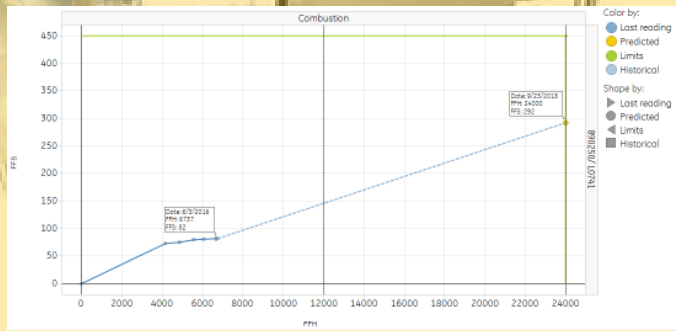
PERFORMANCE & LIFING KERNELS



OUTPUTS

RISK MANAGEMENT





MAINTENANCE PLANNING

Continuously the on line tool computes the risk @ FM, section and unit level and provides a picture how the unit is approaching to the maintenance and so evaluating if it can be postponed if the relevant risk is acceptable

On line CBM
A Real case application

BACKGROUND

GT Model Type: 120MW ISO rating (5 units considered)
Combustion Type: Dry Low NOx 1 (25 ppm NOx)
Fuel Gas: Natural gas (100%)
Maximal expected load: 80%
Service Type: Power generation
ISO rating: 120 MW
Environment: Marine (salty), onshore
Other: simple cycle, IBH available, RM&D available

The 2nd stage turbine blade installed into the units are old design and need to be inspected at 24000 hours to keep under control shrouded tip deformation.

- 2nd stage turbine blade tip deformation is due to creep and so mainly impacted by GT Power, Speed and hot gas flow temperatures.
- The creep failure mechanism is consistent at full speed and full load conditions
- The #5 units will be operated max at 80% of Load and so the 2nd stage turbine blade tip creep deformation is expected to be limited

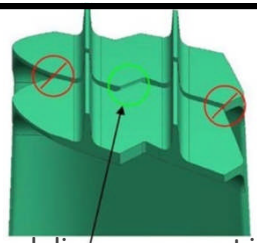
CUSTOMER IMPACT

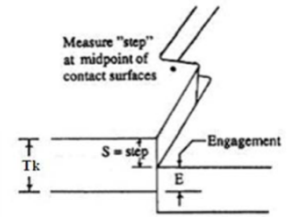
The Hot Gas Inspection at 24000 hours is required to inspect the 2nd stage turbine blade ..... IMPACT on AVAILABILITY

TARGET

Hot Gas Inspection removal at 24000 hours with 2nd stage turbine blade inspection interval extension from 24khrs to 48khrs.

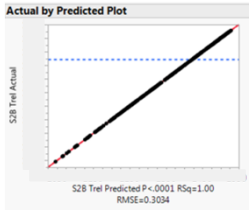
2nd stage turbine blade – Tip creep deflection model





S2B Tip Shroud disengagement is mainly due to the creep failure mechanism. It could lead to the rupture of the shrouded tip and so generating the forced outage of the unit. It is the failure that is mostly impacting the maintenance.

S2B Creep failure mechanism is driven by Stress due centrifugal force and S2B Metal Temp



RM&D

Trel temp
Thermodynamic transfer function

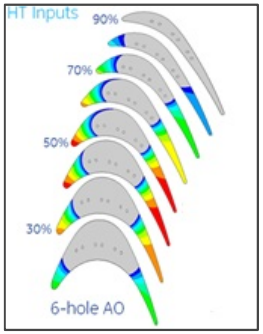
Trel=f(RM&D data)

Tm=f(Trel, TCD, ϕ)

Bulk metal temp
From transfer function

σ=f(speed, Tm)

Bulk stress
Physics based transfer function



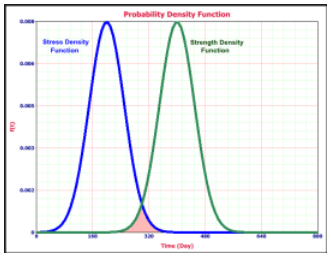
Reference metal temp
From FEA analysis

Reference stress
From FEA analysis

Material Properties

Time to failure/no failure
Time at which the measurements were taken

OIF
Based on units' operation from RM&D data



S2B Risk

$$F(t) = 1 - e^{-\left(\frac{t}{e^{(a_0 + a_1 \ln(OIF))}}\right)^{\beta}}$$

$\mathrm{OIF} = \frac{t_0}{t}$ (OPERATIONAL IMPACT FACTOR)

t_0 - reference creep life corresponding to design limit bulk creep strains

t - creep life corresponding to the actual operating conditions

INPUT

LIFING KERNELS

OUTPUT

2nd stage turbine blade – Tip creep deflection model OUTCOMES

The 2nd stage turbine blade risk model has been created using as input:

- GT operating parameters acquired by RM&D system that have used to estimate the 2nd stg turbine blade metal temperature
- Stresses and creep strain/deformation as outcome of structural model and material properties
- 2nd stage turbine blade tip deformation measures

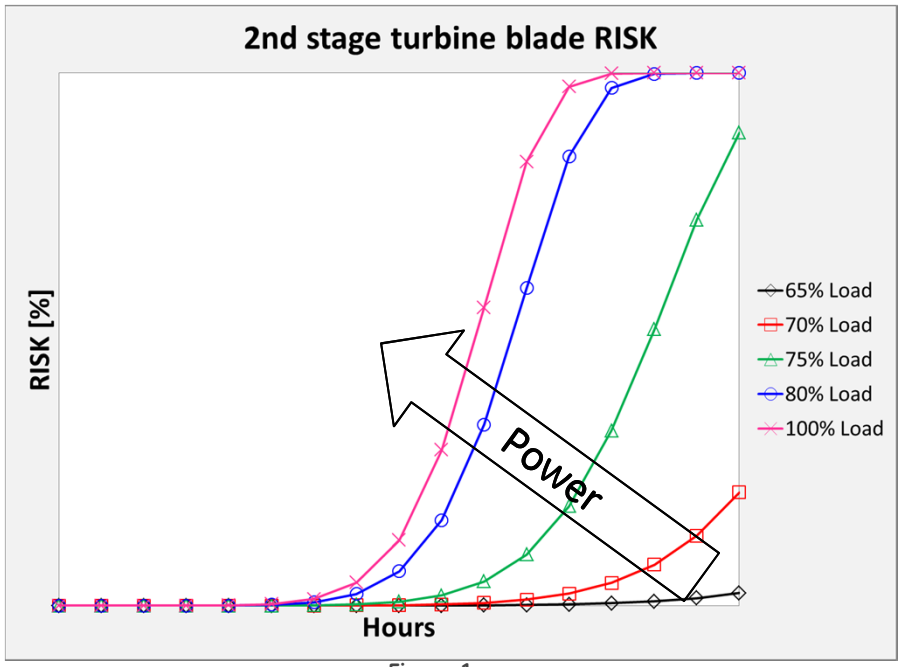


Figure 1

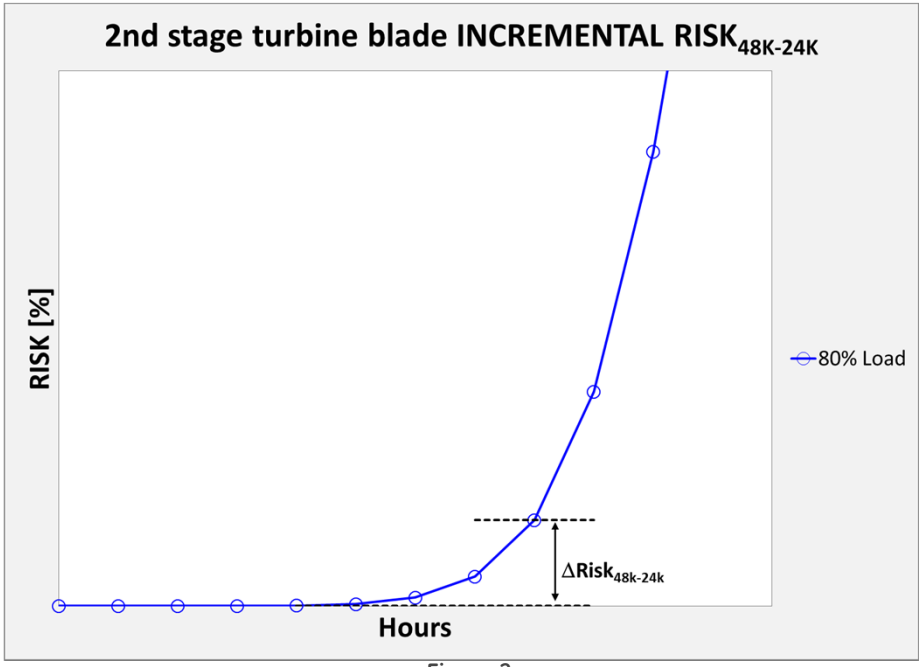


Figure 2

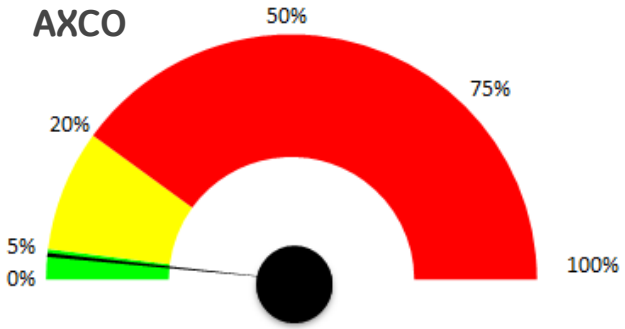
Figure 1 shows the correlation between the 2nd stg turbine blade Risk and the Power of the gas turbine. It is clear how is it important to know the operating conditions and how it is powerful the model connected to RM&D system in order to monitor the Risk and to really customize the gas turbine maintenance.

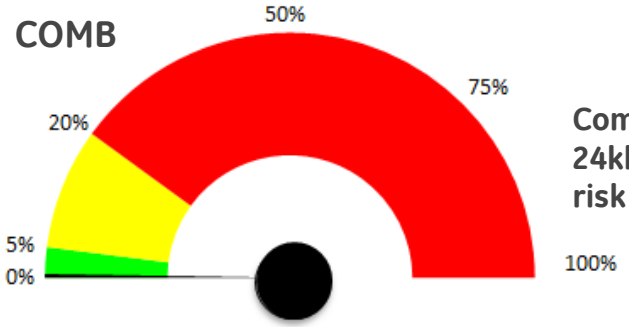
Considering the target to remove the Hot Gas Path inspection at 24000 hours and so extending the inspection interval of the 2nd stg turbine blade from 24khrs up to 48khrs, the 2nd stage turbine blade incremental risk has been considered. Figure 2 shows the incremental risk for the max and expected power level of 80%.

The ΔRisk48k-24k has been considered technically acceptable.

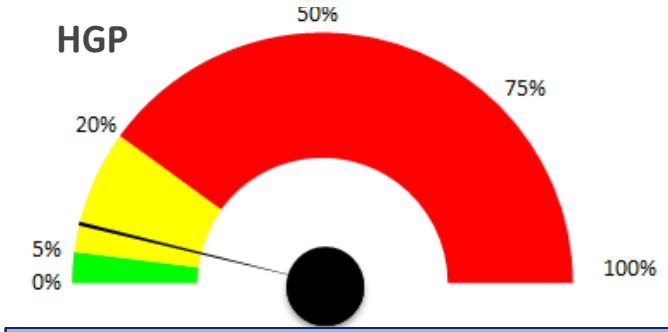
Gas Turbine OVERALL Risk Outcomes

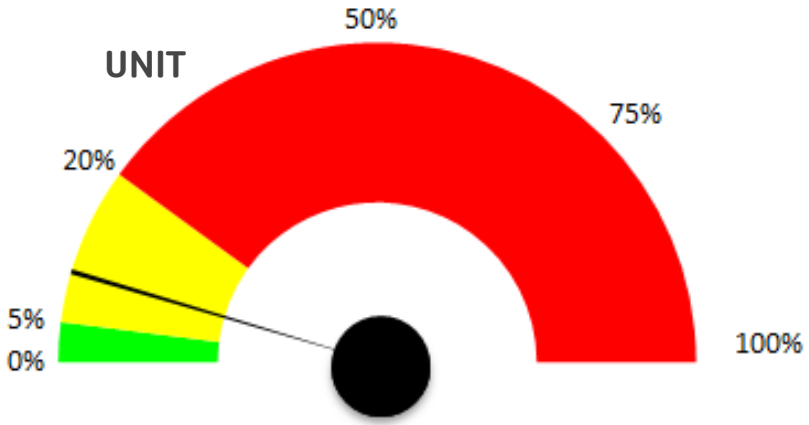
Following as reference it is shown the INCREMENTAL RISK = $RISK_{@48}$-$RISK_{@24}$ for the 80% Load operating profile





Comb hdws is replaced at each 24khrs and so the incremental risk is 0%





$Rel_{UNIT} = Rel_{AXCO} * Rel_{COMB} * Rel_{HGP}$

$Risk_{UNIT} = 1 - Rel_{UNIT}$

For the #5 units operated at 80% of Load the overall unit Risk has been considered acceptable and so the request to remove the Hot Gas Path inspection at 24000 hours approved.

Thank you!

Imagination at work.