Case Study

Design for CBM

Summary

- The OEM is developing a next generation turbine engine for military aircraft.
- The OEM requires an analysis solution to assess the combination of sensors required to enable diagnostics / prognostics and health management of the system, and establish the business case for a Condition Based approach to maintenance.
- The OEM requires a means of validating the capability of the diagnostic design to the customer.

Outcomes

An analysis solution for the OEM that provides:

1. Identification and validation of legacy diagnostic system coverage
2. Identification of potential options to increase system coverage by introducing new sensor locations
3. Sensors allocation based on user defined parameters and restrictions to enable maximal coverage
4. Identification of diagnostic rules to enable isolation of faults (Ambiguity resolution)
5. Propagation tables to detect component responses

Process

The OEM analysed the maintenance records for the platform to identify components that were failing more frequently than expected, and used MADe to:

1. Generate a MADe model of the engine and its expected mission profile/s
2. Generate FMECA to identify / document critical failure modes for the system
3. Assess inherent diagnostic capability (coverage) of the system (incl. BIT, control sensors)
4. Identify additional sensors required to cover all critical / nominated failure modes
5. Select appropriate sensors for nominated diagnostic solutions
6. Compare the metrics for alternate diagnostic solutions (cost, weight, reliability)
7. Select the optimal diagnostic solution (efficacy & business case)
8. Generate diagnostic rules (model-based) for each failure mode

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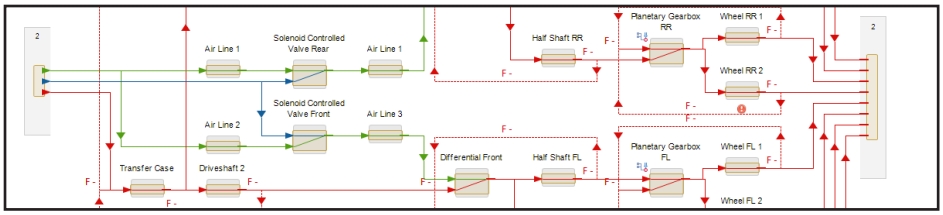
Outputs

MADe was used to generate the following deliverables:

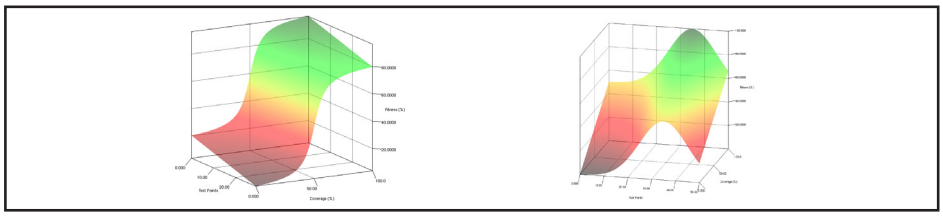
Functional block diagram

Functional block diagram of the selected systems



PHM Coverage

Generation of sensor sets



Diagnostic rules

Identifies failures based on sensor response

Diagnostic Rule

Diagnostic Rule for: Air Line 1 - Static pressure Low (SS) (Gas)

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1  IF [Air Line 1 - Transfer Gas Static pressure IS Low]
2    AND [Air Line 1 - Transfer Gas Static pressure IS Low]
3    AND [Air Line 2 - Transfer Gas Static pressure IS Nominal]
4    AND [Air Line 3 - Transfer Gas Static pressure IS Nominal]
5    AND [Driveshaft 1 - Store Mechanical - rotational Torque IS Nominal]
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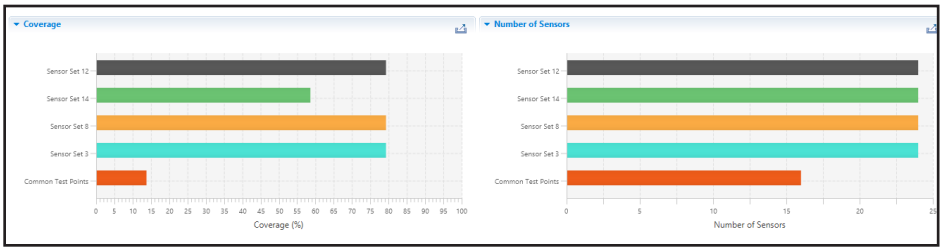
FMEA/FMECA

Automatically generated from the MADe model to identify critical failure modes

ITEM / FUNCTIONAL IDENTIFICATION (NOMENCLATURE)	FUNCTION	FAILURE MODES AND CAUSES	MISSION PHASE / OPERATIONAL MODE	FAILURE EFFECTS			FAILURE DETECTION MEANS	COMPENSATING PROVISIONS	SEV C
				LOCAL EFFECTS	NEXT HIGHER LEVEL	END EFFECTS			
Air Filter An air purifying device, removing particle contaminants from the air.	Refine Gas Contamination Modelled as a resistive device, slightly restricting air flow and removing particles.	High Contamination due to blocking of the Air Filter as a result of silting caused by contaminated input flow and input flow too slow (resulting in Low Torque and High Force	1: Patrol 1 2: Loiter 1 3: Patrol 2	Refine Gas Contamination High Loss of output	Convert Mechanical - rotational Torque Low (Diesel Engine) Loss of output	Convert Mechanical - linear Force High (APC Platform) Loss of output	Sensing Device	Condition-based Maintenance	
	Refine Gas Mass flow rate Modelled as a resistive device, slightly restricting air flow and removing particles.	Low Mass Flow rate due to blocking of the Air Filter as a result of silting caused by contaminated input flow and input flow too slow (resulting in Low Torque and High Force	1: Patrol 1 2: Loiter 1 3: Patrol 2	Refine Gas Mass flow rate Low Loss of output	Convert Mechanical - rotational Torque Low (Diesel Engine) Loss of output	Convert Mechanical - linear Force High (APC Platform) Loss of output	Operator Observation	Modify Mission	
	Refine Gas Contamination Modelled as a resistive	High Contamination due to blocking of the Air Filter as a result of silting caused by contaminated input flow and input flow too slow	1: Patrol 1 2: Loiter 1 3: Patrol 2	Refine Gas Contamination High Loss of output	Convert Mechanical - rotational Torque Low (Diesel Engine)	Convert Mechanical - linear Force High (APC Platform)	Sensing Device	Condition-based Maintenance	

Sensor Set Comparison

Allows users to compare sensor sets parameters (coverage, size, weight, cost)



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