Gas Turbine Linear-GPA Diagnostics Worksheet

Step 1: Simulate measurements of clean and degraded engine using *WebEngine*

Table 1 Clean and Degraded Engine Measurements

	Compressor Degradation		Measurements	
	Efficiency Degradation Index **Δηc/ηc**	Flow Capacity Degradation Index **ΔΓc/Γc**	P7	PCN3
Clean Engine	0.0	0.0		
Degraded Engine	-0.02	-0.03		

Step 2: Calculate fault signature:

$$\begin{pmatrix} \Delta P7/P7 \\ \Delta PCN3/PCN3 \end{pmatrix} = \begin{pmatrix} \quad \\ \quad \end{pmatrix}$$

Step 3: Calculate Influence Coefficient Matrix (ICM) *H*

Table 2 Simulate Measurements Responding to Unit (-1%) Degradation

	Compressor Degradation		Measurements	
	Flow Capacity Degradation **ΔΓc/Γc**	Efficiency Degradation **Δηc/ηc**	P7	PCN3
Clean Engine	0.0	0.0		
Degraded Engine	-0.01	0.0		
Degraded Engine	0.0	-0.01		

$$H = \begin{pmatrix} \dfrac{\Delta P7/P7}{\Delta\Gamma_c/\Gamma_c} & \dfrac{\Delta P7/P7}{\Delta\eta_c/\eta_c} \\ \dfrac{\Delta PCN3/PCN3}{\Delta\Gamma_c/\Gamma_c} & \dfrac{\Delta PCN3/PCN3}{\Delta\eta_c/\eta_c} \end{pmatrix}$$

$$\frac{\Delta P7/P7}{\Delta\Gamma_c/\Gamma_c} =$$

$$\frac{\Delta PCN3/PCN3}{\Delta\Gamma_c/\Gamma_c} =$$

$$\frac{\Delta P7/P7}{\Delta\eta_c/\eta_c} =$$

$$\frac{\Delta PCN3/PCN3}{\Delta\eta_c/\eta_c} =$$

$$H = \begin{pmatrix} & \\ & \end{pmatrix}$$

Step 4: Calculate Fault Coefficient Matrix (FCM) H^{-1}:

$$H = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \qquad H^{-1} = \frac{1}{|H|} \cdot \begin{bmatrix} d & -b \\ -c & a \end{bmatrix} \qquad \text{where} \quad |H| = a \cdot d - c \cdot b$$

$$|H| =$$

$$H^{-1} = \frac{}{} * \begin{pmatrix} & \\ & \end{pmatrix}$$

$$= \begin{pmatrix} & \\ & \end{pmatrix}$$

Step 5: Predict the compressor degradation using linear GPA and fault signature

$$\begin{pmatrix} \Delta\Gamma_c/\Gamma_c \\ \Delta\eta_c/\eta_c \end{pmatrix} = H^{-1} * \begin{pmatrix} \Delta P7/P7 \\ \Delta PCN3/PCN3 \end{pmatrix}$$

(degradation) (FCM) (fault signature)

$$\begin{pmatrix} \Delta\Gamma_c/\Gamma_c \\ \Delta\eta_c/\eta_c \end{pmatrix} = \begin{pmatrix} & \\ & \end{pmatrix} * \begin{pmatrix} \\ \end{pmatrix} = \begin{pmatrix} \\ \end{pmatrix}$$

$$\text{Error } RMS = \sqrt{\frac{(-3- \quad)^2+(-1- \quad)^2}{2}} =$$