

Visual Signal v1.3

振動噪音及訊號擷取模組

SVM & DAQ Module

吳豐泰

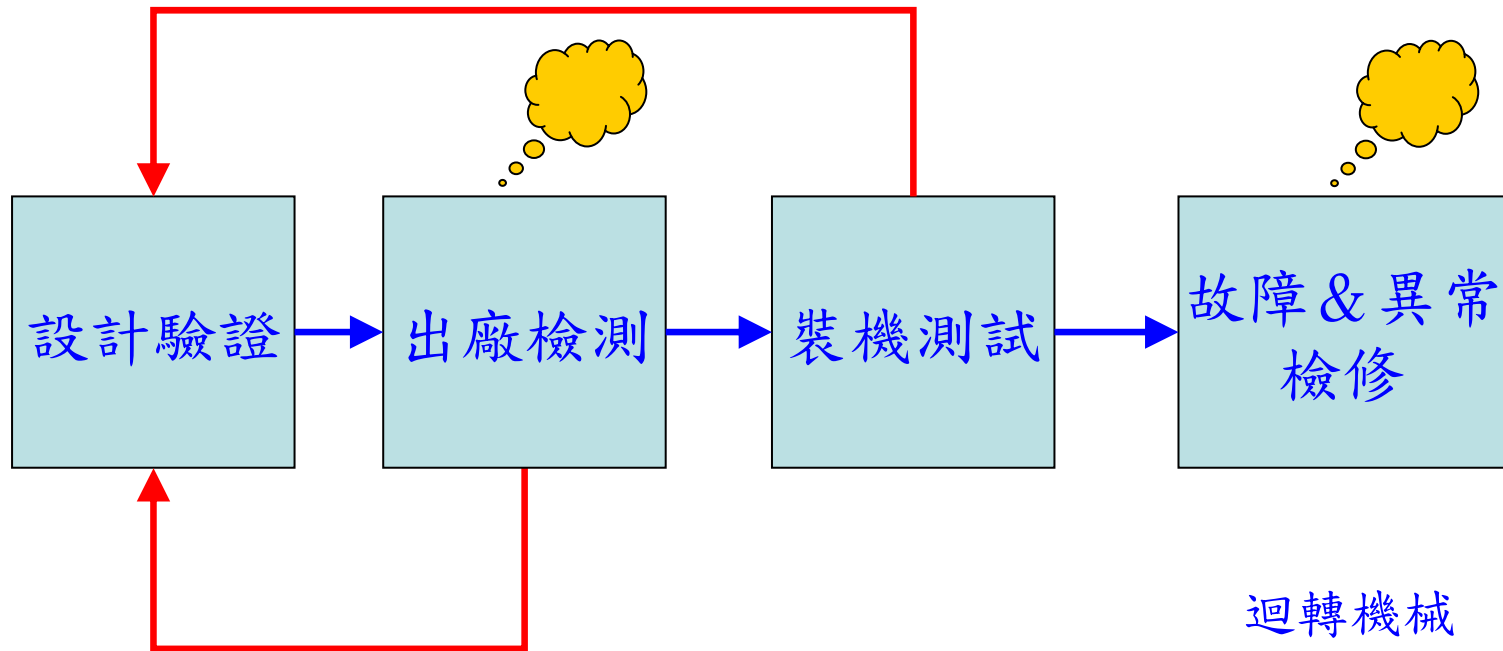
逸奇科技

AnCAD

Contents

- Visual Signal
- Sound and Vibration Module (SVM)
- Time-Frequency Analysis (TFA)
- Empirical Mode Decomposition (EMD)
- Independent Component Analysis (ICA)
- Multi-Scale Entropy (MSE)
- Applications

Why 振動噪音檢測？



FEM模型
原型驗證
參數調測

生產履歷：
製造 & 組裝
品保資料庫
臨界轉速

客戶機台
動態特性
操作頻率
臨界轉速

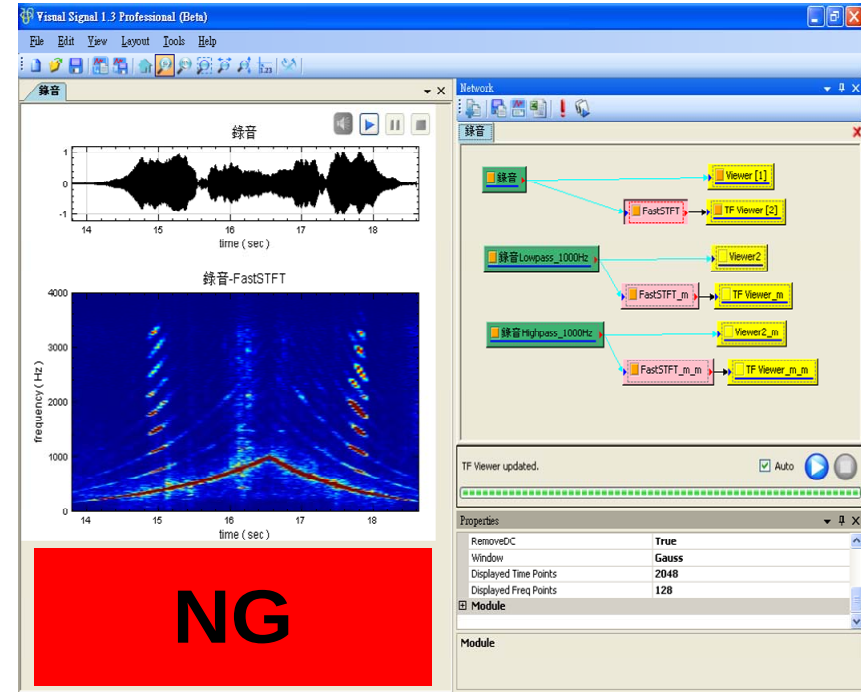
迴轉機械

主軸
齒輪
軸承
馬達

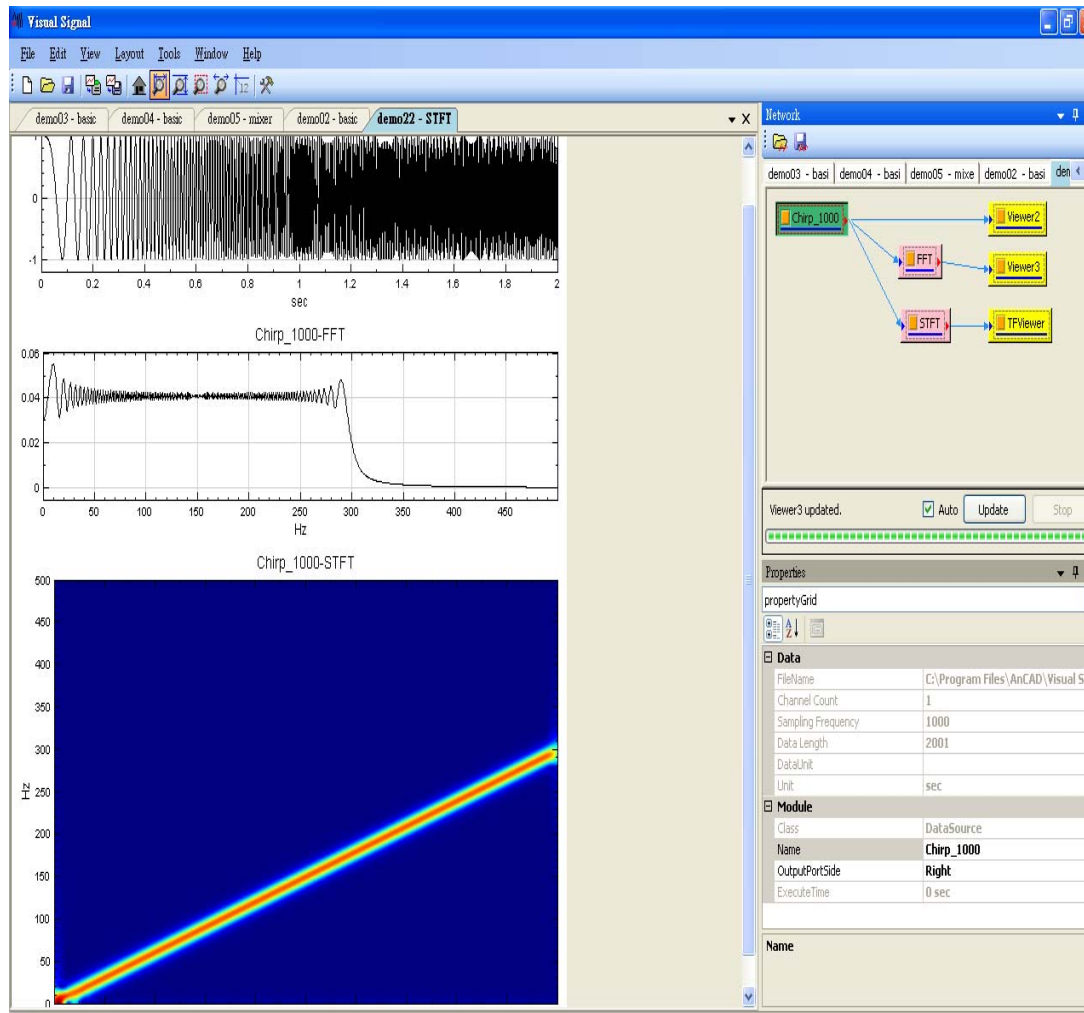
Why Visual Signal & SVM?

PC-based檢測系統架構

- 軟體
 - 檢測與監測操作平台(Visual Signal)
 - 資料擷取軟體(DAQ API)
 - 振動與噪音分析模組(SVM)
- 硬體
 - 資料擷取卡(NI DAQ)
 - 加速規
 - 麥克風



Visual Signal：軟硬體整合平台



資料擷取硬體
檔案
使用者自建函數

輸入

分析

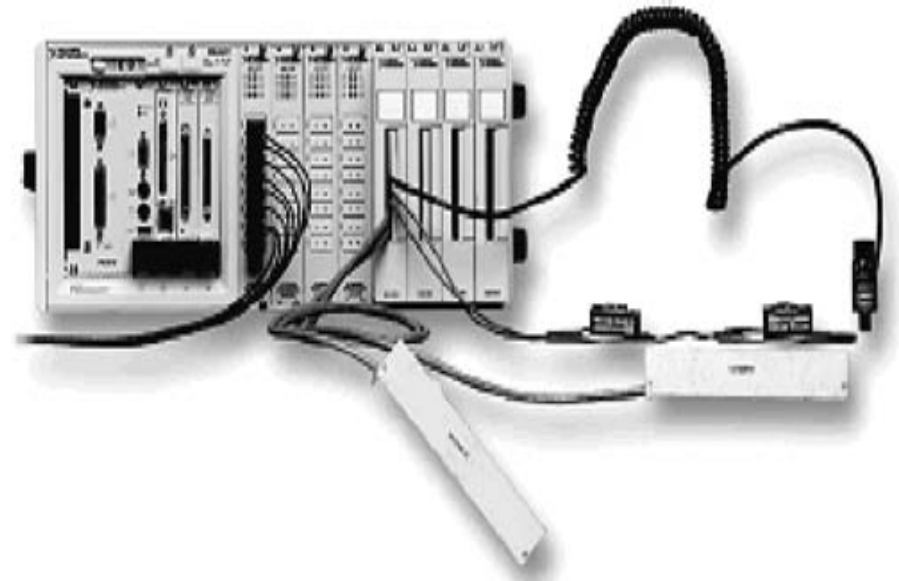
雜訊濾除
趨勢移除
時間域分析
頻率域分析
時頻分析
統計分析
矩陣與數學運算
MATLAB, DLL

輸出

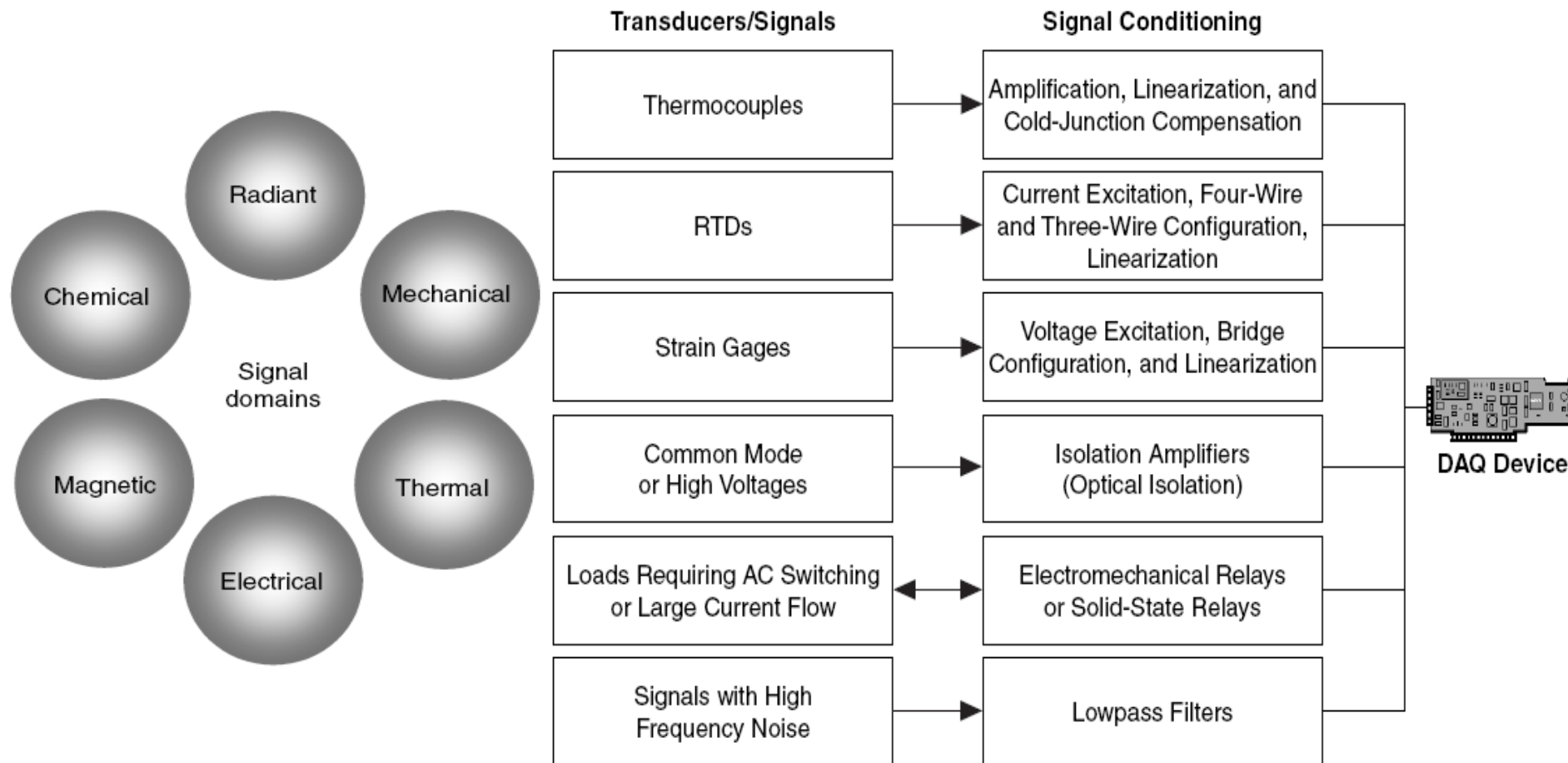
圖形
檔案
訊號產生器



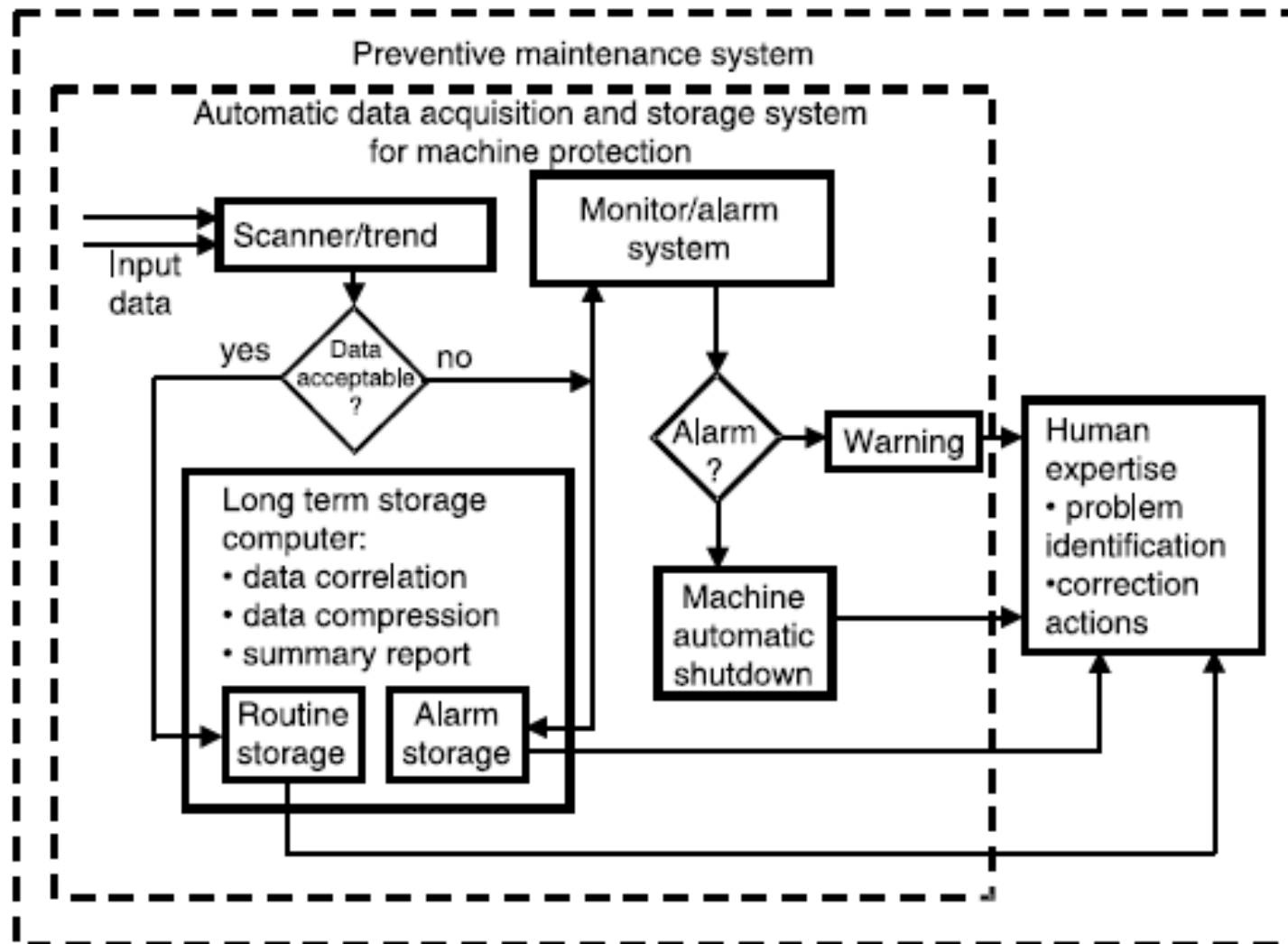
資料擷取卡擴充性：可攜式、工業用、分散式



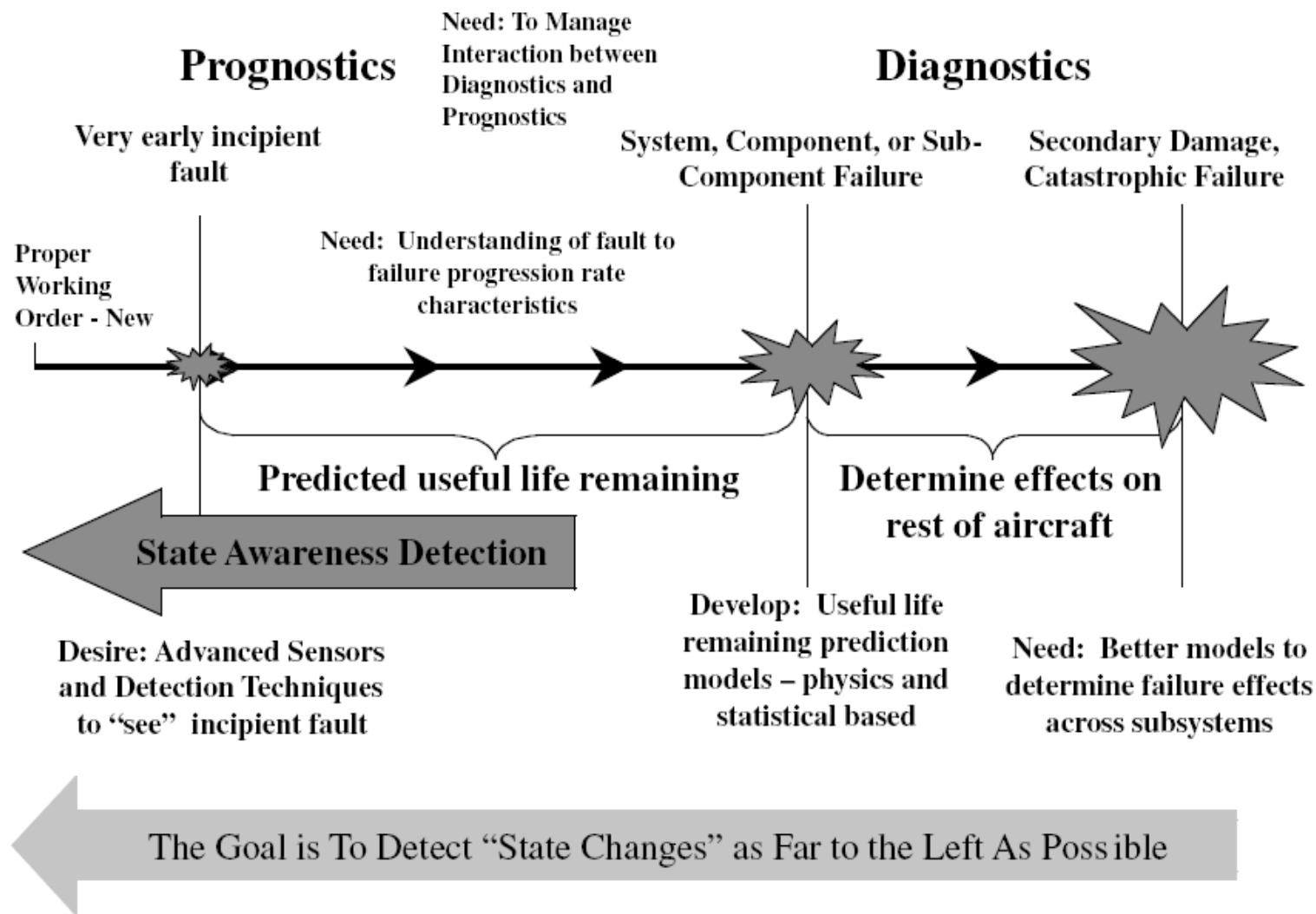
感測器擴充性：多物理場訊號擷取與整合



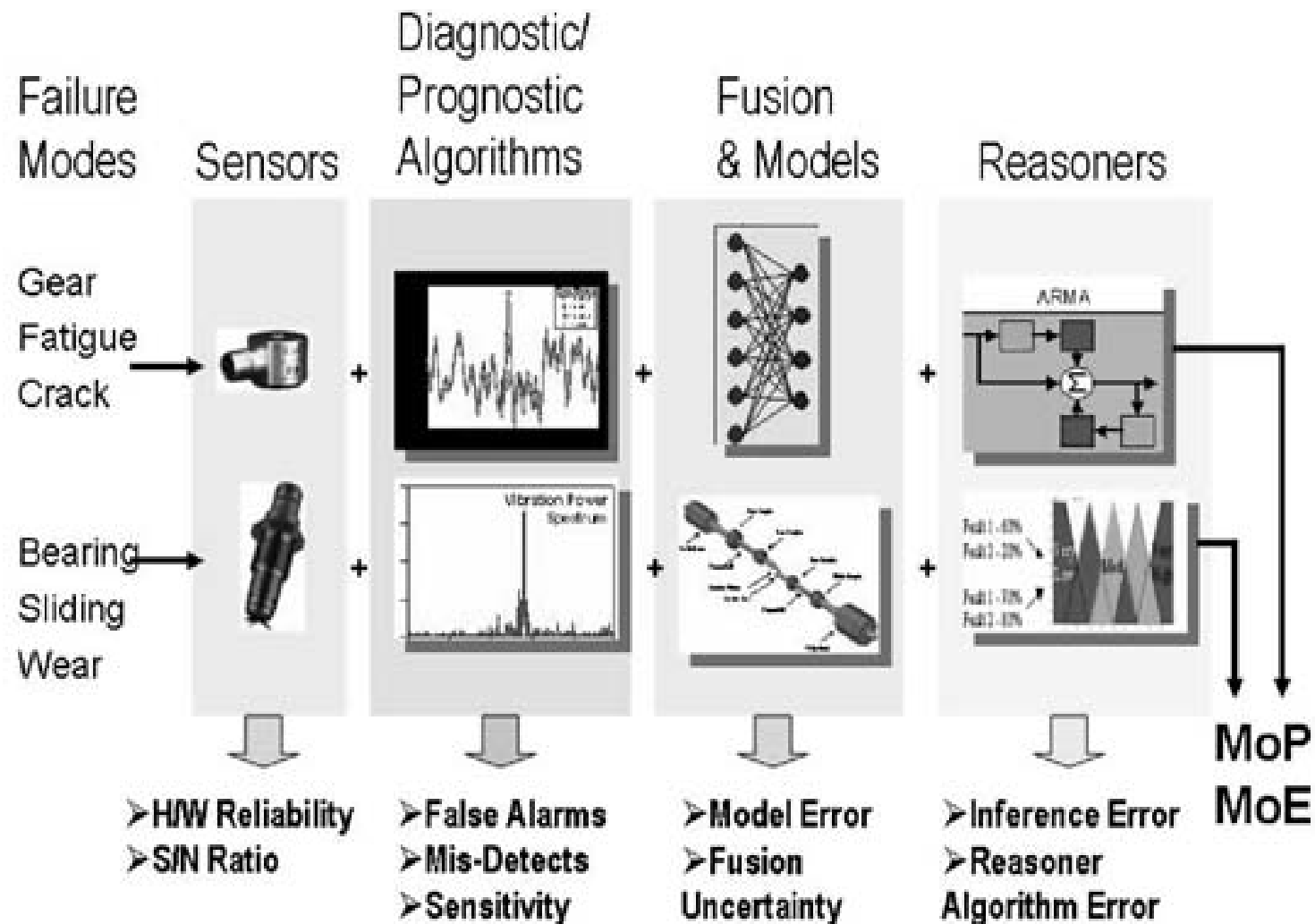
軟體擴充性：預防保養系統



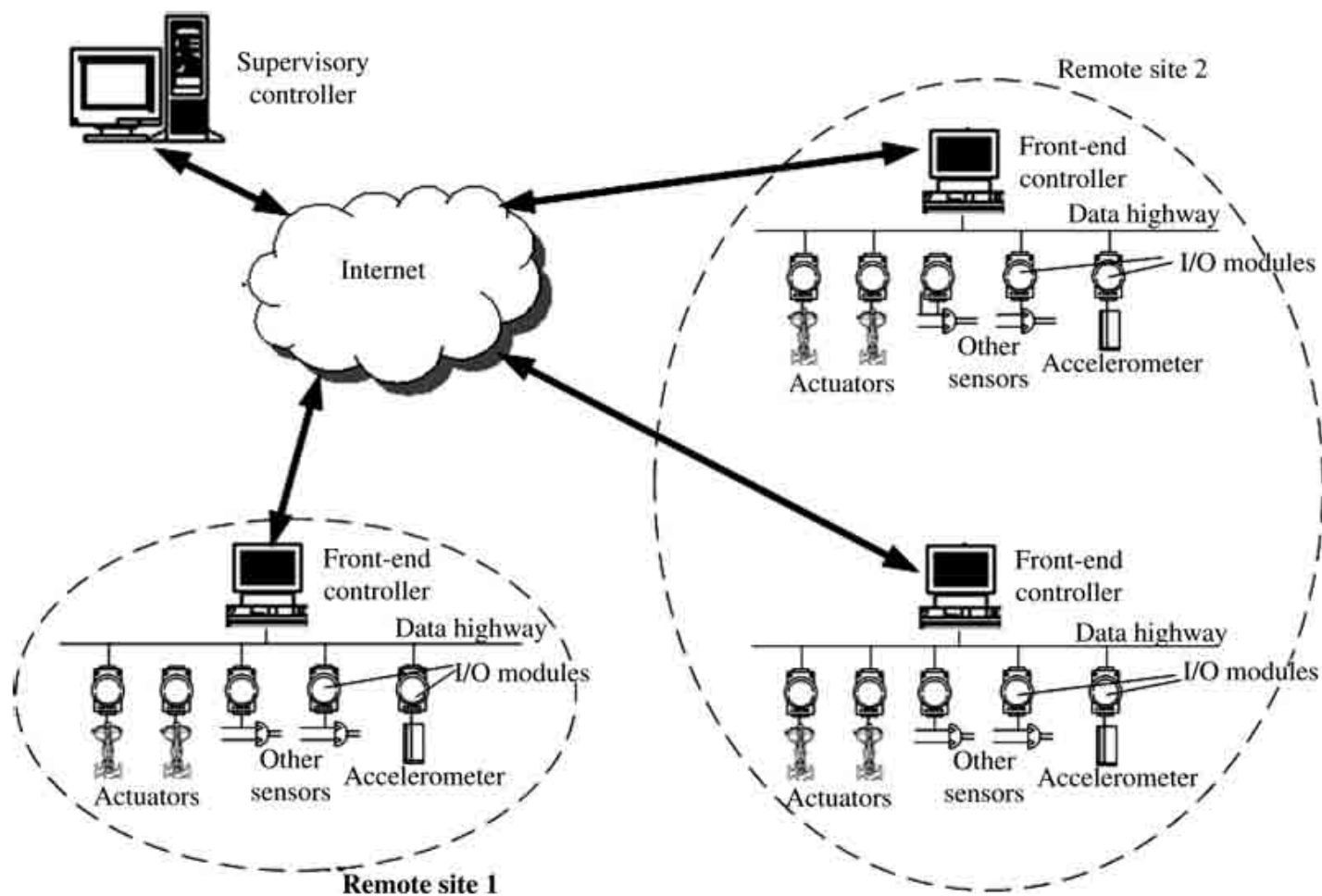
軟體擴充性：線上故障預知與診斷系統



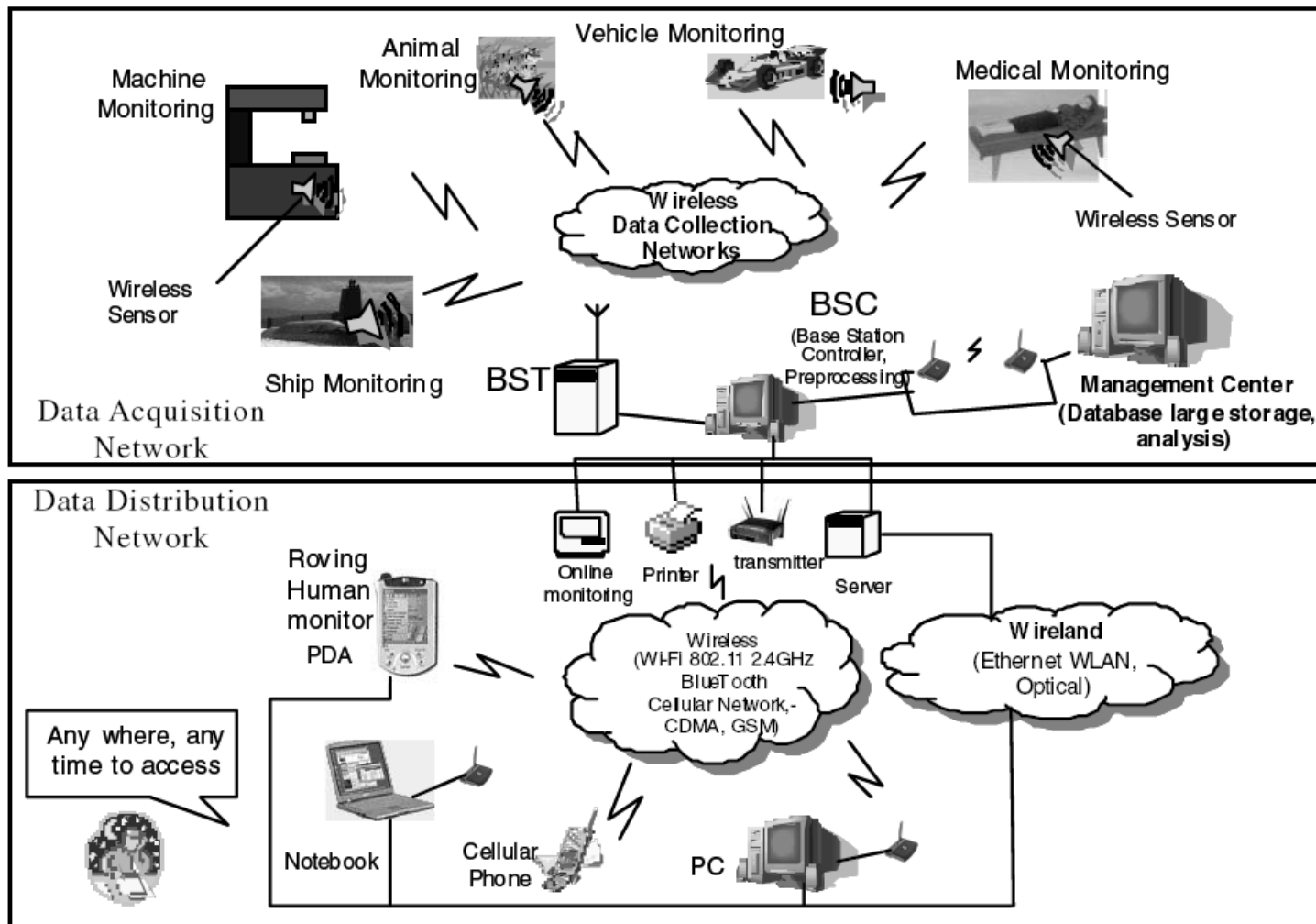
軟體擴充性：智慧型診斷系統



軟體擴充性：遠端監測與控制系統

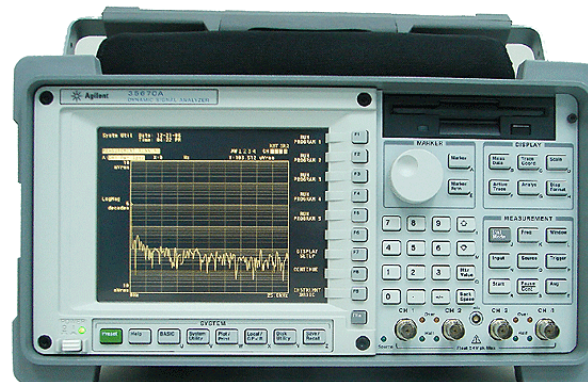


軟體擴充性：資料庫建立與傳輸網路系統

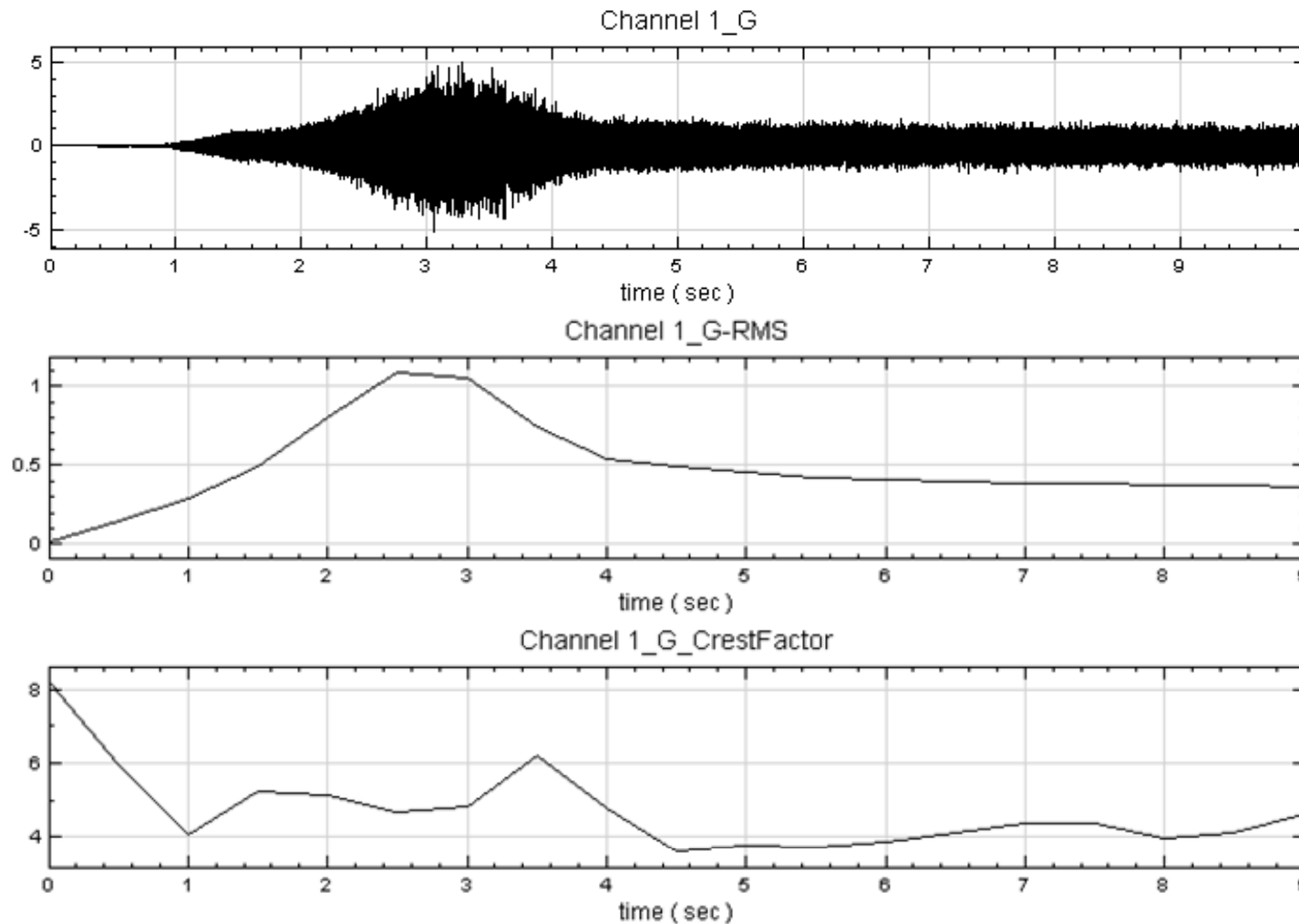


Why Sound and Vibration Module?

- Vibration Level
 - RMS: RMS, Peak, Peak-to-Peak
 - Crest Factor
 - Peak : Max, Min, True Peak, True Peak-to-Peak
- Sound Level
 - A, B, and C Weighting
 - Octave
- Order Tracking
 - Digital Tacho
 - Order Tracking by STFT
 - Order Tracking by EnMorlet
- Bearing Analysis
 - Bearing Defect
 - Envelope Detection
- Cepstrum
- Scale...



Vibration Level: RMS & Crest Factor

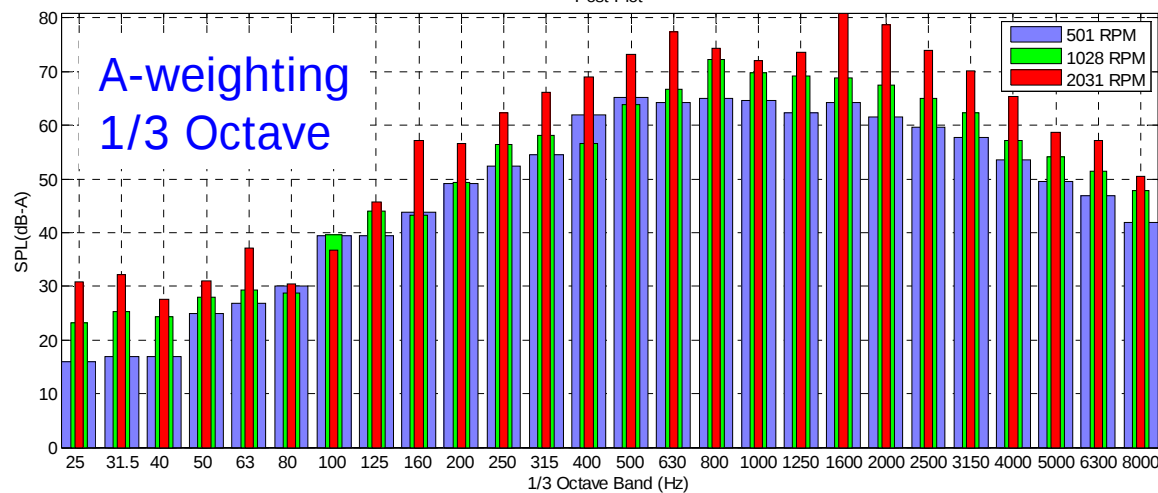
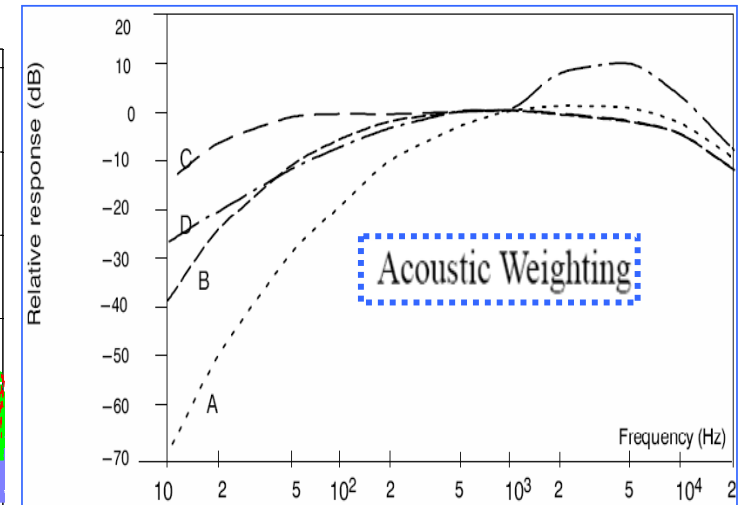
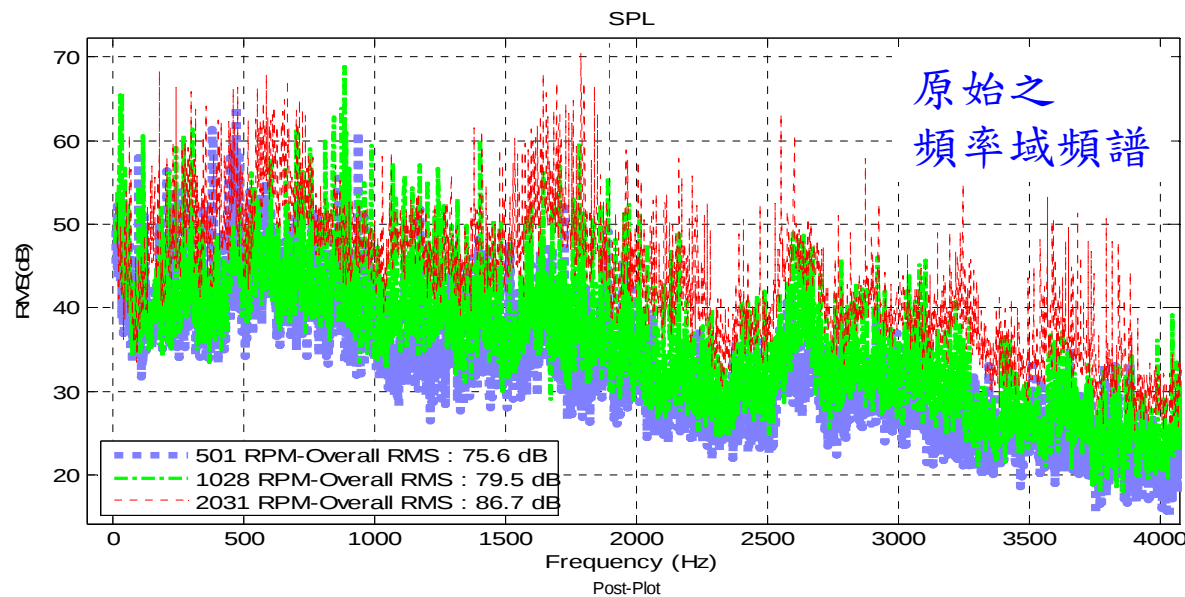


$$RMS = \sqrt{\frac{1}{T} \int_0^T a^2(t) dt}$$

$$CrestFactor = \frac{TruePeak}{RMS}$$



Sound Level: Weighting & Octave



ThirdOctave : $\frac{1}{3}$ 八度音

Octave : 八度音

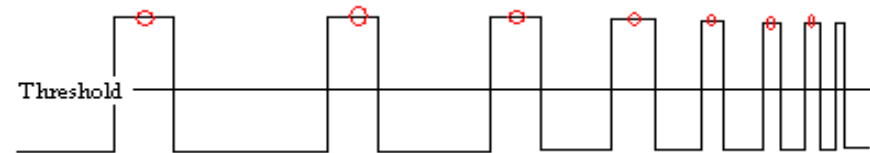
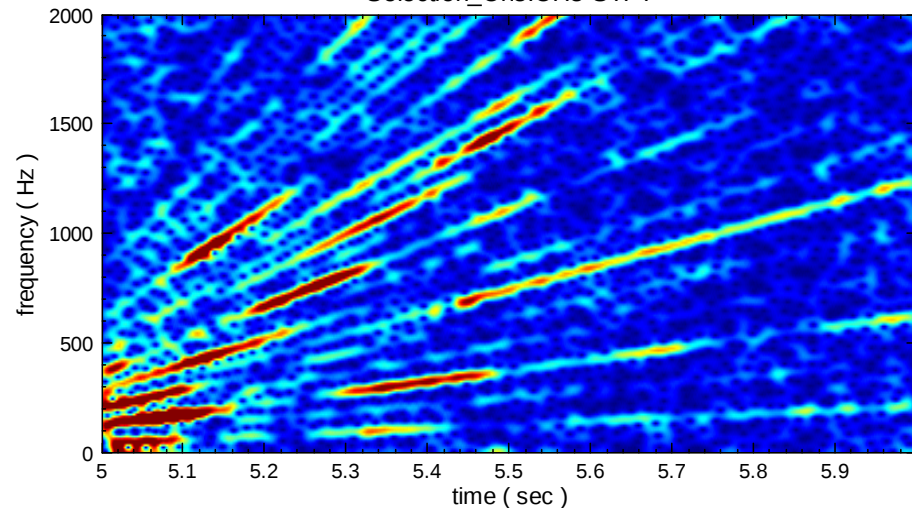
N_Octave : $\frac{1}{n}$ 八度音 ($n = \frac{1}{1}, \frac{1}{3}, \frac{1}{6}, \frac{1}{12}, \frac{1}{24}$)

人耳效應

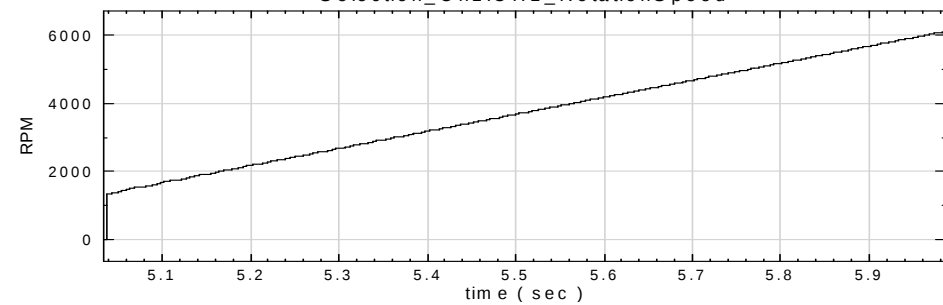


Order Tracking

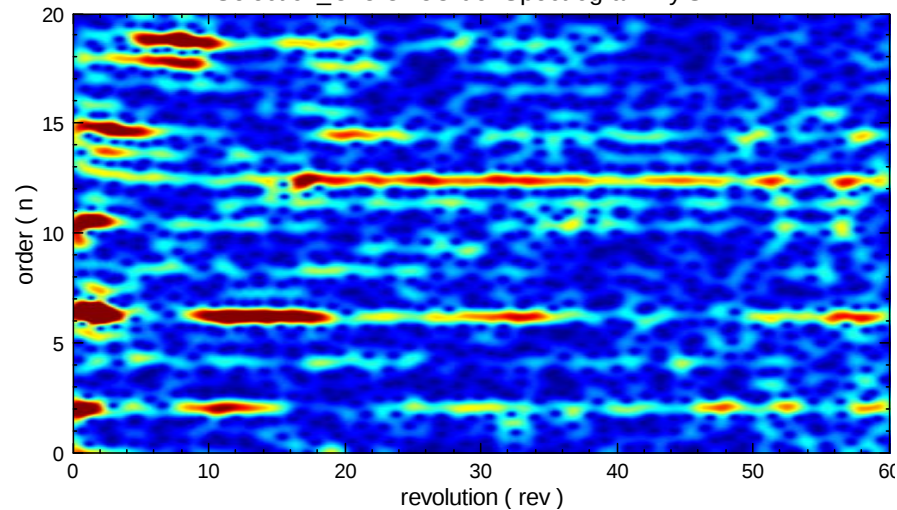
Selection_Ch3:CH3-STFT



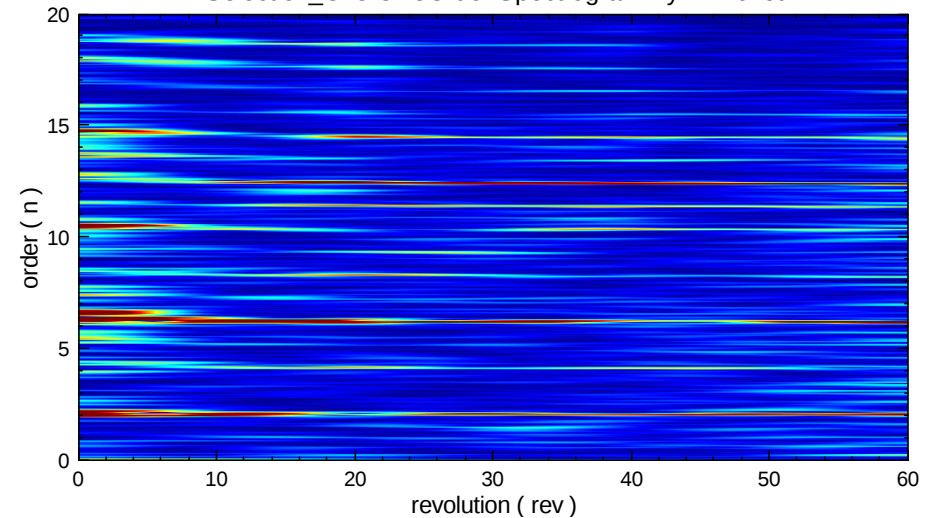
Selection_Ch1:CH1_RotationSpeed



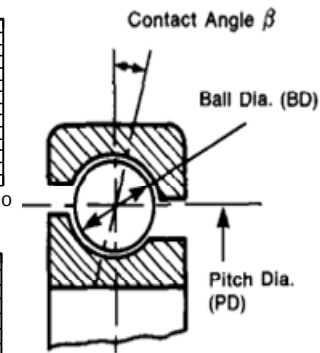
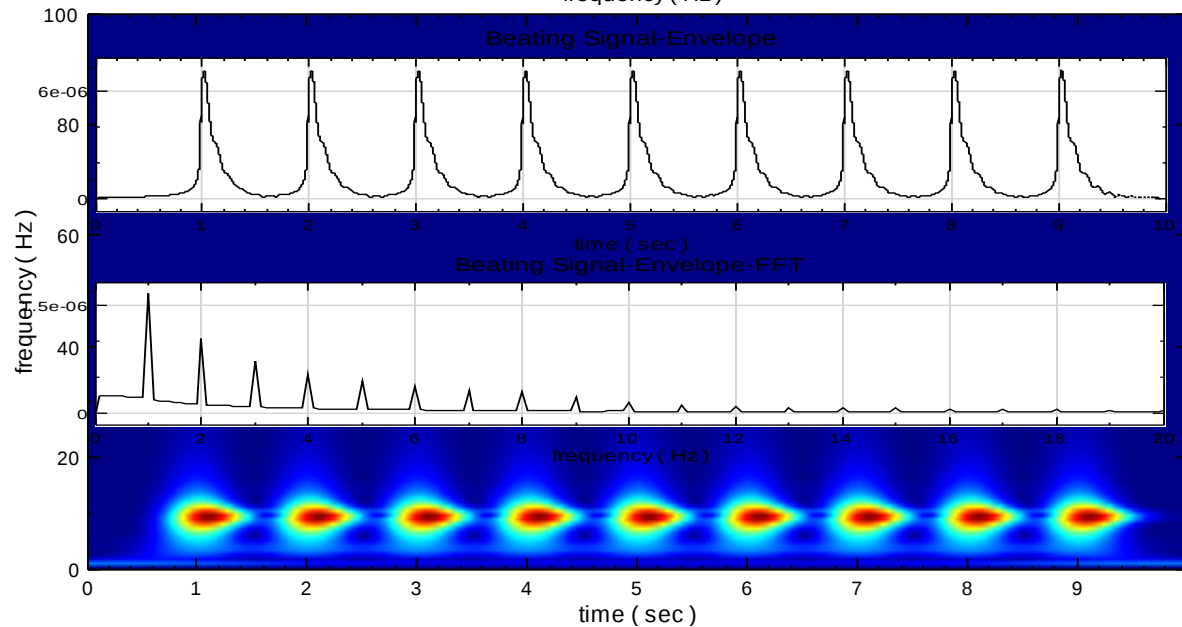
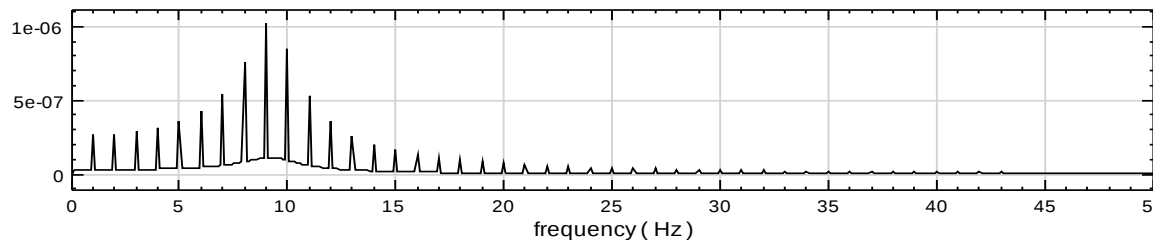
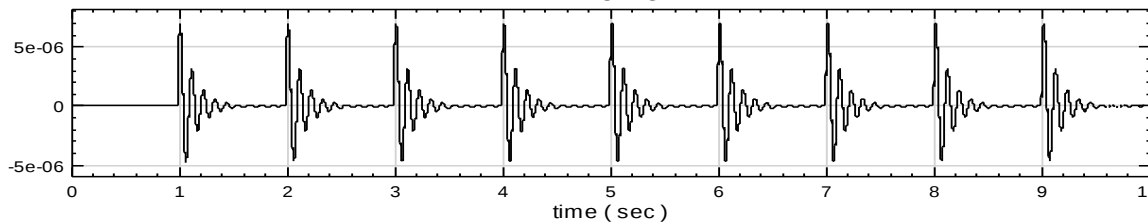
Selection_Ch3:CH3Order Spectrogram By STFT



Selection_Ch3:CH3Order Spectrogram By EnMorlet



Bearing Analysis



n = number of balls or rollers
 f_r = relative rev./s between inner and outer races

Impact Rates f (Hz) (assuming pure rolling motion)

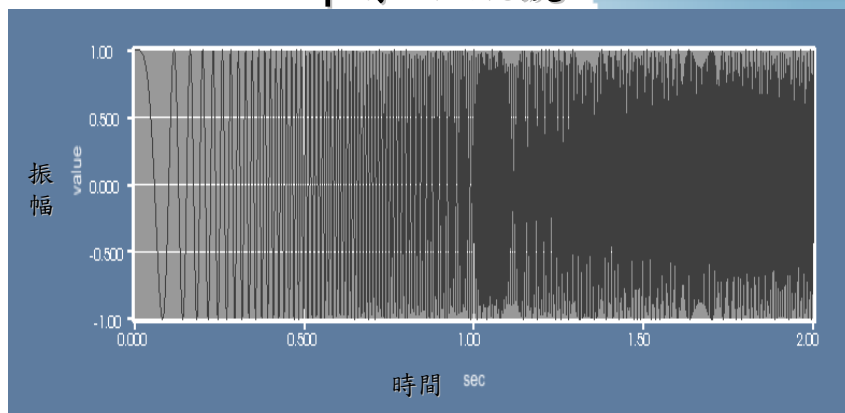
$$\text{For Outer Race Defect: } f(\text{Hz}) = \frac{n}{2} f_r \left(1 - \frac{BD}{PD} \cos \beta \right)$$

$$\text{For Inner Race Defect: } f(\text{Hz}) = \frac{n}{2} f_r \left(1 + \frac{BD}{PD} \cos \beta \right)$$

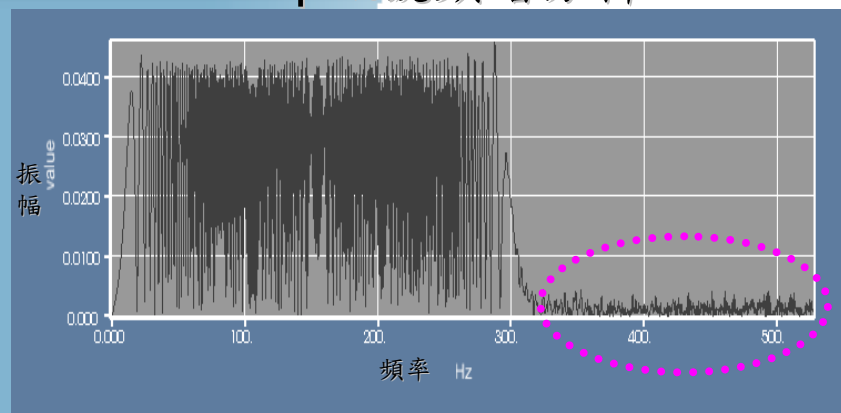
$$\text{For a Ball Defect: } f(\text{Hz}) = \frac{PD}{BD} f_r \left[1 - \left(\frac{BD}{PD} \cos \beta \right)^2 \right]$$

Why高解析時頻分析? $\Rightarrow$ 細微異常檢出

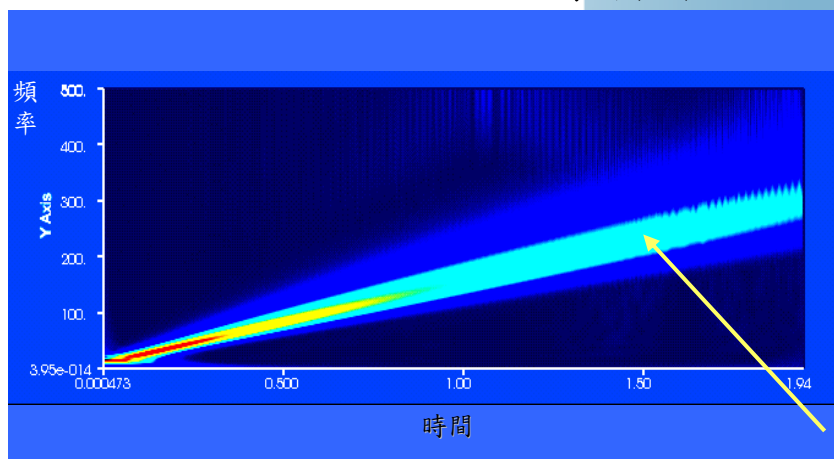
Chirp原始訊號



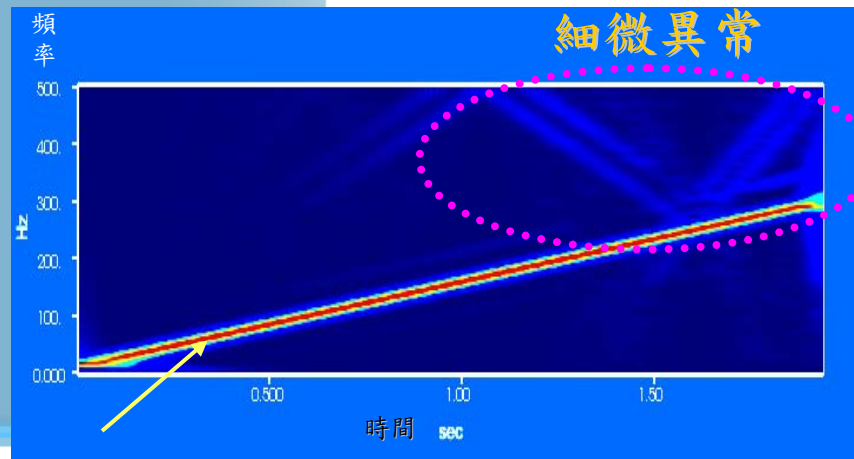
Chirp訊號頻譜分析



Morlet Transform時頻圖



Enhanced Morlet Transform

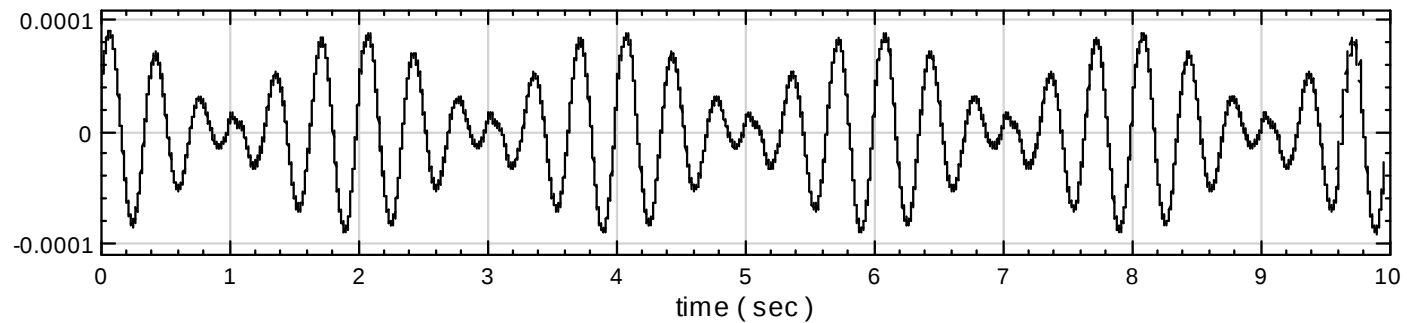


色彩表示其能量或振幅

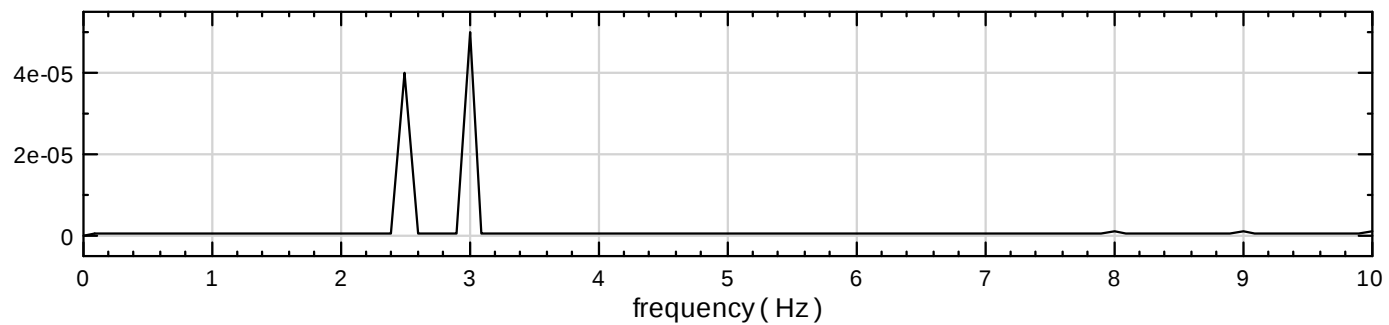
EMD

EMD 應用於微小損壞訊號偵測

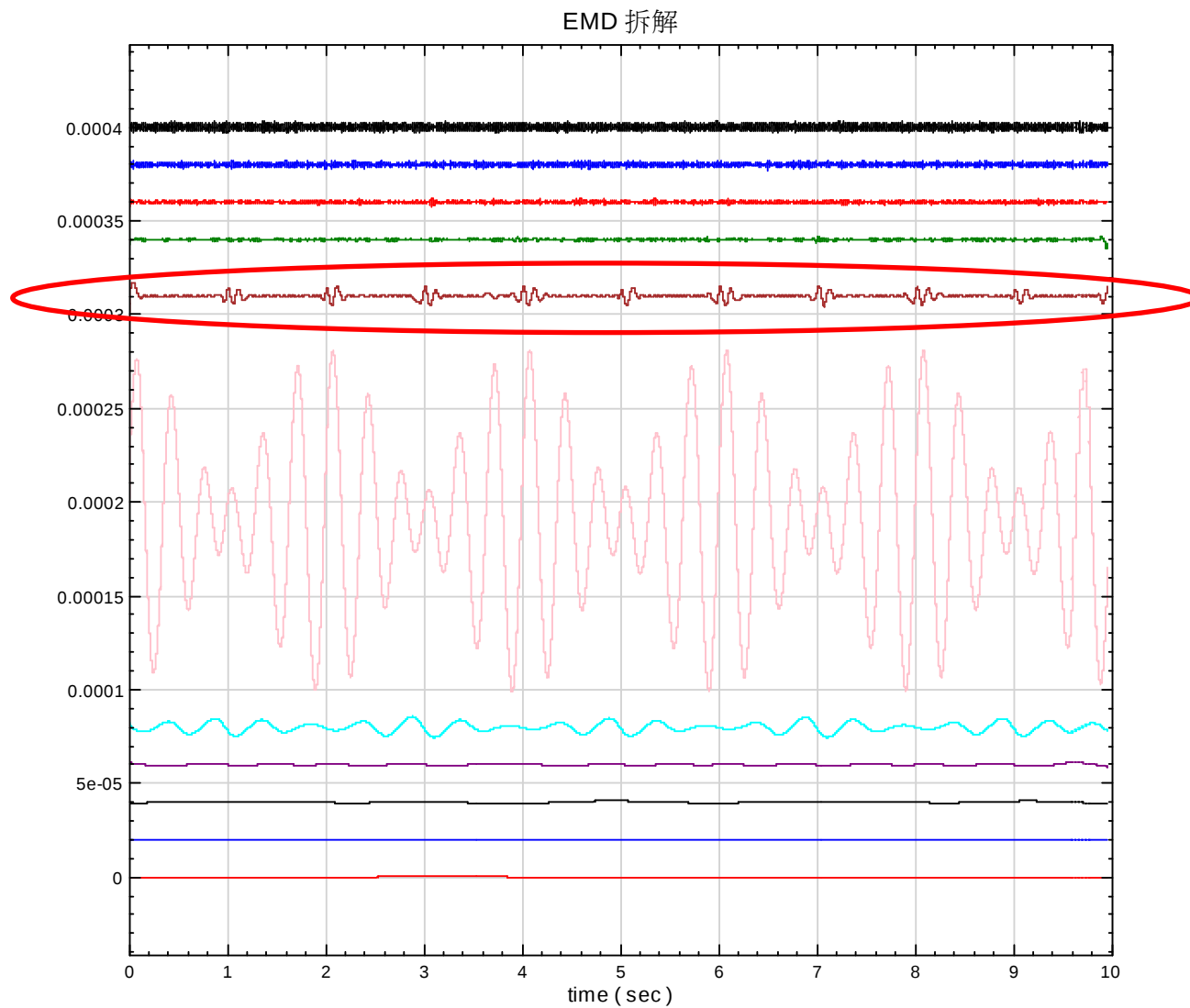
原始訊號



FFT

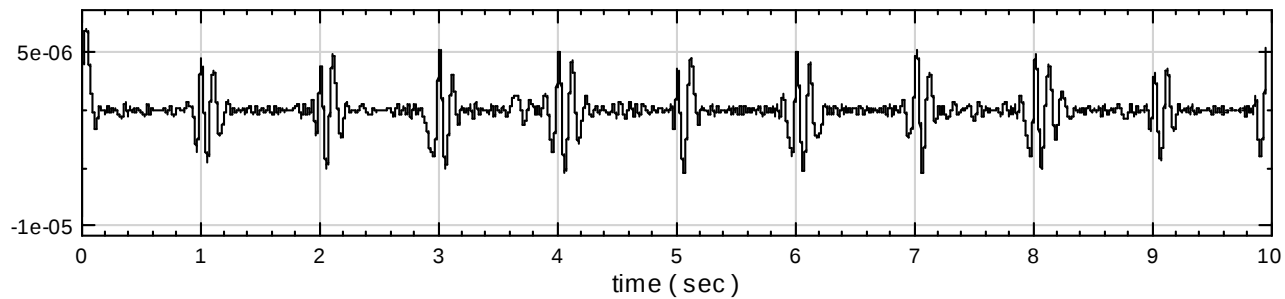


EMD 應用於微小損壞訊號偵測

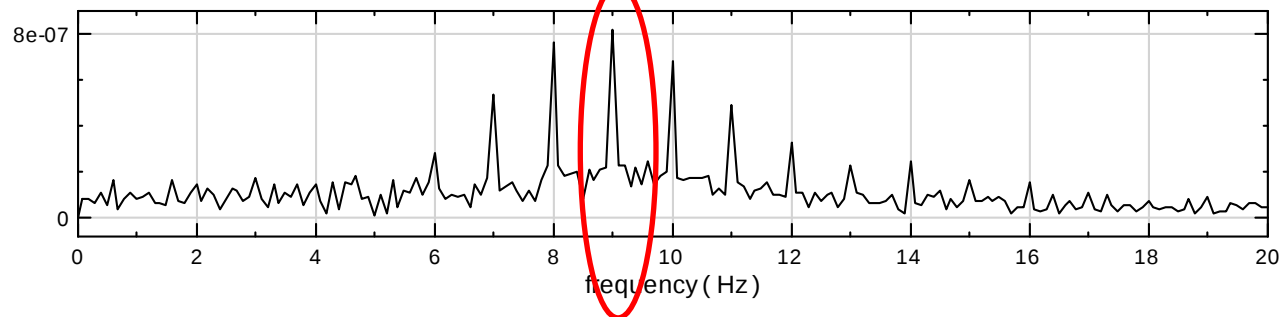


EMD 應用於微小損壞訊號偵測

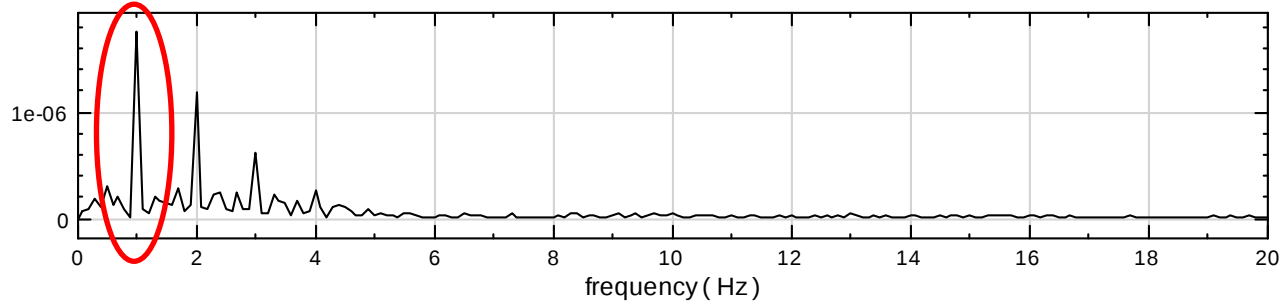
分解出來的損壞訊號



分解出來的損壞訊號頻譜

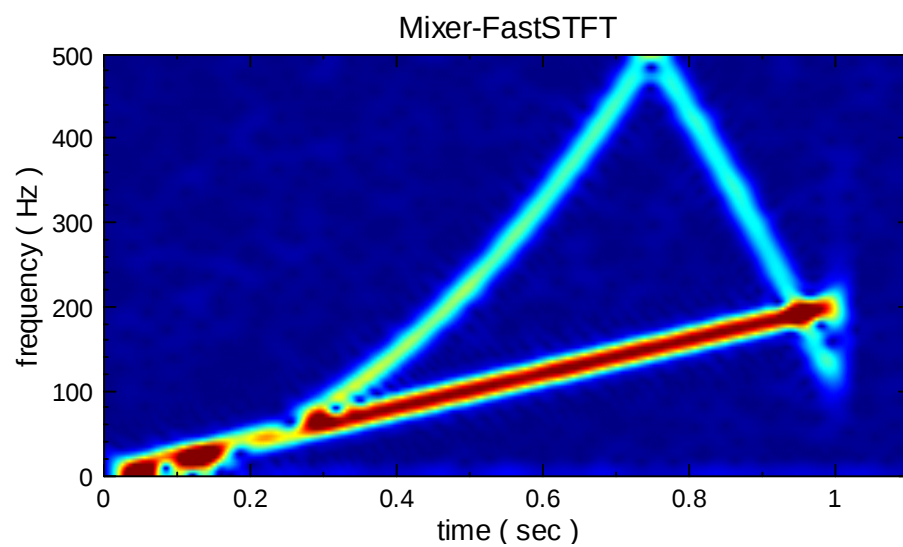
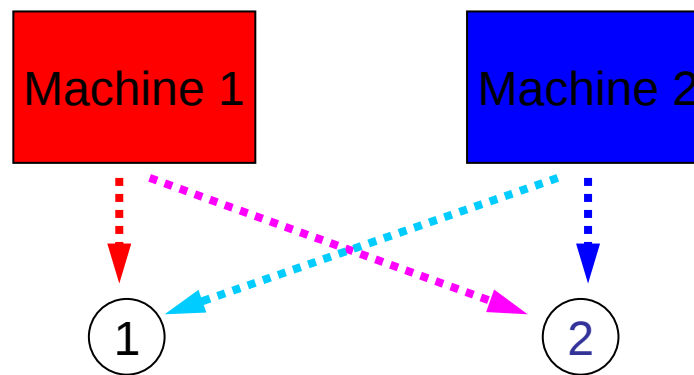


Envelope Detection

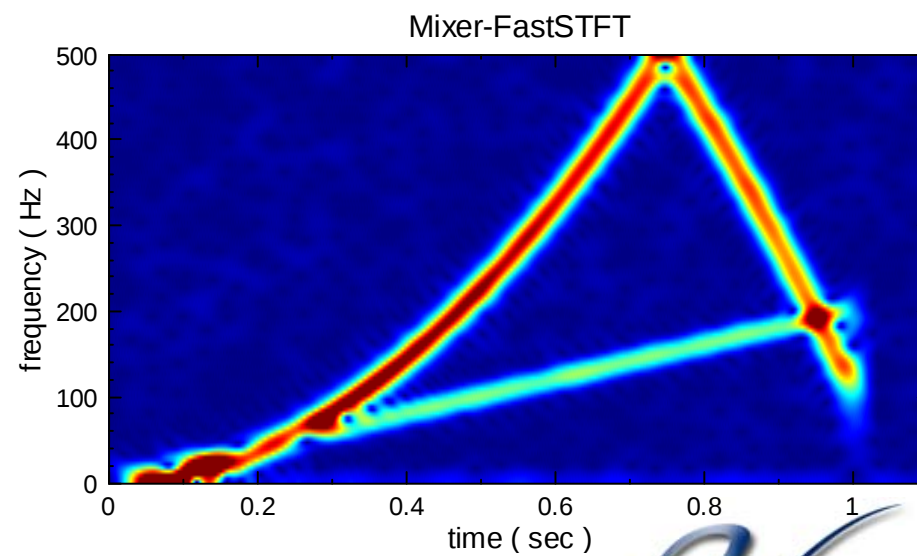


ICA

2個量測點之混合訊號



1

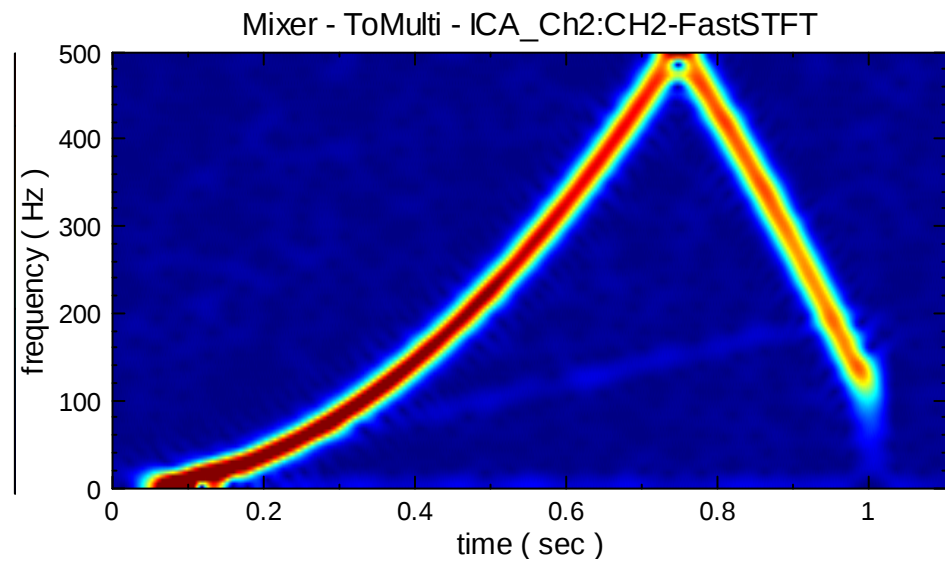
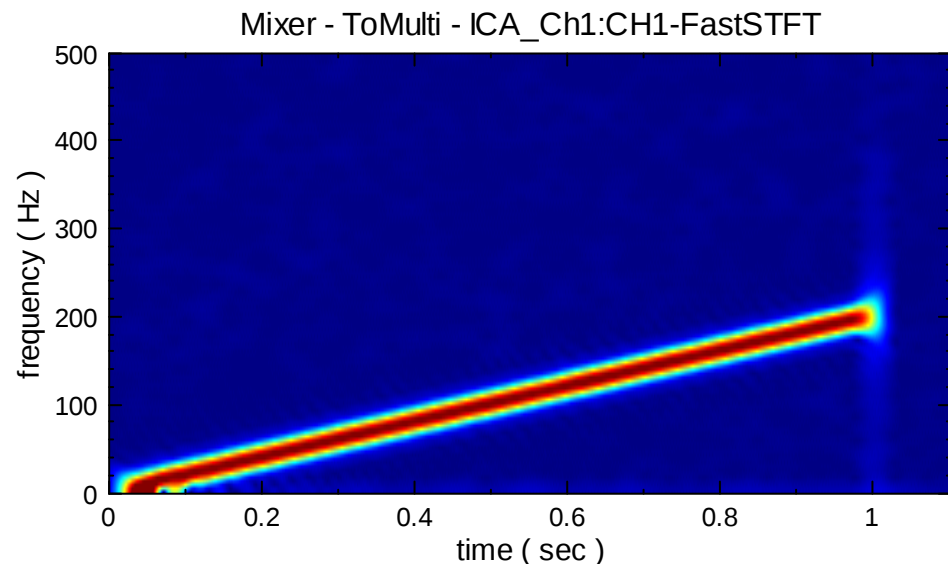


2

ICA分離 $\Rightarrow$ 2個獨立振動源

Machine 1

Machine 2

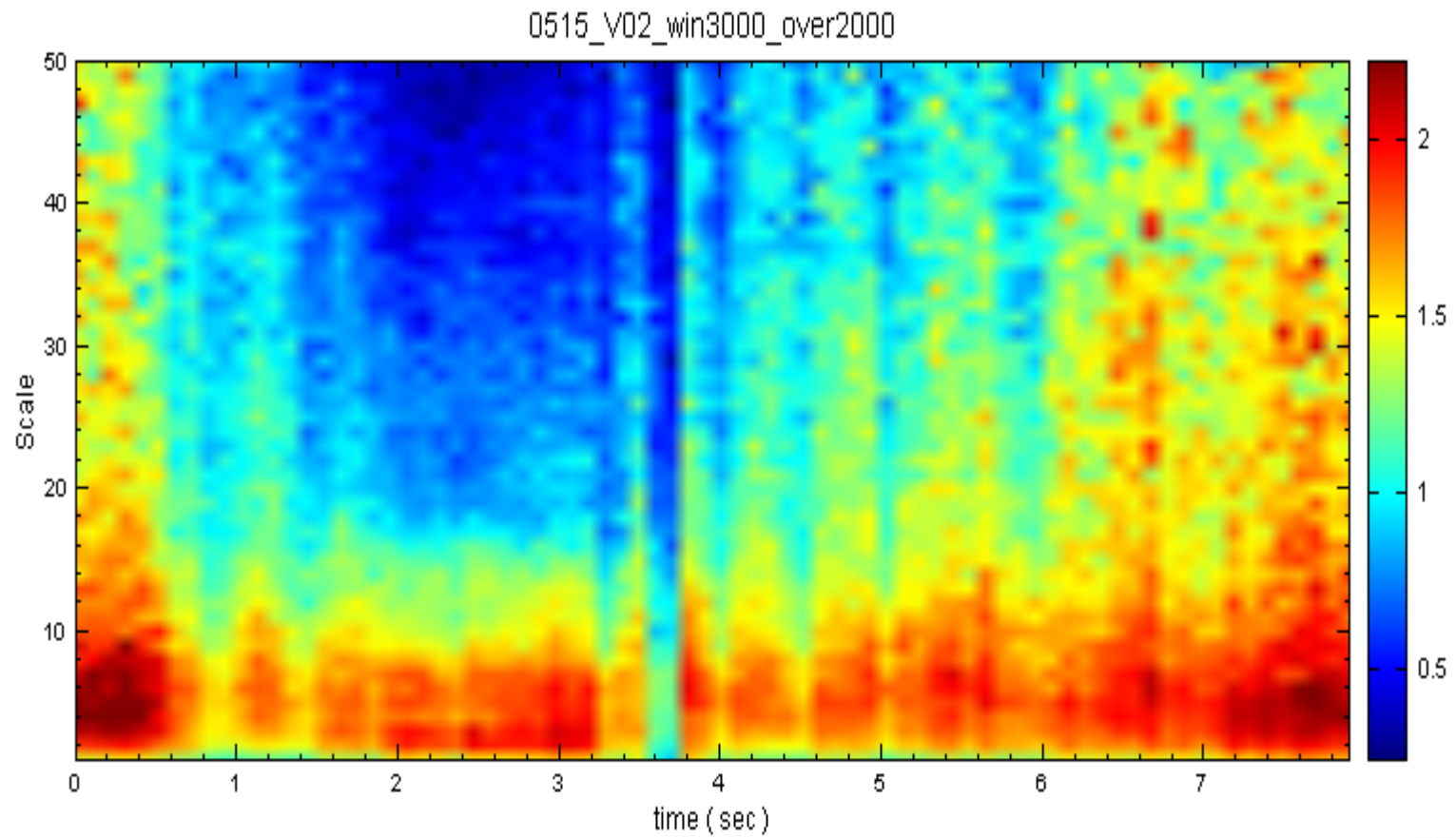


MSE

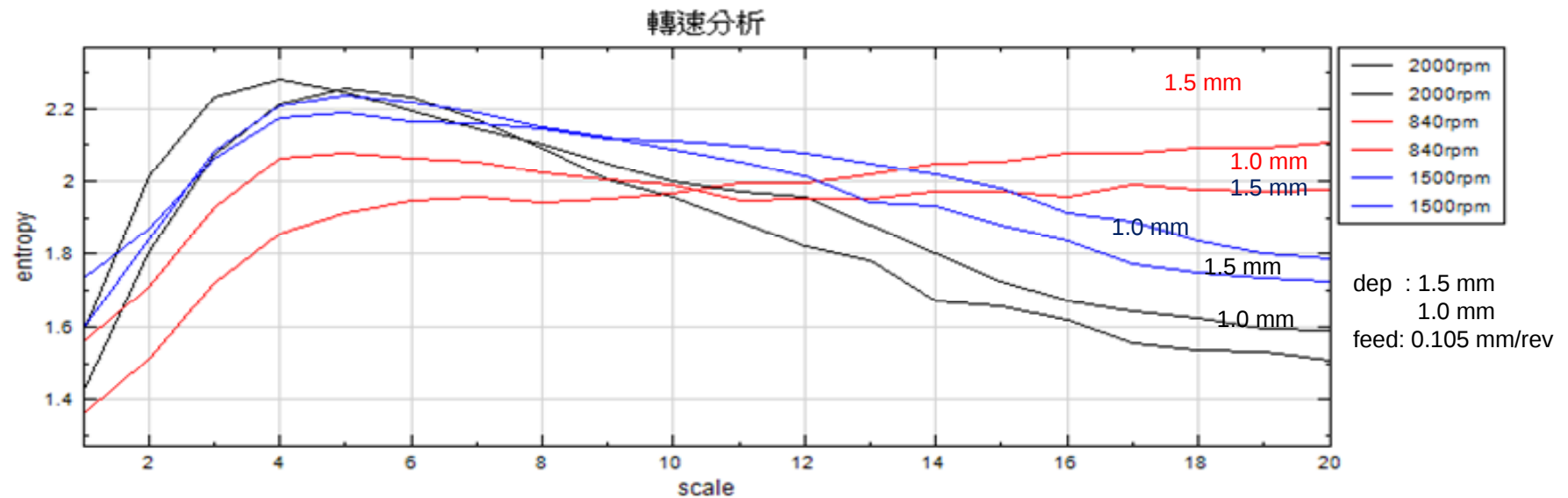
MSE：刀具損壞/加工異常檢測



切削過程：Rolling MSE



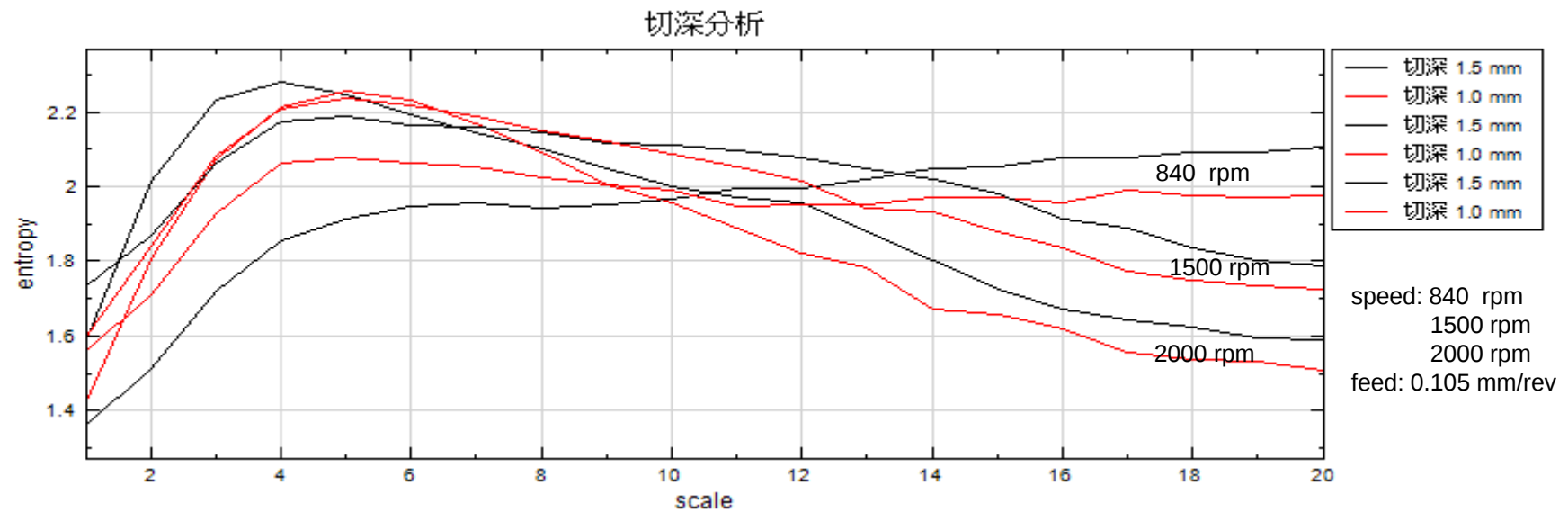
MSE：轉速分析



MSE - 轉速分析

1. 產生較明顯的變化與資料相似度。
2. 轉速在MSE上的表現明顯(決定整體趨勢線走向)。

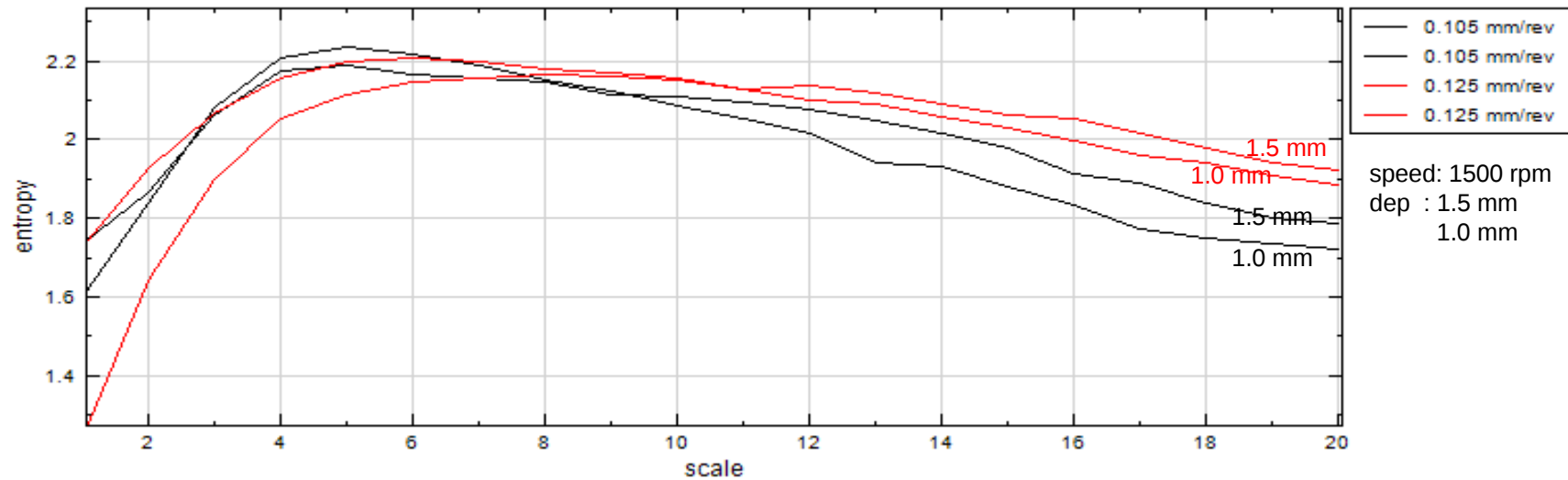
MSE：切深分析



MSE - 切深分析

1. 淺切深的趨勢線較低，穩定度相對較高。

MSE：進給分析

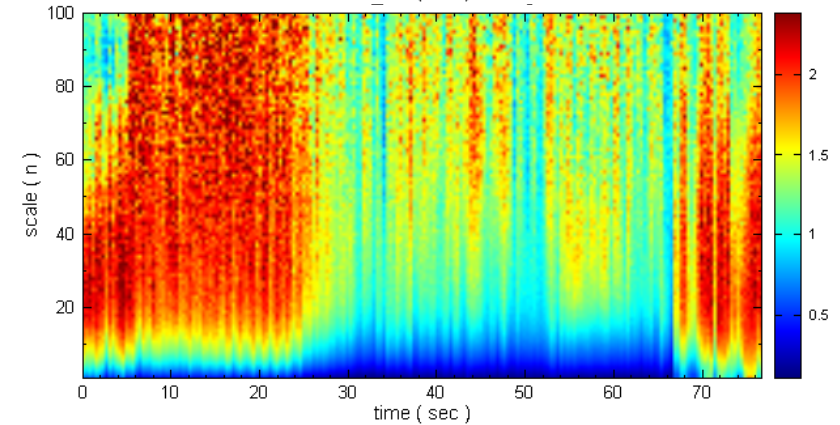
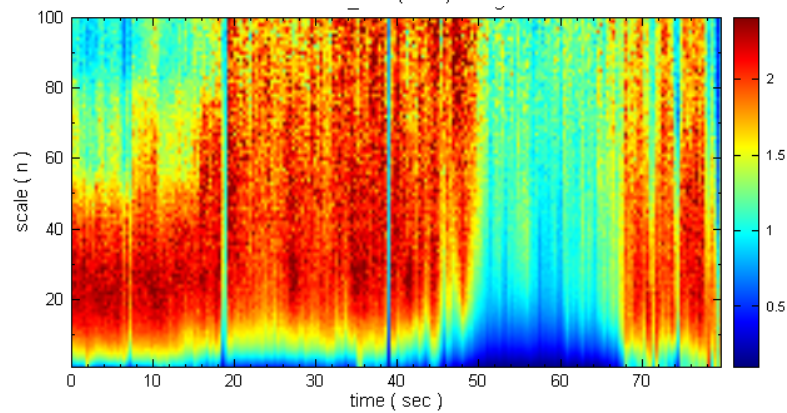
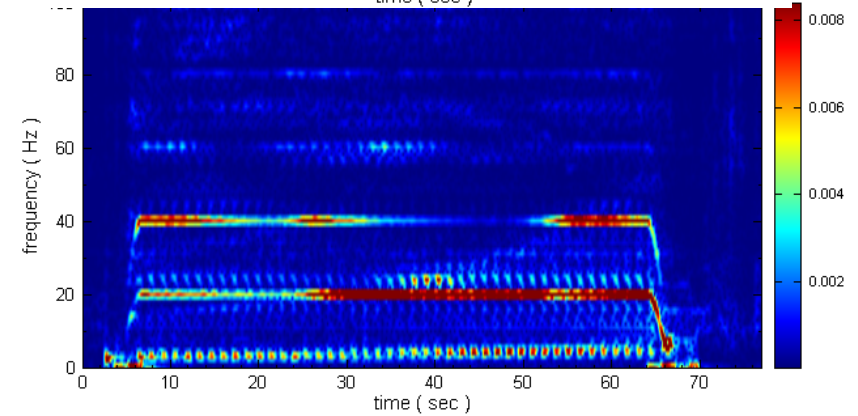
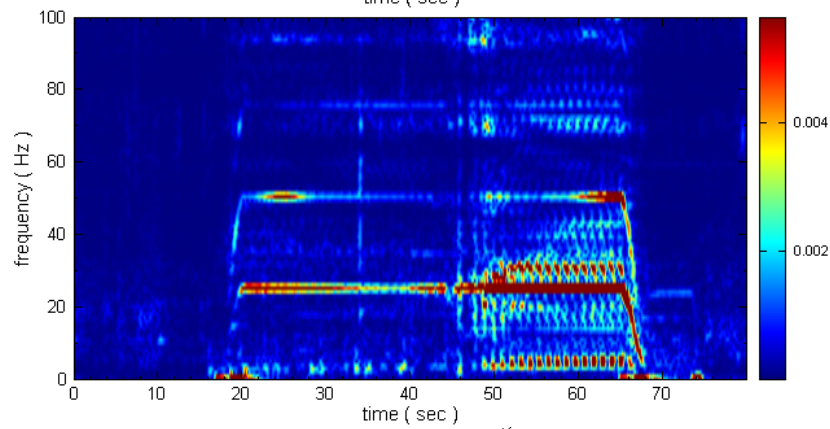
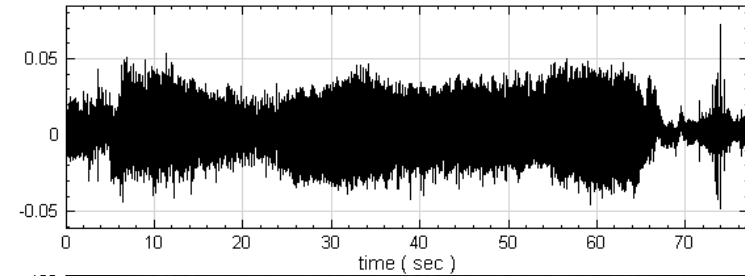
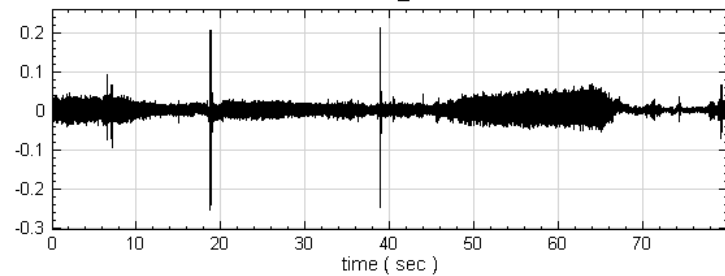


MSE - 進給分析

1. 進給的MSE趨勢線比轉速及切深的趨勢線不明顯。

明顯度判別: 轉速>切深>進給

電梯振動：Rolling MSE



Applications

應用實例：系統整合平台



應變儀

應變規
格式



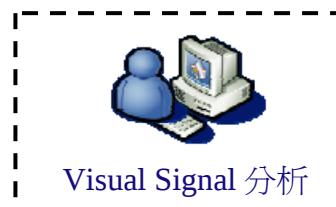
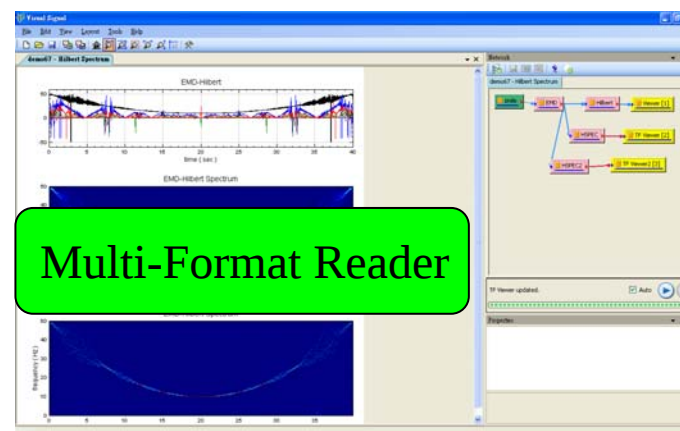
振動儀

振動儀
格式



轉速計

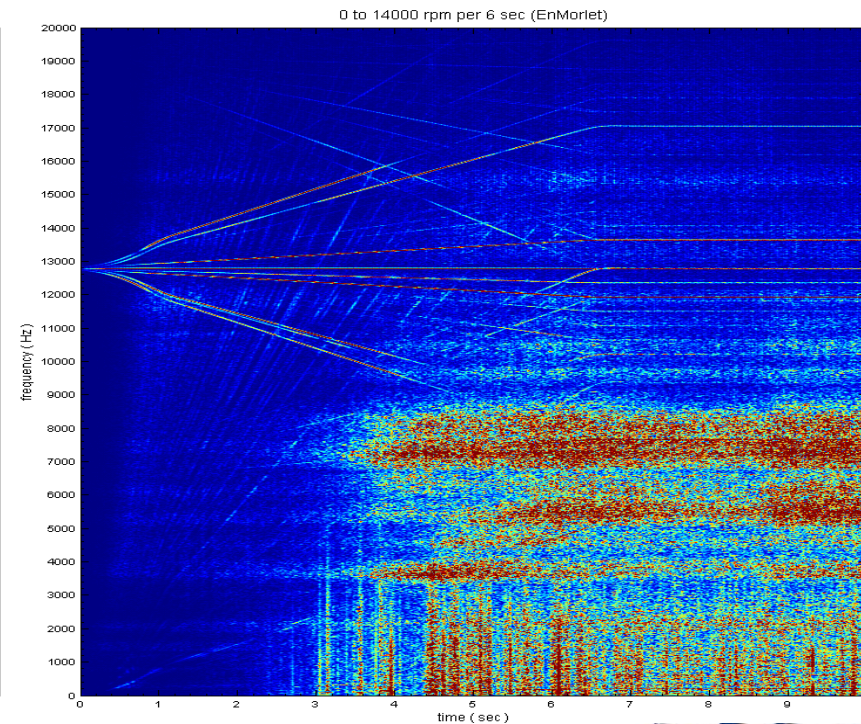
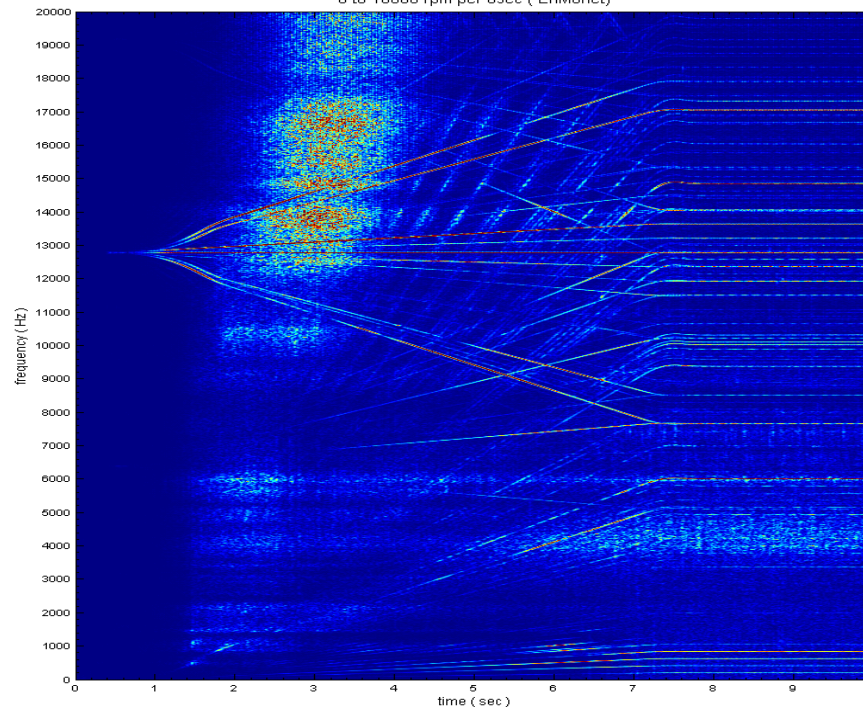
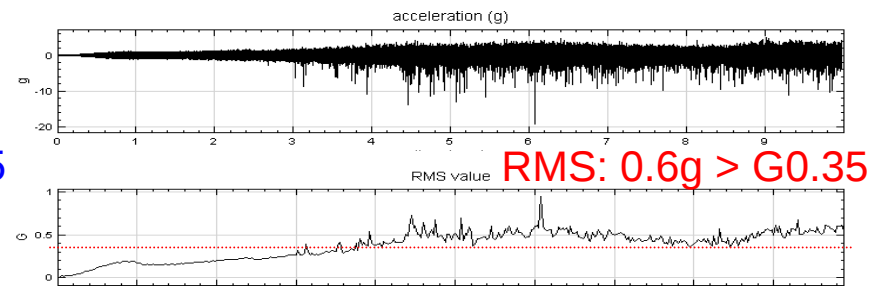
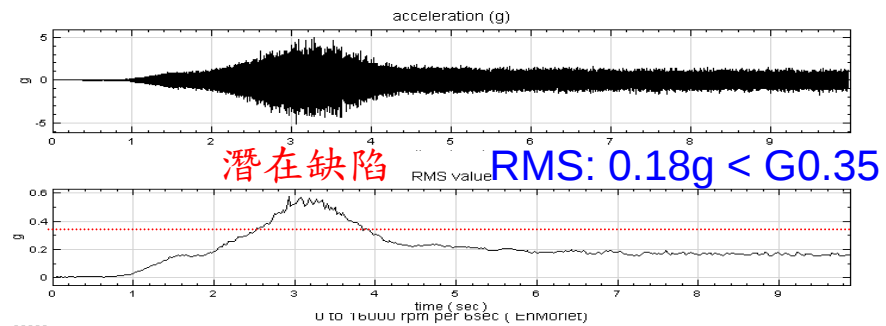
轉速計
格式



應用實例：主軸 QA 檢測系統



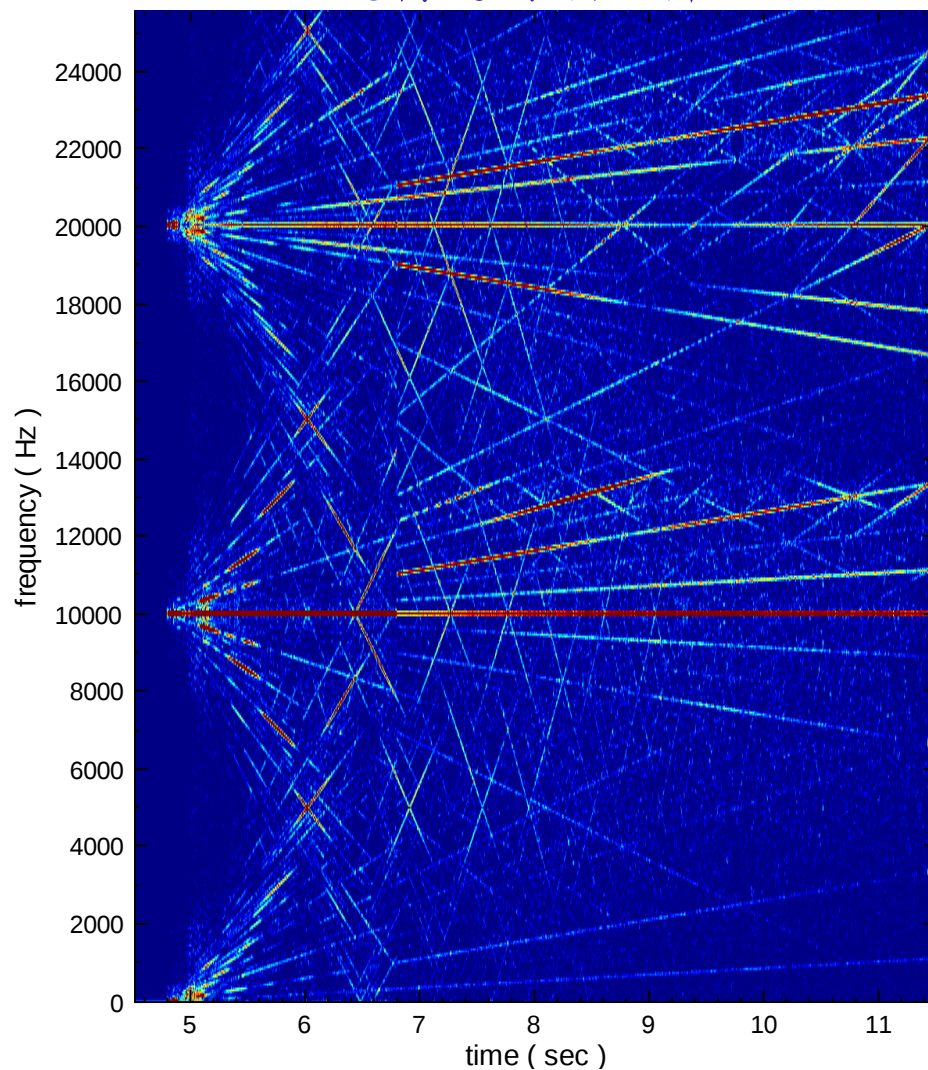
Why變轉速時頻分析? ⇨ 潛在缺陷檢出 先期故障排除



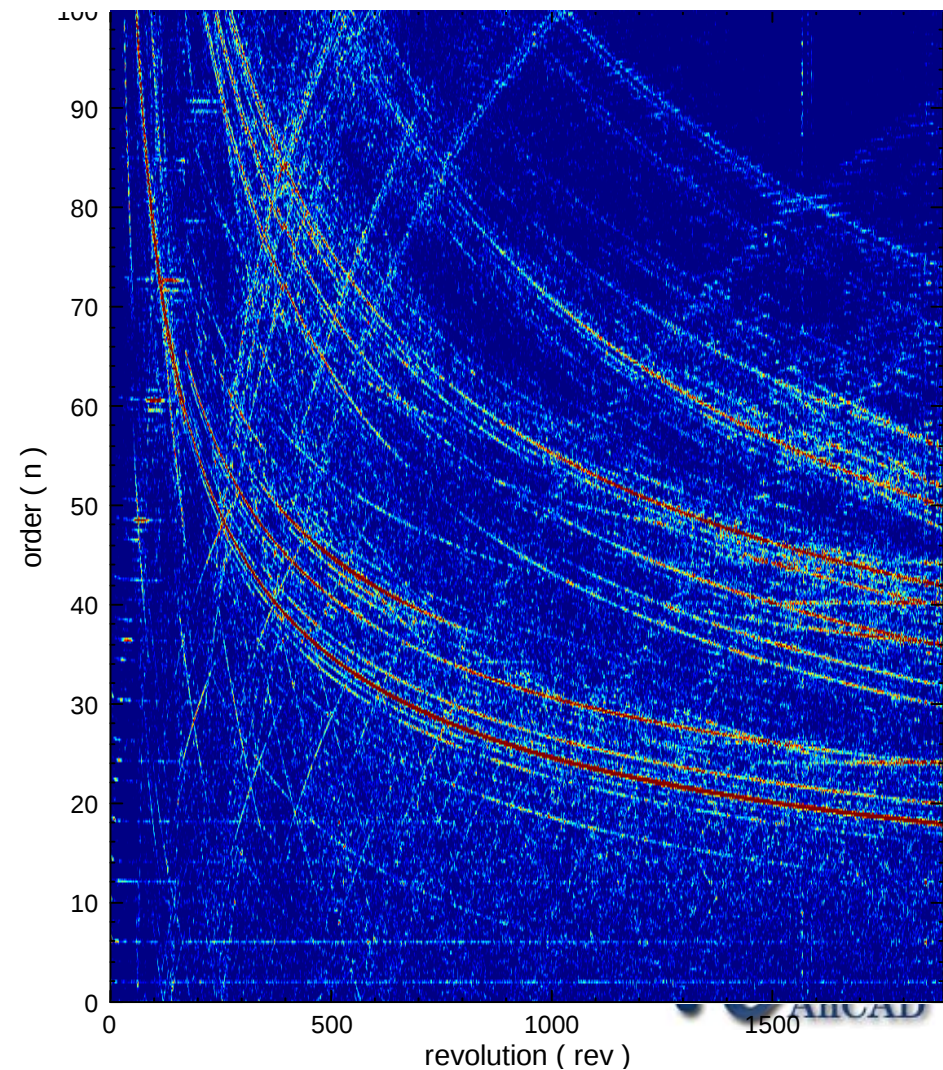
主軸之動態特性檢測

轉速倍頻、共振頻段、異常激振、頻率調變

變轉速時頻分析

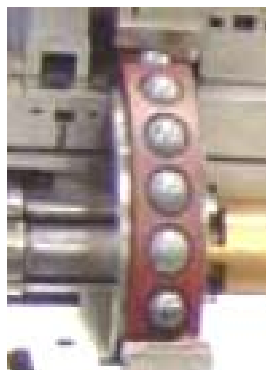


轉速階次分析

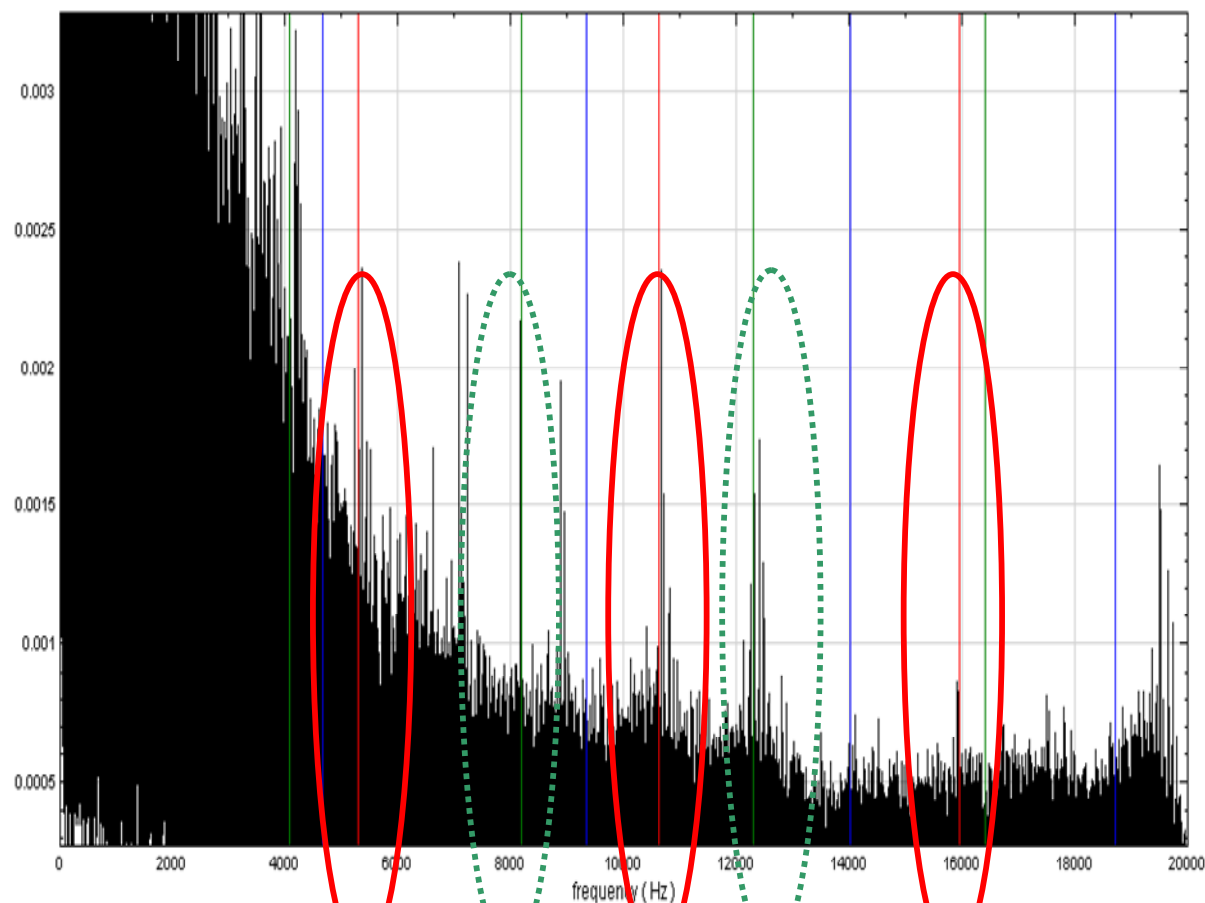


軸承之損壞特徵檢測

依據軸承規格自動計算內外環或滾珠損壞特徵頻率



Properties	
內環損傷頻率	4889.3940246405655
外環損傷頻率	4110.6059753594345
滾珠損傷頻率	4092.8338640344609
參數	
轉速	360
軸承規格	
軸承平均直徑	100
接觸角	25
滾珠直徑	8.73
滾珠數量	25
模組	
類別	BearingDefect
名稱	Bearing Defect
轉速	
主軸每秒轉幾圈，單位為(RPS)。	



滾珠損傷

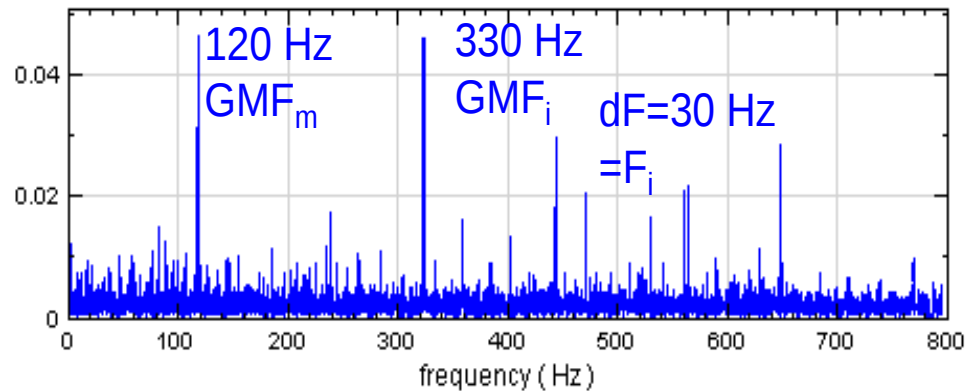
內環損傷

CAD

變速齒輪箱之嚙合異常檢測

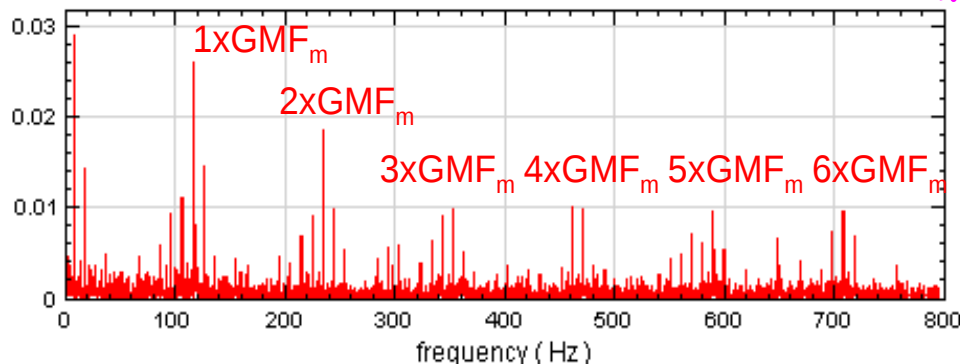
偏心、對心、鬆脫、背隙、磨損、斷齒

正常齒輪箱之包絡線頻譜



$dF=10 \text{ Hz}$
 $=F_m$

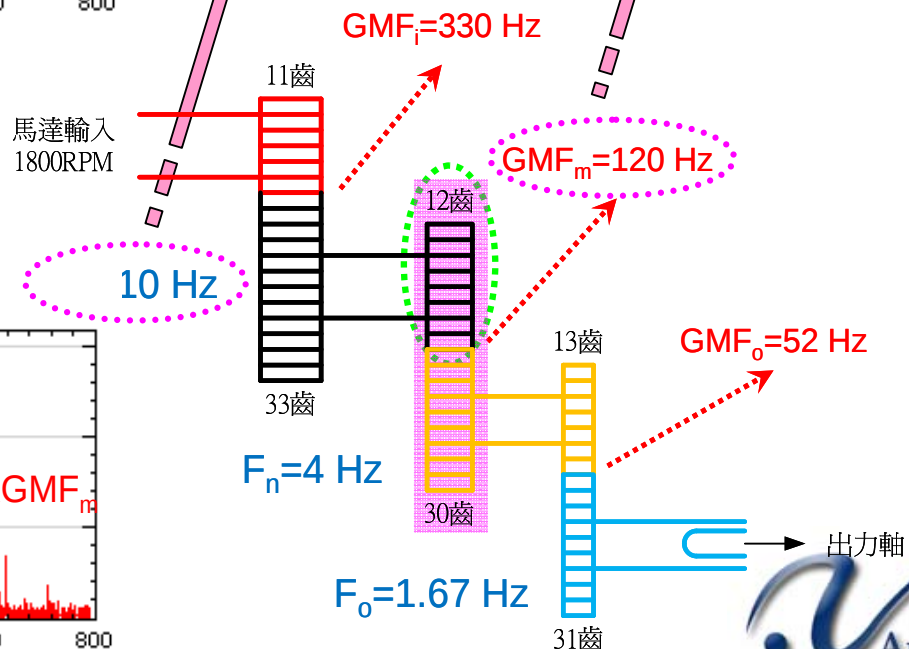
異常齒輪箱之包絡線頻譜



異常之
轉速調變頻率

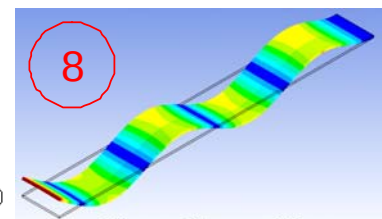
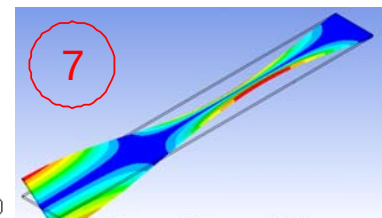
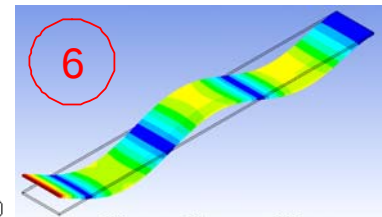
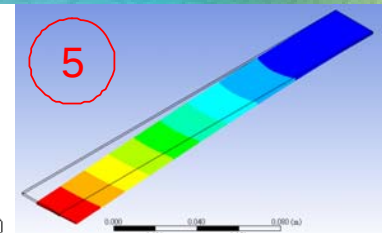
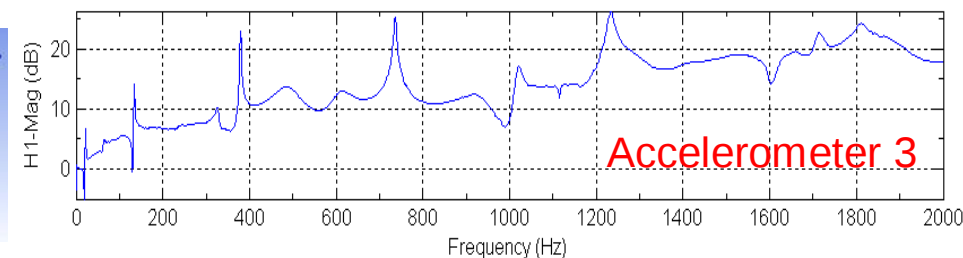
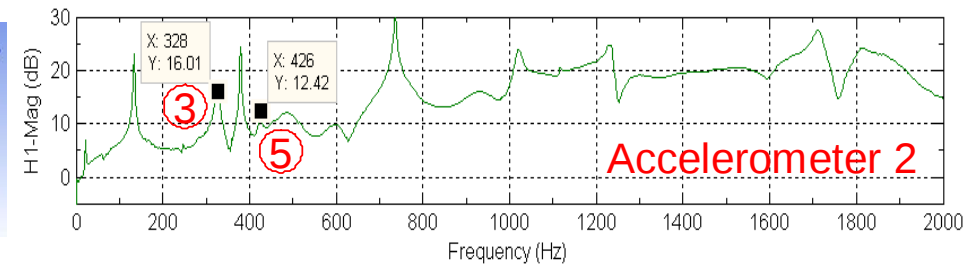
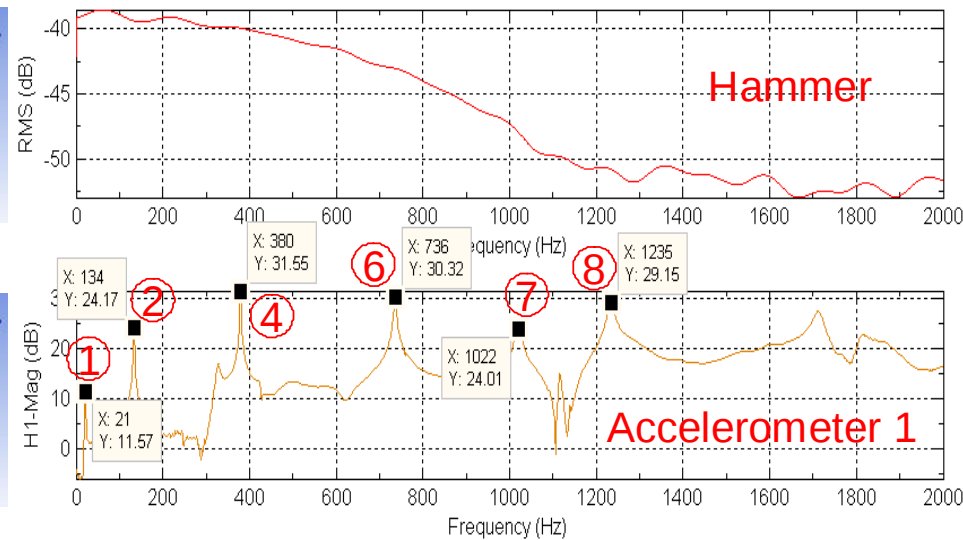
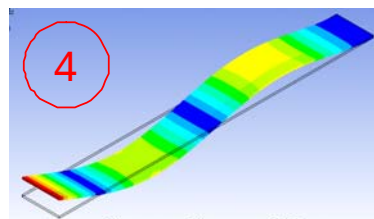
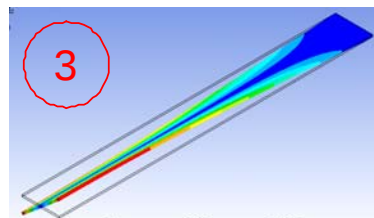
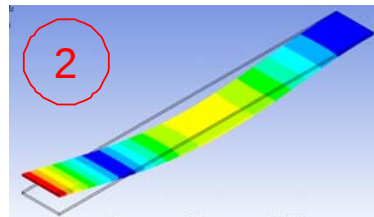
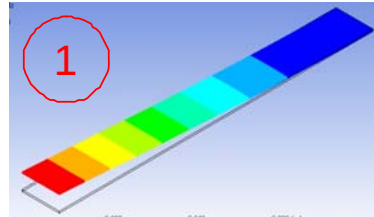
異常之
嚙合頻率

異常之齒輪
12齒



結構之自然頻率檢測

利用敲擊測試之自然頻率驗證有限元素分析之正確性

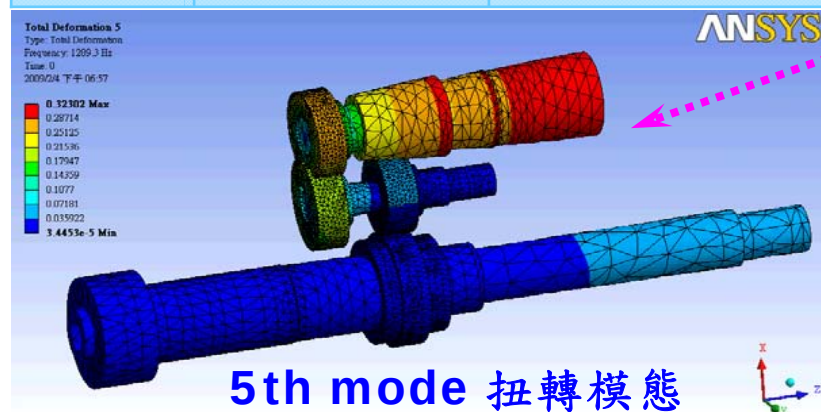


結構之自然頻率檢測

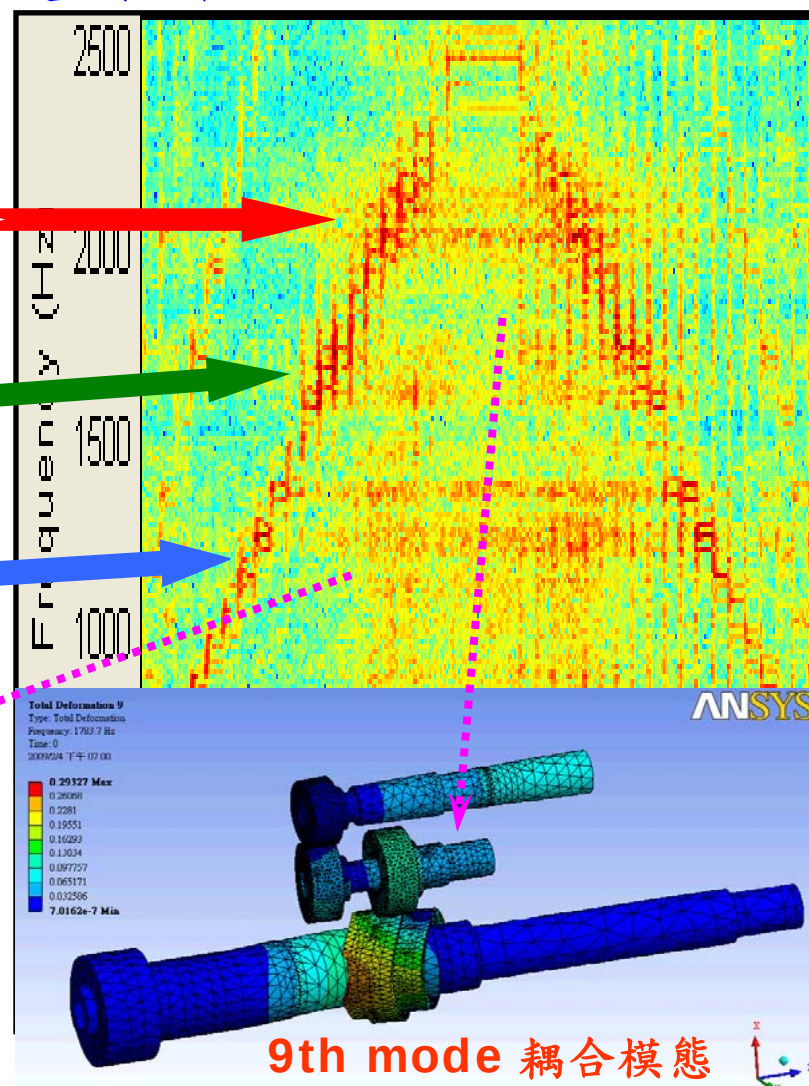
利用變轉速時頻驗證有限元素分析之正確性

FEM模擬結果：

模態	模態形式	自然頻率 (Hz)
12	Coupling	2289
11	Coupling	2176
10	Coupling	2003
9	Coupling	1784
8	Torsion	1541
7	Bending	1421
6	Bending	1415
5	Torsion	1289

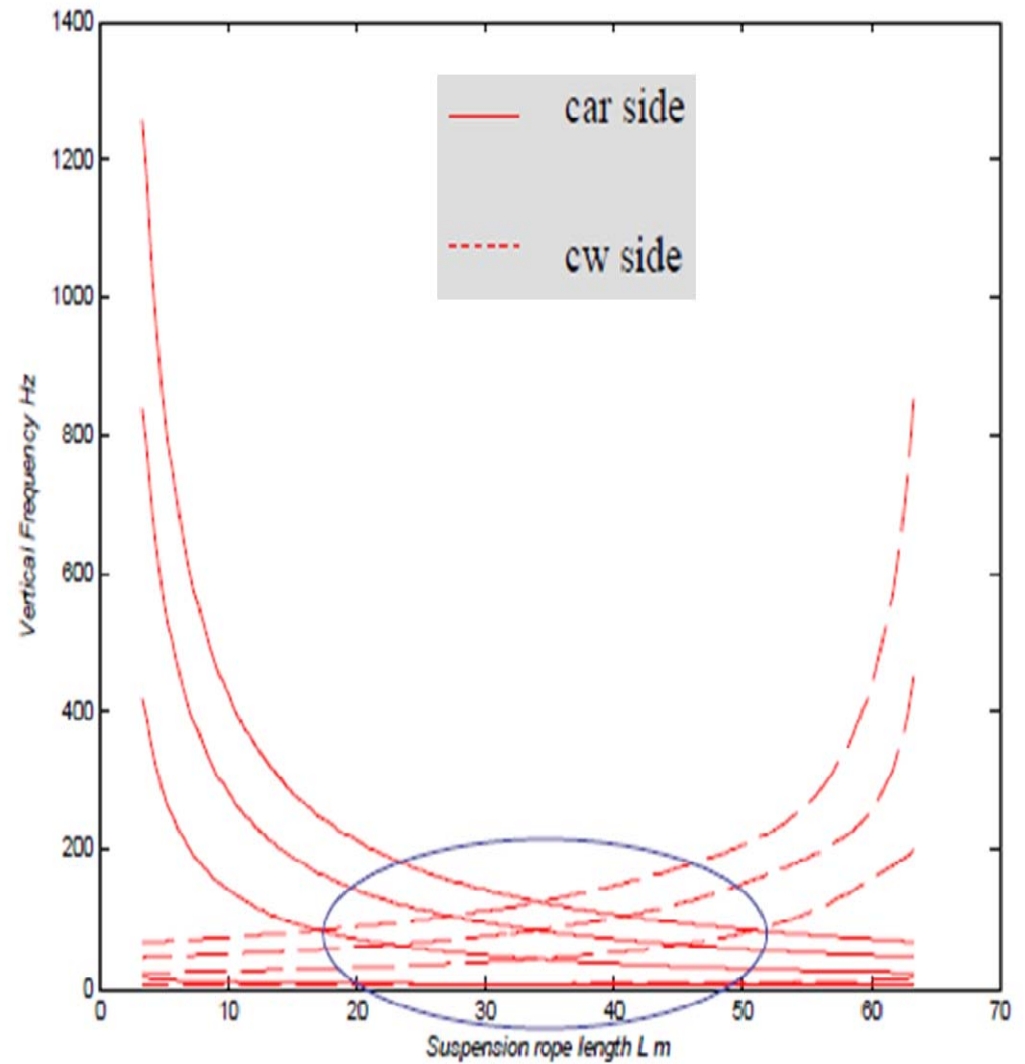
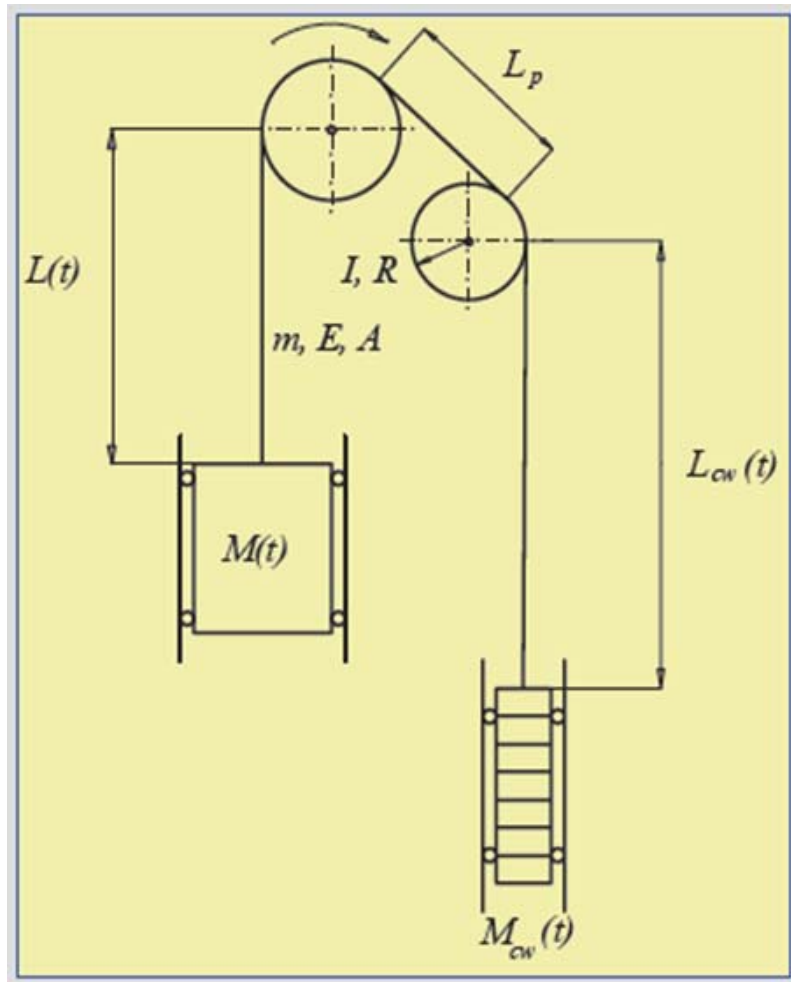


量測結果：



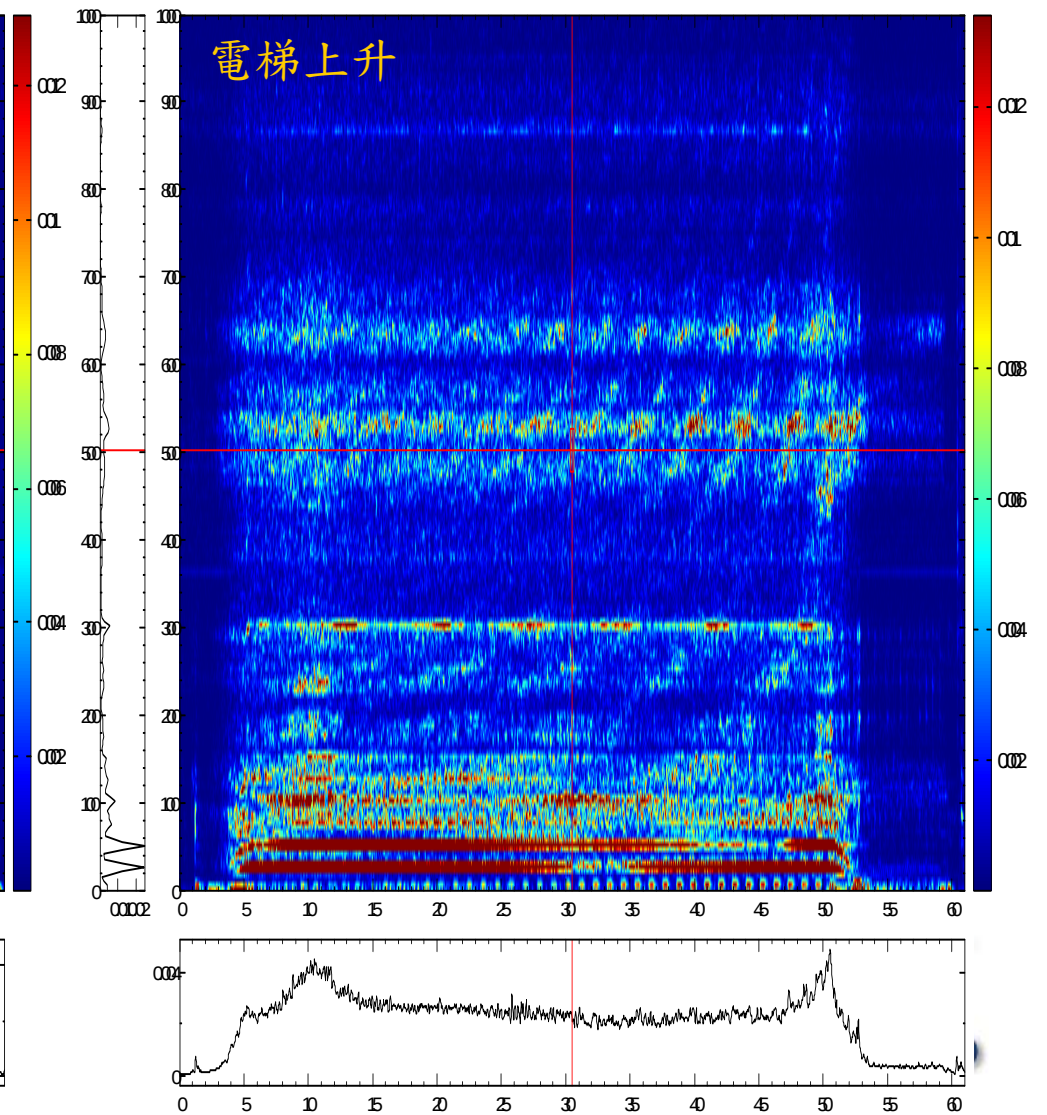
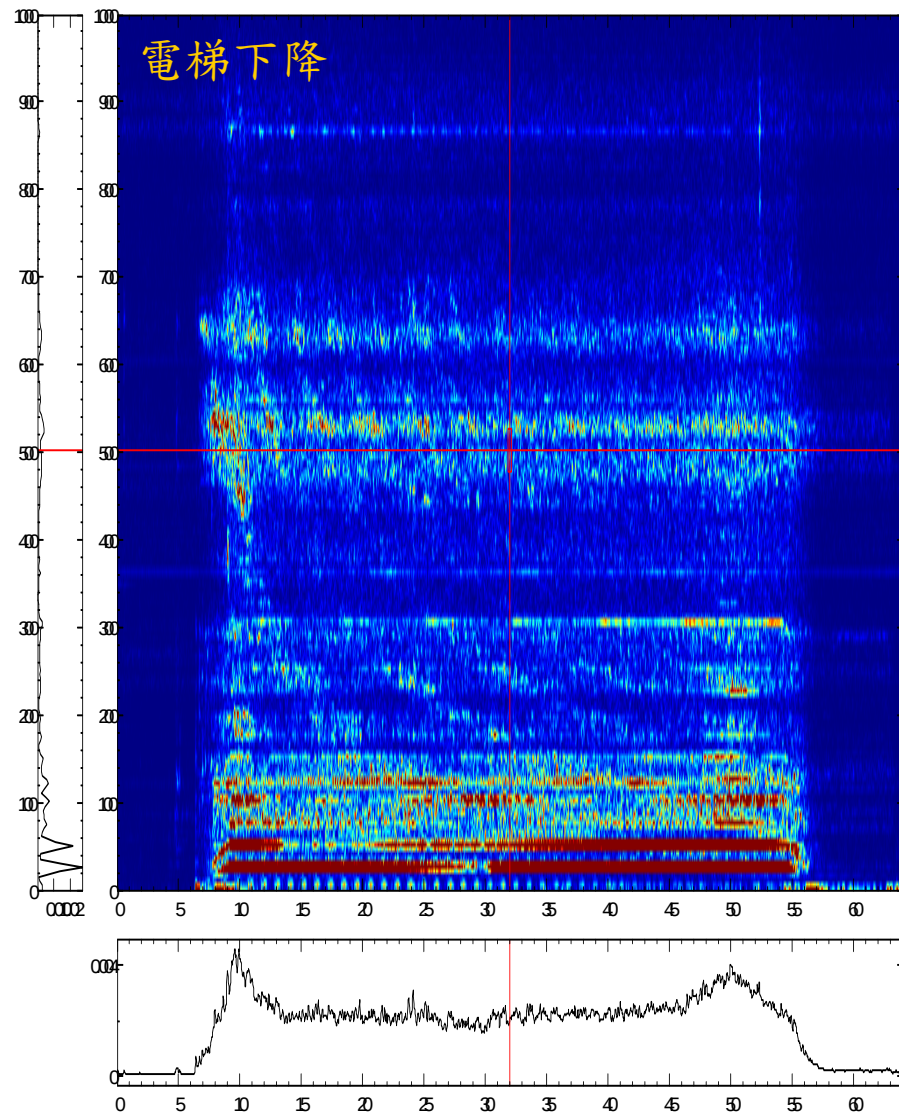
結構之自然頻率檢測

電梯系統自然頻率



結構之自然頻率檢測

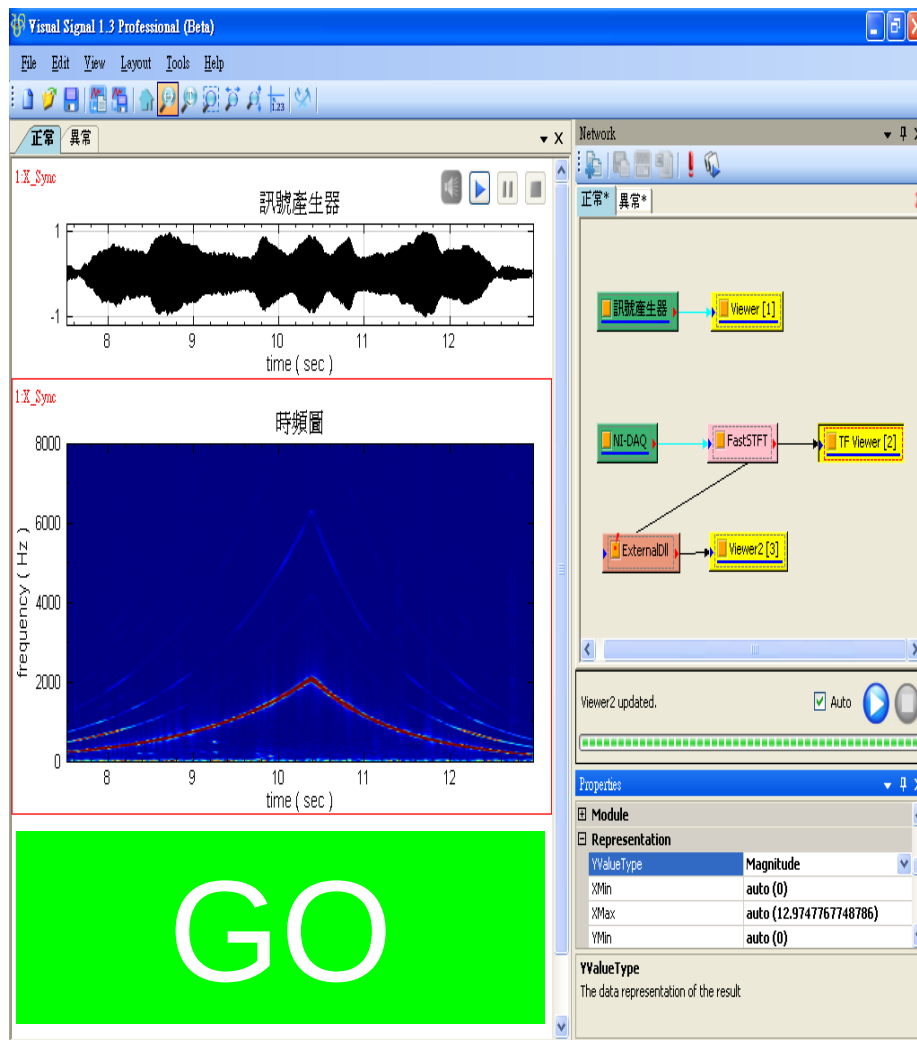
電梯系統振動時頻分析



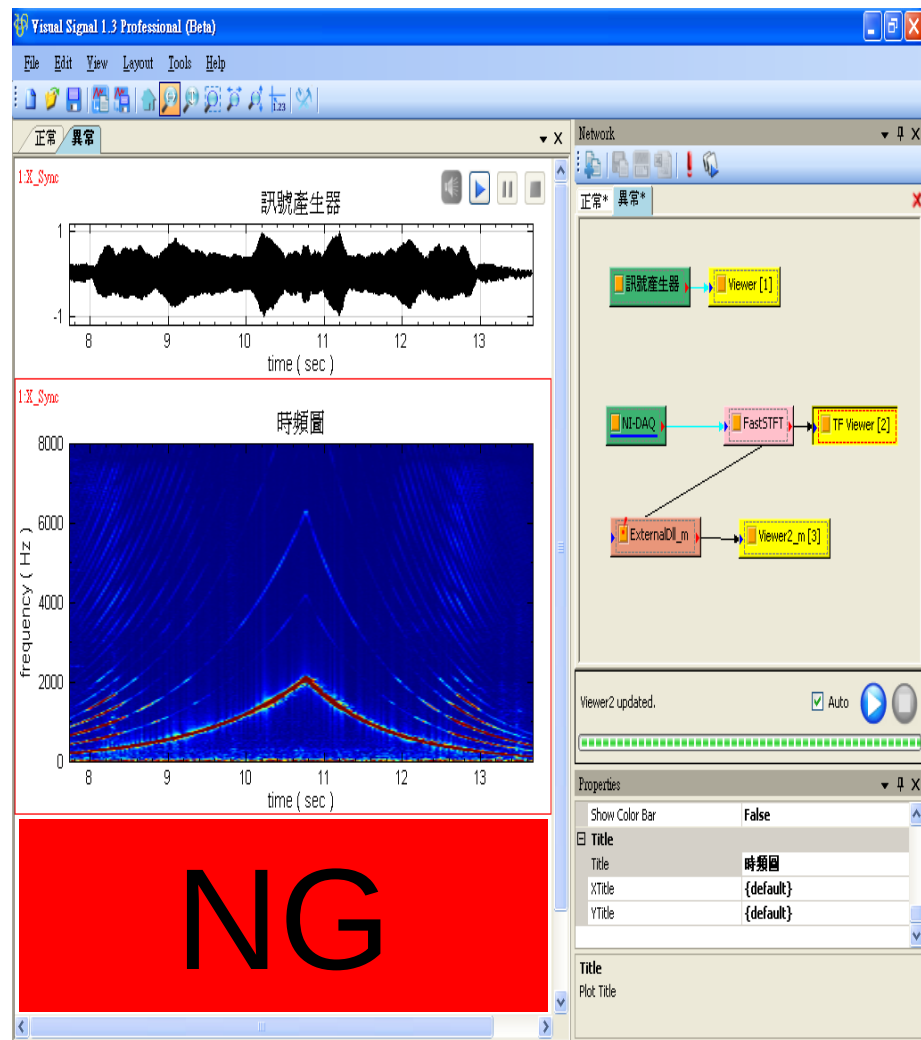
出廠之振噪品管檢測

客製化自動檢測流程、訊號產生器、客製化品管介面

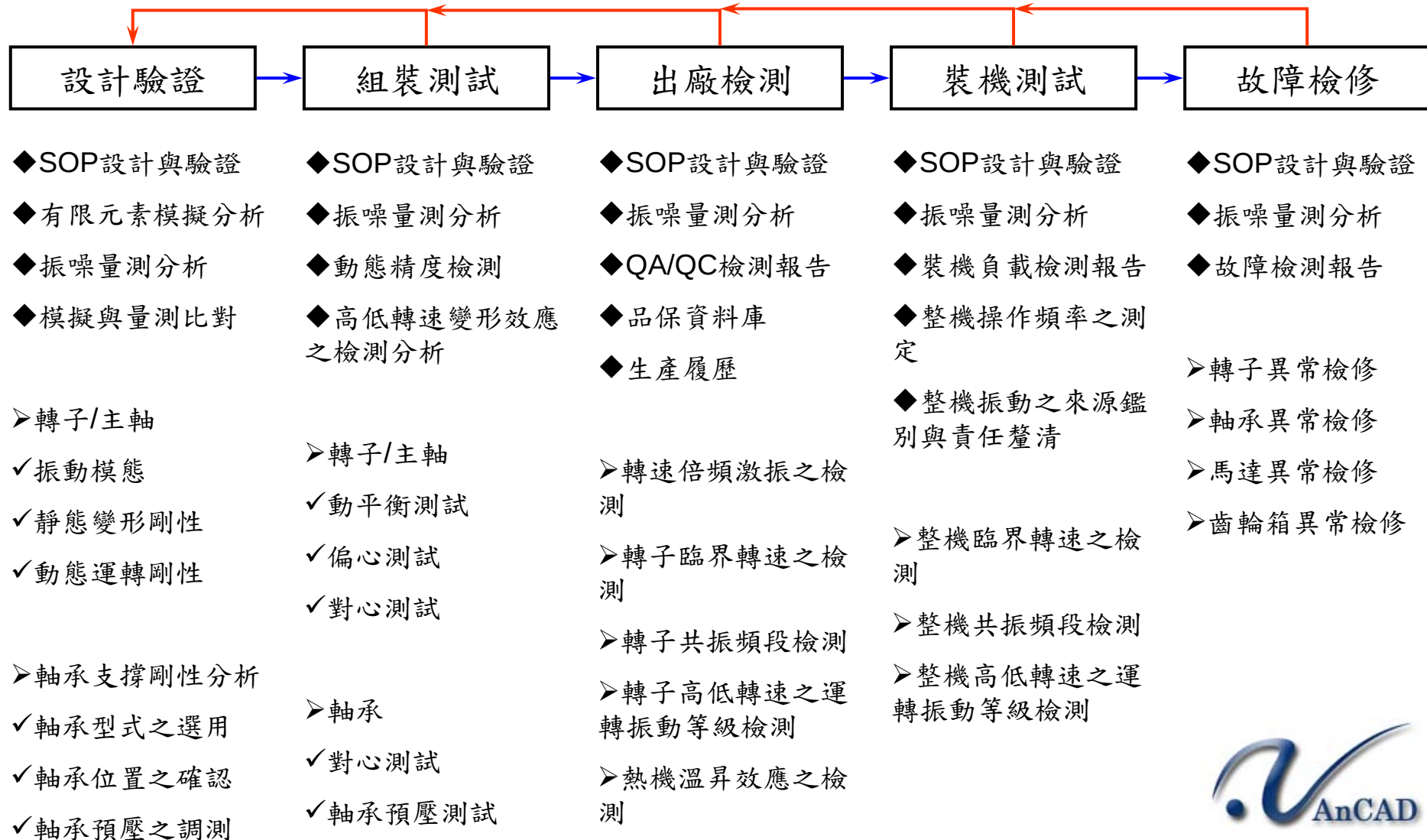
出廠異音檢測：合格



出廠異音檢測：不合格



Visual Signal 於各應用層面可檢測項目



Thank you

