



虛實機器智慧與永續供應鏈 之製造業實務

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務實的ESG



虛實機器智慧



製造業實務案例

虛實整合的機器元宇宙

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美國華盛頓大學博士
10年業界工作經驗
連續9年研究產學傑出
人工智慧國際期刊著作
多項人工智慧專利

- 異常偵測診斷→非接觸式聲光機器學習
- 虛實機器建模→能源管理、可靠度管理、作業管理
- 跨領域數學建模，整合電機、資工、數學與工管等領域，致力於發展工業機電資料分析、生醫信號分析、綠色供應鏈決策、人工智慧平行運算及平台、物聯網等應用。
- 核心團隊成員覆蓋了從物聯網機電光聲整合分析、行為與機器研究、機台良率，到軟硬體開發、UX/UI、供應鏈整合、可靠度管理等產品研發人才，以及國際發表等關鍵能力。

永續供應鏈執行經驗成果

★ 資訊系統: RoHS MCD, RosettaNet

★ 國際期刊: 70+

- Y. J. Chen and T. Chen, "Fair sharing and eco-efficiency in green responsibility and green marketing," International Journal of Production Economics, vol. 217, no. 1, pp. 232–245, 2019.
- Y. J. Chen and J.-B. Sheu, "Non-differentiated green product positioning: Roles of uncertainty and rationality," Transportation Research Part E, vol. 103, pp. 248–260, 2017.

★ 專案計畫

- 韌性農產供應鏈:重構潛在空間-預測及應變脆弱度分析
- 人工智慧全聲景異常故障偵測-無人巡佐
- 人工智慧汽油配方虛擬摻配

★ 導入輔導

- CSR, ERP, SCP, Cold Chain, Reverse Supply Chain
- 政府計畫: 環保署、經濟部、教育部、國科會、國防部、南科管理局、新竹縣、台南縣、高雄市、資策會、工研院、金屬中心、石化產業、半導體產業、業界演講、協會演講、國際研討會演講、國外授課、審查委員、評審委員、國際交流組長、五本書、多個發明專利



務實的ESG

Environmental Social Governance



★ Education+Broadcasting → **Capital Market**

★ (請告訴我，10個3R的方法並**排序**)

★ (請告訴我，什麼是**效率**)

★ (請告訴我，如何**平衡**供給與需求)

★ 以上就是永續供應鏈要談的議題



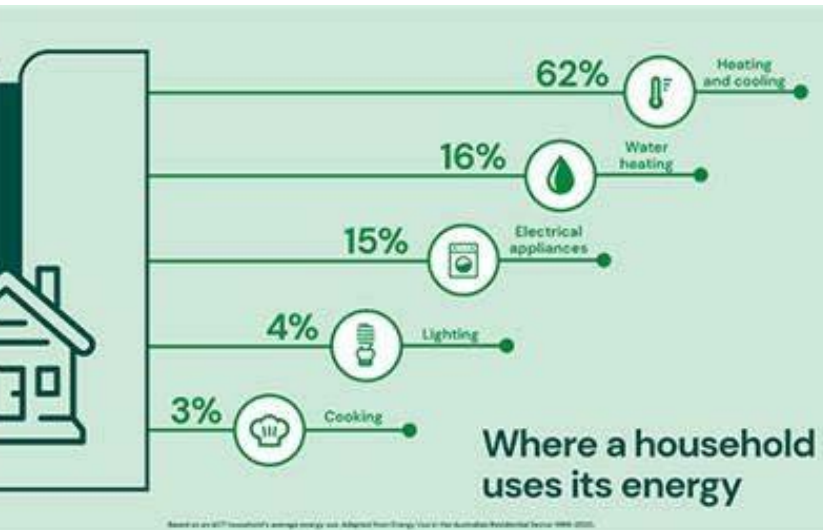
我們先看3R (**Reduce**-Reuse-Recycle)

- ★ 減廢 ← 預知故障、風險管理
- ★ 減排 ← 稼動效率、污染排放
- ★ 減用 ← 能源效率、庫存效率

KNOW BEFORE YOU THROW...



tampa.gov/Recycle





Digital Twin

虛實機器智慧

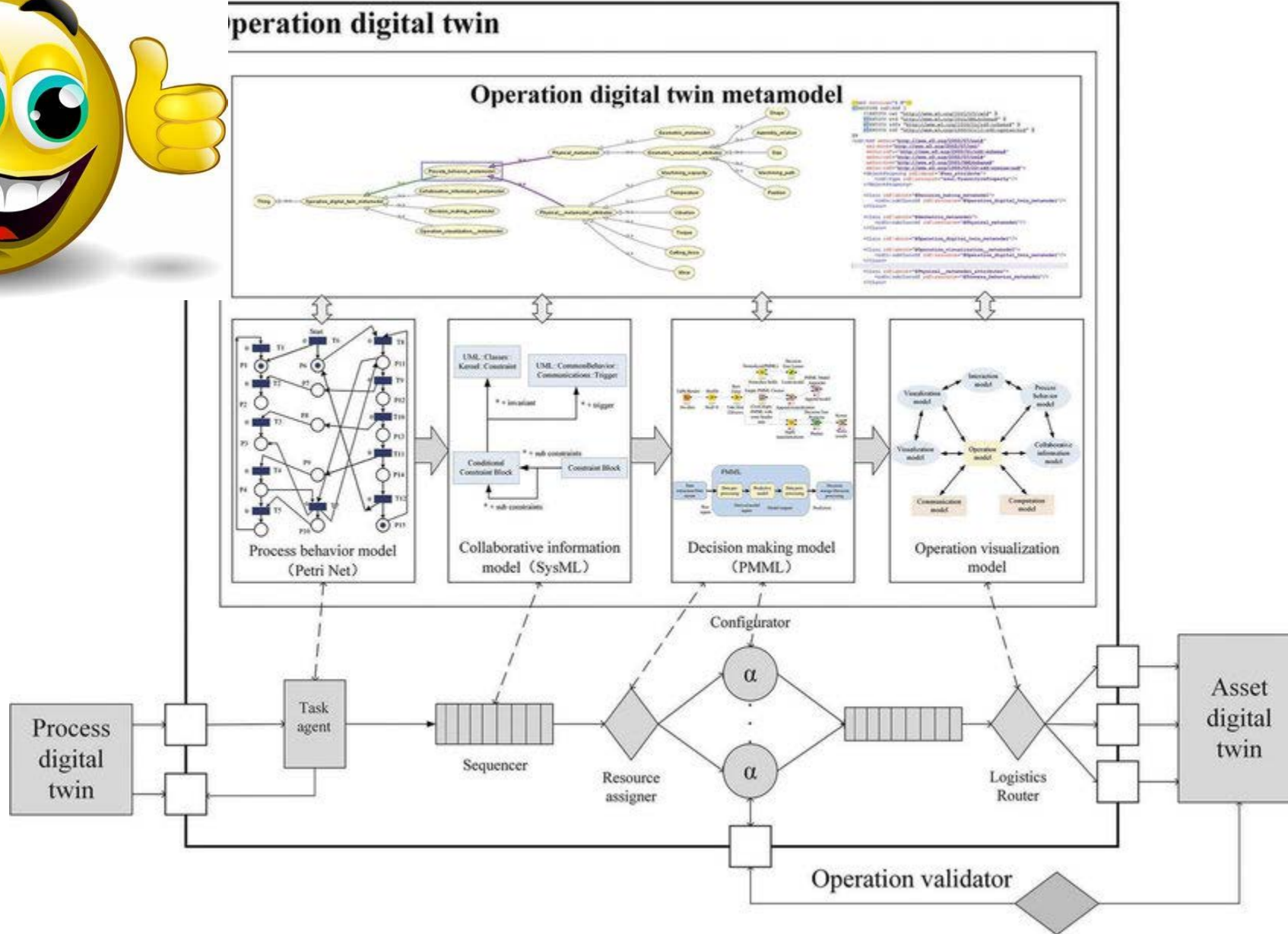
Digital Twin

- ★ (請告訴我，什麼是預測)
- ★ (請問你有跑過數值模擬嗎?)
- ★ (請告訴我，你有一個虛擬複製(人)或(物)，你會怎麼用)
- ★ (請告訴我，從一個空白虛擬複製(人)或(物)，要怎麼變成你要的)

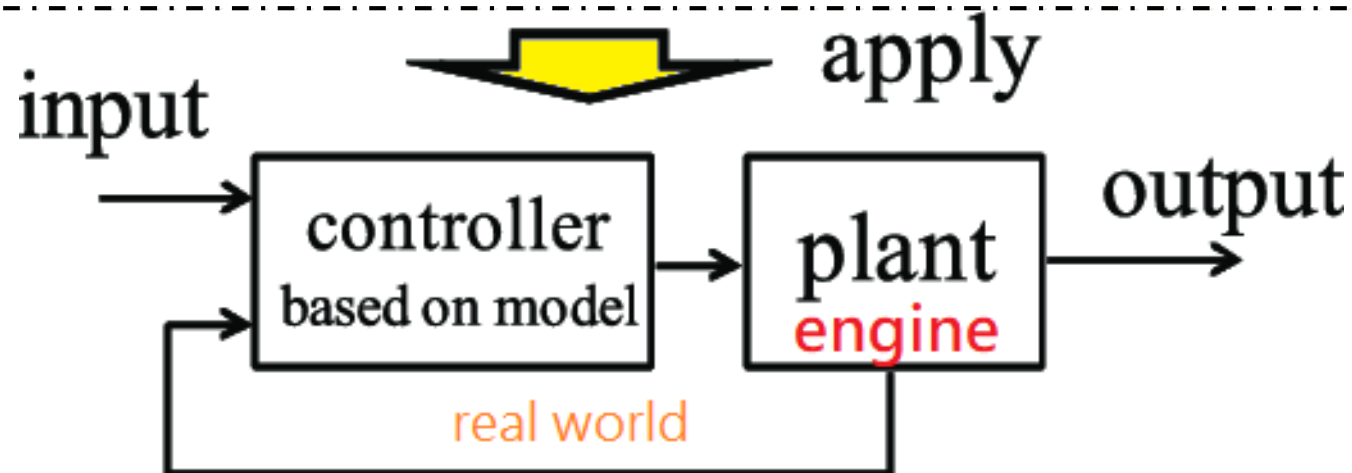
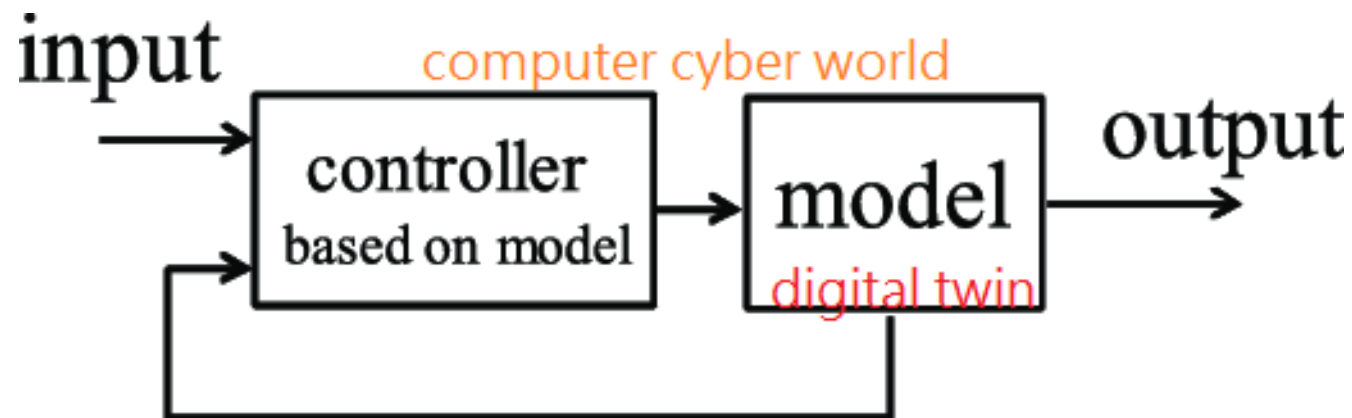




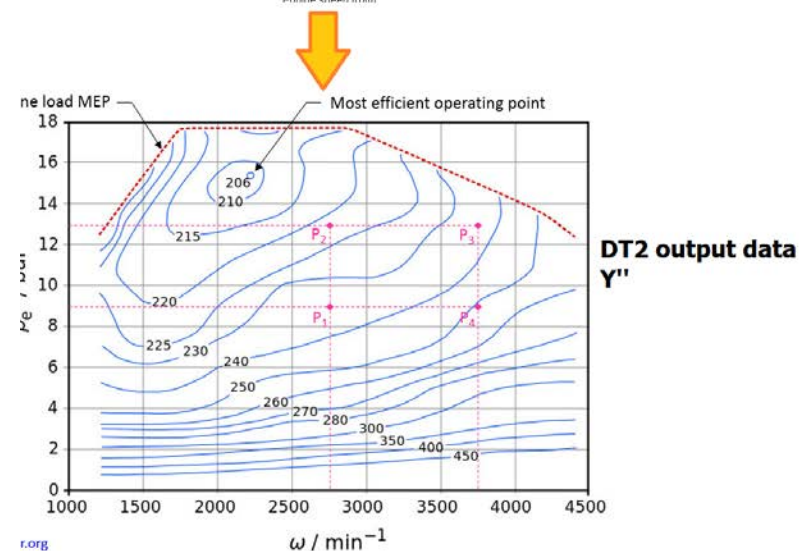
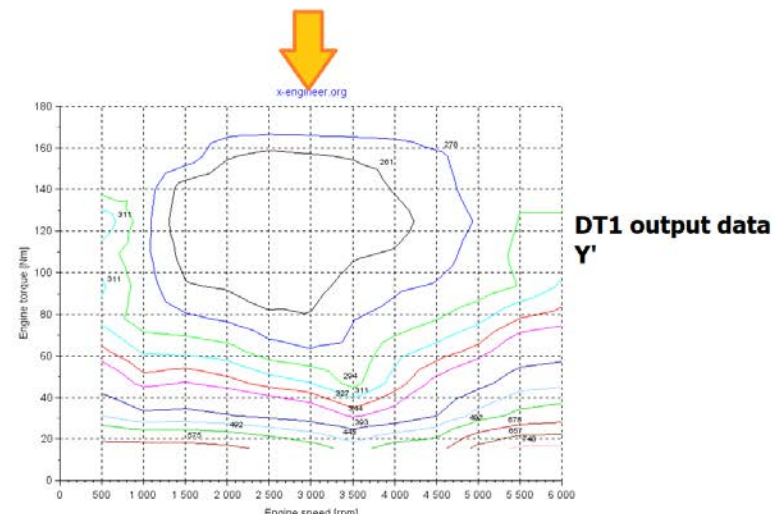
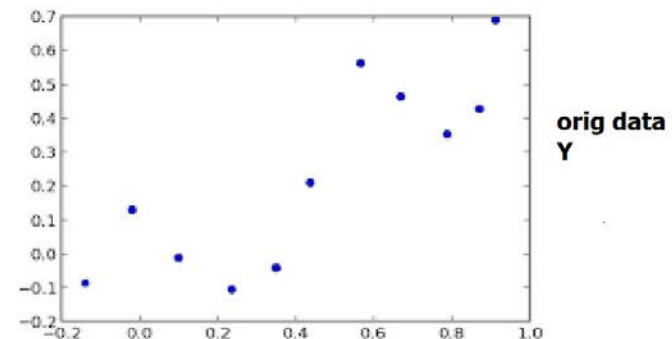
Operation digital twin



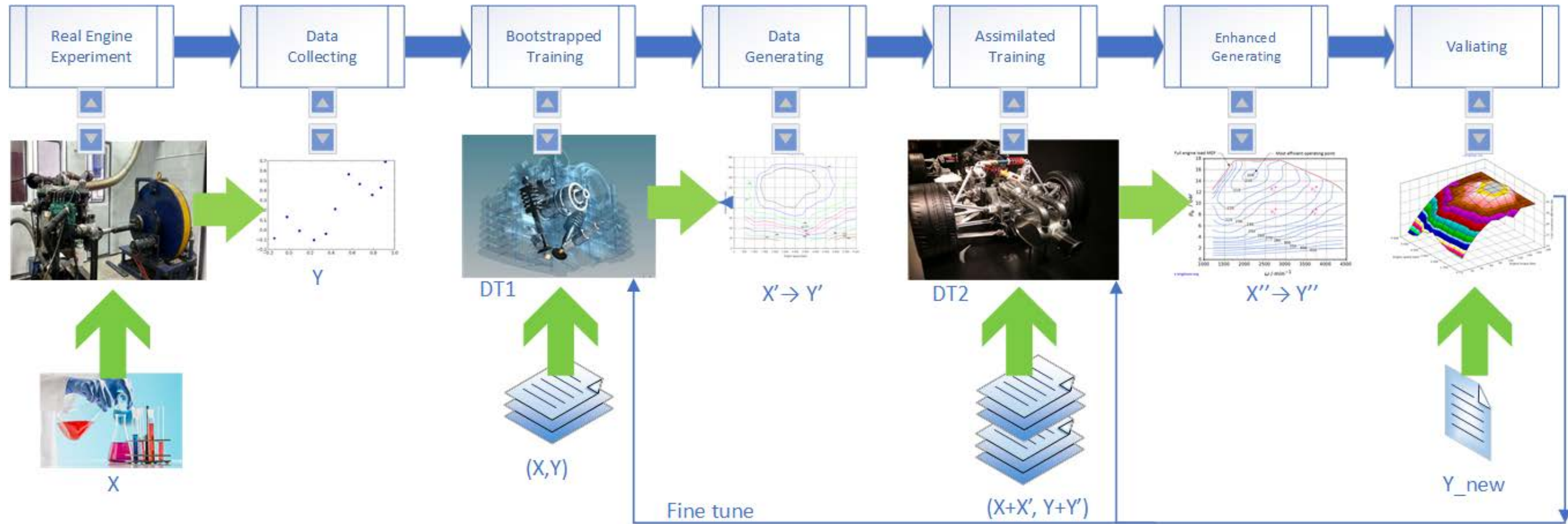
Digital Twin 資料同化增強的過程



智慧關聯DT(雙胞胎) → 虛擬實驗



DT (Digital Twin) Framework



減少實驗次數，快速得到配方

監督式學習 = 給定(輸入/輸出)資料 → 學習其關聯
輸入 = 題目 / 輸出 = 標準答案

非監督式學習 = 給定(輸入)資料 → 歸納相似性

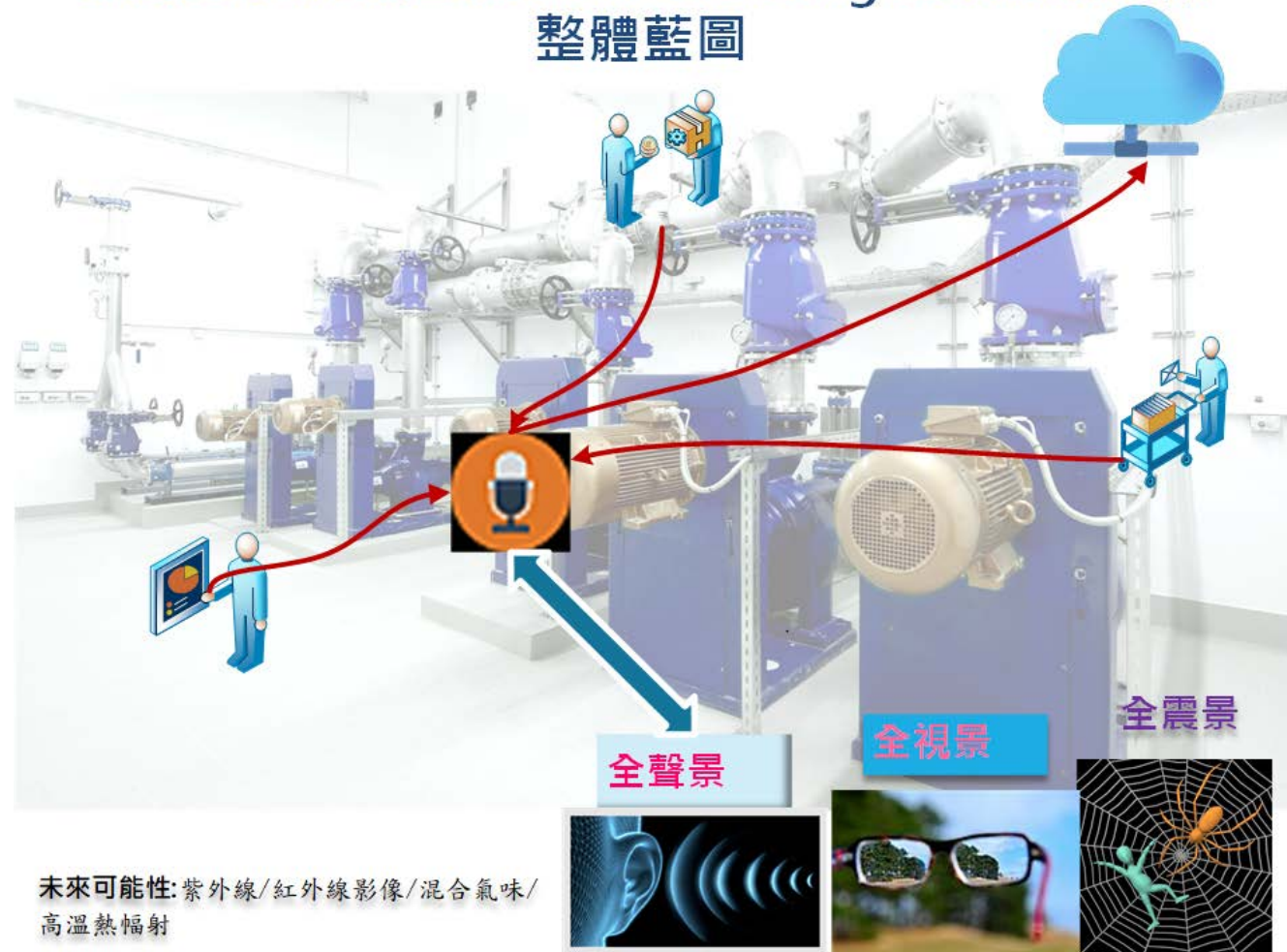
學習鑑別器 = 最佳賽局 → 調校學習DT參數

減廢 ← 預知故障、風險管理

預知故障、提早保養

- ★ 可以減少25%~30%的維修支出
- ★ 儘早發現及排除故障可以節能5%~20%
- ★ 預知保養比反應式保養，節省成比約3倍

智慧工廠 擴增遙感Smart Sensing 全景偵測系統 整體藍圖

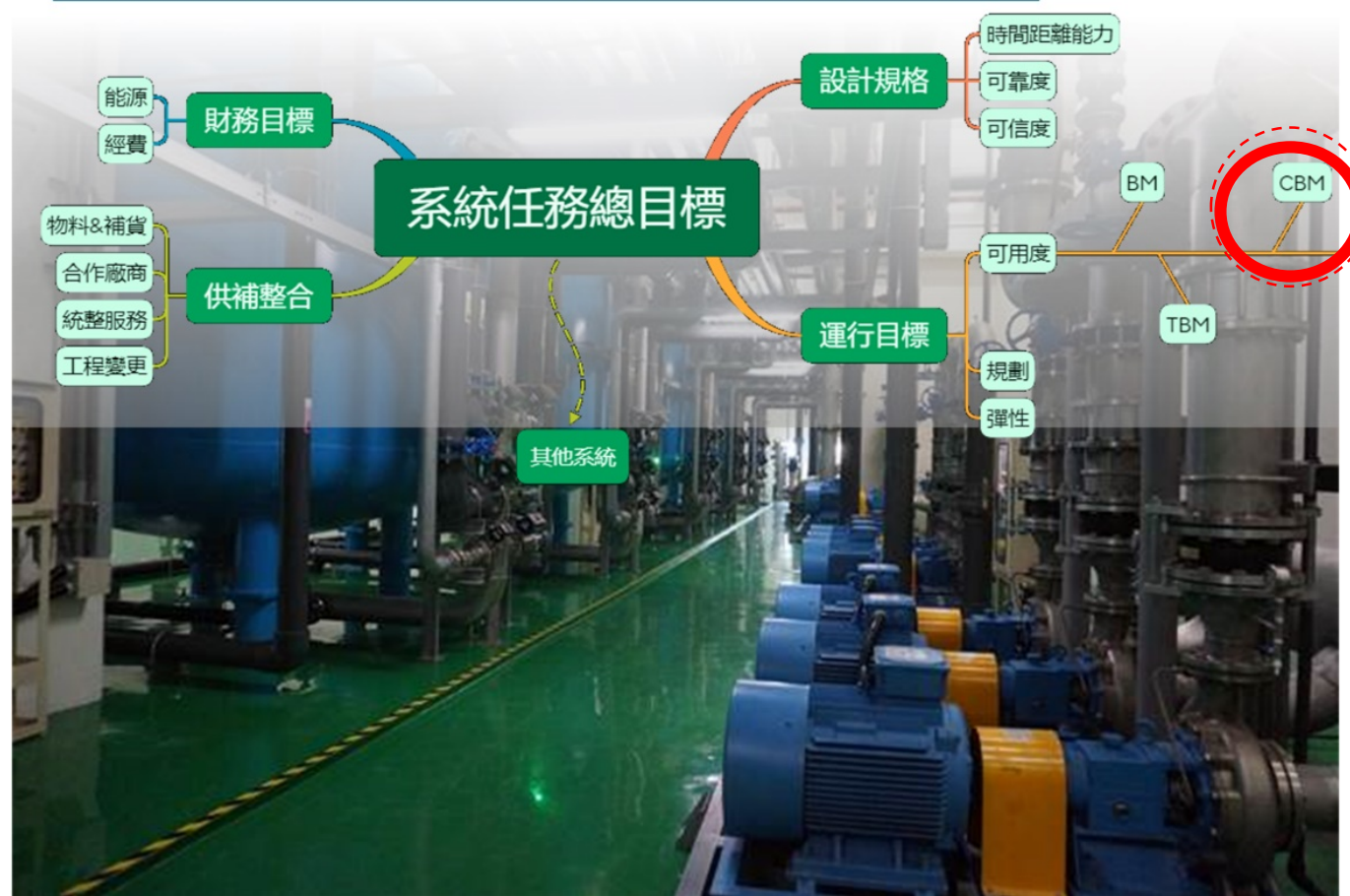


由系統任務出發的預知保養

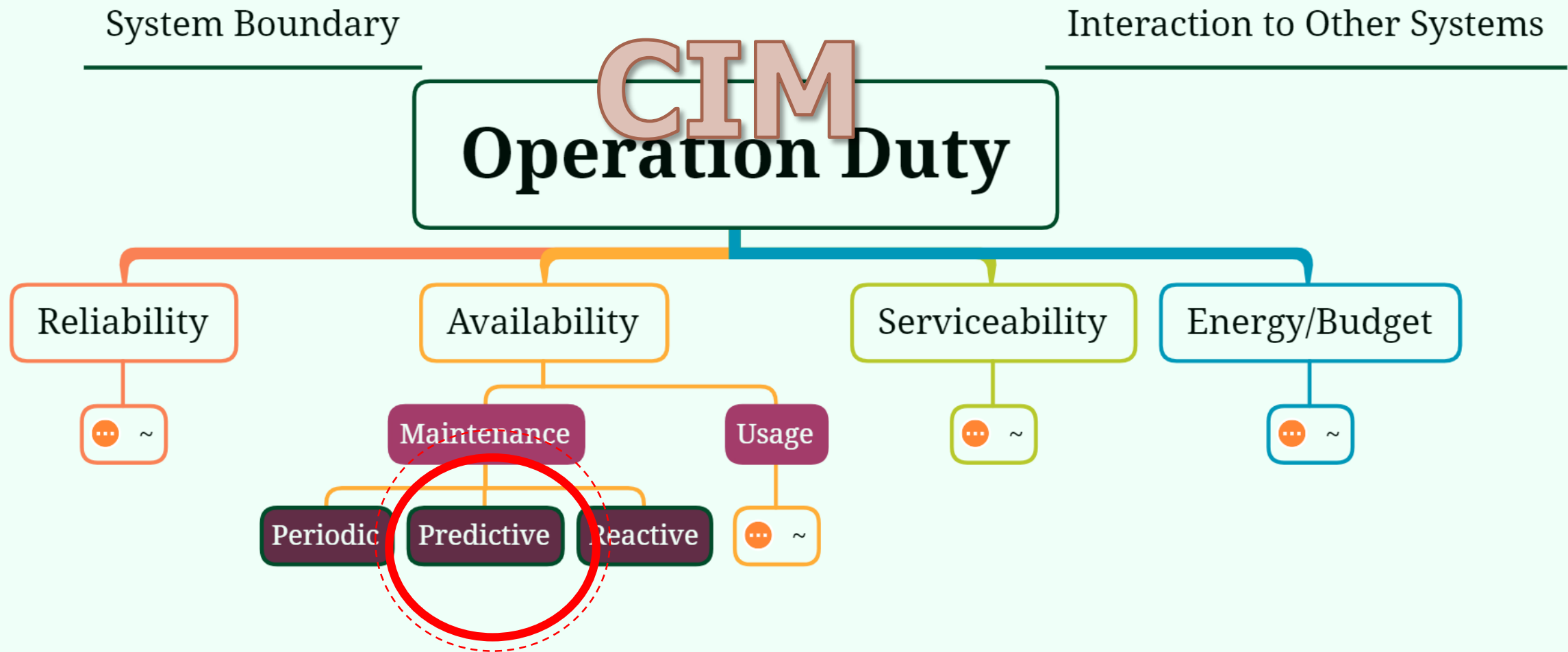
服務化智慧系統作業管理任務大藍圖



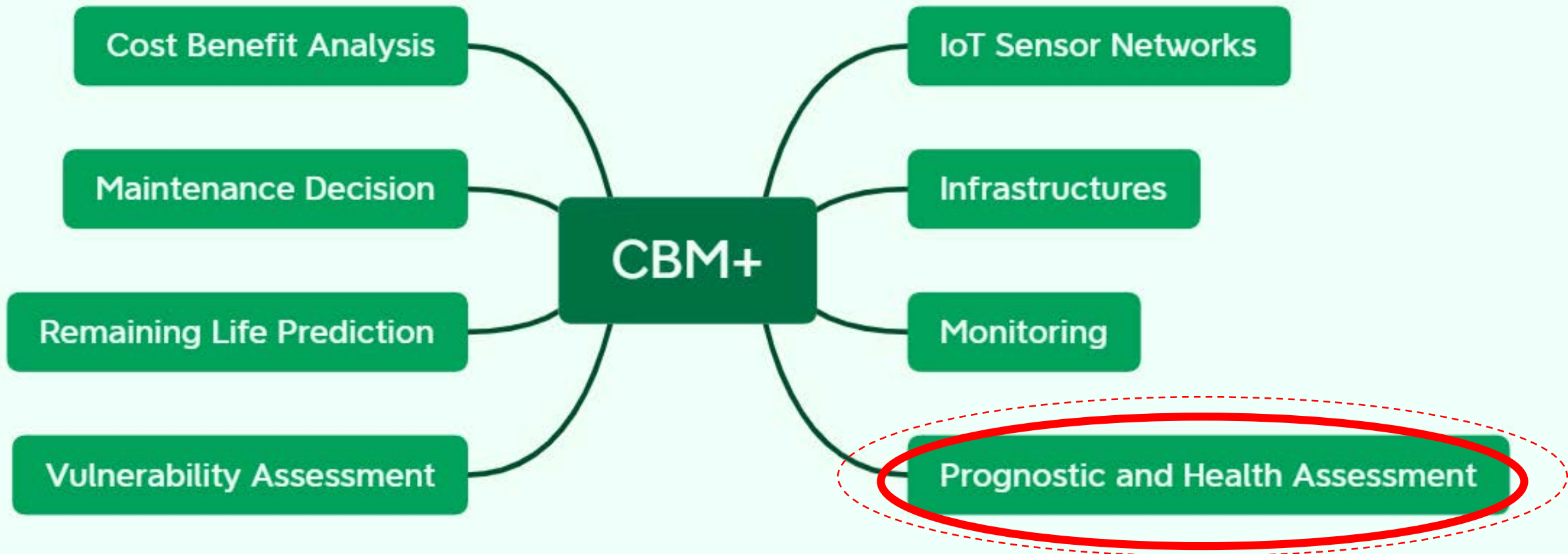
服務化智慧系統作業管理任務小藍圖



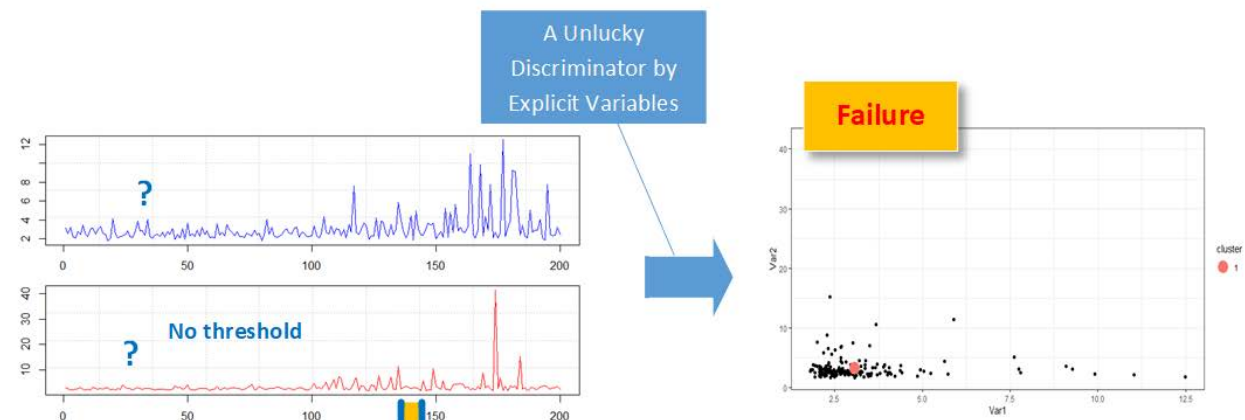
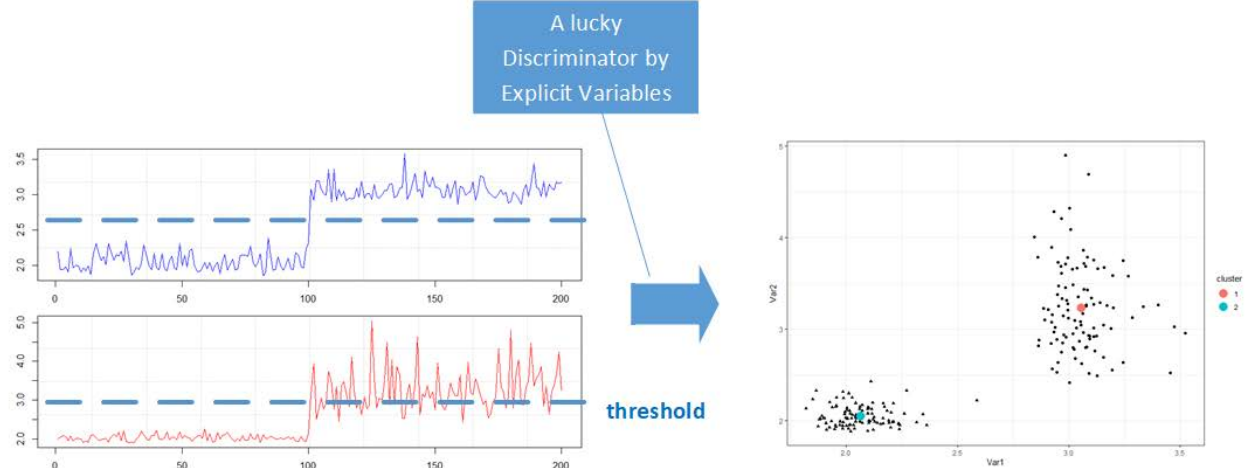
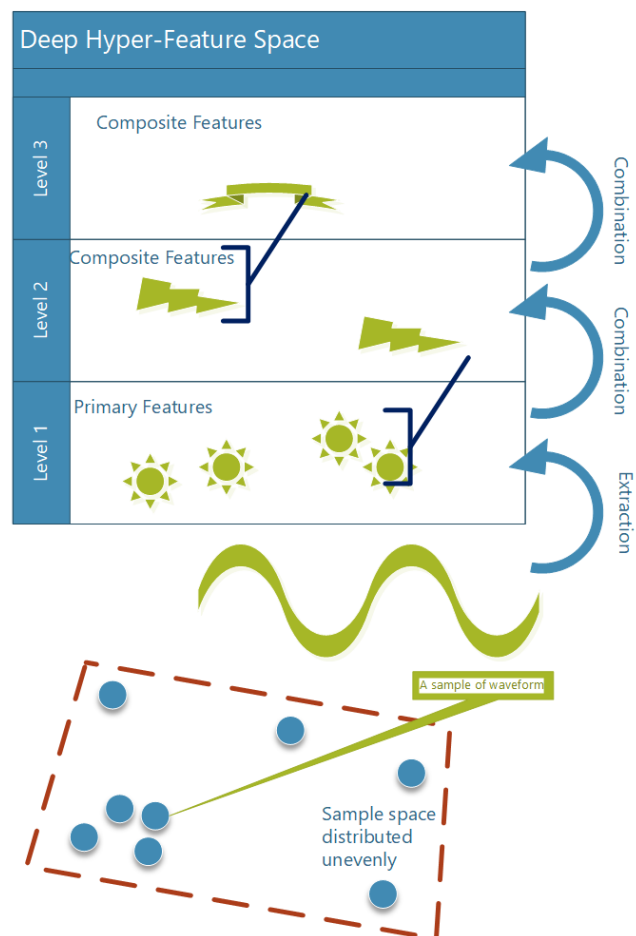
從CIM出發的預知保養



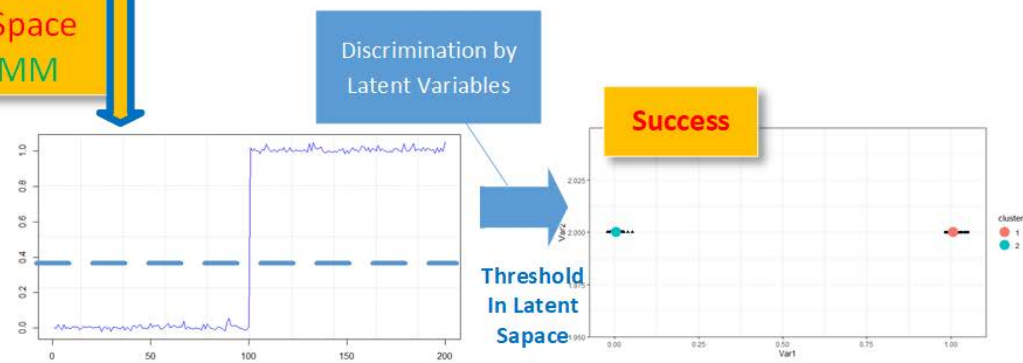
CBM+: Operation Mission Integrated



以高維聲紋， 自動估計轉動設備壽期， 作到預知保養



**Estimation in Latent Space
e.g., HMM**

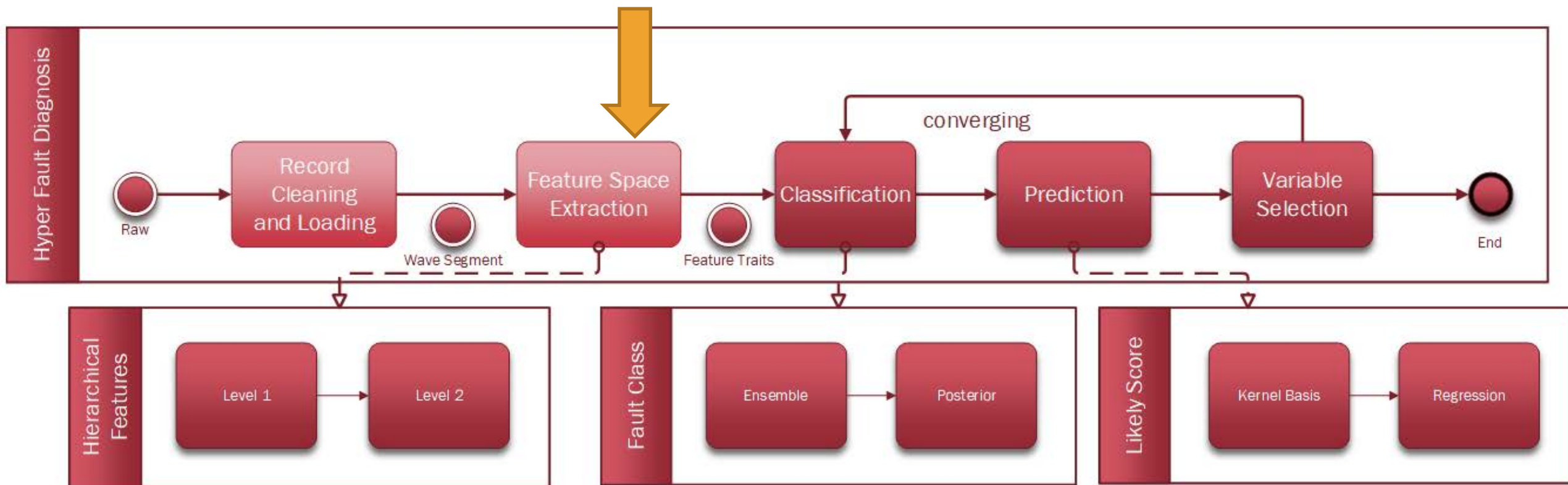


水泵聲洩預知保養



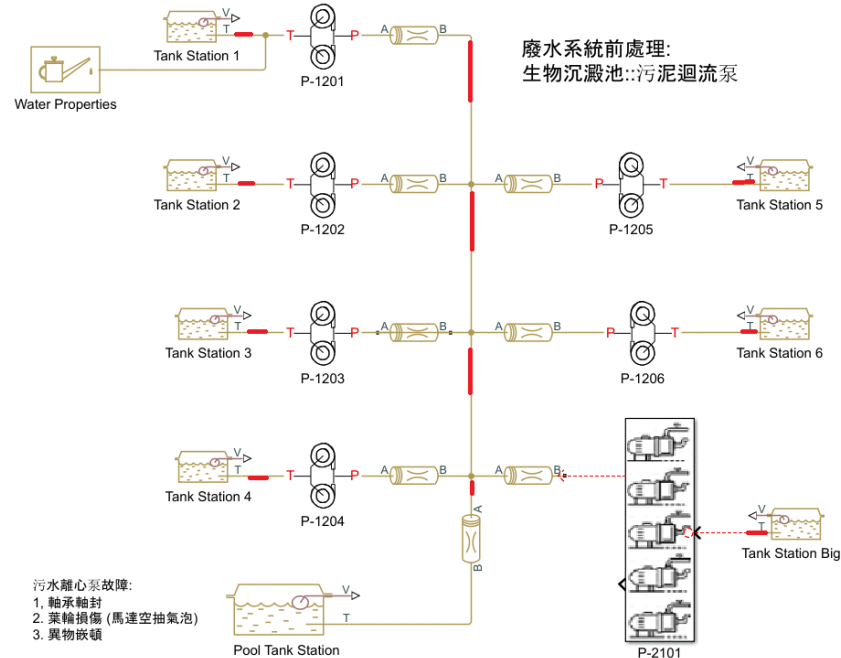
機器學習的流程

不同於傳統方法
我們創造了獨特的方法



圖控面板

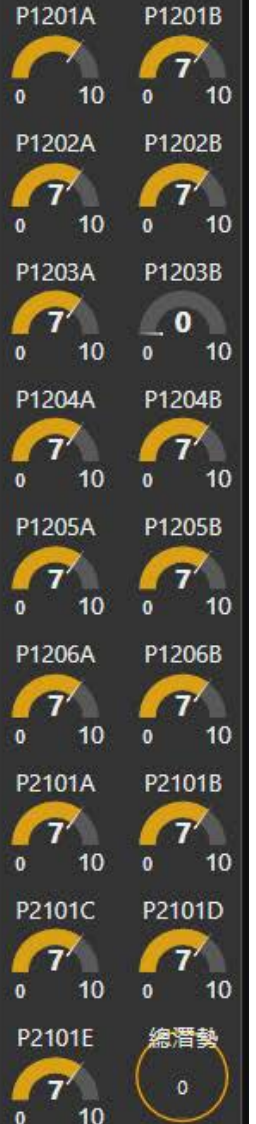
圖控介面



現場實景



水泵警示



與Gateway介接，通知相關人員

slider

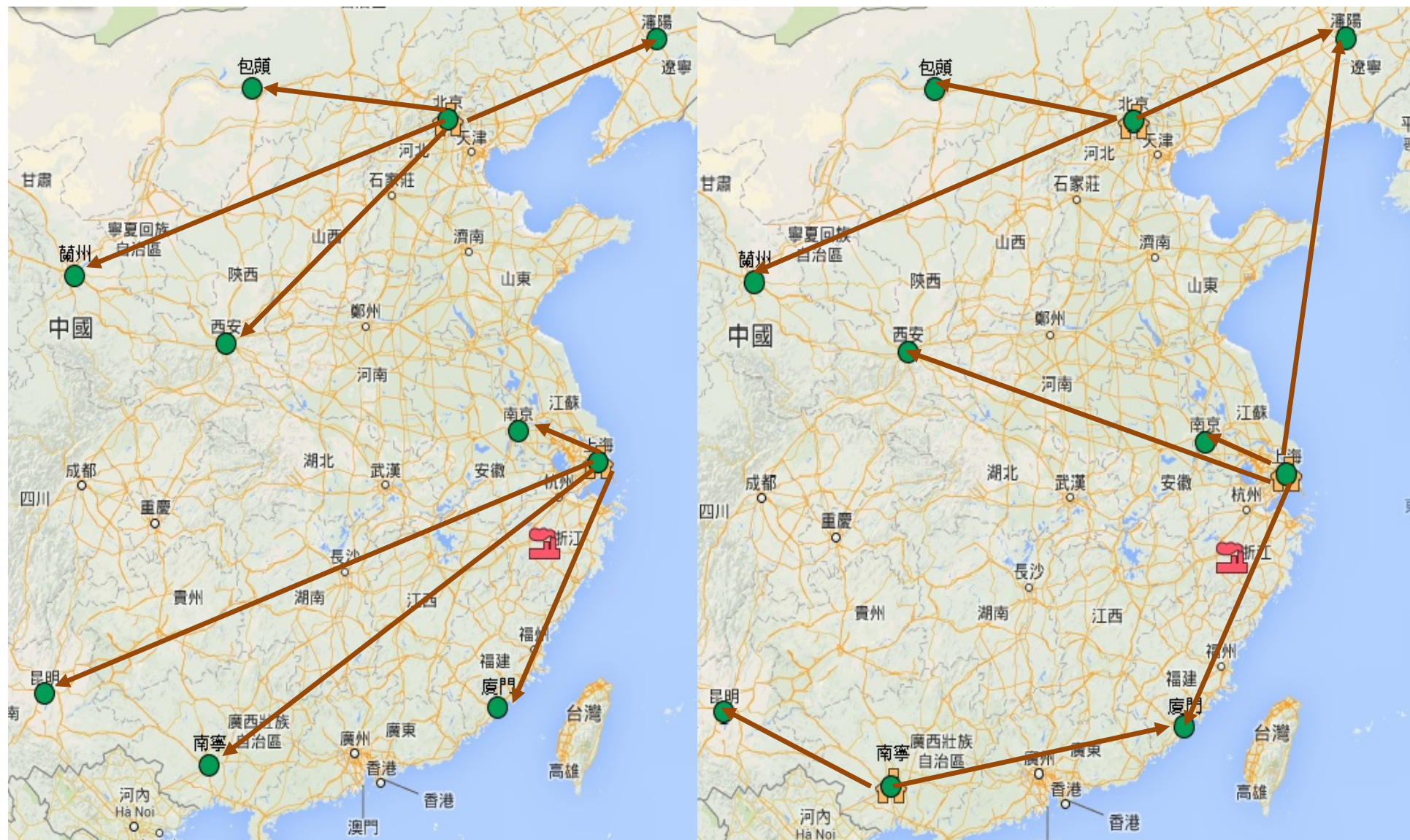


減排 ← 稼動效率、污染排放

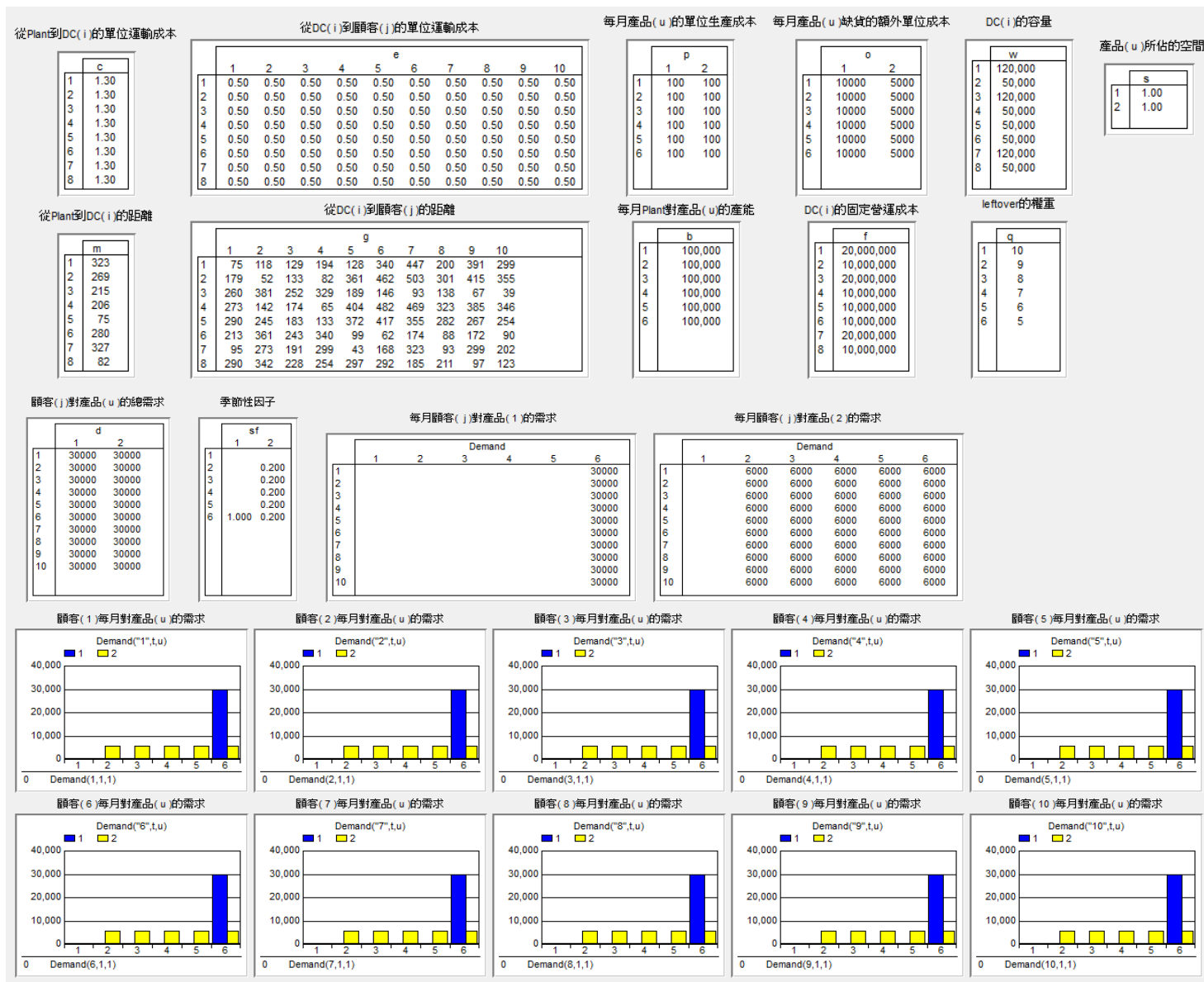


冰棒: 季節性強、
存貨成本較高、
生產成本低、缺
貨成本高

冰淇淋: 季節性弱
、存貨成本較低
、生產成本低、
缺貨成本高



Input:



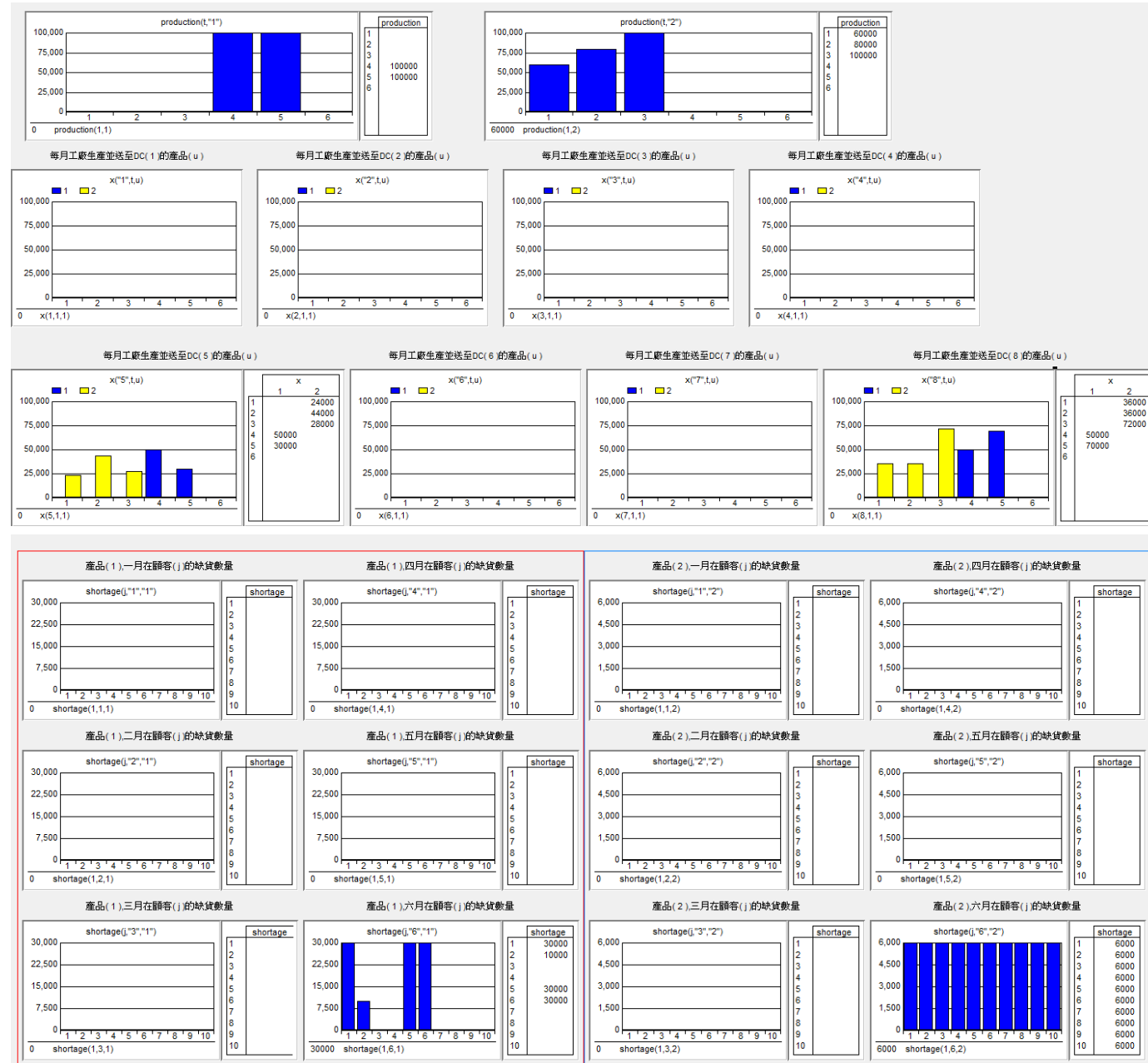
產品1在6月有尖峰，產品2每月都相同。兩產品6個月總需求都相同。

Production:

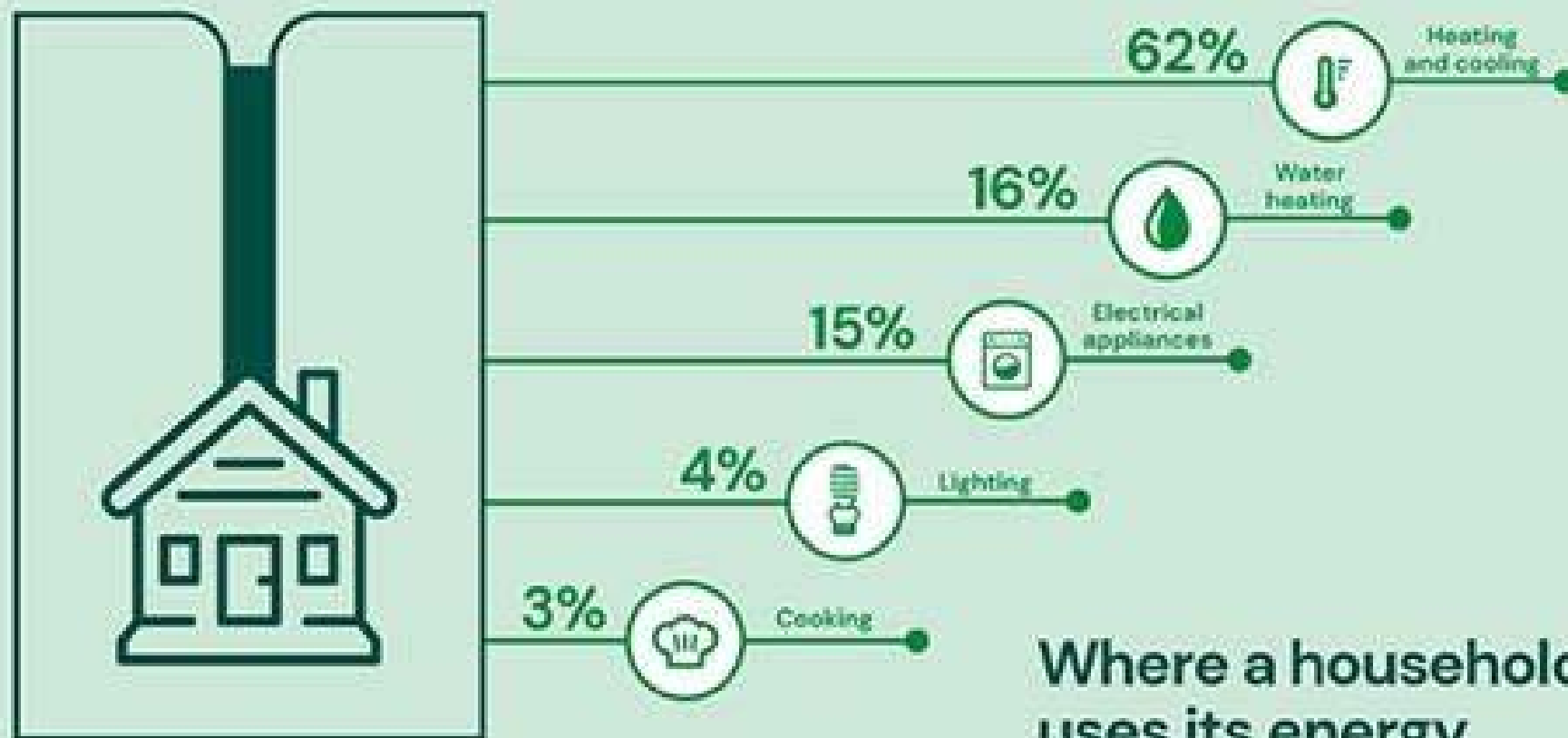
Shortage:

工廠先生產產品2，4月時再轉成產品1，應付6月的高峰。產品2則用庫存應付平日需求。

但在衡量各象限，及成本最小化的情況下，在目前供應鏈的成本設定狀況下，決定讓某些客戶產生缺貨。如果工廠產能可以擴張、倉庫可以有效擴張(有些擴張並非有效)、運輸成本可以降低、品項到貨時效可以放寬、保存期限更久...，便可做出更佳之決策，使得系統性缺貨更少。



減用 ← 能源效率、庫存效率



Where a household
uses its energy

Based on an average household's average energy use. Adapted from Energy Use in the Australian Residential Sector 1999-2000.



製造業實務案例

- ★ 範疇二三間接排放用電，
- ★ 某石化RFCC廠節能10%~15%，
- ★ 某半導體廠水處理泵浦節能5%~10%長晶溫控節能15~20%

【虛實整合數位分身】

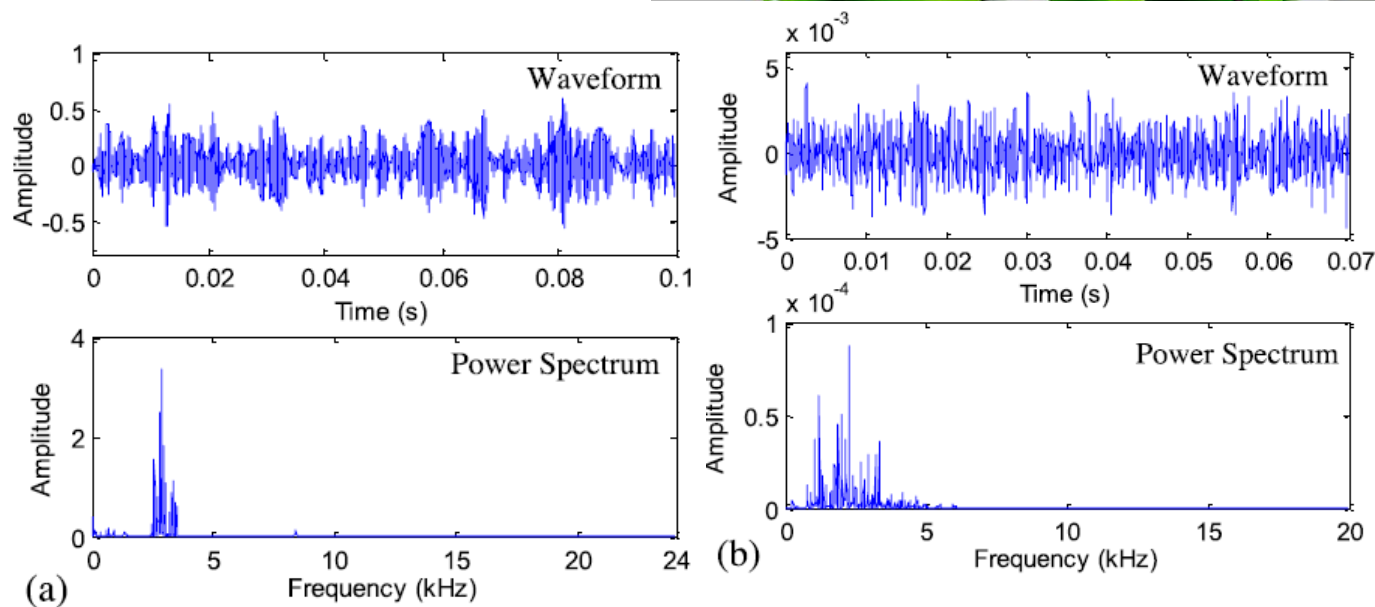
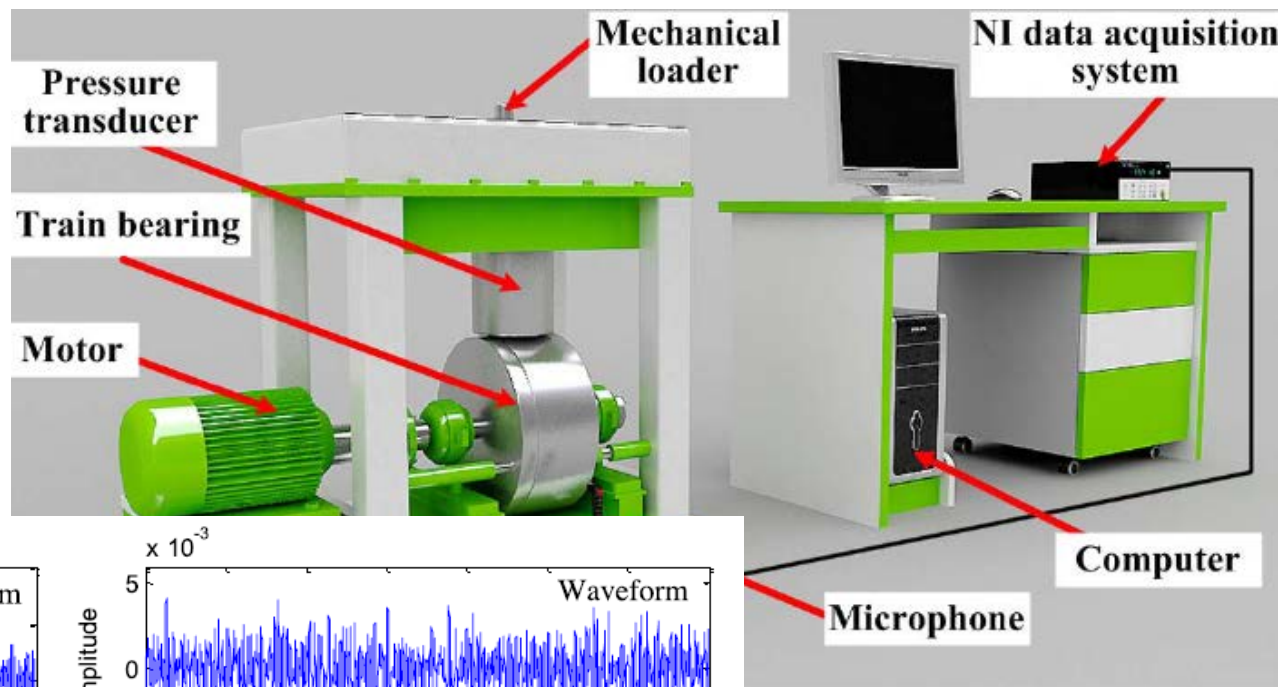
異常偵測防爆收音平台



轉動機械故障預知保養檢測方法

- ★ 振動、溫度、電流 (市售商品)
- ★ 廣域光譜、氣味(無市售商品)
- ★ 轉動設備軸封溫度值、LWIR map
- ★ 馬達及幫浦或管線進出口振動
- ★ 軸封及密封油液位狀態
- ★ 密封油液洩漏圖像UV光譜
- ★ 如同健康檢查一樣，不是一種檢查便能涵蓋所有問題
- ★ 正確的方式是融合多種方法一起
- ★ 簡單的用買現成的就好
- ★ 難的與客製化的再來發展

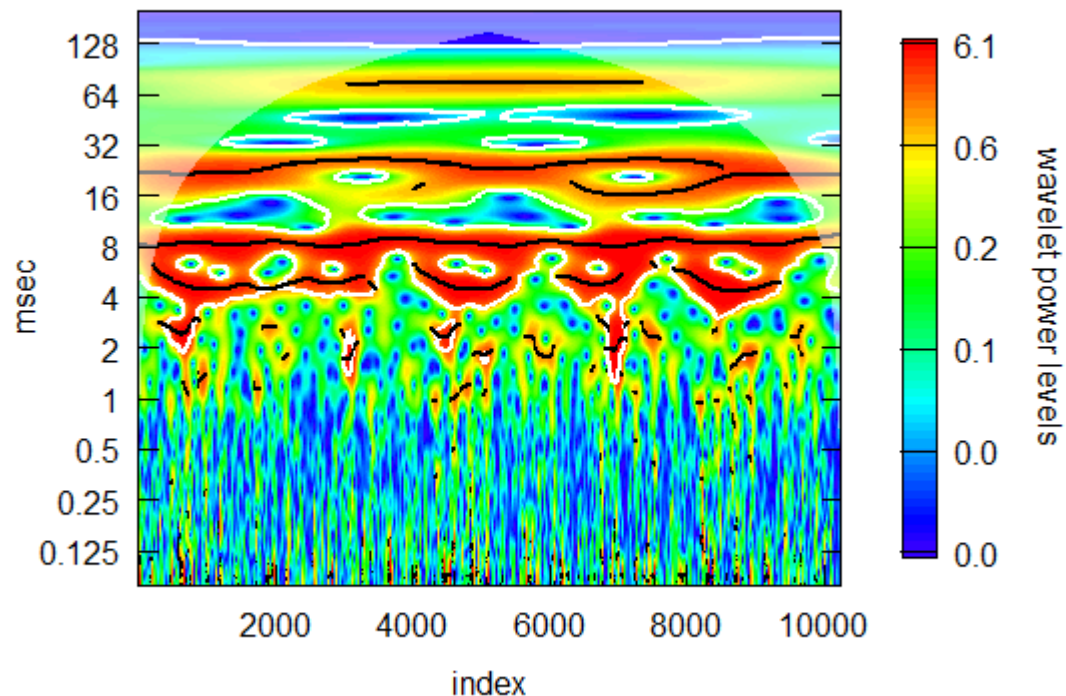
週期波故障型態



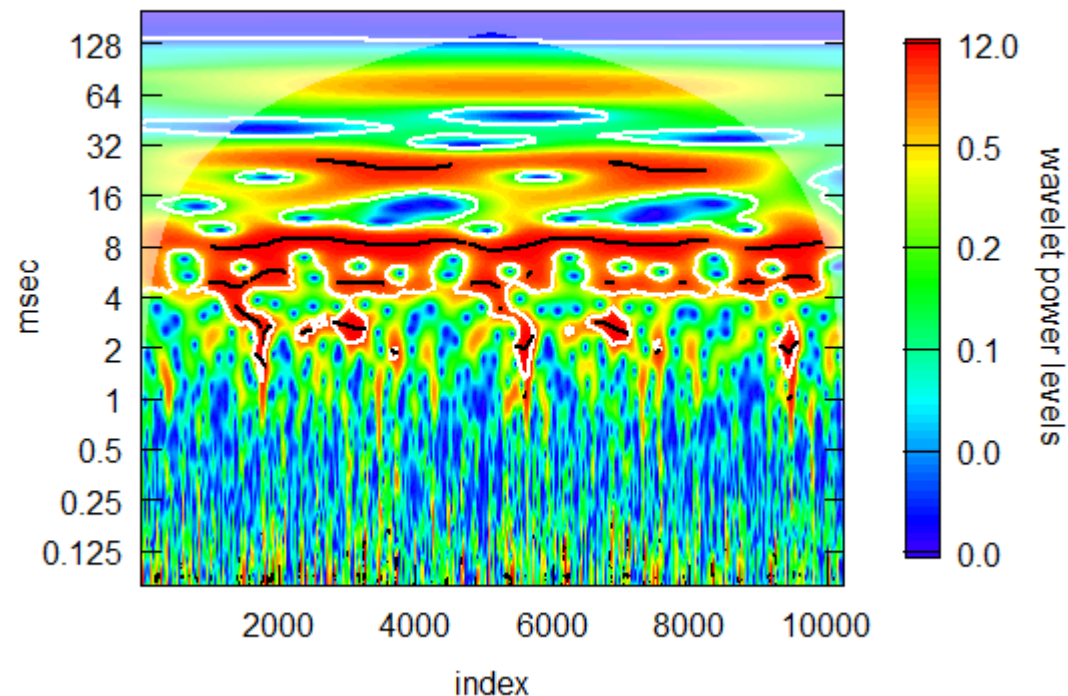
週期波故障:軸承保持器損傷 (聲洩領先)

聲洩 0g load 時，就可以先預警了

mafaulda\underhang\cage_fault\0g\13.312 - sound

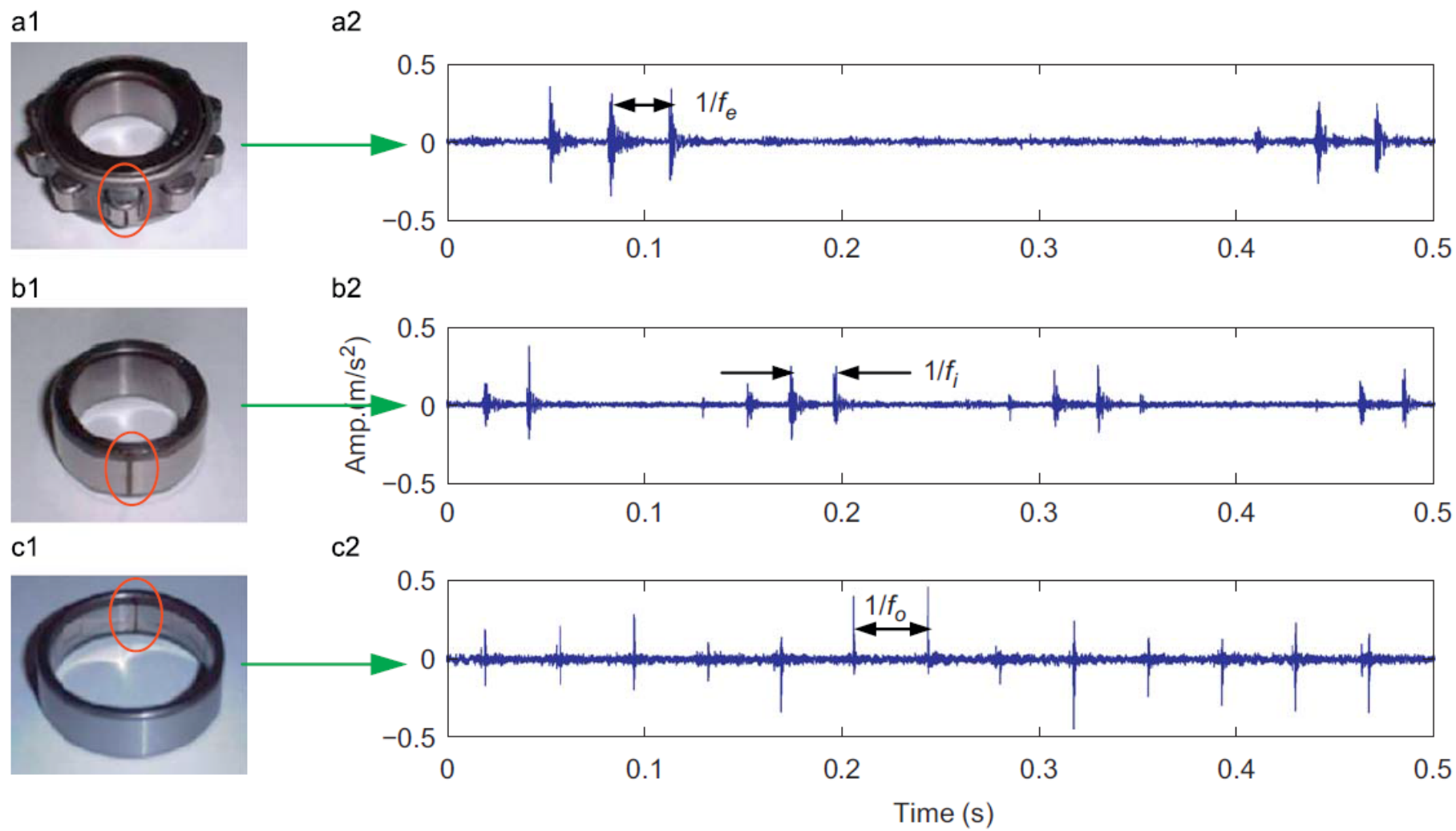


mafaulda\underhang\cage_fault\20g\13.312 - sound

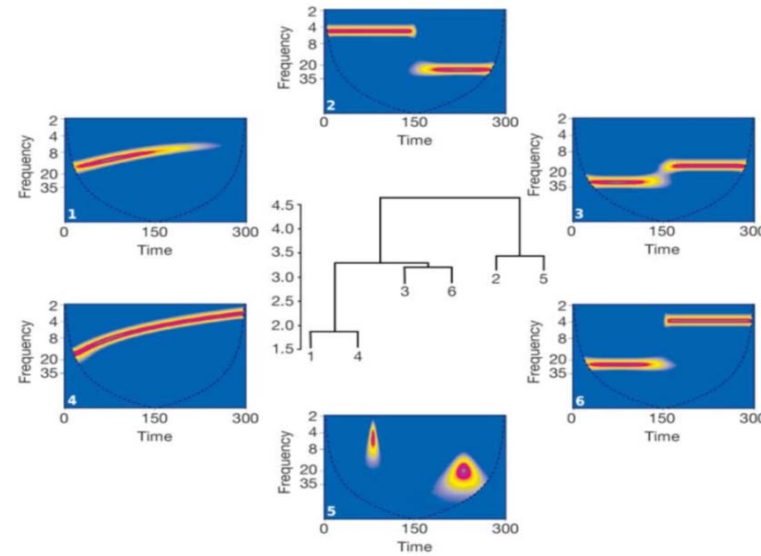
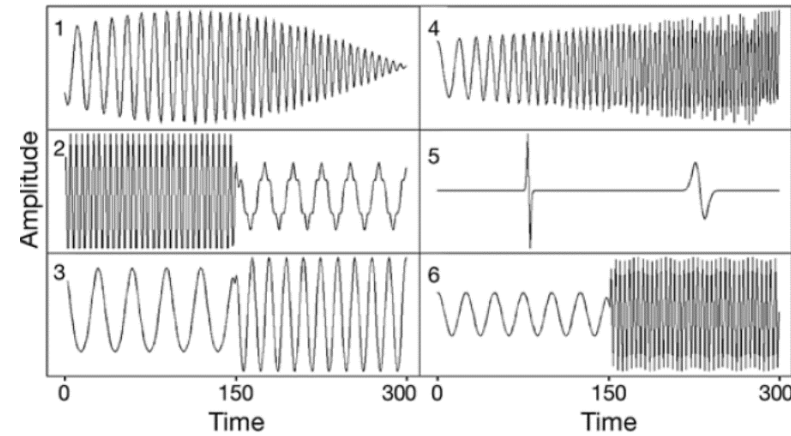
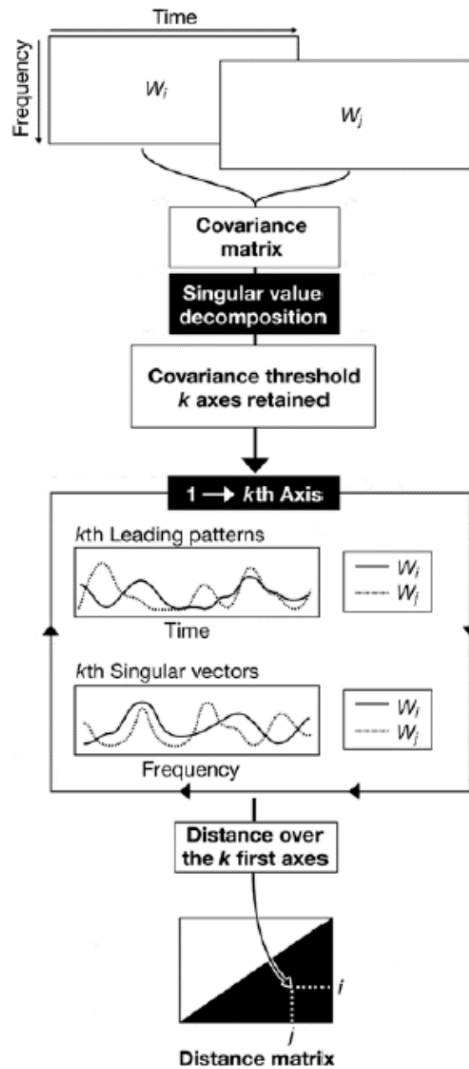


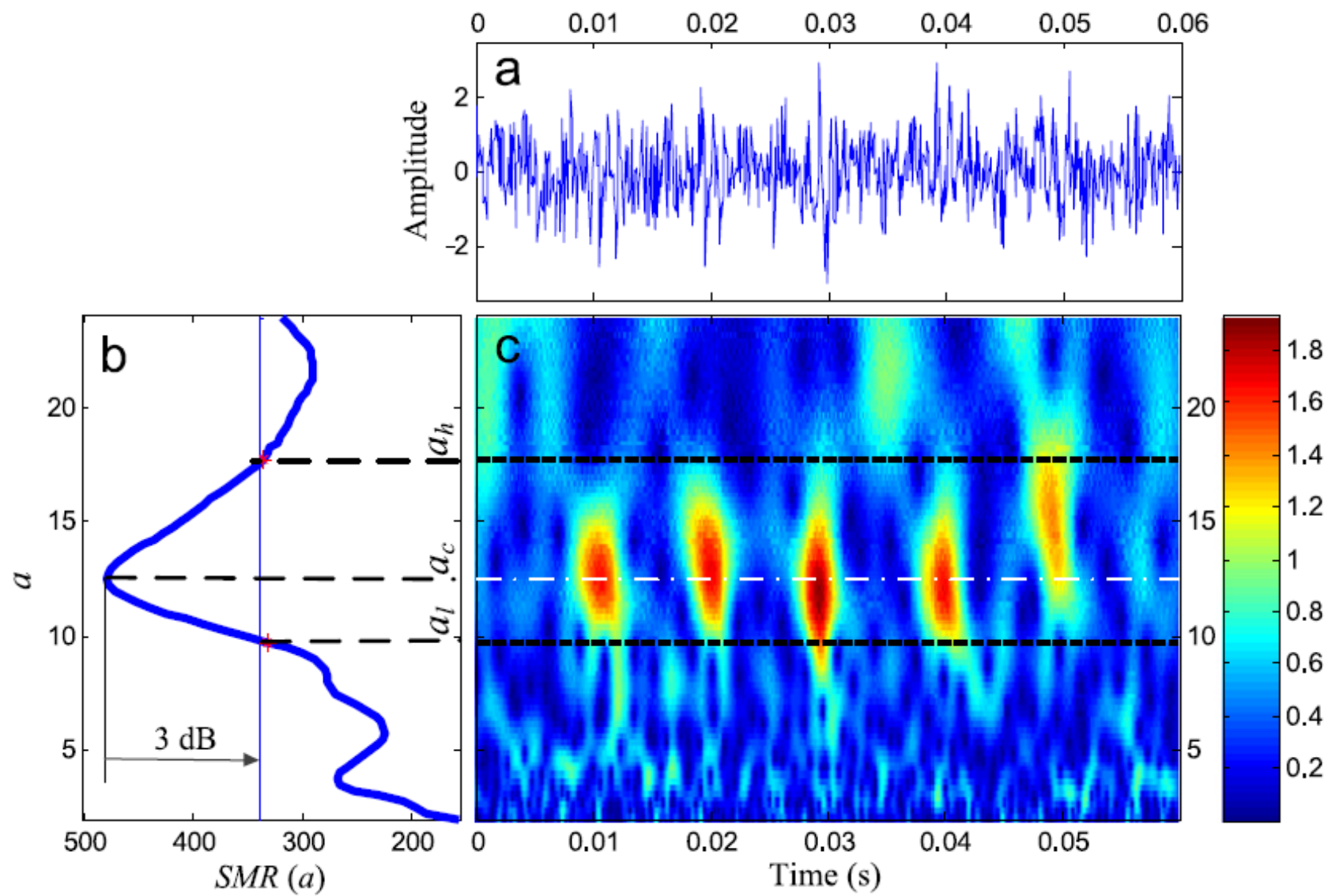
適合機器學習的特徵抽取方式

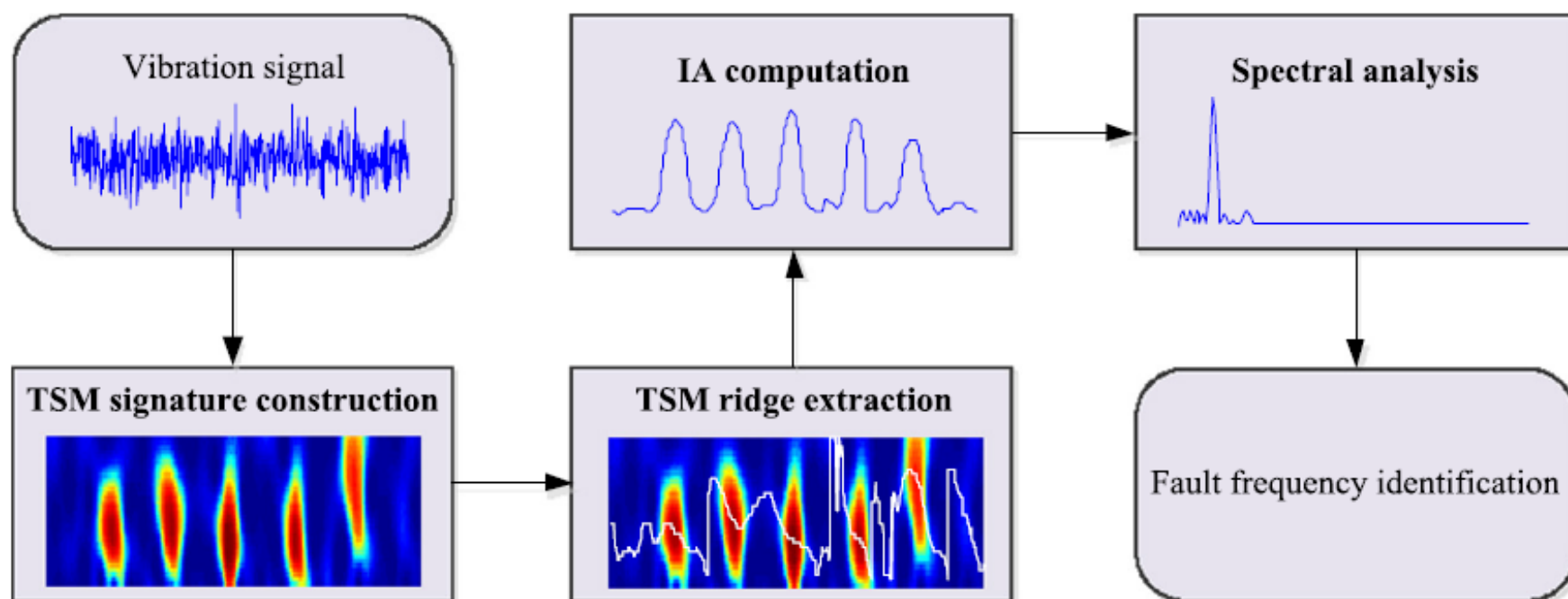
- ★ Noise suppression in time-scale representation
- ★ Instantons Frequency and Amplitude
- ★ Adaptive filtering to high IF
- ★ Entropy on IA and IF
- ★ Entropy on peak periodicity
- ★ Cross Wavelet distance
- ★ adaBoost



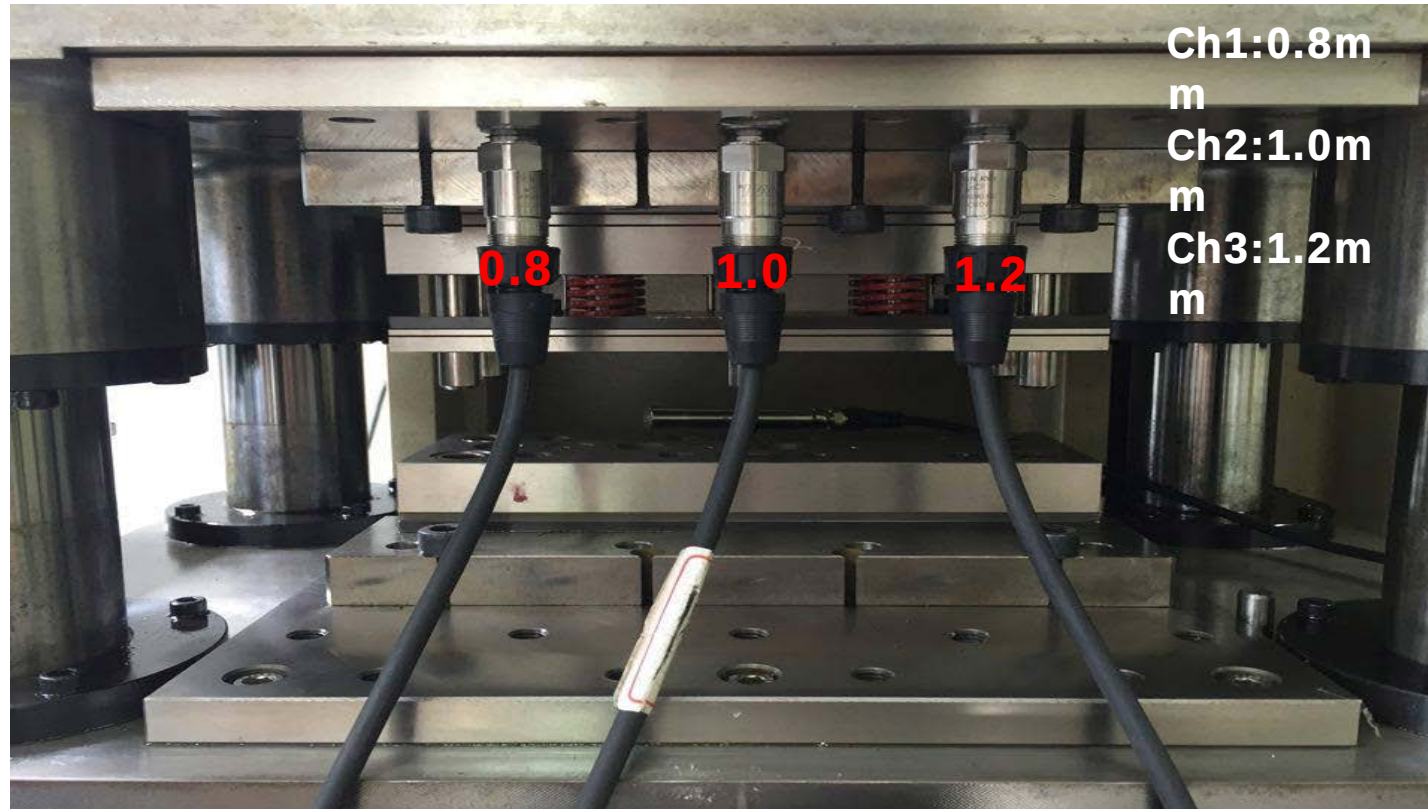
Unsupervised Learning



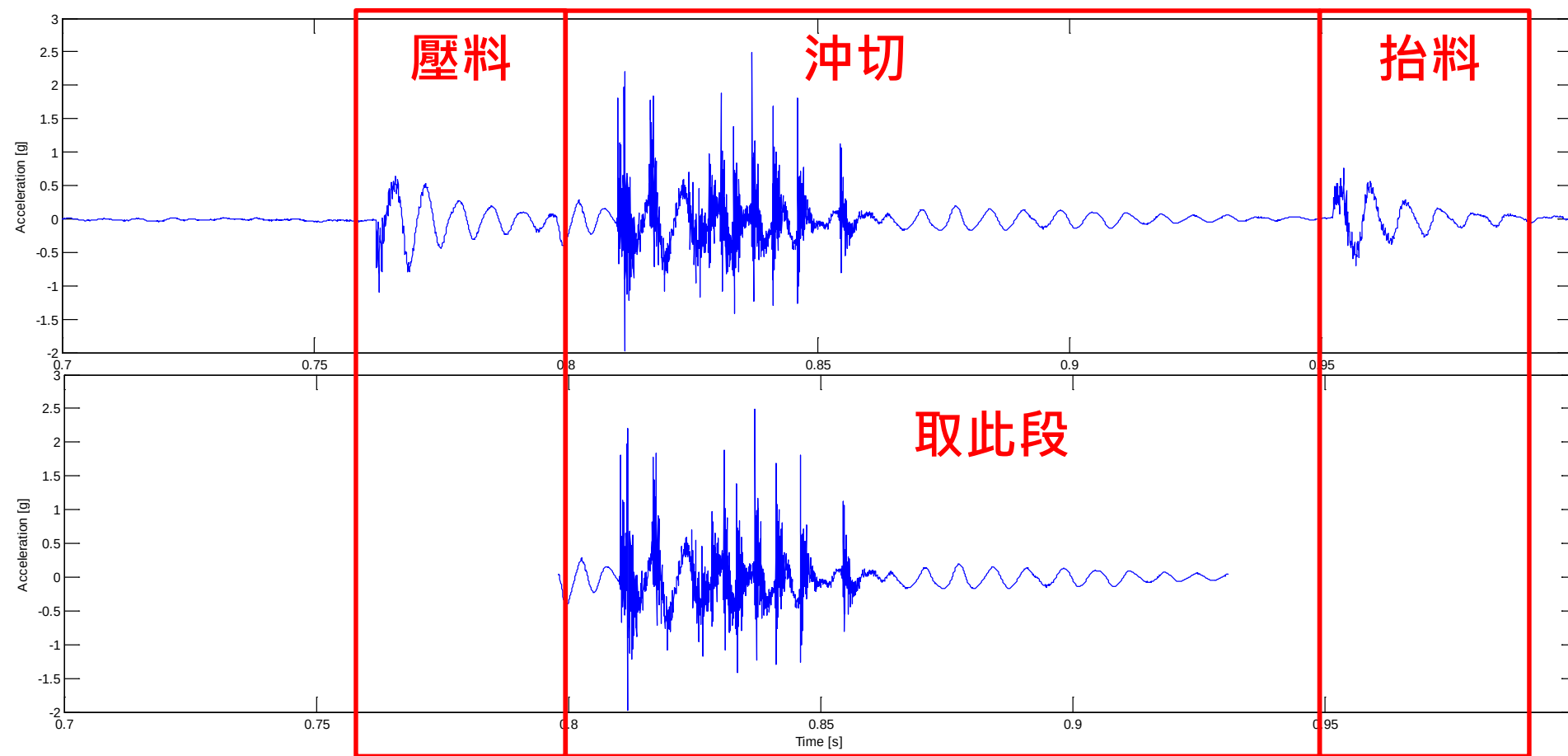




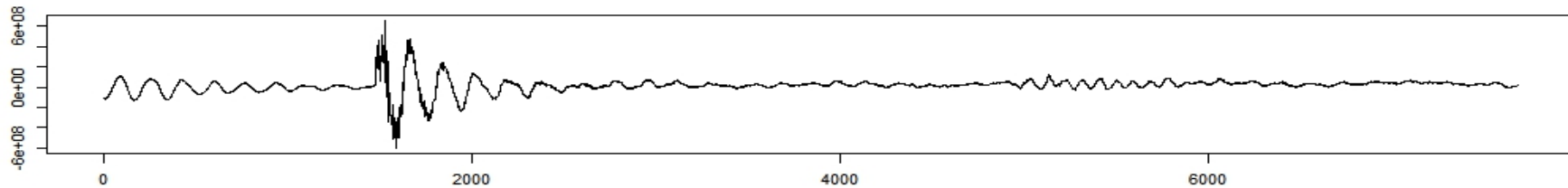
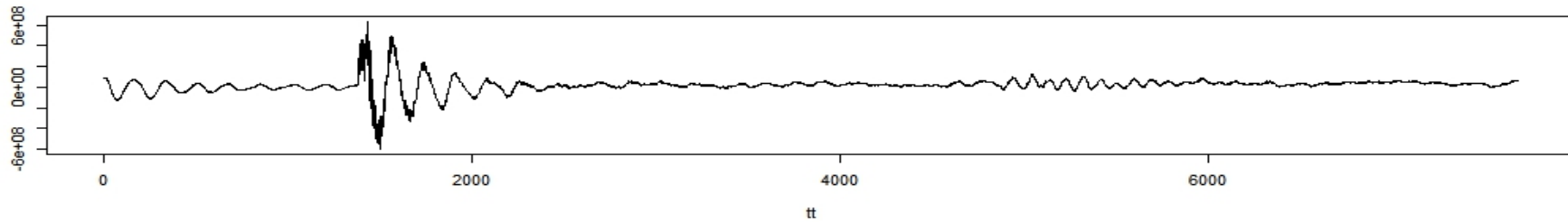
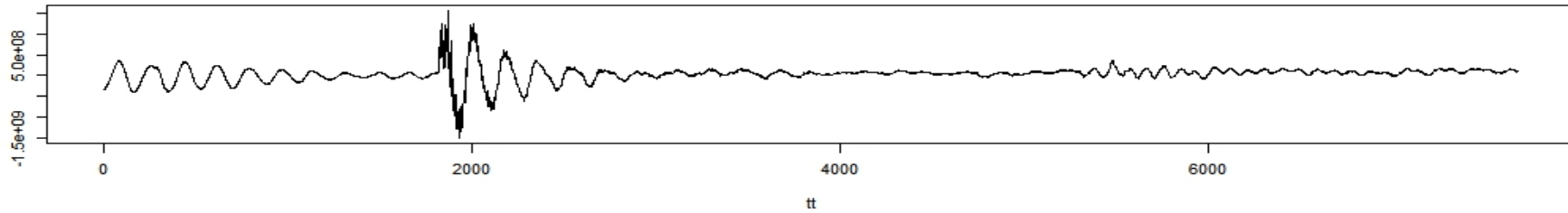
Testing on 精微沖床



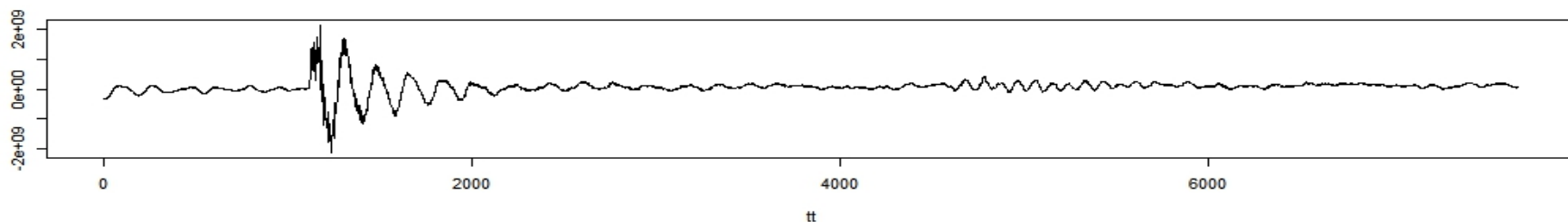
沖切段時序擷取圖解



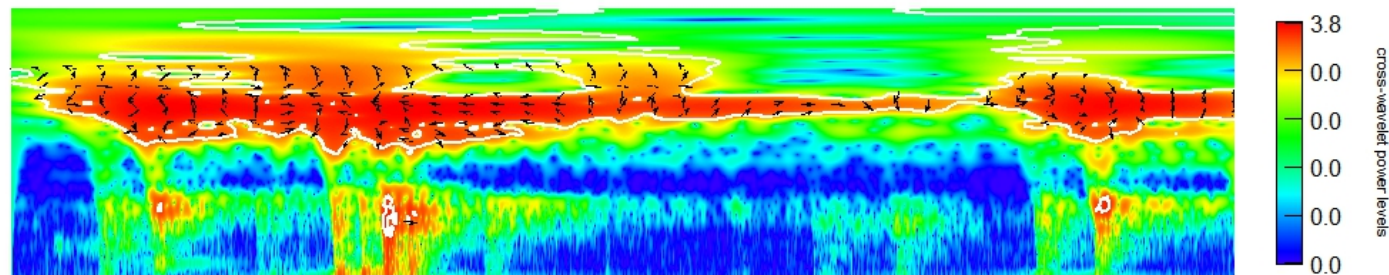
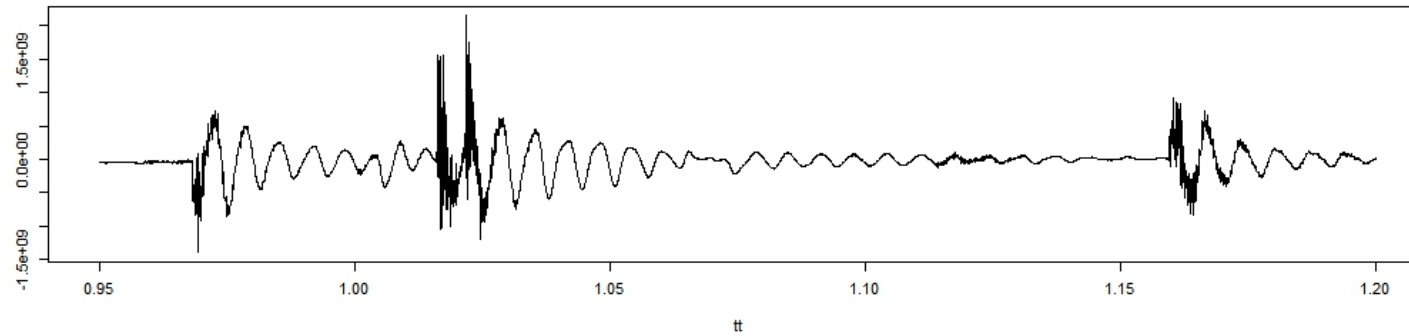
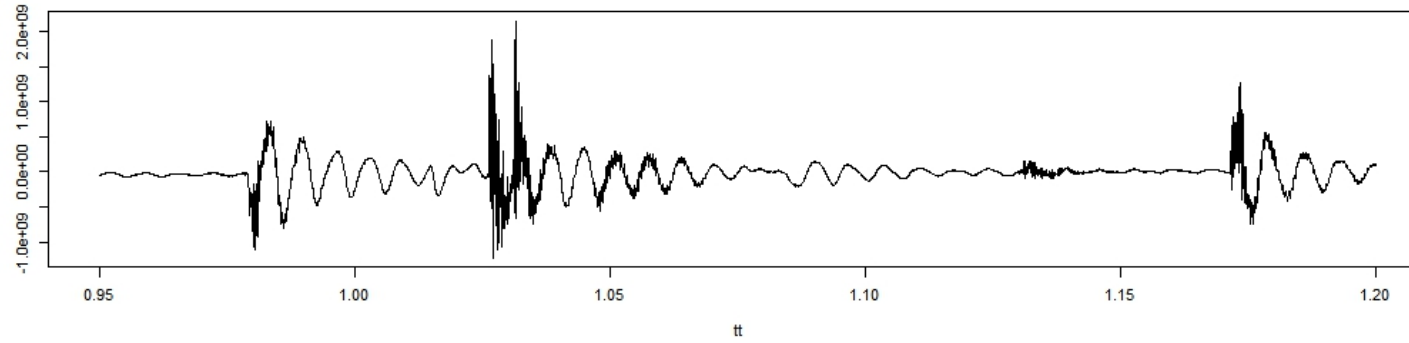
Accelerator signals from #188 to #121



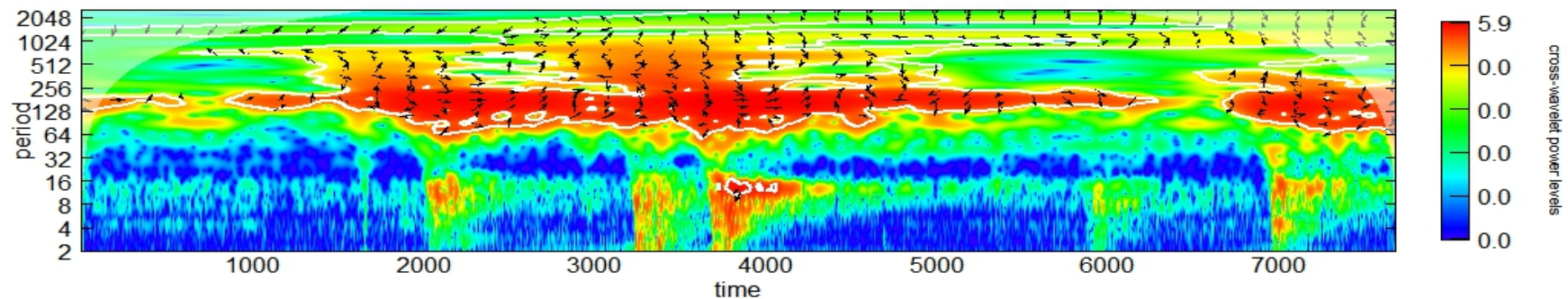
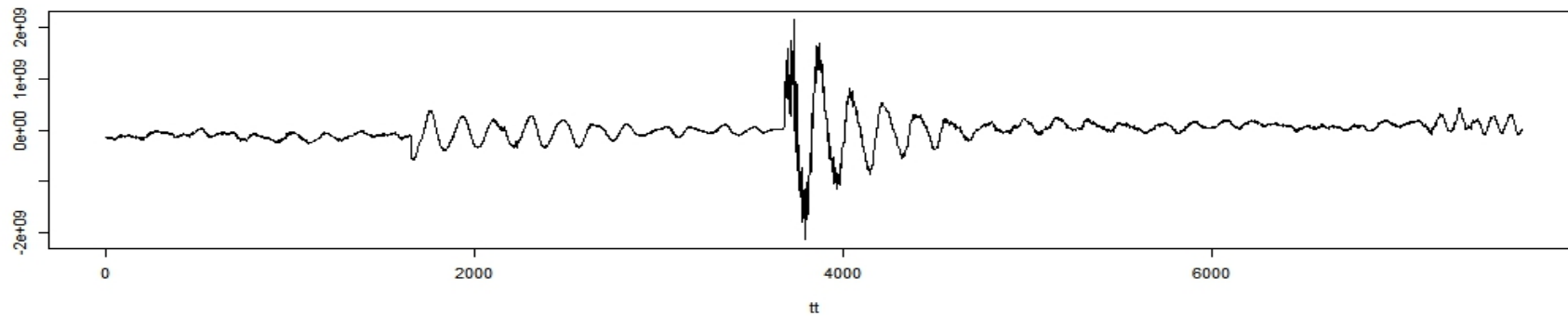
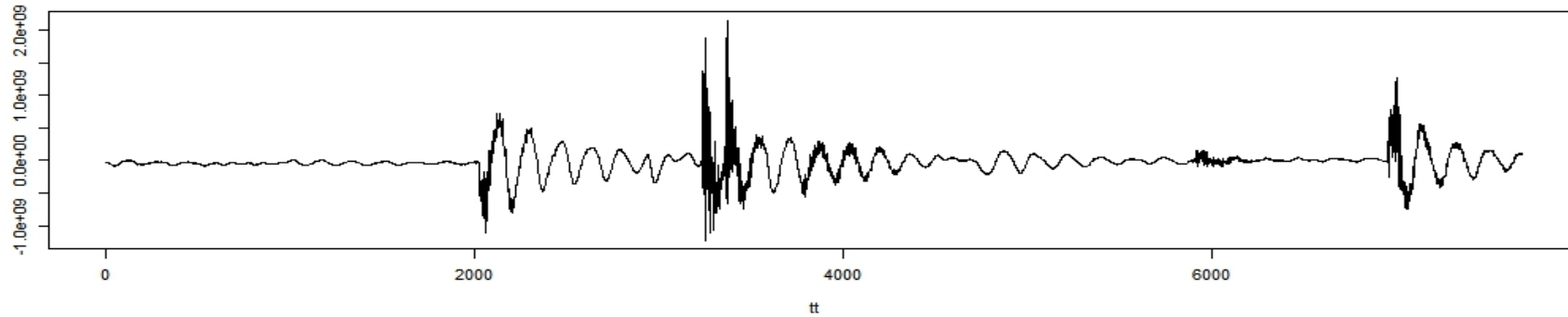
冲切121次有異常訊號，126次0.8mm冲頭斷掉



Cross Wavelet Spectrum between #1 and #5



Cross Wavelet Spectrum between #1 and #121



REUSE











Reusable Packaging: A Growing Business

- ★ Green packaging (recycled content, reusable and degradable) will grow by nearly 4 percent a year in the US market
- ★ Achieving annual sales of **\$41.7 billion** by 2014
- ★ And **\$6.5 billion** for reusable packaging.

Expendable Packaging: Largest Contribution to Solid Waste

- ★ In the US, containers and packaging accounts for 29.5 percent (**71.6 million tons**) of solid waste.
- ★ Americans use about 14.4 billion paper cups each year.
- ★ Plastics accounts for 4% of US energy consumption. The oil used to produce plastic water bottles in the US is enough to fuel about 100,000 cars per year, and 8 of every 10 bottles will end up in landfill (2011).
- ★ Comparing to corrugated board packaging, RP consumes 39 % less energy, makes 95 % less waste and results in 29 % fewer greenhouse gas emissions.

Examples

- ★ Reusable Pallets

- ★ Pallet Collars



- ★ Reusable Handheld Containers

- ★ Reusable Bulk Containers

- ★ Reusable Dunnage

- ★ Reusable Straps



- ★ Oxygen/ LPG cylinders

- ★ Flower roll cages

- ★ Beer crates

- ★ Surgical tools/Service tools

- ★ Roll Containers

- ★ Steel containers

- ★ Shopping Carts



- ★ Automotive Racks

Glass Packaging for LCD Assembly

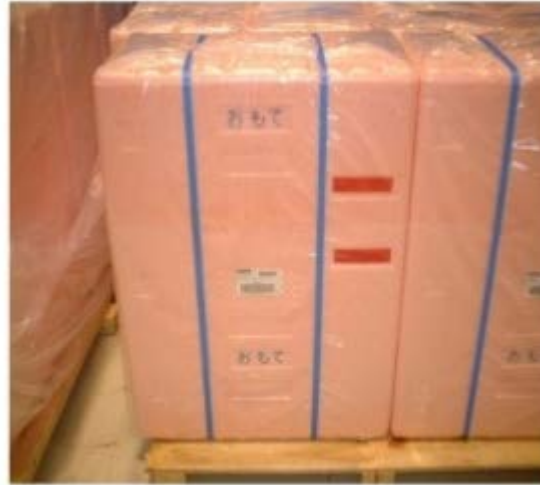
L-supporter



20 pcs

dispensable
returnable

PP case



20 pcs

returnable



500 pcs



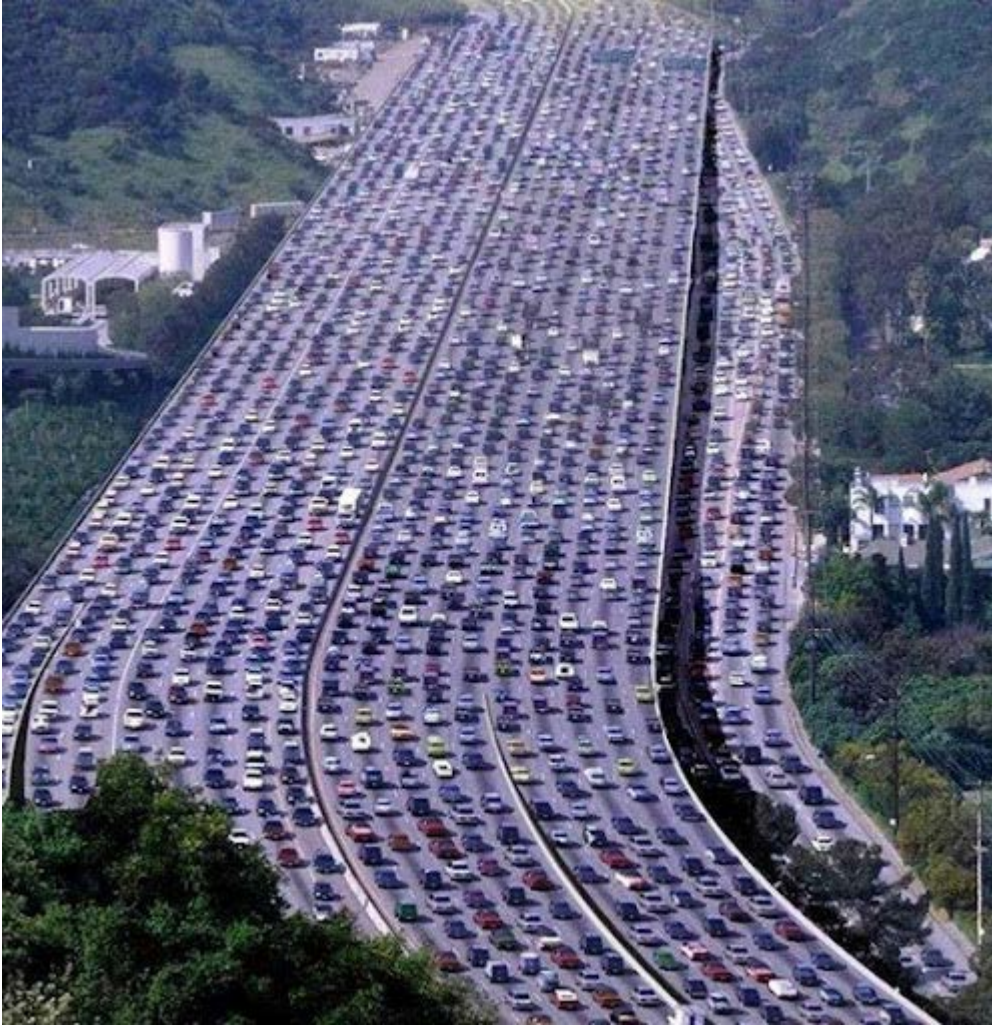
Before turning green
You have to be profitable

If reuse is so good, why not do it earlier?

- ★ My experience in carrying chopsticks
 - ★ 1. Too many thinks around me and some of them pay less attention.
 - ★ 2. After continuing losing, the cost is extremely high
 - ★ 3. Our students then started a voluntary initiative in providing plastic chopsticks for school meetings
 - ★ 4. It ends up with a problem of uncertain supply
- ★ Reusing packaging involves not only reverse but also circular logistics

The notion of
averaging
could be very wrong.

How Many Buses Are Needed for a Route?



Backhauls?
Running business by luck?

Suitable Application Situations for RP

- ★ High volume shipments
- ★ Frequent deliveries
- ★ Shorter distances
- ★ Dedicated delivery provider
- ★ High volumes of solid waste
- ★ Frequent shrinkage or product damage
- ★ Expensive expendable packaging
- ★ Underutilized trailer space in transportation
- ★ Insufficient storage/warehouse space
- ★ Worker safety or ergonomic issues
- ★ Significant need for cleanliness/hygiene
- ★ Need for unitization

Applicable Industries

- ★ Beverage
- ★ **Produce**
- ★ General Manufacturing
- ★ Appliance
- ★ **Automotive**
- ★ Food/Grocery
- ★ Pharmaceutical
- ★ Electronics
- ★ Aerospace
- ★ Chemicals
- ★ Textile

Oblivious Advantages

- ★ Economic Benefits: direct savings through repeated usage, expensive design providing better protection for transport
- ★ Sustainability: reduce waste
- ★ Social Outcomes: ergonomics for works

But, how to implement a sustainable packaging reuse system?



Static Factors in the Cost-Benefit Analysis

- ★ Capital equipment and tooling depreciation
- ★ Packaging materials cost
- ★ Packaging storage space
- ★ Packaging performance
- ★ Labor
- ★ Product damage, shrink, or spoilage
- ★ Shipping
- ★ Disposal

Challenges

- ★ Large capital investment for huge quantity of containers
- ★ Hidden cost in logistics operation
- ★ Recipient's burden in managing and storage
- ★ Recollecting articles from far away recipients
- ★ Unexpected shortage occurs very often
- ★ Cascade effect on a single surge
- ★ Quality disputes if practicing exchange
- ★ Article thieving
- ★ (The most unwanted situation: bus arrival pattern)



禁用物質=

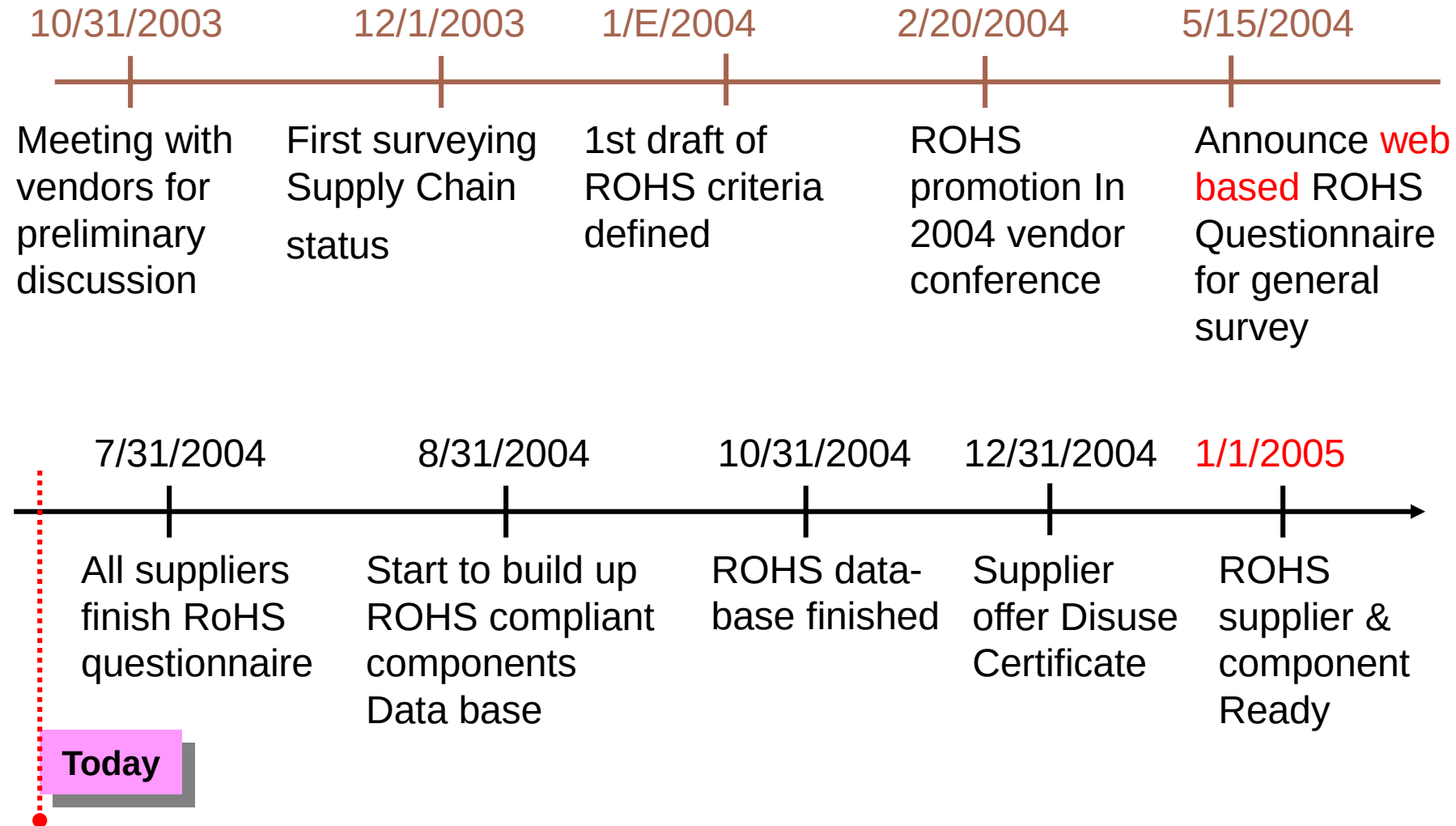
做得到，容易做，逃不掉

禁排氣體=?

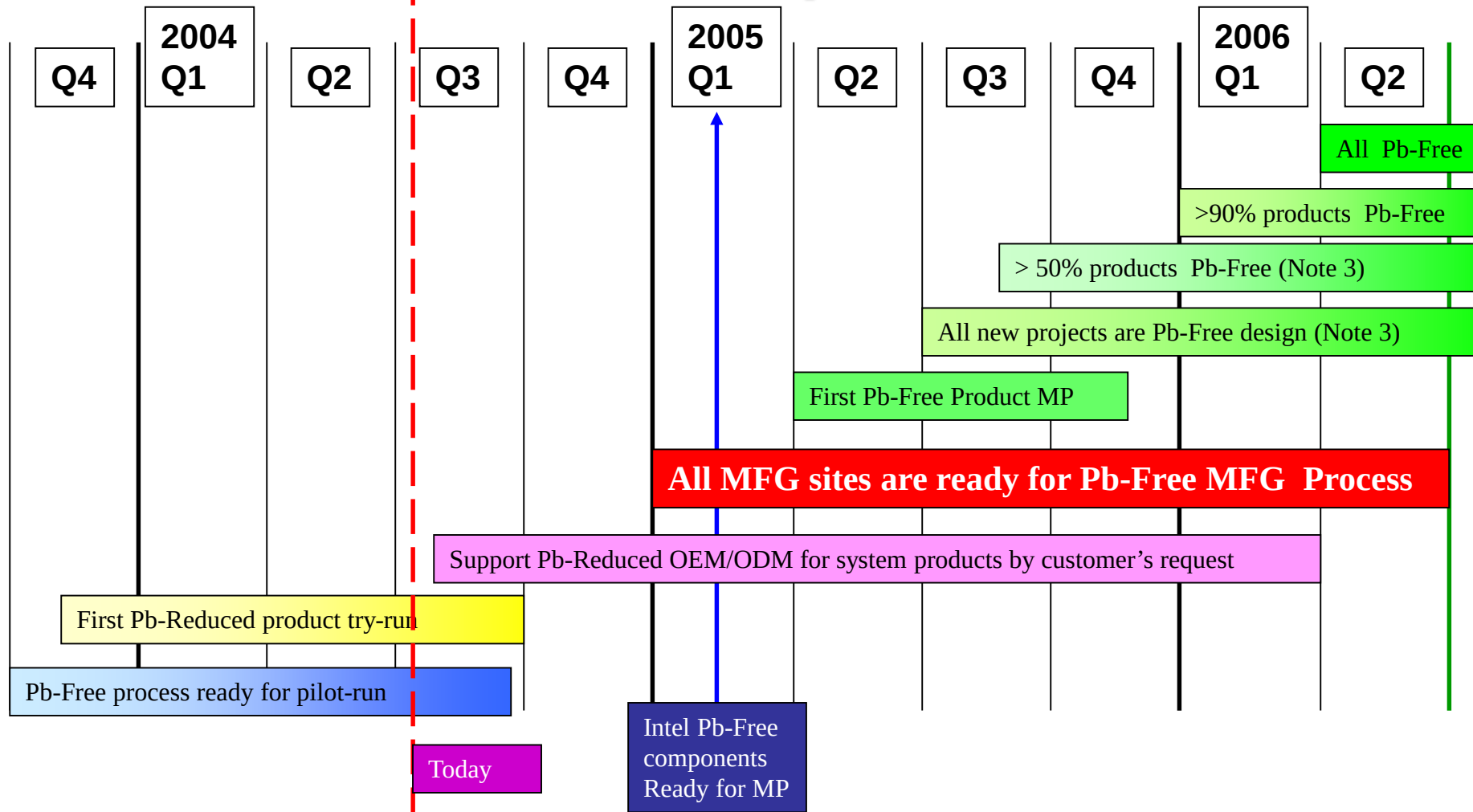
The Restriction of Hazardous Substances Directive 2002/95/EC (RoHS 1)

ROHS

Milestone: RoHS SCM



Milestone: Lead-free MFG process



Note 1 : Pb-Reduced means only MFG process, PCB and part of components are Pb-Free
 Note 2 : The milestone will be updated according to Pb-Free components readiness
 Note3 : The percentage of Pb-Free product is for Wistron ODM project/product

 網際網路

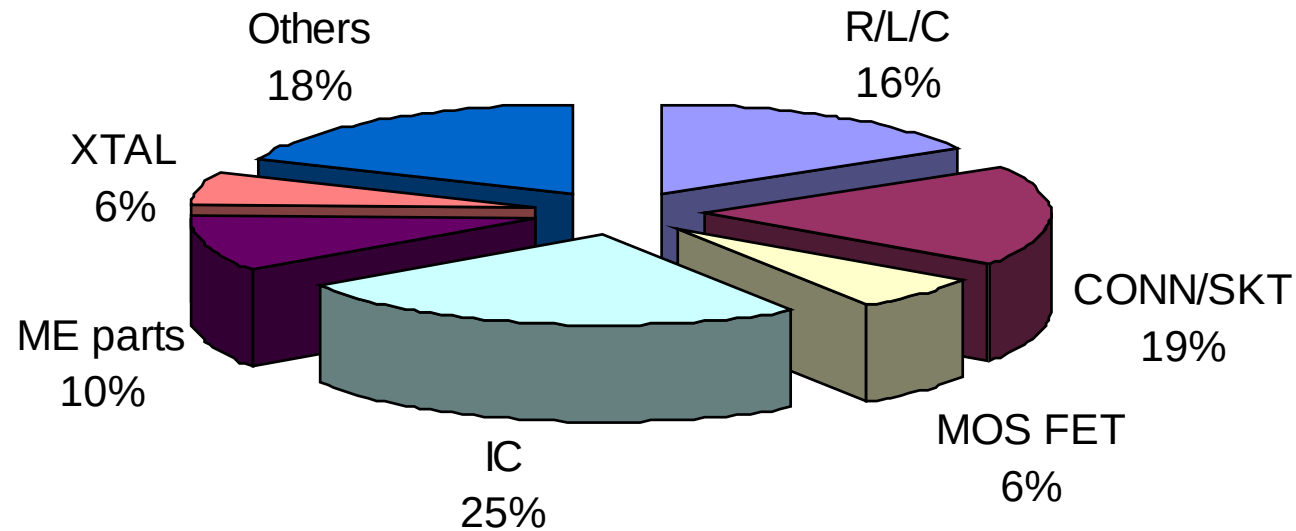
Training Programs

Subject	Outline	QA	SQM	PUR	RD	Time
Trends and Requirements of Green Product	國內外系統廠商之產品環保性要求	O	O	O	O	1.5 HR
	歐盟之WEEE & RoHS條文	V	O	O	O	
	建立管理系統對應	V	X	X	O	
Reporting and testing for environmental restricted substance	產品檢測執行與報告判讀	V	V	V	V	2 HR
	危害物質特性	O	X	X	O	
	產品環保性之檢測技術與說明	O	X	X	X	
	X-ray儀器原理及檢測應用	O	IQC	X	X	
	環境管理物質種類與管制來源	O	O	O	V	
Reliability Test for Pb-free products	制定測試規格	V	O	X	V	2 HR
	制定無鉛產品可靠度測試	V	O	X	V	
Auditor training and supplier assessment	第二者稽核原理	O	V	X	X	12 HR
	稽核準則介紹	O	V	X	X	
	稽核計畫擬定	O	V	X	X	
	第二者稽核人員資格	O	V	X	X	
	稽核查檢表建立及使用技巧	O	V	X	X	
	供應商現場稽核活動執行及稽核技巧	O	V	X	X	
	稽核報告撰寫及缺失項目追蹤結案	O	V	X	X	
	案例演練	O	V	X	X	
Green Supplier Chain Management	定立綠色採購政策/策略	X	O	V	X	3 HR
	定立綠色產品規格	X	O	V	V	
	整合既有採購管制作業流程	X	O	V	X	
	定立綠色產品標示機制	X	V	O	X	
	如何建立物料特性之溝通流程或平台	X	V	V	X	
	如何訂立件料檢驗/物料保存/物料儲存要求	X	V	O	X	
Auditing Process for vendor survey	供應商提具限定物質保證書	X	V	V	X	3 HR
	供應商品質檢驗與承認	X	V	O	X	
	供應商系統/能力評鑑	X	V	O	X	
	供應商現場定期查核機制	X	V	O	X	
	系統評鑑查檢表建立	X	V	O	X	
	協助定立供應商溝通流程	X	V	V	X	

V: MUST
O: OPTIONAL
X: Don't NEED

Status of Supplier's RoHS Readiness

SMD Component Supplier: 49 Vendors



Substance	RoHS Test Report	RoHS Compliant	Threshold (ppm)
Pb	79.9%	95.9%	1000
Hg	75.0%	100%	1000
Cd	79.5%	100%	75
Cr6+	74.6%	100%	1000
PBB	56.8%	100%	1000
PBDE	56.8%	100%	1000

Detail



Thank You