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Trends and Recent Advances on ICT-Enabled Smart Products and Service Innovation *Innovating the Invisibles*

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Univ. of Cincinnati, Univ. of Michigan, Missouri Univ. of S&T

www.imscenter.net



Outline



- Innovation Models and Changing Product Service Systems
- Tools for Dominant Product and Service Innovation Design & Examples
- Recent Advances of ICT-Enabled Smart Service Systems & Examples
- Opportunities for Taiwan's Transformation



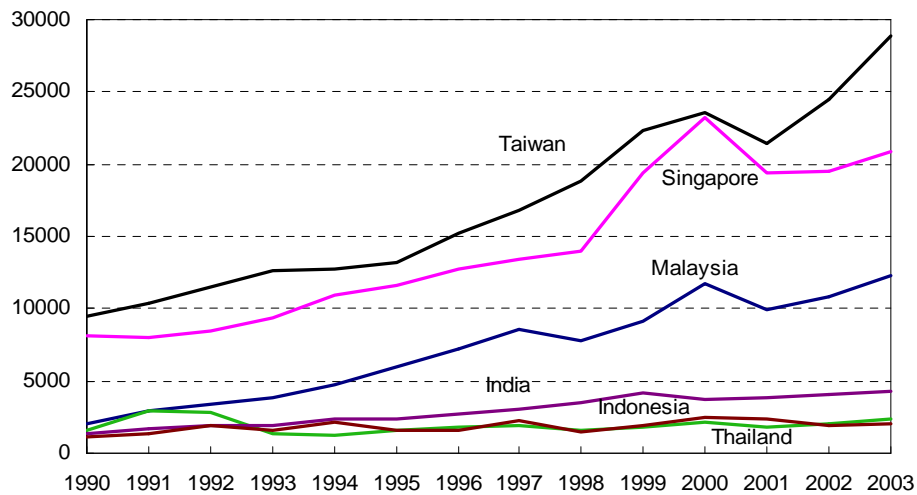
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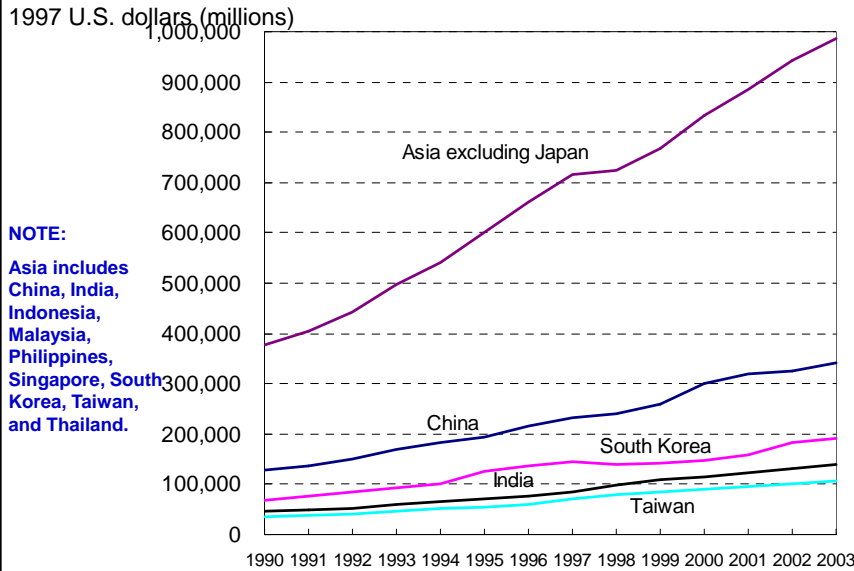


Value Added in High-Technology Manufacturing Industries by Selected Asian Country/Economy



Source: NSF S&T Indicator 2007

Revenues Generated by High-Technology Services, by Selected Asian Country/Economy



NOTE:

Asia includes China, India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand.

Source: NSF S&T Indicator 2007



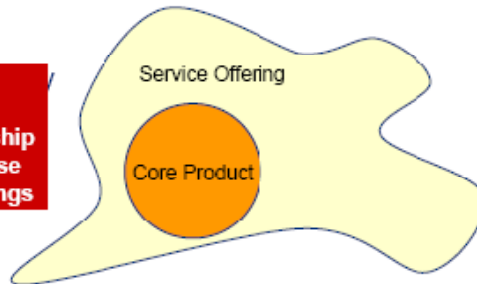
Product Service Model



The Fried Egg Model

Your Core Product

Emphasis is on establishing and maintaining a relationship with your customer base through broader offerings



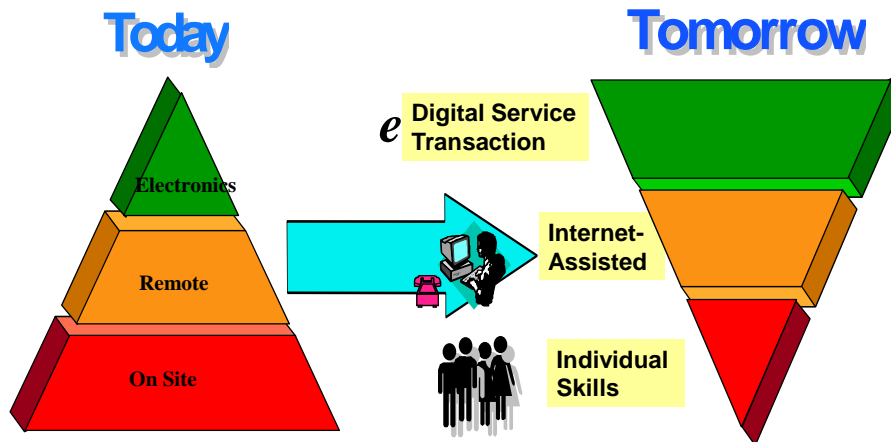
Very difficult to compete on this level with the low cost copies

Your differentiator in the marketplace is more to do with the unique package of services offered with the core product



IMS Product Service Systems Workshop, Cranfield Univ. UK, Sept. 2006

Business Trends



Service Innovation for Tomorrow:

- Service is a **Customer-Intensive System**
- Service using a **System Instrumentation (Smart Agent)**
- Service through **Smart Operation Analytics**
- Service for **Knowledge Management Business**
- Service to **Avoid Potential Issues for Customers.**

J. Lee, NSF Symposium on Technology Management in the Service Sector
Portland, OR, August 5, 2007 (Co-Sponsored by IBM Service Science)

John Deere Agri Service System & Precision Farming

Embedded Soil Analysis System





GE Medical →
GE Healthcare Technologies (2004~)

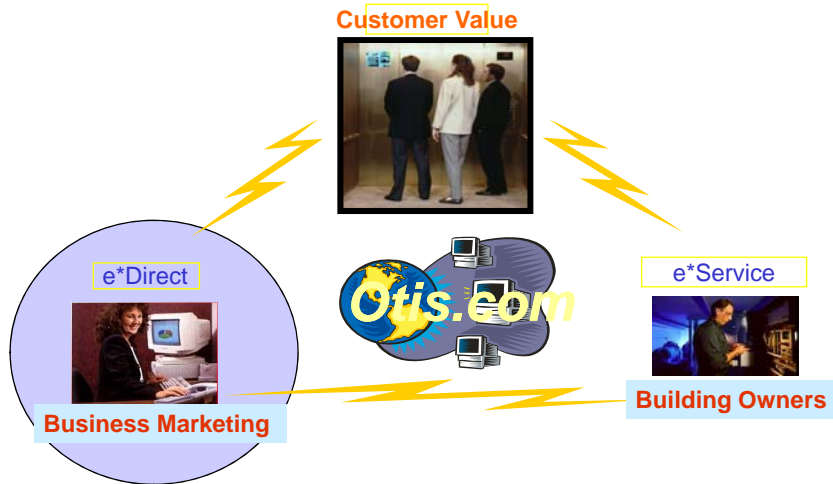
iPod Connected Nike and Nike+



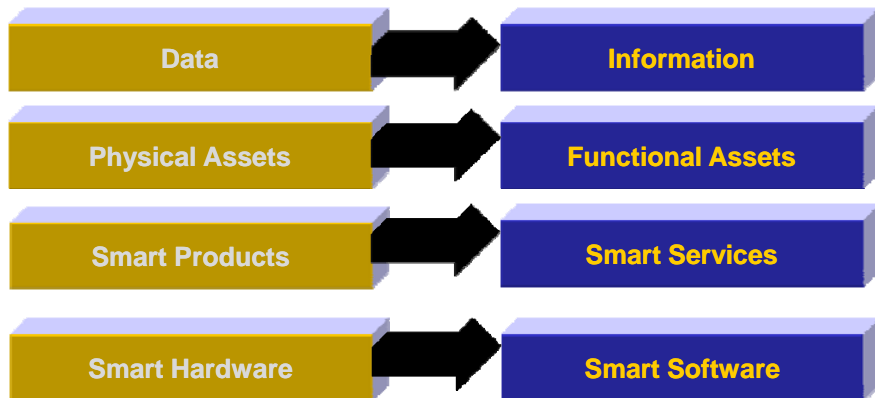
Lesson Learned Case Study – Otis Elevator 1990s Farmington, CT



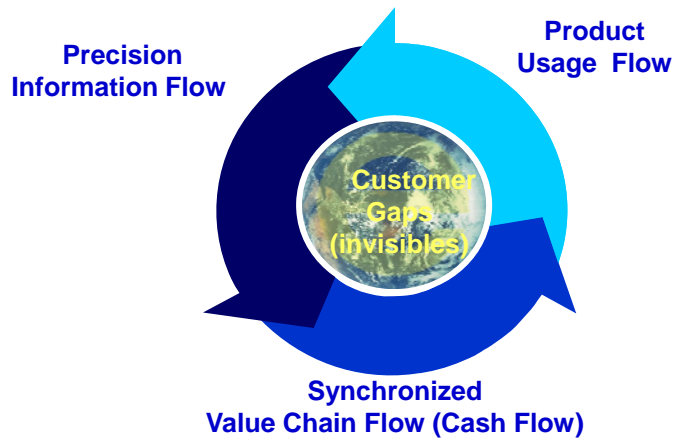
Enhancing Customer Value at Otis Elevator



Value Shift



Needs on Service Intelligence



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Key Service Design Issues



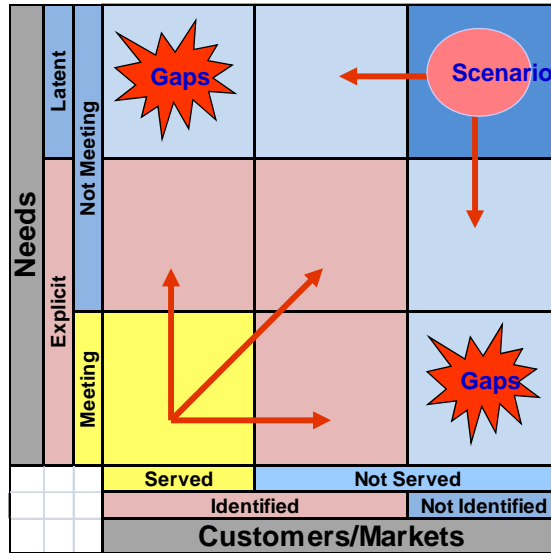
- **Who are your customers?**
- **What do your customer REALLY want?**

Tools for Dominant Innovation



- **Innovation Matrix**
- **Application Space Mapping**
- **Quality Function Deployment (QFD)**

Innovation Matrix



Source: Jay Lee, Univ. of Cincinnati, www.DominantInnovation.com

Customer Application Space Mapping

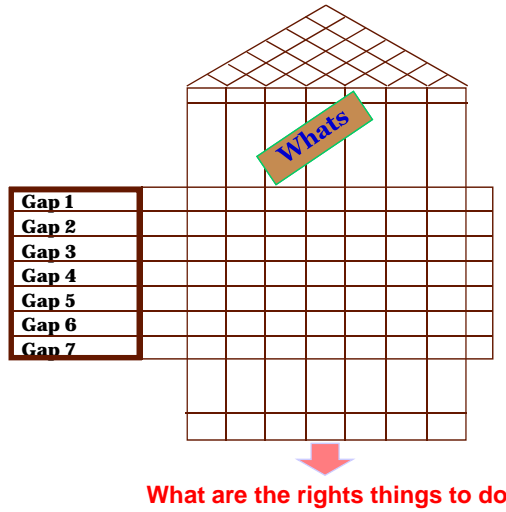


Product/Service 1	Gap 1	Gap 1	Gap 1		
Product/Service 2	Gap 2	Gap 2			
Product/Service 3	Gap 3				
	Application Space A	Application Space B	Application Space C	Application Space D	Application Space E

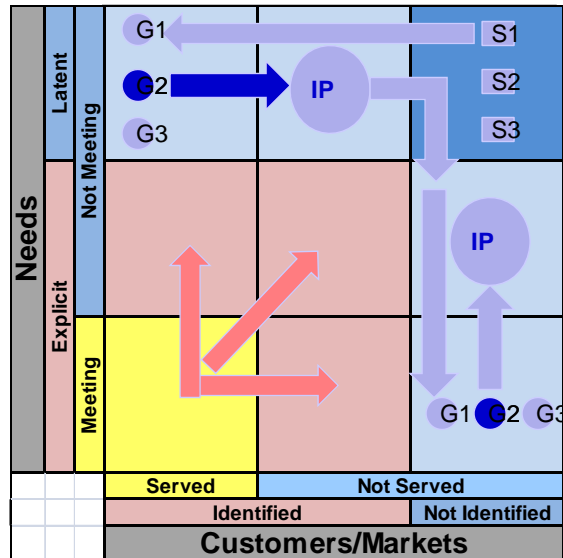


Source: Jay Lee, Univ. of Cincinnati, www.DominantInnovation.com

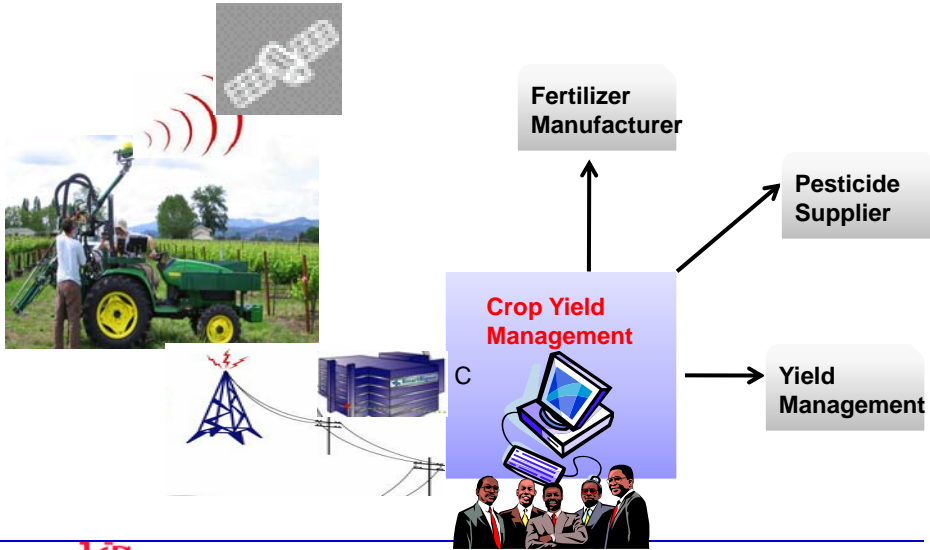
From Gaps to “Whats” using QFD



Innovation Paths



John Deere Precision Farming Systems



DD Matrix for Precision Farming



Needs	Latent	Customized Soil Mgt For Crop Growth	Soil Instrumentation Systems	Precision Farming
	Not Meeting	Crop Harvesting	Smart Farming	Crop Yield Management IT & Software
	Explicit Meeting	Farming Equipment	Corn, Vineyard, etc	Fertilizer and Pesticide B2B and B2C
		Served	Not Served	
		Identified		Not Identified
Customers/Markets				



**IT化加盟式家庭射出工廠
-以微小型射出爲例**

**Smart Mechanical Coupling &
Maintenance Service
a Brazilian Company**

Smart ComPen Sweden



What is “service” gaps?



LiXing Case Study Wuhan, China



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The IMS Consortium



AMD Smarter Choice

CISCO

TOYOTA

Parker

SIEMENS

ADVANTECH

API

P&G

PMC

OMRON

TechSolve

Syncrude

UNIVERSITY OF CINCINNATI

Center for Intelligent Maintenance Systems

ims

GE Aircraft Engines

DAIMLERCHRYSLER

Intellogistics

FESTO

TOSHIBA

AVETEC

BOSCH

100 Years in USA 1906 | 2006

KISTLER

measure. analyze. innovate.

GM

Honeywell

Chevron

BorgWarner

Ford

CATERPILLAR

2IGSI

BOEING

NATIONAL INSTRUMENTS

EDaptive COMPUTING, INC.

Industrial Technology Research Institute

Center for Environmental Safety and Health Technology Development

SPiRiT AEROSYSTEMS

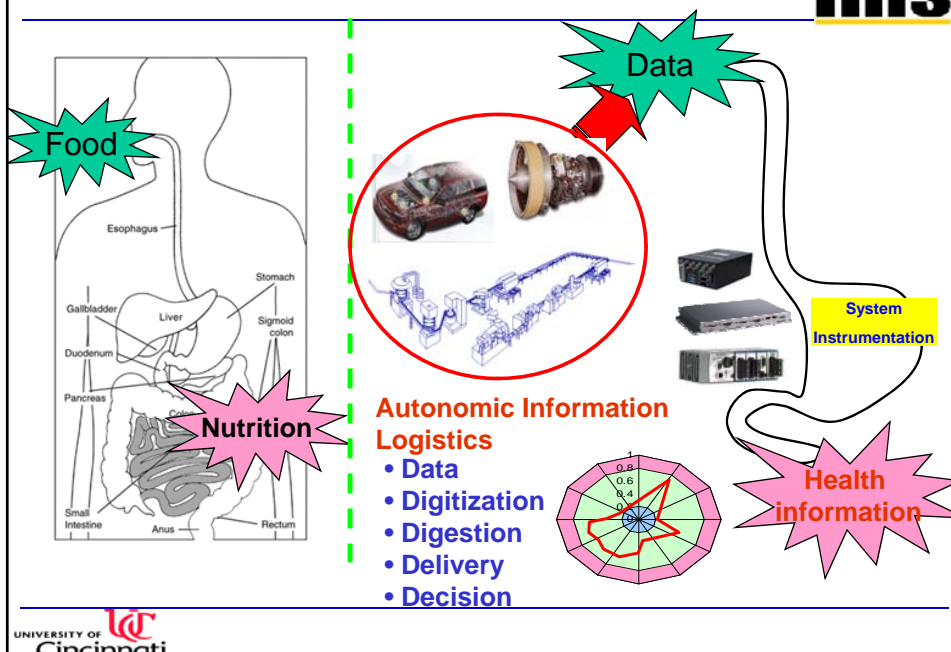
NISSAN

UNIVERSITY OF CINCINNATI

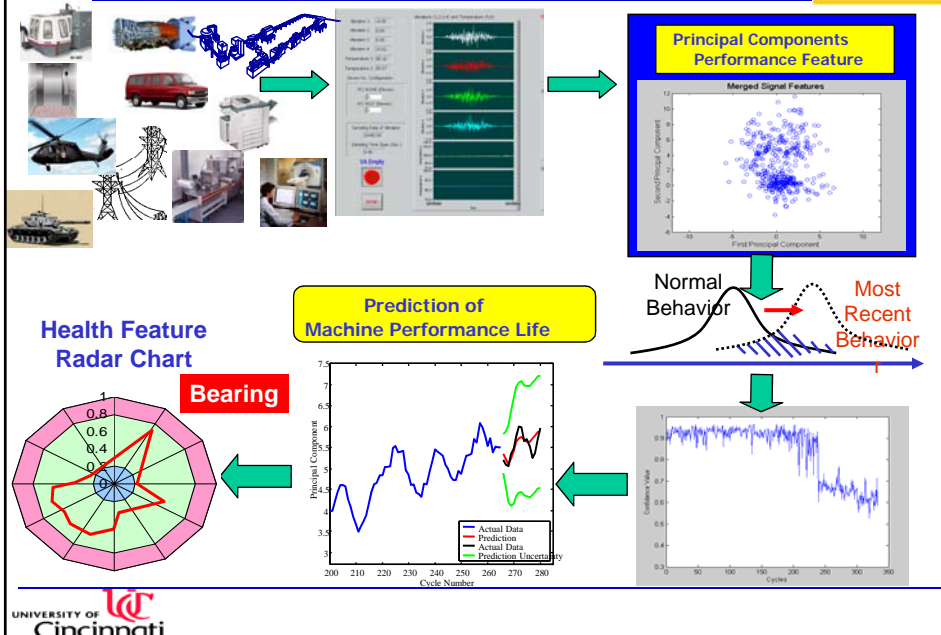
IMS Vision and Mission Statement

To enable products and systems to achieve and sustain **near-zero breakdown performance**, and ultimately **transform machine condition data to useful information for improved productivity and asset utilization.**

Smart Infotronics - An Analogy



Embedded ICT-enabled Instrumentation

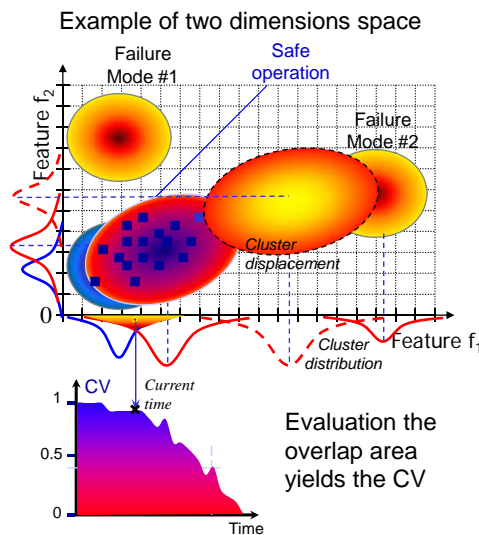


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Smart Operation Analytics



- What?
 - Analytical comparisons of feature distributions
- When?
 - Features are (approximately) Gaussian
 - Stable operation without too many impacts
- Possible application:
 - Repeatable processes and operations



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Tools for Autonomic Computing



Watchdog Toolbox Selection		Y's (WHATs)		X's (HOWs)			
Customer Requirements and Application Conditions	Importance	Watchdog Tools	Weight	Function	Suggestion Tools		
Non-stationary Signals	5	Time-frequency Signal Analysis	0.155	Feature Extraction	Wavelet Packet Decomposition		
Stationary signals	1	Wavelet Packet Decomposition	0.161				
High Frequency Signal	5	Autoregressive Modeling	0.098				
Low Frequency Signal	1	Fourier Transform	0.131	Performance Assessment	Statistical Pattern Recognition		
Highly Dynamic Systems	1	Logistic Regression	0.092				
Sufficient System Knowledge	1	Feature Map	0.074				
Insufficient System Knowledge	5	Statistical Pattern Recognition	0.119	Diagnostics	Adaptive Resonance Theory II (ART2)		
Interchangeability	1	Hidden Markov Model (HMM)	0.086				
Human Involvement	5	Particle Filters Performance Assessment	0.086				
Low Cost Implementation	1	Support Vector Machine (SVM)	0.092	Prognostics	Autoregressive Moving Average (ARMA)		
Possibility of Cost-Effective Embedding	1	Hidden Markov Model (HMM)	0.080				
		Bayesian Belief Network	0.059				
		Adaptive Resonance Theory II (ART2)	0.113				
		Autoregressive Moving Average (ARMA)	0.125				
		Compound Match Matrix / ARMA Prediction	0.089				
		Fuzzy Logic Prediction	0.125				
		Elman Neural Network Prediction	0.122				
		Support Vector Machine (SVM)	0.092				

User input

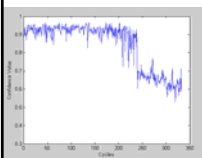
Rate the customer requirements and applications on a scale of 1 - 5. 5 being the most important, 1 the least



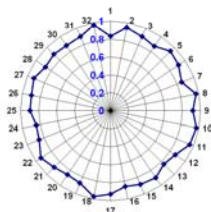
Information Delivery



Results of Smart Prognostics Tools for Asset Health Information



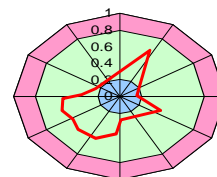
Confidence Value for performance degradation assessment (0-1)



Health Radar Chart for multiple components degradation monitoring



Health Map for potential issues and pattern classification



Risk Radar Chart to Prioritize Maintenance Decision



IMS Tools for Commercial Platform



ADVANTECH

UNO-2160 Watchdog Agent® System



Robust Embedded OS

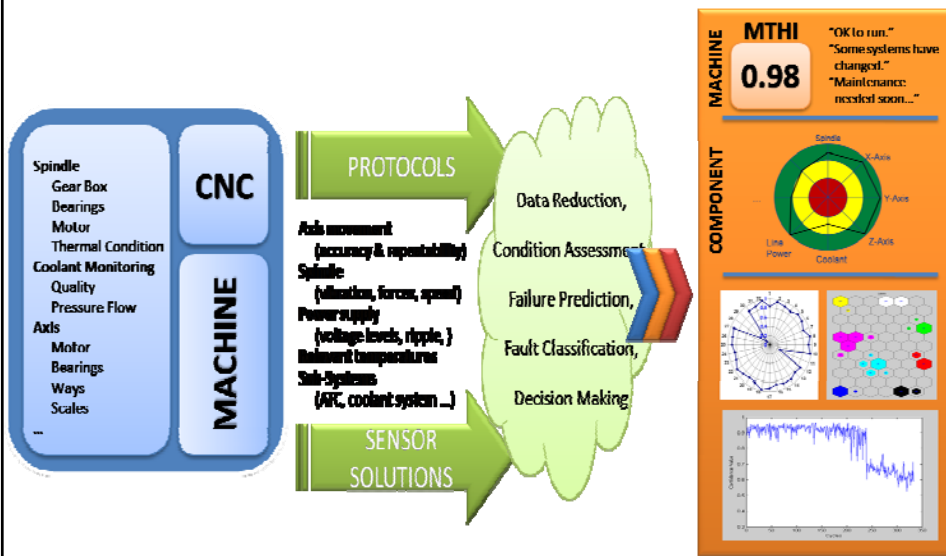
- Windows CE.NET
- Windows XP embedded

NATIONAL INSTRUMENTS

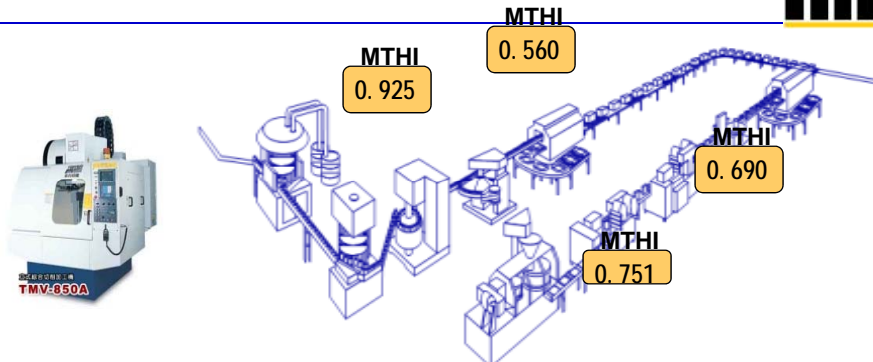
CompactRIO reconfigurable embedded system



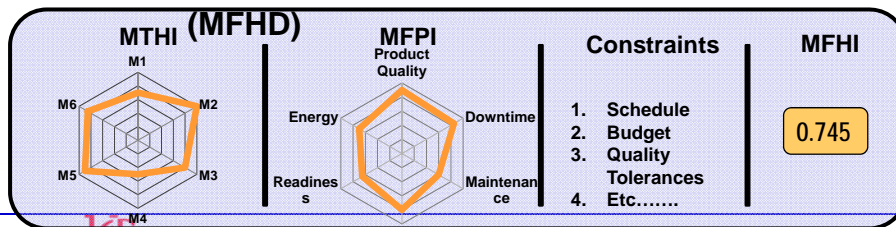
Smart Machine Tool Systems



ICT-Enabled Smart Machines

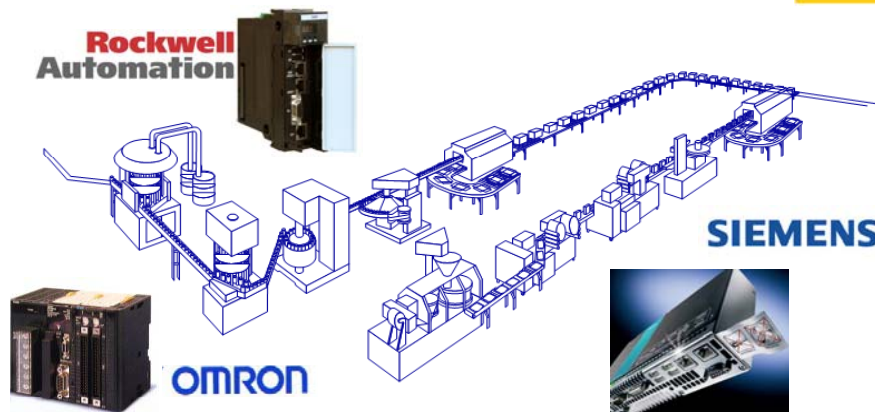


Machine Tool Health Dashboard



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Prognostics for Productivity Service



Reconfigurable Prognostics Systems

Enable Zero-Breakdown Productivity

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Validated Hardware



- Allen-Bradley ControlLogix/1756 Rack with Logix 5550
- Special Application Module for ControlLogix
 - Intel Pentium 266MHz CPU, 128MB of RAM and Windows XP Professional as operating system
 - Communication between 56SAM module and processor is realized over the backplane of the rack



Precision Energy Management and Industrial Machinery Performance Monitoring

Omron, Japan

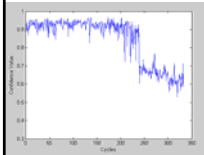


OMRON

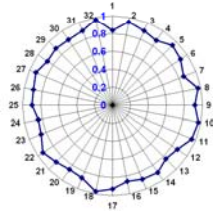
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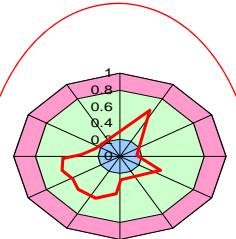
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Komatsu Smart Service Business Transformation for Earth Moving Equipment





Predictive Robot Maintenance at Toyota Georgetown, KY

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Darwin's Law of Evolution



- **Over production**
- **Competition**
- **Variation**
- **Adaptation**
- **Natural Selection**
- **Speciation**

Service Innovation for Tomorrow:

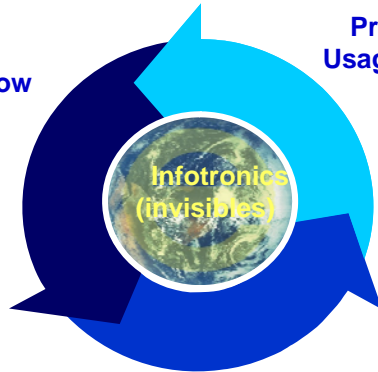


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Precision
Information Flow

Product
Usage Flow



Synchronized
Value Chain Flow (Cash Flow)



New Book on

Innovating the Invisibles

--- coming in late 2009

產品與服務創新的機會辨識與設計導向

日期: **2008/12/19 & 20**

時間: **9-5 PM (14 小時)**

地點: 新竹市 國立清華大學工程一館

李傑 (Jay Lee) 教授

許棟樑 (D. Daniel Sheu) 教授

**Thank
You !**

For More Information

Please visit:

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