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## Recent Advances of Industrial Big Data Analytics for Smart Product Service and Social Innovation



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## Outline



- ▶ Changing Role of Data and Value Creation
- ▶ Industrial Big Data Analytics, CPS, and Social Innovation
- ▶ Examples
- ▶ Conclusions



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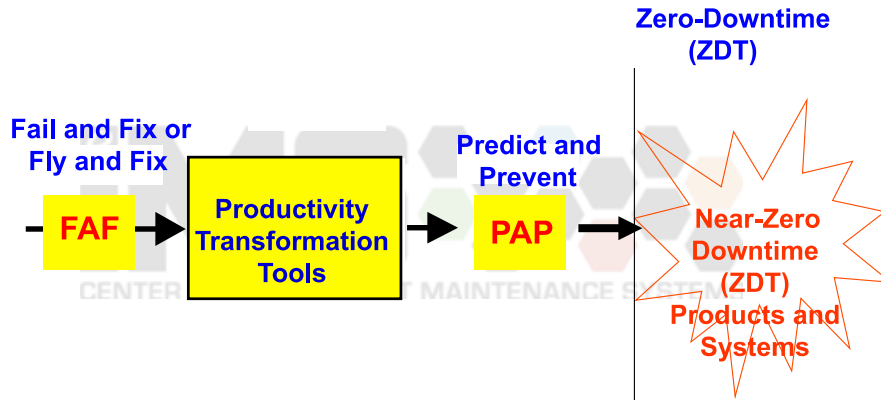
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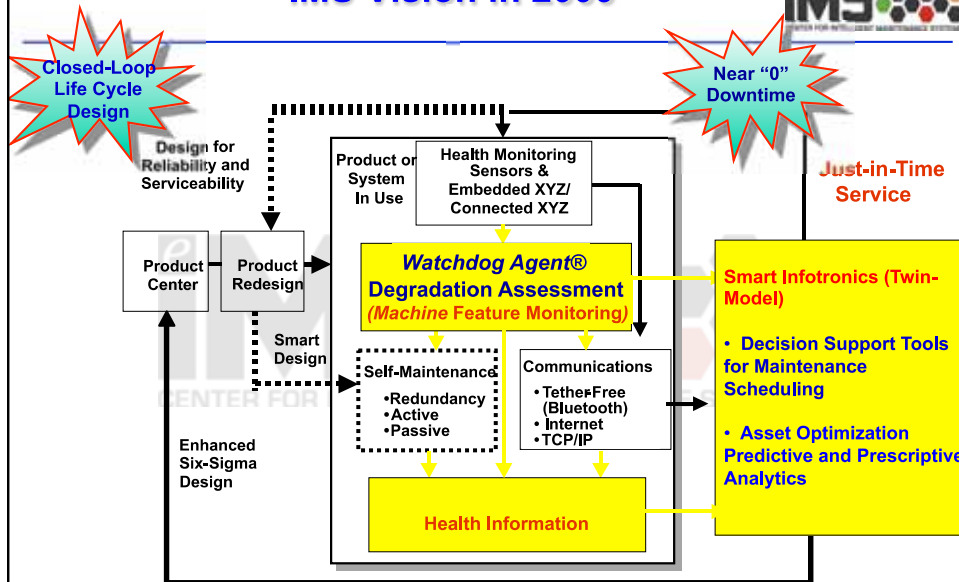
# IMS Vision and Grand Challenges



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# IMS Vision in 2000



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## GE Industrial Internet System



IMS Adventure in 2001 → Catalyst → GE Venture in 2011



Ref: GE Industrial Internet



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## Outline



### ► Changing Role of Data and Value Creation

### ► Industrial Big Data Analytics, CPS, and Social Innovation

### ► Examples

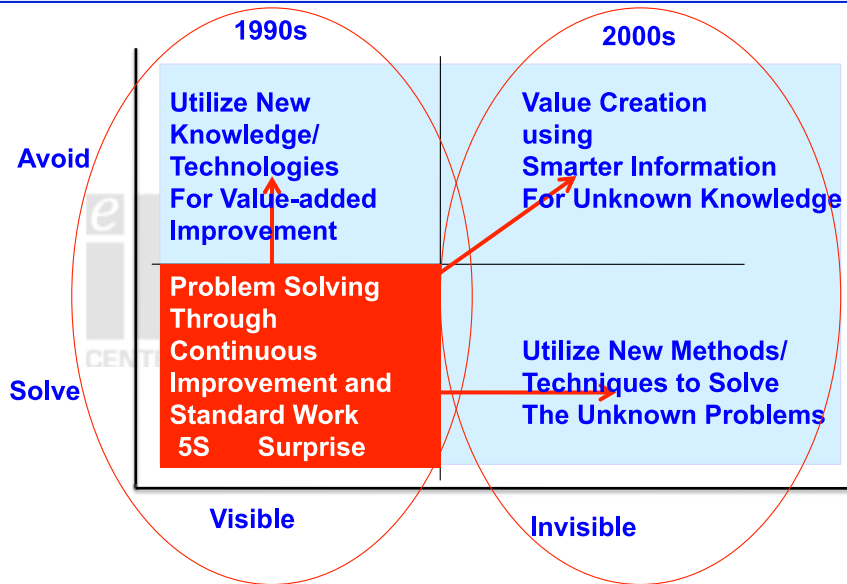
### ► Conclusions



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## Competitiveness Transformation Strategy



## Industrial Big Data in 1990s

▶ GM OnStar®

▶ UTC Otis Elevator REM®

▶ GE Medical InSite®

## Industrial Big Data in 2000s



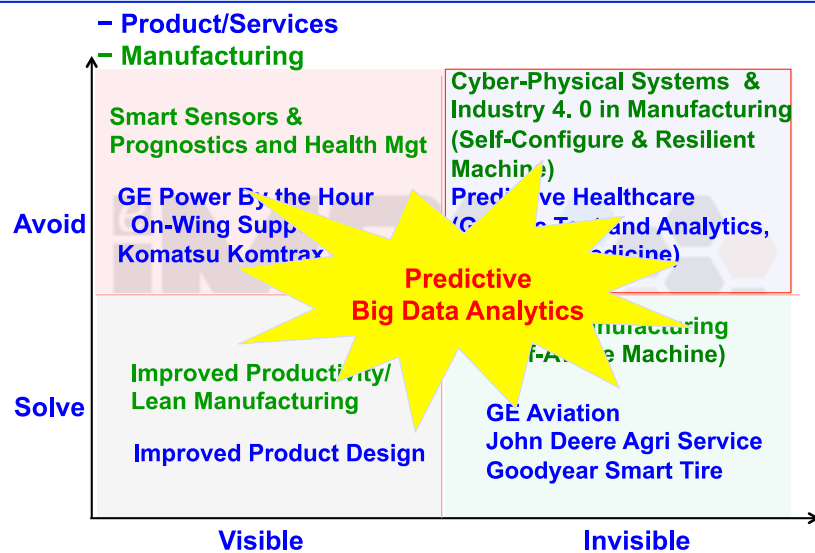
- ▶ John Deere Agri Service® 2002
- ▶ Komatsu Komtrax® 2002-2005
- ▶ GE Aviation OnWing Support® 2005
- ▶ Alstom Train Tracer® 2006
- ▶ Goodyear FuelMax® 2008



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## Product/Manufacturing Evolution



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# Outline



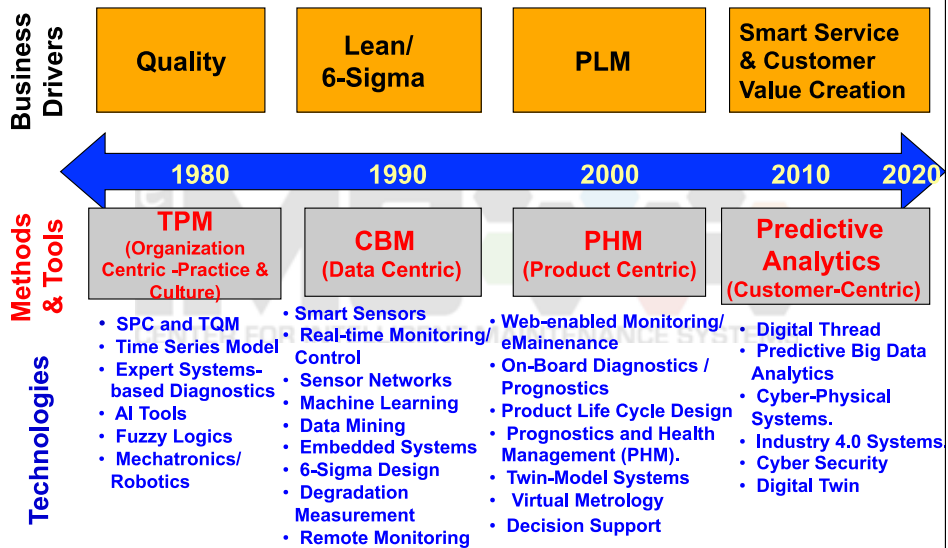
- ▶ Changing Role of Data and Value Creation
- ▶ **Industrial Big Data Analytics, CPS, and Social Innovation**
- ▶ Examples
- ▶ Conclusions



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# Industry Transformation



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## Value of Predictive Analytics



- ▶ Apply Data Analytics to large amounts of data of a variety of types to uncover **hidden patterns, unknown correlations and other useful information** from industrial and manufacturing systems and integrate with business automation software for improved productivity and innovation.

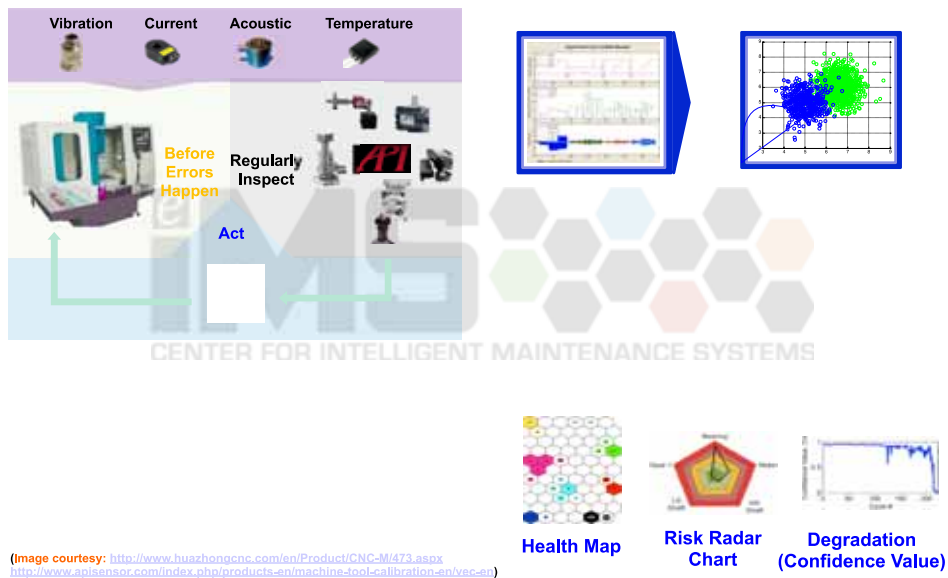
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## Watchdog Agent® → Self-Aware Machine



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## 6Cs in Big Data System



1. **Connection --RFID, Wireless, Sensor Networks**
2. **Cloud – Computing and Data on Demand**
3. **Cyber— Model and Memory**
4. **Content/Context – Relationship and Reference**
5. **Community -- Relationship and Sharing**
6. **Customization – Service and Value**



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## Challenges of Industrial Big Data



1. **Broken**
2. **Bad**
3. **Background**

Jay Lee. Industrial Big Data Book (2015)



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## What are Cyber-Physical Systems?



- ▶ **Physical**
  - natural and human-made systems governed by the laws of physics and operating in continuous time
- ▶ **Cyber**
  - computation, communication, and control that are discrete, logical, and switched
- ▶ **Cyber-Physical Systems**
  - systems in which the cyber and physical components are tightly integrated at all scales and levels

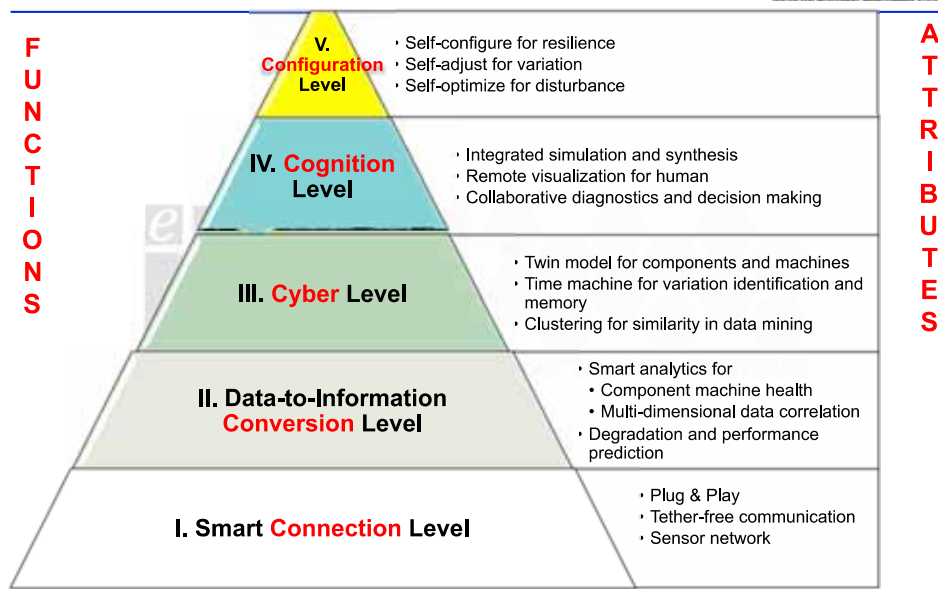
Ref: NSF CPS Program, 2007



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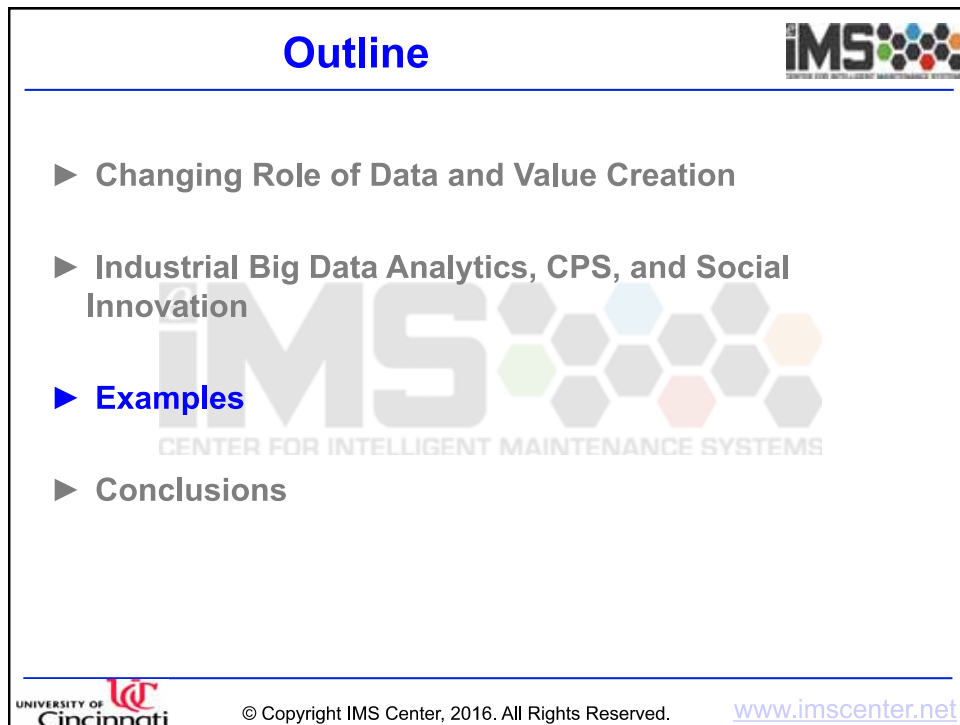
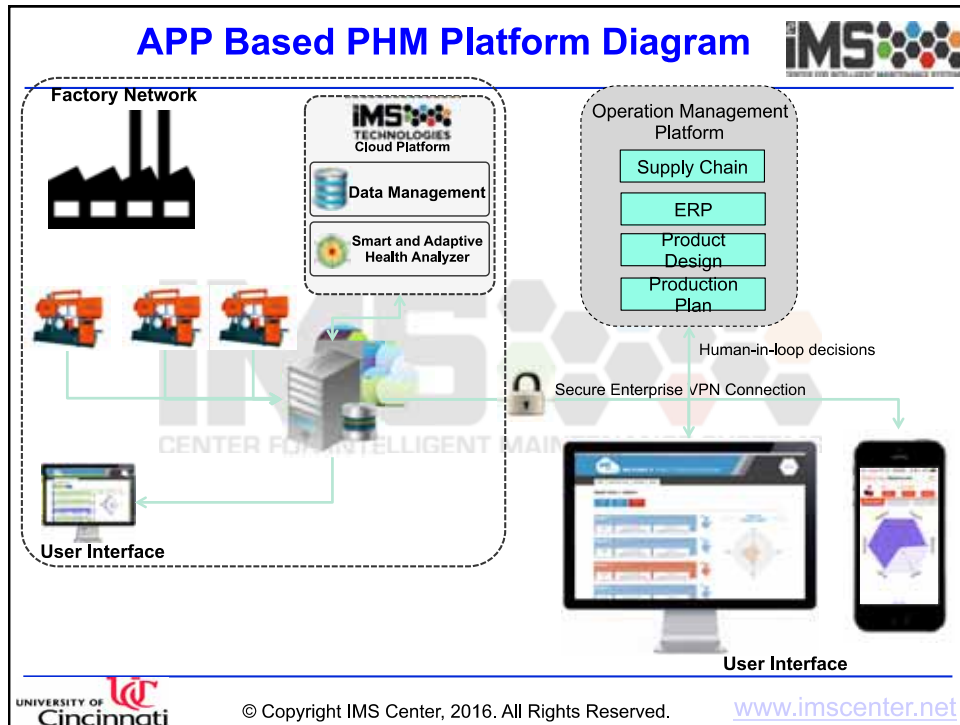
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## Architectures for 5 Levels (5C) of CPS

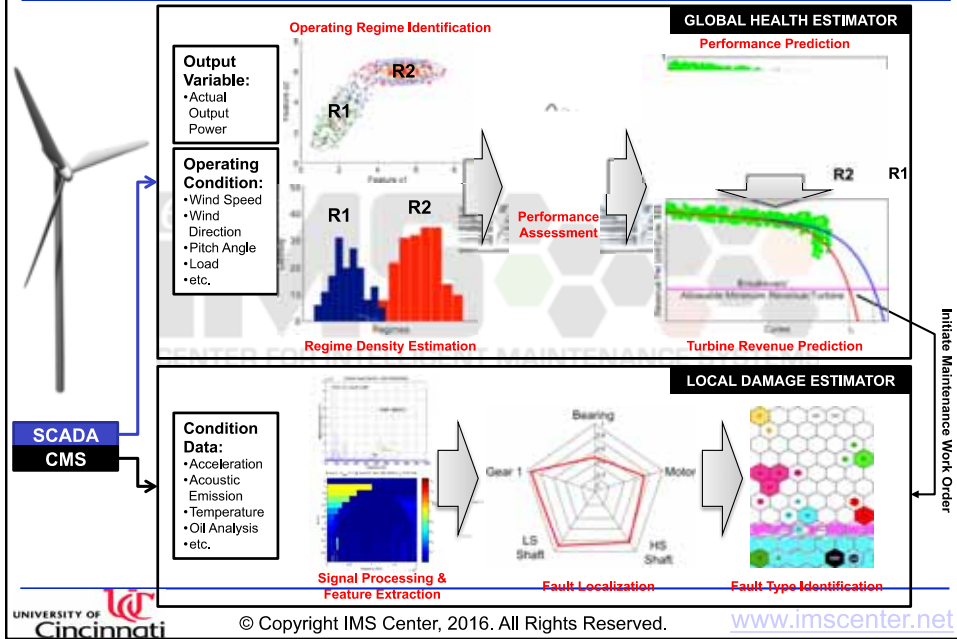


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# Smart Wind Turbine Prognostics



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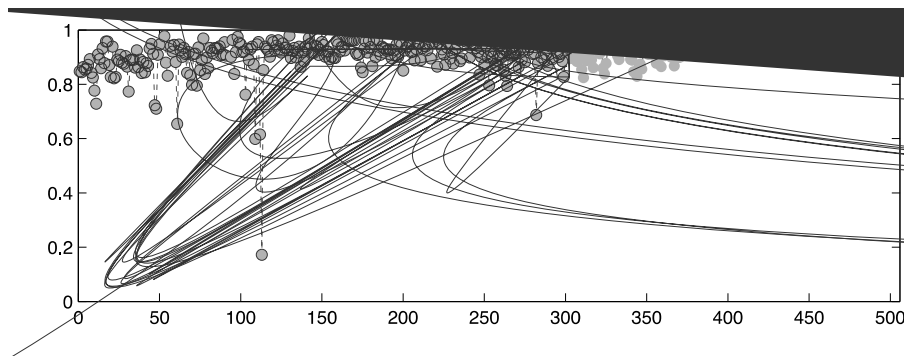
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# Fleet Cluster-based Health Analytics



Data was prepared similarly with unit-specific modeling method. Daily wind speed measurements were used for regime similarity evaluation, power curve data was used for health metric evaluation.



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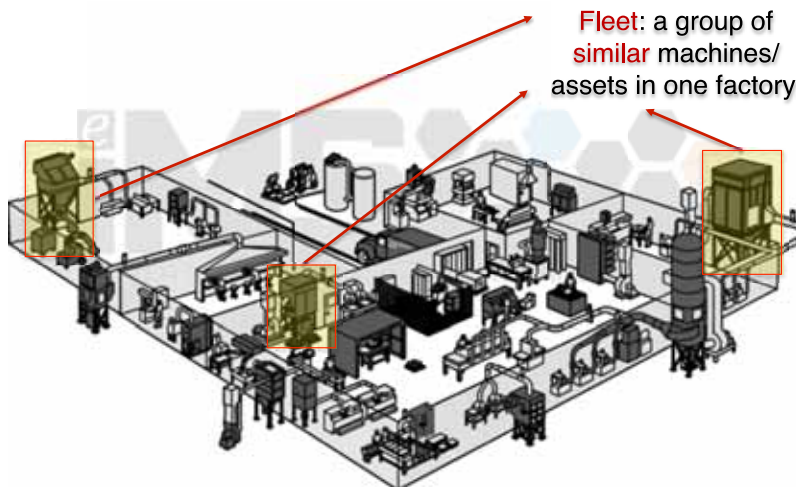
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## Rethink the “Fleet Systems”



## What is a fleet? (1/2)

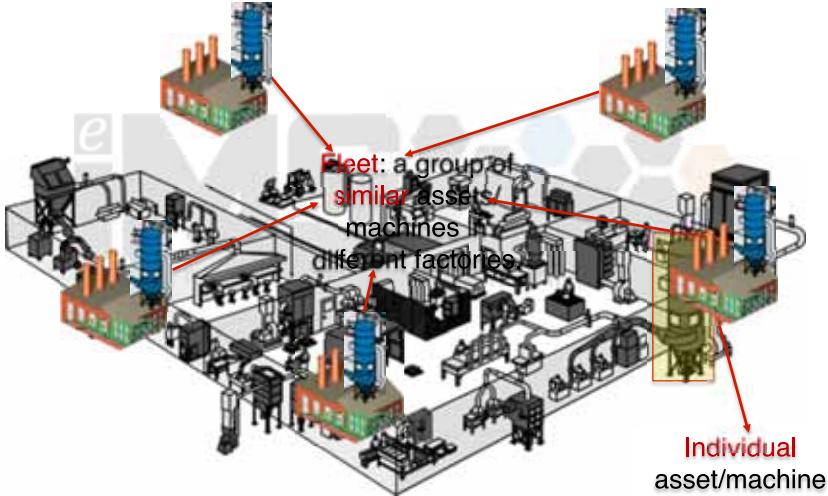
- Scenario 1: For manufacturing, in **one factory**, there are equipment/assets of the same type. These similar assets are referred to as a fleet.



# What is a fleet? (2/2)



- Scenario 2: Assets/machines of similar type that are experiencing similar working conditions, while **located at different factories**, can also be considered as a fleet – focus of this research.



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# Smart ECU to Save Lives



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## Smart Wearable Systems for Sports and Peer-to-Peer Personal Healthcare

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### Application Example

- New Sensor technology allows long-term studies with consistent electrode placement, unlocking previously unattainable connections between muscle activity and any number of factors (mood, weather, time of day, sleep, etc)
- Develop conformable force-measurement device to make set-up completely wearable, allowing for in-the-field analysis of fatigue.
- Apply methods and technology to other muscles of interest within the body (such as leg-foot interactions)



# Outline



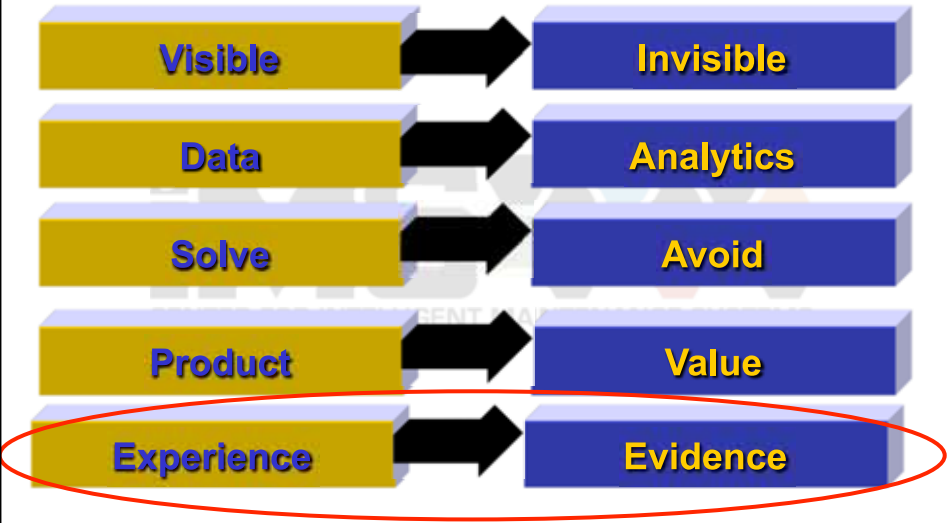
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# Transformation



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## IMS Major Impacts



1. IMS is the “*Catalyst*” of GE Industrial Internet and Fanuc ZDT Technologies.
2. Ranked the highest Economic Impacts (1:270) by NSF Economic Impact Study Report in 2012.
3. Won PHM (Prognostics and Health Mgt) Data Challenges Competition for 2008 (1<sup>st</sup> and 3<sup>rd</sup>), 2009 (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>), 2010 (3<sup>rd</sup>), 2011 (1<sup>st</sup> and 3<sup>rd</sup>), 2012 (3<sup>rd</sup>), 2013 (3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup>). 2014 (1<sup>st</sup>). 2015 (4<sup>th</sup>)
4. NSF ICORPS Award (2012) for New Company Spin Off **Predictronics**.
5. 5 Spin-off Companies (U.S., Japan, Taiwan, China)
6. NI for IMS License Trials in 2011 & NI LabView Watchdog Agent® Toolkit Official Global Licensing in 2015.



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