Fit Manufacturing

Duc Truong Pham, Andrew Thomas and Paulette Pham

with contributions from the FIT Manufacturing Team* at the MEC,
Cardiff University and University of Wales Newport

*A Abdulwahab, J Z Ebrahim, J Kutbi, T Shamsuddin and O Williams

LESS 2010 - Helsinki
Contents

- **MEC**
- Lean Manufacturing
- Agile Manufacturing
- Sustainable Manufacturing
- Fit Manufacturing
- Conclusion
Mission: To conduct world-class research and development in key areas of Advanced Manufacturing and use the output to assist industry

R&D, PhD training, and ISO 9001:2000 accredited industrial consultancy and technology transfer

WAG Centre of Excellence in Technology and Industrial Collaboration

Founding partner in the EPSRC Innovative Manufacturing Research Centre at Cardiff University

The Queen’s Anniversary Prize and the Secretary of State’s First Prize
■ 70 full-time engineers and researchers

■ Active customer base of over **3000 companies**
  - 5000 projects undertaken since 1996
  - Partnership with 8 multinational corporations

■ Income > £60M
  - Research grants £35M (55 projects)
  - Industrial Matched funding £15M
  - Commercial income £10M
Recent World First Achievements

- The smallest electrode (0.006 mm diameter) – Guinness world record
- The smallest haiku carved onto the point of a needle
- The high pressure laboratory for maintaining the life of bacteria and other creatures from 1500 m below the ocean bed in the Gulf of Mexico (1000 atmospheres)
- The moth-eye lens
- The thinnest metal casting (0.22 mm)
- The ‘Beyond Lean’ (‘Fit Manufacturing’) paradigm
Fit Manufacturing Systems

Lean

Agile

Sustainable
Lean Manufacturing – Concepts

- Achieve more with less
- Focus on value & waste

Source: Professor Peter Hines, Lean Enterprise Research Centre, Cardiff University
More with Less?

It is possible to cut

- Throughput time & defects
- Inventories
- Space & unit costs

At very little capital cost … with flexibility to meet customer needs….

So increasing output & profits …with the same head count

Source: Professor Peter Hines, Lean Enterprise Research Centre, Cardiff University
Sports Analogy

Lean
Potential Problem

Too lean?
Grand Master Kwang J. Lee, 9th Dan, demonstrating a flying side kick
http://www.eagletaekwondo.org/taekwondo/index.html
- **Agility** - ability to respond **rapidly** to changes in customer demand and the market environment

- Agile manufacturing exploits a **fundamental resource** - knowledge

- A necessary condition for **global competitiveness**

Sources:
2. Y. Y. Yusuf, M. Sarhadi and A. Gunasekarann
A strategy for being competitive by becoming responsive to customer requirements:

- improving speed of response to customer requirements
- continuously upgrading products
- bringing products to the market quickly and cost effectively
- applying appropriate knowledge-based technology and systems methodology
- adopting continuous improvement philosophy
Agile Manufacturing

- **Time to Customer Reduction**
  
  *Fast Flexible Flow*
  
  Flow Production
  
  Production Efficiency
  
  Quality as Standard

- **Time to Market Reduction**

  *Concurrent Design and Manufacture*

Source: Dr A. Thomas, Newport
Product modularisation
CAD / CAE enhancement and development
Value stream analysis
Equipment reliability
Rapid prototyping
Virtual prototyping
E-Manufacturing
Technology development

Source: Dr A. Thomas, Newport
Agility in NPD Process

- Conceptual Design
- Detail Design
- Engineering Analysis
- Prototyping
- Tooling
- Production

Serial

Concurrent

- Conceptual Design
- Solid Modelling
- Detail Design
- Engineering Analysis
- Prototyping
- Tooling
- Production
- Rapid Prototyping & Manufacturing

Time Savings

Source: Pham and Dimov
1. Satisfy the customer through early and continuous delivery of valuable software.

2. Welcome changing requirements, even late in development.

3. Deliver working software frequently.

4. Ensure business people and developers work together daily throughout the project.

5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.

6. Adopt face-to-face conversation for communication with and within a development team.

http://agilemanifesto.org/principles.html
7. Measure progress primarily by the amount of working software produced.

8. Promote sustainable development through agile processes to maintain a constant pace indefinitely.

9. Pay continuous attention to technical excellence and good design to enhance agility.

10. Maximise the amount of work not done.

11. Encourage team self-organisation to facilitate the creation of the best architectures and designs.

12. Regularly reflect on how to become more effective and then tune and adjust behaviours accordingly.

http://agilemanifesto.org/principles.html
Potential Problems with Agility

- Over reactive -- unstable
- Over flexible -- inefficient
- Over engineered -- complex
- Over expensive -- unsustainable
Agility or Fragility?

Sustainability

http://en.wikipedia.org/wiki/Marathon
sustainable /səˈsteɪnəbl/ adj.

1 involving the use of **natural products** and **energy** in a way that does not harm the **environment**

2 that can continue or be continued for a **long time**

© Oxford University Press, 2005
Not only concerned with:

- ecological or environmental issues
- energy or other natural resource issues
- socio-political issues

i.e. not only concerned with manufacturing environmentally friendly products or using natural products and energy in a way that does not harm the environment

=> Not just Green Manufacturing
Sustainable Manufacturing


Economically sustainable manufacturing

… that can continue or be continued for a long time
## The World’s Oldest Companies

<table>
<thead>
<tr>
<th>Year</th>
<th>Company</th>
<th>Country</th>
<th>Field</th>
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<tbody>
<tr>
<td>578</td>
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http://en.wikipedia.org/wiki/List_of_oldest_companies
# The World's Oldest Companies

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<td>Mill</td>
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<td>1580</td>
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<td>Netherlands</td>
<td>Publisher</td>
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<tr>
<td>1599</td>
<td>Mulliner (Bentley)</td>
<td>UK</td>
<td>Coach builder</td>
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</table>

The ability constantly to *innovate* is their secret to sustainability.
Clock builders, not timekeepers

Core preservation (values and ideology); Progress stimulation

BHAG

Cult-like cultures

Opportunistic experimentation

Home-grown management

Continuous improvement and innovation

Clear vision with practised values and ideology

Constant alignment

1. Get on with it.
2. Learn from the customer.
3. Foster innovation and nurture champions.
4. Treat employees as the main source of productivity gains.
5. Practise a hands-on, value-driven management philosophy.
6. Stay with the business that you know.
7. Have few administrative layers and few people at the top.
8. Maintain core values but allow individual autonomy.

In Search of Excellence - McKinsey 7-S model

- structure
- strategy
- systems
- style of management
- skills - corporate strengths
- staff
- shared values

Low labour cost economies place increasing pressure on EU industries.

Mass customisation forces companies into low volume manufacture of products to be sold at mass production prices.

Lean and agile manufacturing approaches have limitations.
‘a company’s ability to compete and prosper in a sustainable manner through making high quality products using an integrated, robust, highly responsive and reconfigurable lean manufacturing system that returns high product quality and reduced internal and external manufacturing costs’
A *Fit Manufacturing* company must:

- operate **efficiently** and **flexibly**
- be able to **respond rapidly** and **effectively** to change
- constantly **innovate**
- continually **explore** and **exploit**
- **evolve** or **periodically renew** itself
- focus firmly on market **needs** (existing and future)
- be **robust** against disturbances
- continually seek to **improve** itself
Fit Manufacturing Axioms (2)

- know its balance/unbalance points to resist/promote change
- make use of power leverage
- control growth to limit inertias
- control damping to achieve stability
- strive to operate in steady state
- possess a capability for accurate prediction
- minimise entropy
- maximise simplicity
‘Fit’ integrates business process strategies with a company’s existing and future technology platform and support systems to provide a manufacturing system that optimally combines the capabilities of a range of business process concepts.
A ‘Fit’ manufacturing enterprise requires:

- an *integrated* supply chain to *ensure* high quality, *highly* responsive and dependable supply of raw material and sub-contracted products
- a *lean*, *technologically driven* and *highly* agile production system *designed to convert* customer requirements to finished products quickly and efficiently
- a support system *that enhances* sustainability by *fostering* the performance of both logistics and manufacturing
The ‘Fit’ Approach

- 5 major elements used to develop manufacturing fitness in a company:
  - Manufacturing Strategy
  - Manufacturing Technology
  - Agility
  - Leanness
  - Business Support Systems

- The balance between agility and leanness will vary depending on a company’s strategic and technological systems and capabilities
The ‘Fit’ Approach

Strategy
Technological Systems
Agility
Leanness
Business Support Techniques

C4 Manufacturing Strategy
C3 Customer Demands
C3 Company Policy
C2 Supply Chain capability
C5 Knowledge Management

I2 Strategic and Operations Requirements
I3 Technology Requirements
I1 Customer Requirements
I4 Systems Design

M2 Manufacturing Data
M1 Technology
M3 Workforce
M4 Systems

Reconfigurability
Performance Targets
E-Manufacturing Capability
Capable Machinery
Responsive Manufacturing
Responsive Supply Systems

Waste Free Manufacture
Single Unit Flow

Reduced Unit cost of manufacture
Mass Manufacture Capabilities

Customisation Capabilities
Sustainable Enterprise
Flexibility

Machine Reliability Analysis
Knowledge Management
Product Quality Analysis
SMED / Value Mapping
Measures of Fitness

- **Health Indicators**
  - Body Mass Index: \( \frac{\text{weight (kg)}}{\text{height (m)}} \times \text{height (m)} \)
  - Waist Circumference
  - Waist-Hip Ratio

- **Manufacturing Key Performance Indicators**
  - Quality, Cost, Delivery
  - Leanness measures (*Soriano-Meier and Forrester*):
    - waste elimination, continuous improvement, zero defects, JIT deliveries,
    - pull of materials, multifunctional teams, decentralisation, integration of
    - functions, vertical information systems and managerial commitment to
    - lean production
Measures of Fitness

- **Input measures**
  - **Foundation**: knowledge, strategy, marketing, finance
  - **Operation**: leanness, agility, sustainability
  - **Enabling**: reconfigurability, demand/supply chain, innovation

- **Output measures**
  - **Flexibility**
  - **Efficiency**
  - **Efficacy**
  - **High productivity**
  - **Mass customisability**
  - **Economic sustainability**
  - **Downtime**
  - **Quality**
  - **Product cost**
  - **Delivery targets**
# The elements of Fit Manufacturing

## Marketing / Sales Integration
- Customer Monitoring
  - Trend analysis
  - Product life cycle analysis
  - Competitor analysis
- Integrating sales with manufacture to produce AWM

## Knowledge and Skills Integration
- Knowledge Management
  - Workforce
  - Technological capacity
  - Management vision & capacity
  - Leadership
- Teamworking
  - Leadership, Culture etc

## Lean
- Elimination of Waste
  - Continuous Improvement
  - Zero Defects
- Pull on raw materials
  - Just in Time delivery
  - Multi-functional Teams
- Decentralisation
  - Integration of Functions
  - Vertical Information Systems
  - Value Adding Operations

## Agility
- Workforce Flexibility
- Supply Chain Flexibility
- Flexible Technologies
- Scheduling Flexibility
- Product Mix
  - Physical Infrastructure
- Information
  - Infrastructure
- Market Tracking
  - Distribution Channels
  - Routing Flexibility

## Sustainability
- Organisational Structure
  - Value Measurement
  - Competitive position
- Performance and Growth
  - Political Factors
  - Economic Factors
  - Environmental Factors
  - Social Factors
- New Product introduction
- New Product development

## Performance
- Flexibility
  - Efficiency
  - Efficacy
  - High productivity
- Mass customisability
- Economic sustainability
- Downtime
- Quality
  - Product Cost
  - Delivery Targets

## Strategy and Integration

<table>
<thead>
<tr>
<th>Financial Integration</th>
<th>Systems Reconfigurability</th>
<th>Demand / Supply Chain Integration</th>
<th>Technological Systems</th>
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<tr>
<td>Turnover</td>
<td>Systems complexity</td>
<td>Supplier Integration</td>
<td>CAD / CAM / CAE</td>
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<td>Hardware systems</td>
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<td>ROCE / ROI Analysis</td>
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<td>Supply chain reengineering</td>
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Mark each element 0-1
Total = 5 Marks

Mark each element 0-1
Total = 5 Marks

Mark each element 0-1
Total = 10 Marks

Mark each element 0-1
Total = 5 Marks

Mark each element 0-1
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Mark each element 0-1
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Total = 100 Marks
## Fitness Profiling

### Before TPM

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### After TPM

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Total: 47
Results of ‘Fit’ Manufacture

- Ensures that a company has the optimum balance of leanness and agility to meet its strategic needs.
- Provides the ability for a company to reconfigure its manufacturing operations in response to future customer requirements.
- Encourages a culture of continuous innovation, technology development and product quality enhancement.
Fit Manufacturing is a philosophy integrating Lean, Agile and **Sustainable** approaches.

- Lean is *mean*
- Agile can be *fragile*
- Fit delivers *sustainable benefits*
ERROR:
syntaxerror
OFFENDING COMMAND:
--nostringval--
STACK:
/m말
/Author/
(/Speed)
/Creator/
/D:2010120214701+01'00'
/Creator
/DateCreation Version 0.9.5)
/Keywords/
()
/ModDate/
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/Subject/
()
/Title/
STACK:
OFFENDING COMMAND: --nostringval--
ERROR: syntaxerror