



EPSRC Centre for
**INDUSTRIAL
SUSTAINABILITY**

Technical Seminar Series

**Sustainable value creation in manufacturing:
understanding the contribution of
maintenance function**

Maria Holgado, University of Cambridge

16:00-17:00 4 June 2015



EPSRC Centre for
INDUSTRIAL
SUSTAINABILITY

*We will record this
webinar and issue the
recording afterwards*

*Slides will also be made
available*

*Please use chat to raise
questions throughout the
presentations*

*Questions after this
presentation finishes?*

Please contact

Maria Holgado

mh769@cam.ac.uk

Technical webinar series – schedule

4 JUNE 2015

- **Today:** Sustainable value creation in manufacturing: understanding the contribution of maintenance function, Maria Holgado, University of Cambridge
- Future months: much more to follow!!
- ... and it could be you...
- Typically first Thursday of the month



EPSRC Centre for
INDUSTRIAL
SUSTAINABILITY

Technical webinar series – the aims

4 JUNE 2015

If you have interesting content to share from research and development, good practice, valuable results in practice, etc then perhaps you should be scheduled in the series.

Contact **Sharon Mey** cis-admin@eng.cam.ac.uk
or **Peter Ball**,
p.d.ball@cranfield.ac.uk

- Sharing **research** results and **industrial** practice for Centre members
- **Connecting people** within the Centre as well as outside the Centre
- Providing **feedback**, comments, suggestions, refinement, etc to those presenting



EPSRC Centre for
**INDUSTRIAL
SUSTAINABILITY**

How is the Centre structured?



Eco-efficiency

Reducing resource use (water, energy, materials)
Improvements without radical changes to product or process



Eco-factory

Increasing added value and improving production capability
and responsiveness
Decreasing consumption of natural resources



Sustainable Industrial System

Exploring future configurations of the industrial system and
their implications
Taking first steps to improve understanding of the long term
challenges facing industry



EPSRC Centre for
INDUSTRIAL
SUSTAINABILITY

Educating the
**Leaders of
Tomorrow**
TODAY

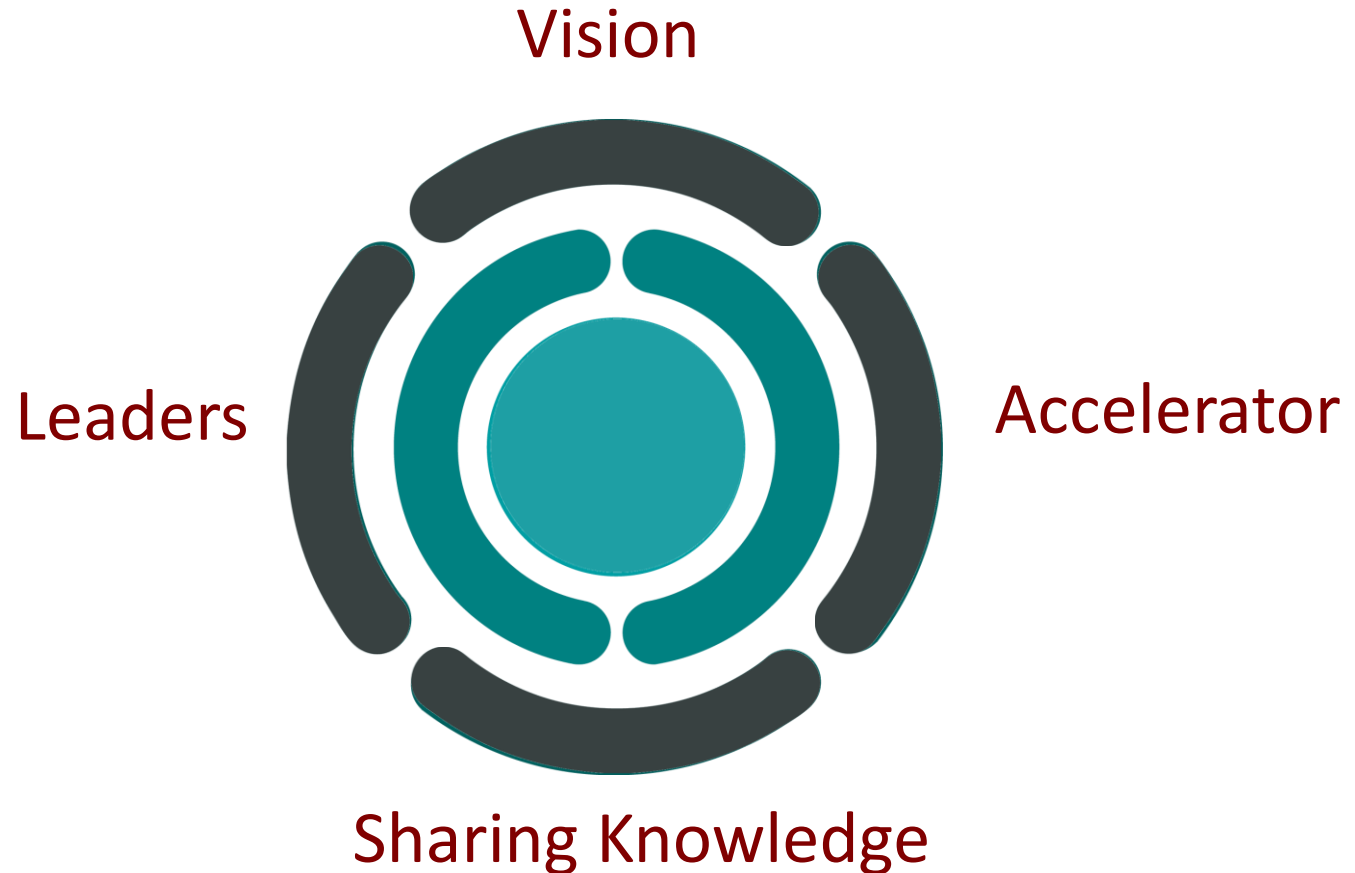
Bigger **Impact**,
faster, wider,
sooner

Sharing **Knowledge**

Building & Sharing
a **Vision**

How the Centre works - Impact

WEBINARS ... CONTRIBUTING TO SHARING OUR KNOWLEDGE





EPSRC Centre for
INDUSTRIAL
SUSTAINABILITY

Eco-Efficiency Grand Challenge: Resource Efficiency in the Factory

4 JUNE 2015

16.00 Introduction (Peter)

**16.10 Sustainable value creation in
manufacturing: understanding the contribution
of maintenance function (Maria)**

16.30 Q&A (Maria)

16.40 Wrap up (Peter)

16.45 Close

*Questions after this
presentation finishes?*

Please contact

Maria Holgado

mh769@cam.ac.uk



EPSRC Centre for
INDUSTRIAL
SUSTAINABILITY

Sustainable value creation in manufacturing: understanding the contribution of maintenance function

Maria Holgado, University of Cambridge

Based on Chapter 4 of PhD thesis: “Sustainable Value
Creation in Manufacturing through Maintenance Services”
Politecnico di Milano, Italy. 2014



Context of Research

Industrial Sustainability refers to the end state of a transformation process where industry is part of, and actively contributing to, a socially, environmentally and economically sustainable planet.

(Tonelli et al., 2013)

- Maintenance function has a role to play:
 - As a contributor to longer equipment life cycles *(Garetti, 2011)*;
 - Provide society with the required functions while minimizing material and energy consumption *(Takata et al., 2004)*;
 - As an enabler of energy efficiency *(Tousley, 2010, Demirbas, 2008)*;
 - As a contributor to eco-efficiency while preserving equipment availability, reliability, safety and maintainability *(Levrat et al., 2008)*;



Research Design

RESEARCH QUESTION: How does maintenance function contribute to more sustainable manufacturing operations?

- Exploratory study: multiple cases in multiple sectors
- Cases selection
 - Medium/big companies
 - Higher or same maturity score respect to its sector, according to analysis done by TeSeM Observatory of MIP School of Management, Politecnico di Milano
 - Different sectors and different types of products

Research Gap: Although several authors (Liyanage, 2007; Ahuja and Khamba, 2008:2009; Garetti, 2011; Yan et al., 2012) claim the potential of maintenance to contribute to sustainable manufacturing goals, there is no comprehensive empirical study done so far regarding the dimensions / elements of this contribution.

#	Company sector	Company size	Maturity Index	Sector average Maturity Index
1	Chemical/Pharma	Medium	ML3 low	ML3 low
2	Textile	Medium	ML3 high	ML2 high
3	Other mechanical	Big	ML3 high	ML3 low
4	Chemical/Pharma	Big	ML3 low	ML3 low
5	Other mechanical	Big	ML3 high	ML3 low
6	Metal	Big	ML2 high	ML2 high
7	Chemical/Pharma	Medium	ML4 high	ML3 low
8	Food/Beverage	Big	ML4 high	ML3 low
9	Automotive	Big	ML4 high	ML3 high



Sustainability in Industry

WHAT ARE THE MAIN DIMENSIONS?

Environmental

- Materials
- Energy
- Water
- Bio-diversity
- Emissions
- Waste
- Products and services
- Compliance
- Transport

Social

- Work practices & adequate working conditions
- Diversity & equal opportunities
- Relations with the community
- Social policy compliance
- Consumer health & safety
- Human rights

Economic

- Economic performance
- Market presence
- Indirect economic impacts

Dimensions of industrial sustainability according to Arena et al. (2009)



Overview of findings

- There is an alignment between the company's vision and goals and maintenance function
- Maintenance contributes to competitive manufacturing capabilities: cost, quality, delivery performance and flexibility (Capabilities defined by Ward et al., 1996)
- Additionally, maintenance contributes to the realization of innovations at factory level.
- Maintenance contributes to the sustainability dimensions:
 - Economic sustainability, at both business level and at production process level.
 - Environmental sustainability, including the concept of product/equipment life cycle. The inclusion of the life cycle perspective here is coherent with the perspective of sustainability given by Rachuri et al. (2011).
 - Social sustainability. Taking into account that stakeholder participation is suggested to be related to this dimension by Vinodh and Joy (2012), the analysis of maintenance stakeholders is included in this last section.



Alignment between maintenance function and company's vision & goals

“There is actually a transition from maintenance seen as a cost center... to instead a unit that can give value, a strategic contribution to business, that can move the business forward”

*(Transcript excerpt, Maintenance and technical materials manager,
Headquarters of company 7)*

“Maintenance’ s main objective is to assure the reliability of the plants, which then allows the company to perform its mission”

(Maintenance manager, company 4)

“the company is surely looking to create competitiveness and then through this competitiveness, [...] to grow [...] then this surely go through all lines of authority and come directly to maintenance as a contributor to product competitiveness”

*(Transcript excerpt, Operations director,
Headquarters of company 8)*



Contribution to manufacturing capabilities / priorities (1)

- Quality

“Quality means getting the machine ready to work in optimal conditions [...] Then, the goal of high quality means mechanic control of machines, control of all devices that ensure continuity and repeatability of chemical and thermal recipe”

(transcript excerpt , Plant technical manager of company 2)

- Delivery punctuality

“Complete on time regards reliability, that is, to be punctual I need to have reliable plants”

(transcript excerpt , Maintenance manager of company 5)

- Cost

“The challenge of this type of product [commodities] is to reduce the performance losses, in all of this, maintenance is also involved”

(transcript excerpt , Maintenance and production manager of company 9)



Contribution to manufacturing capabilities / priorities (2)

- Flexibility & adaptability

“For us, it is continuous to change disposition, change raw materials (...) in this sense, maintenance function is necessary”

(transcript excerpt, Plant technical manager of company 1)

- Innovation

“Innovation brings the introduction of new technologies, that have to be maintained, the new processes have to be maintained... thus, wherever innovation brings new processes, it happens to talk about empowerment of maintenance personnel”

(transcript excerpts, Plant engineering manager of company 3)

“Maintenance works a lot with the industrialization, that is the part of the company than once the product to be produced is defined, it is responsible for the configuration phase of the production line”

*(transcript excerpt, Operations director,
Headquarters of company 8)*



Contribution to economic sustainability (1)

- Maintenance cost & budget reporting has been expanded to include also **outcomes and performance** of maintenance activities in order to:
 - (i) assign maintenance interventions to the *impact categories* defined as important by top management, such as safety and energy saving (*Company 1*)
 - (ii) be used as a means for *performance benchmarking* between production sites (*Company 7*)
 - (iii) to *communicate* with plant management (*Company 6*)
- Maintenance costs are not just those directly related to interventions, manpower and spare parts. **Hidden costs** have been often mentioned by interviewees:
 - Cost of non-quality associated to *rework* (*Company 2*) or associated to *customer complains* (*Company 3 and 8 > B2C companies in the sample*)
 - Opportunity costs due to *not serving the demand* (*Company 8*)
 - Costs related to *process inefficiency*: performance losses (*Company 9*) or non-optimum transformation of materials (*Company 2*)



Contribution to economic sustainability (2)

- **Investments** related to maintenance consist of:
 - (i) extraordinary or non-routine maintenance activities (*Company 6*);
 - (ii) acquisition of maintenance tools to perform activities and or acquisition of maintenance software (either acquiring directly a Computerised Maintenance Management System , CMMS, or adapting a software bought by another business function) (*Cases of Company 1 and Company 4 respectively*)
 - New tools to perform maintenance activities that bring higher work accuracy and motivational benefits to maintenance operations (*Company 4*).
- Maintenance contributes to the acquisition of new technologies and machinery with **knowledge & information** regarding status of plant current machinery, historical reliability and expected reliability, spare parts conditions and reliability, ...
- Collaboration between maintenance and other plant departments is necessary to make sound decisions on the future investments, this is related directly to the concept of **equipment life cycle and life cycle costs** (*Company 5 and 7*).



Contribution to environmental sustainability (1)

“A proper maintenance, for example, avoids that you rework a fabric because it has creases or stains [...] So, you have to rework and consume energy again, consume water again, you consume air again”

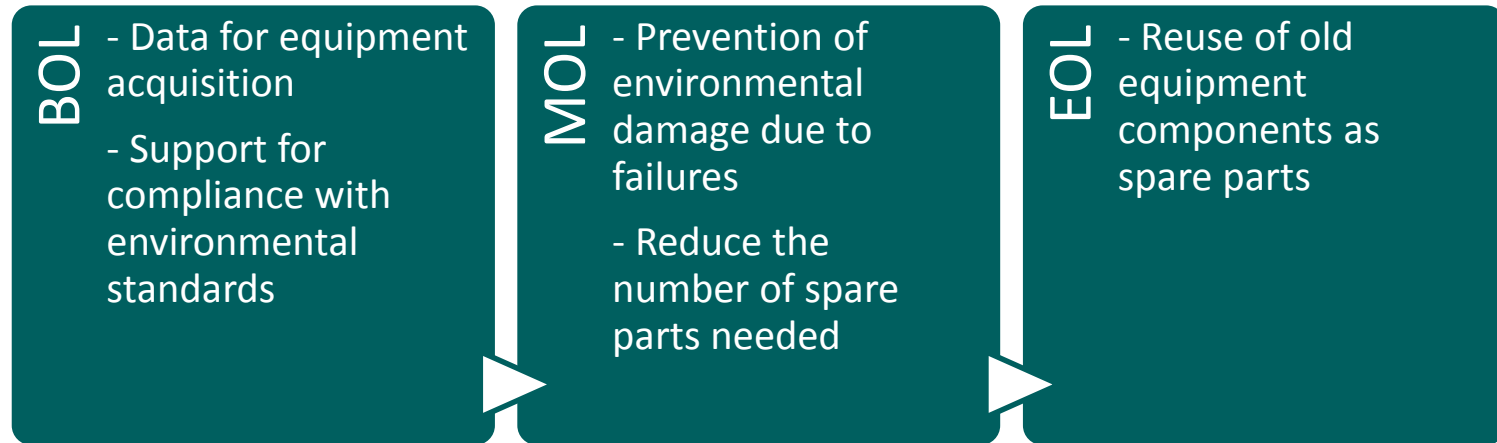
(transcript excerpt, Plant technical manager of company 2)

- WATER, AIR, ENERGY: Utilities consumption due to rework or bad performance of machinery will have different importance / effect depending on the type of production process and also between areas in the same factory:
 - high impact was mentioned for companies 6 and 8 (metal and food industry), while medium impact for company 2 (textile sector)
 - impact only on air and energy was mentioned for company 5 (mechanical sector)
 - low impact on all applies to company 3 (mechanical sector)
- MATERIALS: Good working conditions for the equipment contributes to product quality and safety, as well as materials savings, scrap production and allowance of input materials.



Contribution to environmental sustainability (2)

EQUIPMENT LIFE CYCLE



“So maintenance understood as proper timing, proper use of materials, e.g. using the right lubricant, and proper management could bring to a reduction of spares, such as bearings”
(transcript excerpt, Maintenance manager of company 2)

BOL: Beginning of Life; MOL: Middle of Life; EOL: End of Life



Contribution to social sustainability (1)

- Maintenance stakeholders

Internal stakeholders	External stakeholders
<ul style="list-style-type: none">➤ Quality and production functions are the most cited.➤ Other: procurement function, R&D function, workforce.	<ul style="list-style-type: none">➤ Customers / suppliers are those with higher impact / interest➤ Others: regulation & certification bodies, the local government.

Examples:

“the main internal stakeholders of maintenance are certainly production and quality, they are the main stakeholders (...) when there is a problem it is consulted and attempted to be solve together”

(transcript excerpts, Plant engineering manager of company 3)

Good suppliers are seen as contributors to good maintenance service, while the management of bad suppliers could create high hidden costs.

(Maintenance manager, company 4)



Contribution to social sustainability (2)

- Plant safety

“Maintenance has a very high impact on safety [...] the restoration of a safe condition after an intervention is essential” – The company has implemented a Behaviour-based Safety Initiative

(transcript excerpts, Plant Engineering manager of company 3)

- Working conditions

The reduction of failures brought *less pressure in the working environment and no need to work extra hours* - Company 4

- Personnel empowerment: career opportunities, training
 - Initiatives in order to improve *the team work and collaborative relationships* (between maintenance teams & with other functions) as well as increase the *motivation of maintenance personnel*
 - Training needs driven either by the implementation of new technologies, by a need that arise from maintenance plans or by the professional paths established by the company
 - Equal opportunities > promotion of maintenance personnel into white-collar / headquarters brings motivation to the team



Overview of findings

- There is an alignment between the company's vision and goals and maintenance function
- Maintenance contributes to competitive manufacturing capabilities: cost, quality, delivery performance and flexibility (Capabilities defined by Ward et al., 1996)
- Additionally, maintenance contributes to the realization of innovations at factory level.
- Maintenance contributes to the sustainability dimensions



EPSRC Centre for
INDUSTRIAL
SUSTAINABILITY

Next Steps: Research Directions

- Implications for practitioners
 - Findings can support the development of actions / guidelines to improve the sustainability of operations in industrial plants at process and equipment levels
- Limitations
 - Exploratory character of the study > no generalizability
 - Selected companies are “mature” in terms of maintenance management compared with their sector
- Further research
 - Improve the generalizability of results through including a broader study with large number of companies (through survey research)
 - Deepen into a concrete dimension of sustainability (environmental / social) and on the business level (through case study research)

*Questions after this
presentation finishes?*

Please contact

Maria Holgado

mh769@cam.ac.uk



EPSRC Centre for
INDUSTRIAL
SUSTAINABILITY

Technical Seminar Series

More events to follow ... we'll email out the next event!

