

# THE APPLICATION OF RAPID MANUFACTURING TECHNOLOGIES IN THE SPARE PARTS INDUSTRY

S. Hasan & A.E.W. Rennie

Lancaster Product Development Unit, Engineering Department, Lancaster University, Lancaster, LA1 4YR, UK

## ABSTRACT

The advancement of Rapid Manufacturing (RM) has ushered the possibility of realising complex designs. This paper identifies the potential of possible applications of RM in the spare parts industry. It further underlines the need for a fully functional RM supply chain before proposing an e-business enabled business model for RM technologies.

## INTRODUCTION

Rapid Manufacturing (RM) has evolved from Rapid Prototyping (RP) technologies that have been successfully used to physically create designs and concepts. RM is concerned with the direct manufacture of parts and components using additive manufacturing techniques [1]. RM differs from traditional production technology in that the *modus operandi* is not subtractive or formative (machining and moulding respectively), but rather, is additive in the way it layers up parts during manufacture. One of its particular advantages over these traditional techniques is that no tooling is required to manufacture a component [2]. This paper explores the scope and opportunity of RM technologies in the spare parts industry before proposing an e-business enabled model for RM products.

## THE AEROSPACE INDUSTRY IN THE NORTH WEST OF UK

The UK aerospace sector is the world's second largest with a turnover of £18.6 billion, with North West aerospace companies contributing nearly £7 billion per annum, accounting for a third of the UK's turnover in this sector [3]. The UK and the European aerospace industry are expected to experience tremendous growth with the news that Emirates Airlines has ordered Airbus planes totalling £16.7 million [4]. It is a fact that the North West of England has a thriving aerospace industry. The North West has a number of major players in the aerospace industry including BAE Systems and Rolls-Royce Plc. There are also a number of smaller specialist companies that play a vital role in both equipping the UK's Armed Forces and generating high quality jobs at the leading edge of technology. It is estimated that there are almost 1,000 companies associated with aerospace in the North West, employing over 50,000 people and accounting for approximately 4.5 per cent of the regional employment figures [3]. This research focuses on the possible application of RM technologies in the repairable spare parts industries in the north west of the UK including the aerospace sector. Apart from the aerospace sector, the automotive industry remains a lucrative prospect for RM usage and this includes the manufacture of classic bike spares [5].

## Application of RM in aerospace and automotive industry

There is a saying in the aerospace industry that 'Nothing is more expensive than an airline in the ground'. This is because it not only costs for hanger fees but also incurs loss due to the lack of flying opportunity. An analysis of spare parts reveal that most parts are infrequently needed [6], the result being lots of infrequent parts stored

for long periods of time. One can imagine the situation when considering that aircrafts manufactured by Boeing or Airbus consist of around 4 million components [6]. According to the Pareto rule [7] 20% of the items make up 80% of the sales where as 80% of the items are not high on demand. One of the solutions to the problem is RM. The concept is to make spare parts on demand. RM could be particularly useful for low volume production of parts that are normally not needed but have to be on the shelf in order to avoid an aircraft being grounded for a long time. These are parts where inventory holding logistical costs are high in relation to production costs [6]. The aerospace industry has been one of the early adopters of RM technologies. Parts for aircraft are made in small quantities, are often complex and must meet stringent requirements. Price is almost always secondary to function [8]. This is essentially the definition of a high value-added application - which is exactly the type of application that RM is most appropriate for at present. Parts for the International Space Station and other projects were being made as long as several years ago by Boeing using selective laser sintering (SLS). In 2002, the company spun off Boeing On-Demand Manufacturing (ODM) to independently pursue the market for RM parts. ODM has latterly been acquired by RMB Products, Inc [9].

A laser powder forming process called Laser Additive Manufacturing (LAM) was in development for seven years by AeroMet Corp. Parent company, MTS Systems Corp. shuttered the effort in Oct., 2005 [8]. The process was aimed directly at fabricating large metal parts for the aerospace market. Major cost savings were said to be realised both from the speed of near net shape fabrication and from waste material savings. A major area of interest is in the application of additive manufacturing technology to the fabrication of jet engine components. For example, turbine blades have complex shapes and must meet extremely stringent specifications. Direct write technology can be used to improve blade finishes and for repair, and laser powder forming technologies for fabricating sensors within blades [8].

A Foresight Vehicle Initiative in Europe investigated the possibilities of custom seats, steering wheels, gear knobs and hand brakes. Dashboard air-ducts could be designed by drivers and built to order at a local automobile dealership. The ability to economically fabricate complex structures using multiple materials means that it will be possible make parts with previously unattainable functionality [8]. Such parts may provide improved fuel savings and engine life, or lower assembly costs. For example, metal matrix composites may provide extraordinarily durable, low-inertia valves, and Sprayforming (TM) is being explored to make motors, actuators, generators and permanent magnets as integral assemblies [8].

### **THE DIFFERENCE BETWEEN RP AND RM SUPPLY CHAIN**

There are now more than 830 listed locations worldwide where RP services can be obtained, including commercial businesses, academic institutions and government agencies [8]. The services of most RP bureaus include producing functional prototypes and aesthetic models. The following is an example of kind of services provided by a RP bureau.

#### **Example of a RP product**

Sean Henry, a world-renowned sculptor, was commissioned to create the UK's first permanent offshore sculpture for the Northumbrian coastal village of Newbiggin-by-the-Sea, as it underwent a major development project. Before Sean could begin

work on the full-size bronze sculptures, he needed a way of visualising his design in 3-dimensional form in a more manageable size. He also had to present his proposal to Wansbeck District Council; the main client behind the commissioning of the full sized "Couple", and members of the South East Northumberland Public Art & Design Initiative (INSPIRE). Sean commissioned 3T RPD Ltd, a UK based RP service bureau to build various sized scale model versions of the figures in a white Nylon material using their Selective Laser Sintering (SLS) technology as shown in Figure 1 [10].



Figure 1. SLS models of the breakwater "Couple"

**RP supply chain**

A RP product supplied as in the above mentioned example can be segmented into four parts as shown in Table 1 [11]:

Table 1: RP Supply chain

Concept design
Production design
Prototyping
Preproduction

**RM supply chain**

However, the RM supply chain is not that straightforward. The definition of RM means that it is to be employed for producing end used products not just creating prototypes. However, it is true that at present RP machines are used to make RM products. In future it is expected that the production process could differ and a multi-axis production process could be used instead of the present preference of layer manufacturing [12]. What ever the scenario, it is clear that the RM supply chain is deep rooted as listed in Table 2 [11]:

Table 2: RM supply chain

Concept design
Production design
Prototyping
Preproduction
Production
Part supply & logistics
Assembly and integration
Customer distribution
After sales services
Life Cycle engineering

The difference between the two supply chains is pictorially demonstrated in Figure 2.

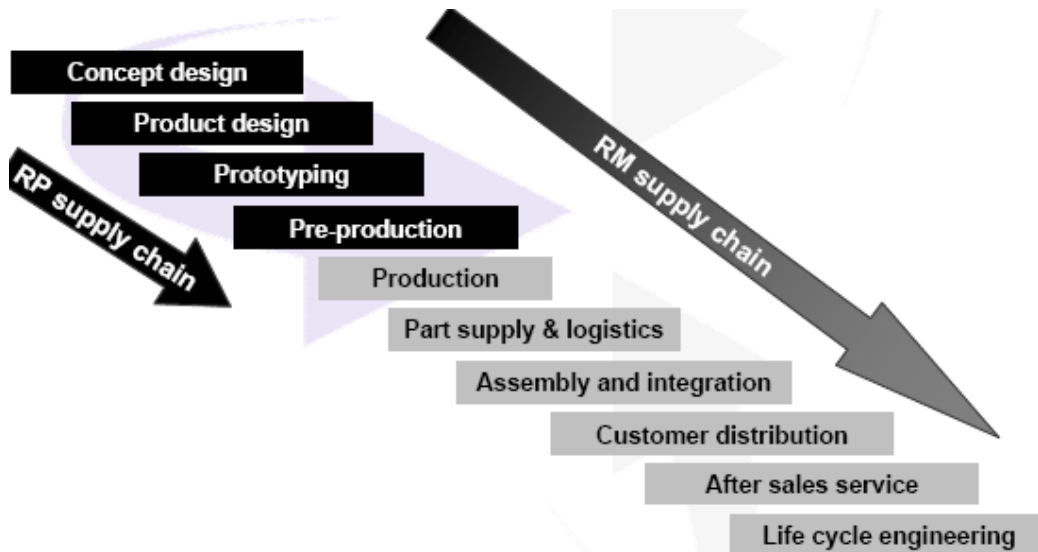


Figure 2. RM supply chain is far deeper than RP supply chain

In order to increase the application of RM including for repairable spare parts, it is necessary that a business model supporting a fully functional RM supply chain is identified. This paper proposes an e-business enabled business model for RM made repairable spare parts. It is proven that inventory management undergoes significant advancement when coupled with the latest ICT technology. Effects are noticeable in inventory cost, data management, planning, procurement, distribution and manufacturing strategy [12].

In this regard, it is important to be aware of some of the existing e-business platforms. Exostar [13] is an example of such platforms which was originally founded in 2000 to support the complex supply chain and security requirements of the global aerospace and defence industry, whereas Covisint [14], provides comprehensive

online communication systems in the world. Originally developed as a supply chain management solution for the automotive industry, it has expanded in scope and now serves many other purposes for a variety of industries.

Electronic commerce or e-business can be defined as any electronic communication that facilitates the exchange of goods, services or other assets between suppliers and buyers. It is also termed as Business-to-Business or B2B, which can be classified as including sell-side (e-catalogues), e-marketplaces, trading partner agreements and buy-side (e-procurement) [15]. An e-business platform could potentially provide an alternative to the RM industry, in terms of supply chain functionality.

### Comprehensive Support

The model has to integrate critical issues such as process/material selection, designing and trading into a common online platform. This would ensure total end to end service of realising a design from concept to manufacturing and distribution [16]. This is pictorially presented in Figure 3.

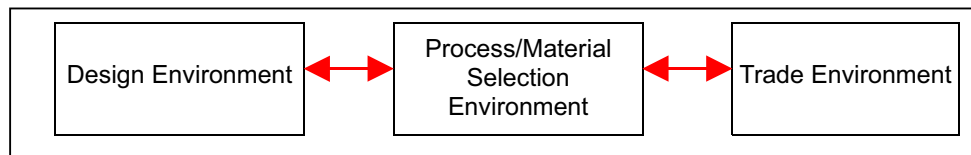


Figure 3: Online Platform

### Potential Services provided by the business model

The potential services that the proposed e-business platform could provide are tabulated in Table 4.

Table 4: Potential services

Services	Description
<i>Sourcing or discovery</i>	Giving buyers an easy access to a pool of suppliers, a process that can save time and offer buyers better prices due to the increase in competition amongst suppliers.
<i>Demand identification</i>	Suppliers can identify customers and their demands in a free market economy.
<i>Content</i>	Through the e-catalogue that could contain a vast volume of products, the buyer can acquire the required product
<i>Transaction</i>	The actual exchange of procurement information, such as purchase orders, between the buyer and supplier.
<i>Promotion</i>	Advertisement for suppliers through the platform

### INVENTORY MANAGEMENT

RM could further provide a solution to the batch size problem. RM can be used to manufacture products to batch sizes of one, since it is cost effective for products with small batch sizes compared to producing them using high speed machining techniques. RM could also negate the effect of faulty forecasting since the

use of RM would result in more on demand production. Figure 4 analyses the RM usage requirements and ICT benefits.

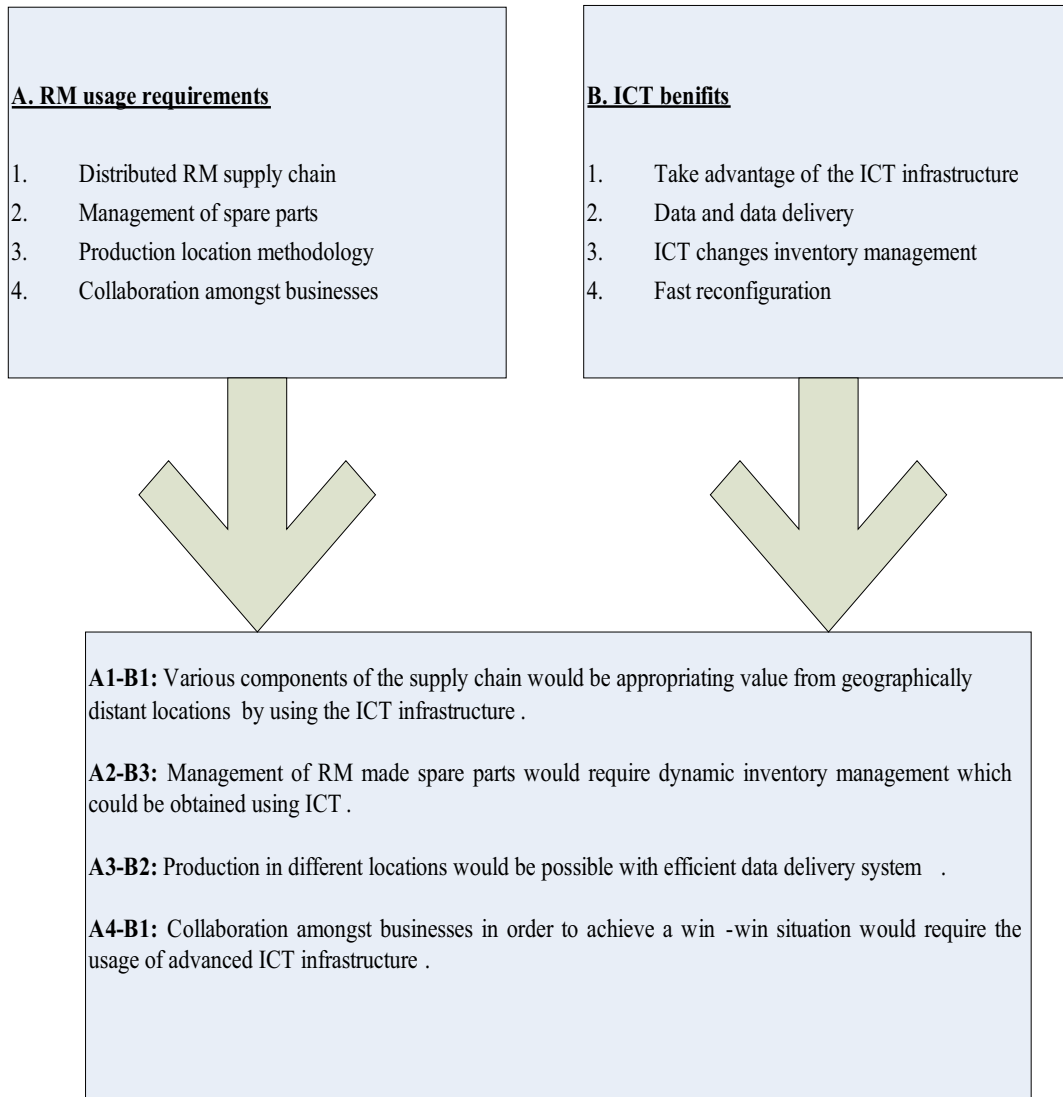


Figure 4: Analysis of RM usage requirement with ICT benefits

### CONCLUSION

This paper has discussed the scope of RM technologies in the spare parts industry. It outlined the major difference between the RM and RP supply chain and identified the lack of a fully functional RM supply chain as a major obstacle towards increasing the usage of RM technologies. The paper later went on to propose an ICT enabled e-business model as a possible alternative for the RM supply chain to function.

### ACKNOWLEDGEMENTS

This research is part-funded under the auspices of the European Regional Development Fund Rapid Manufacturing North West Project and the Higher

Education Innovation Fund. Additionally, the authors wish to acknowledge the input of Dr Phil Reeves of Econolyst Ltd in the support of this Project and its activities.

## References

- [1] DTI Foresight Vehicle Grant Reference LCBH/002/00021, (2002), Management Organisation and Implementation of Rapid Manufacturing (ManRM), “Rapid Manufacturing- Impact on Supply Chain Methodologies and practice”
- [2] Tuck, C; Hague, R. and Ruffo, M. (2005), “Customised Rapid Manufacturing”, World Congress on Customization and Personalization, Hong Kong, Advanced Manufacturing Institute, HKUST, Track No- B-4-4, Paper No-44
- [3] <http://www.aerospace.co.uk/about-nwaa/company-profile.php> [accessed 22 January, 2008]
- [4] <http://www.ukinvest.gov.uk/OurWorld/4018087/it-IT.html> [accessed 23 January 2008]
- [5] Hasan, S. and Rennie, A.E.W. (2008). Virtual Trading System For Rapid Manufactured Products, *Proceedings of the Ninth National Conference on Rapid Design, Prototyping and Manufacturing*, Lancaster University, June 13, 2008, Lancaster, UK, pp127-135, ISBN 978-0-948314-55-1.
- [6] Walter. M. Holmstrom, J and Yrjola, H. (2004), “Rapid manufacturing and its impact on supply chain management”, Logistic Research Network Annual Conference, September 9-10, 2004, Dublin, Ireland.
- [7] Christofer, M. (1992), *Logistics and Supply Chain Management*, Pitmann Publishing, London, UK
- [8] <http://home.att.net/~castleisland/home.htm> [Accessed 19 June 2008]
- [9] [http://www.boeing.com/news/releases/2005/q1/nr\\_050210a.html](http://www.boeing.com/news/releases/2005/q1/nr_050210a.html) [Accessed 11 June 2008]
- [10] <http://www.3trpd.co.uk/> [Accessed 11 June 2008]
- [11] Reeves, P. (2007), “The need for mid layer intelligence”, European Union Rapid Manufacturing Platform ([www.rm-platform.com](http://www.rm-platform.com)) [Accessed 15 November, 2007]
- [12] Hopkinson, N; Hague, R.J.M. and Dickens, P.M. (2006), *Rapid Manufacturing: An Industrial Revolution for the Digital Age*, John Wiley & Sons Ltd, West Sussex, U.K.
- [13] <http://www.exostar.com/> [Accessed 9 June 2008]
- [14] <http://www.covisint.com/> [Accessed 9 June 2008]
- [15] Stein, A and Hawking, P. (2002), “Reverse Auction e-Procurement: A Suppliers Viewpoint”, The Eighth Australian World Wide Web Conference, Twin Waters Resort, Sunshine Coast Queensland, 6-10 July.  
<http://ausweb.scu.edu.au/aw02/papers/refereed/stein/index.html>
- [16] Ariadi, Y., Hasan, S., Smith, P.C. and Rennie, A.E.W. (2008). Development of an Additive Layer Manufacturing Business Model: Creating an Environment to Support Designers from Concept to Distribution, *Proceedings of the 32<sup>nd</sup> Japan Rapid Prototyping Symposium*, June 23-24, 2008, Tokyo, Japan, pp.79-84.