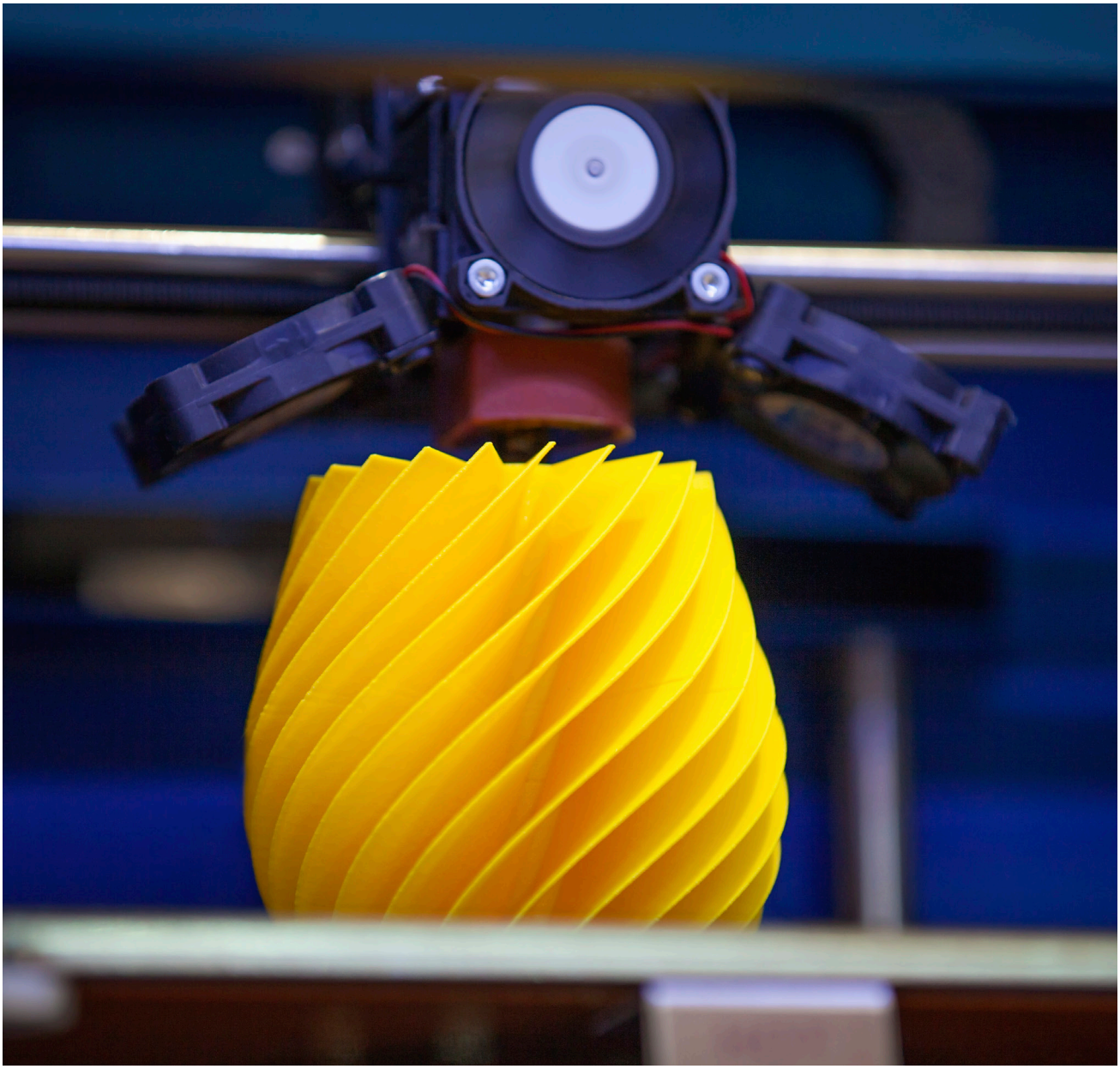
MARSH

Manufacturing for the future – the 3D shape of things to come?



CONTENTS

MANUFACTURING FOR THE FUTURE – THE 3D SHAPE OF THINGS TO COME?

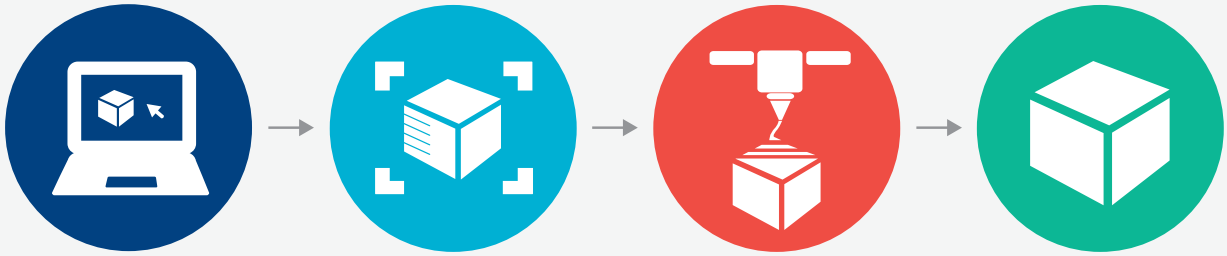
The rapid development of additive manufacturing has taken it from the laboratory to the marketplace – but is this an opportunity or risk for manufacturers? This *insights* report examines current and future applications of the technology, together with an overview of the potential risk issues and mitigation efforts that need to be considered.

ADDITIVE MANUFACTURING DEFINED

The term, additive manufacturing (AM), also referred to as 3D printing, has been around since the 1980s and refers to technologies that create objects by laying down one layer at a time from a digital file. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object. The materials used range from plastics to metals, all in fluid form, and the process is entirely controlled by a computer under automated control.

Global revenue from additive manufacturing is expected to top **USD21 billion** by **2020** — a seven-fold increase from **2013**.[1]

FIGURE 1 Additive Manufacturing Process



Electronic design file of object is created

Software slices model into layers and sends file to 3D printer

3D printer layers raw materials to build up the product

Final object with little or no waste

[1] Wohlers Report 2014. 3D Printing and Additive Manufacturing State of the Industry, Annual Worldwide Progress Report.

SPOTLIGHT

GBP154 million

invested by the UK government in four 3D printing research projects.[6]

100,000

additive parts will be manufactured by GE Aviation by 2020.[7]

Largest-ever

civil aero engine component produced by Rolls-Royce using 3-D printing.[8]

AEROSPACE AND DEFENCE INDUSTRY LEADS THE WAY

The aerospace industry has had a long history of being an early adopter, and innovator,[2] and has been utilising additive manufacturing technology to speed up the production of prototype parts. 3D printers have allowed designers to go straight to the printing of finished parts with minimal investment in part-specific tooling for the prototype refinement process.[3]

The industry is now looking to exploit this technology to build in-flight production components for aircraft. The testing of the A380 Airbus aircraft marked a major milestone in aerospace manufacturing. This was because the Rolls-Royce Trent XWB-97 engine powering the aircraft was equipped with the largest civil aero-engine component ever built, using 3D-printing techniques.[4] Being able to adhere to the stringent safety controls in the aviation industry is testament to the robust nature of 3D manufactured components.

GE has also invested some USD50 million in a new 300,000 square-foot facility in Auburn, Alabama to use additive manufacturing to create the most complex components of its newest fuel nozzles for next-generation jet engines. The nozzles will be on the LEAP jet engine, which is being developed by CFM International, a 50/50 joint company of GE and Snecma (Safran) of France. This is the first time such a complex component will be manufactured using additive technology. There are 19 nozzles per engine, and production will ramp up quickly over the next five years, going from 1,000 fuel nozzles manufactured annually to more than 40,000 by 2020.[5]

LOOKING BEYOND THE PROTOTYPE

Since this technology was first developed, the manufacturing industry has seen a rapid advancement in tools, techniques, and applications with 3D machines fabricating complex components, crossing the gulf between prototype and production component. Some processes that already involve the use of additive manufacturing include: aerospace, medical, automotive parts, and some basic consumer items.

Medical equipment manufacturers are utilising 3D printing to produce acetabula cups (used in hip replacement surgery), knee implants, cranial patches, and maxio-facial implants (used in reconstructive surgery following trauma or disease).[9]

[2] Stratasys 2014. Additive Manufacturing Trends in Aerospace Whitepaper.

[3] PWC. "3D printing: A potential game changer for aerospace and defense," available at www.pwc.com/us/gainingaltitude, accessed 5 December 2015.

[4] Knight H. "Aerospace takes to additive manufacturing," available at http://www.theengineer.co.uk/aerospace/in-depth/aerospace-takes-to-additive-manufacturing/1021249.article, accessed 5 December 2015.

[5] GE. "GE Aviation Executive, Greg Morris, Honored for Ground-breaking Work in 3D Printing," available at http://www.geaviation.com/press/services/services_20150306.html, accessed 5 December 2015.

[6] "Nick Clegg announces £154 million for aerospace research," available at https://www.gov.uk/government/news/nick-clegg-announces-154-million-for-aerospace-research, accessed 5 December 2015.

[7] "Additive Manufacturing," available at http://www.ge.com/stories/advanced-manufacturing, accessed 5 December 2015.

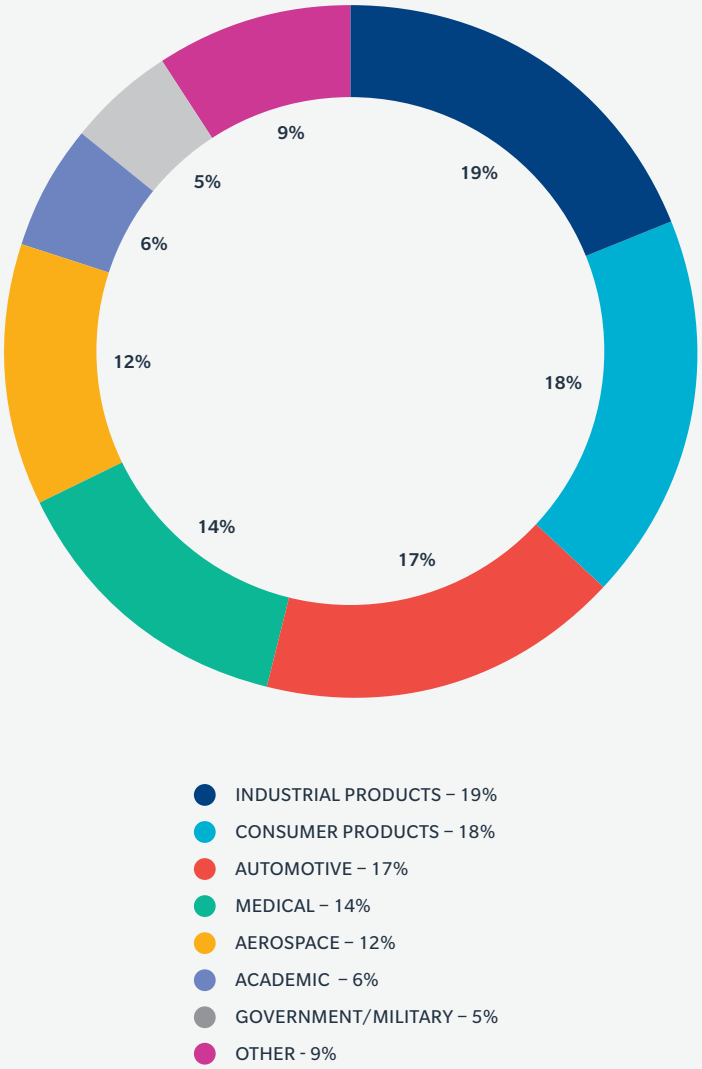
[8] Rolls-Royce. "Rolls-Royce breaks additive record with printed Trent-XWB bearing," available at http://www.theengineer.co.uk/news/news-analysis/rolls-royce-breaks-additive-record-with-printed-trent-xwb-bearing/1020596.article, accessed 8 December 2015.

[9] Intellectual Property Office/University of Bournemouth. "The Current Status and Impact of 3D Printing Within the Industrial Sector: An Analysis of Six Case Studies. March 2015," available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/413673/The_Current_Status_and_Impact_of_3D_Printing_Within_the_Industrial_Sector_-_Study_II.pdf, accessed 5 December 2015.

Applications are also ongoing in the consumer electronics sector for the manufacture of cases and covers used on smart phones, tablets, and other portable devices.

Once the domain of multinational corporations due to the scale and economics of owning a 3D printer, smaller, albeit, less capable, 3D printers can now be acquired for under GBP1,000; with current applications in the toy, gifts, and collectables industries.

FIGURE 2 Additive Manufacturing Sales Revenue to Various Sectors, 2013.[10]



[10] Wohlers Report 2014. 3D Printing and Additive Manufacturing State of the Industry, Annual Worldwide Progress Report.

SPOTLIGHT

3D PRINTING GOING MAINSTREAM:

- AEROSPACE
- AUTOMOTIVE
- INDUSTRIAL manufacturing
- HEALTHCARE and medical equipment
- RETAIL
- SPORTS equipment

THE POTENTIAL AND PROMISE OF 3D PRINTING

As a "tool-less" and digital approach to production, 3D printing will inevitably change the economics of manufacturing and the way that components are distributed.

THE MANUFACTURING INDUSTRY

The industry may witness:

- Faster product development.
- Manufacturing closer to point of use.
- Increased responsiveness and flexibility to demand.
- An increased production according to customer requirements.
- Reduction in required inventory, reduced storage costs, and associated risks.
- Cost savings compared to traditional manufacturing processes – energy consumption/workforce costs.
- Reduction in the amount of raw materials used during production – leading to reduced waste.
- Component simplification, requiring less assembly, and improved quality.

As AM technologies develop and costs fall, a remodelling of production sites and supply chains is likely to accelerate. The flexibility of the technology will increase with new materials and processes creating opportunities for new industries to enter the arena.

For some industries, however, components are so intricate that they will continue to be made using sophisticated manufacturing processes currently in place.

SUPPLY CHAIN SIMPLIFICATION – FACT OR FICTION?

3D printing has the potential to change the model for manufacturing, moving away from mass production in centralised factories in locations dictated by low-cost labour, to a world where the choice of production location is driven by demand, rather than the economics of supply. In the supply chain there are also immediate potential benefits, including ready availability of spare parts produced at the point of use or a reduction in the necessity to maintain inventory stock levels, improving supply chains, and reducing operating costs.

For the automotive industry, this could have fundamental consequences in avoiding costly production-line disruptions if the supply chain fails in the supply of a particular component. Interruption could be avoided if parts could be printed on site from an electronically stored data model. Shorter waiting times for the delivery of critical and specialist parts and being less dependent upon suppliers could, one day, become the norm.

Additive manufacturing can be used to:

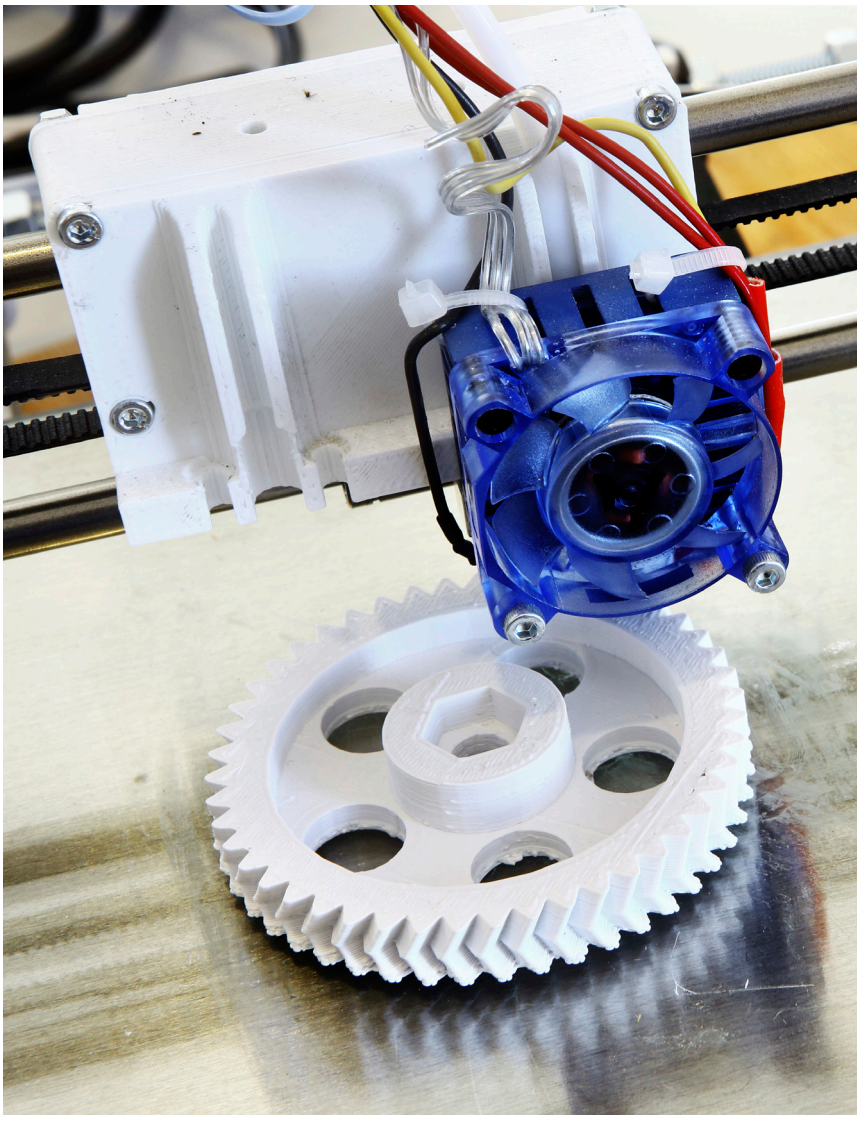
IMPROVE FLEXIBILITY.

REDUCE COSTS.

SIMPLIFY THE SUPPLY CHAIN.

Also in the automotive parts industry, the adoption of 3D printing to make component replacement parts directly from digital design files, rather than high-cost manufacturing processes such as injection moulding or rotational moulding is very compelling. The adoption of this process could reduce the need for car manufacturers and third-party suppliers to over produce and stock spare parts, which they currently do for many years after the sale of a vehicle.

Recent natural catastrophes such as the Japan earthquake/tsunami and Thailand floods in 2011, demonstrated the vulnerability in the supply chain for technology manufacturers with an over-reliance on one supplier for component parts — could 3D printing have come to the rescue? A shift in end-part production closer to customers will also streamline the logistics of distribution and accelerate delivery, altering business models in these industries as well.



The worldwide automotive aftermarket accounted for **GBP135 billion** of revenue in **2010**.[11]

[11] Based on the purchase of components alone. ibid.

NEW RISKS TO BE MANAGED – UNCHARTED TERRITORY

For many manufacturers outside of the multinational corporations in aerospace and defence, AM will represent a step change in understanding the new nature of the risks they face. Intellectual property (IP) infringements and product liability risks will be in the spotlight as technological advances lead manufacturers to new ways of working.

One of the major challenges as AM becomes more widely adopted, is the issue of traceability, which is an important factor in establishing liability for product defects. Clear and unambiguous contractual arrangements between parties in a supply chain are vital. Clear rights of recourse against the party responsible if something goes wrong with a product using AM technologies are also a must.[12]

The boundaries between manufacturer and end-user will be blurred by the adoption of 3D printing. End-users will be able to print partial or even complete products by themselves. They may even be able to participate in the production process, which will pose a question in product liability cases: Who is responsible for the damage?

Swiss Re notes that lines will be confused between product designer and producer, which would require a review of the existing scope of professional indemnity covers. We will witness an increased complexity and cross-over between professional indemnity for design risk and product liability for the physical product.

Architects, designers, and engineers may look to determine if their policies apply to computer-aided design production. Similarly, with the increasing use of 3D printing in the construction and medical industries, alterations may need to be considered to medical malpractice and engineering insurance.[13]

The risks and exposures a customer will face will depend on how that customer operates and how it utilises 3D printing. With new materials and processes, questions will also be asked regarding longevity and structural integrity of 3D printing methods. When assessing new technology, risk management should be an essential part of the continuum to ensure that risk is considered throughout the value chain.

"Intellectual property infringements and product liability risks will be in the spotlight as technological advances lead manufacturers to new ways of working."

[12] Lloyd's. "The Future in 3D, December 2013,"available at https://www.lloyds.com/news-and-insight/news-and-features/market-news/industry-news-2013/the-future-in-3d," accessed 8 December 2015.

[13] Swiss Re. "3D printing: implications for the re/insurance industry," available at http://www.swissre.com/reinsurance/insurers/casualty/3D_printing_implications_for_the_reinsurance_industry.html, accessed 8 December 2015.

CYBER CRIME AND INTELLECTUAL PROPERTY THEFT

This shift in manufacturing capability also raises a number of questions relating to IP. With new technology, parts will be vulnerable to being copied, modified, or replicated; with no reference to the original owners. It is estimated by Gartner, the US market research firm, that by 2018, 3D printing will likely result in the loss of at least USD100 billion per year in IP globally.[14]

Manufacturers will need to audit their current IP practices to determine the adequacy of their current IP protection strategy. They will need to consider a number of IP protection tools – including design patents, trademarks, and copyrights. Increasing connectivity using automated control and computer files in the manufacturing process will bring to the fore cyber cover issues. Unauthorised parties or hackers could capture data or alter records; the protection of virtual files from theft adds another dimension for the industry to consider.

By **2018,** 3D printing will likely result in the loss of at least **USD100 billion** per year in intellectual property globally.[14]

CONCLUSION

With advances in quality and speed, 3D printing will become a viable option for a number of applications, which will include replacing traditional production methods. While numerous 3D printed consumer products are already available today, important advances are still required to make the technology viable and cost effective for many industries.

As is commonplace with emergent technologies, the speed of adoption is unclear, although change will take place incrementally and without us noticing. A move to AM will inevitably lead to business-operating drift, a shift in the operating model of a business from its original purpose leading to an altered risk landscape. Old risks will reduce or disappear, while new risks will emerge which need to be identified, reviewed, and managed.

[14] Gartner. "Gartner Reveals Top Predictions for IT Organizations and Users for 2014 and Beyond," available at http://www.gartner.com/newsroom/id/2603215, accessed December 2015.

Risk Management Checklist

- Any change in your operating model should result in a review of all operations, equipment, processes, training, and safety controls.
- Review policy wordings with your broker and advise insurers of any change to processes.
- Review contracts to agree and document, as far as possible, the intended responsibilities of each party as AM brings into question the definition of "producer."
- Review how new processes and materials may impact your risk profile and whether any further controls are required.
- Undertake robust supply-chain mapping.
- Review trademarks, patents, IT security, and other means of intellectual property protection.
- Consider if any additional classes of insurance are required, for example, intellectual property, medical malpractice, and product recall.
- Review product quality management procedures.
- Determine the ownership and control of design, production, installation, testing, maintenance, repair, and overhaul risks.

About Marsh

Marsh is a global leader in insurance broking and risk management. Marsh helps clients succeed by defining, designing, and delivering innovative industry specific solutions that help them effectively manage risk. Marsh's approximately 27,000 colleagues work together to serve clients in more than 130 countries.

About this report

This report examines how technological change is redefining the nature of risk in the manufacturing industry.

Marsh's Transportation and Engineering Practice in the UK sees understanding and keeping at the forefront of technological change as key to providing the best client advice and enhancing the benefits we can deliver to clients' businesses.

MARSH

For more information, contact the colleagues below or visit our website at:
www.marsh.co.uk.

IAN HAYHOE

UK & Ireland Transportation and Engineering Practice
+44 (0) 207 357 1948
ian.e.hayhoe@marsh.com

DAVID STOKOE

UK & Ireland Transportation and Engineering Practice
+44 (0) 207 357 3176
david.stokoe@marsh.com