HIGH VALUE MANUFACTURING LANDSCAPE 2016
Interim Report

Annex 3: Sector Summaries

Version 1.3

Date: 22/10/2015

17 Charles Babbage Road, Cambridge CB3 0F

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Food sector[1]

Challenges

- New, sustainable food manufacturing processes, reducing energy and water usage, mitigating increasingly volatile resources in the low carbon economy (ʬ) (≡) **(⊓)**
- Digital manufacture, using improved generation and analysis of data to reduce waste and mitigate supply volatility and support development of personalised food (ʬ) (≡) (@)
- Personalised mass produced food at low cost to meet individual health- or aspiration-related needs and wants (ʬ) (≡) (@)
- Food industry response to maintaining biodiversity **(≡)**

Key[2] (ʬ) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(⊓) Challenge identified at industrial consultation dinner(s)
(@) Challenge reinforced by HVM CTO review

Other business capabilities identified in sector documentation and by HVMC CTO review, but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Smart packaging
- Distributed manufacturing with more flexibility and high quality at low capital cost

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Plastic and silicon electronic technologies
Sensor technologies
Advanced and autonomous robotic technologies
Packaging
Other product technology competencies[3]
Materials
Biomaterials
Management/operational/supply chain
Supply chain and business model innovation
Enabling technology
Big data management and analytics
Autonomy
Internet of things

1 **Sources** a) Documentation: Sustainable Growth through Innovation; Vision for Food Innovation 2012; FDF Pre-competitive Vision for the UK Food and Drink Industry; HVM Deep Dive – Food. b) Landscaping workshops 26th Feb and 6th March 2015. c) Industry consultation dinners, May – July 2015.

2 (ʬ) Supporting detail of workshop outputs is available separately. **(≡)** Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.

3 Product technologies relevant only to the sector

Production technology

Additive manufacturing/3D printing

Surface engineering (finishing and coating)[1]

Biological and synthetic biology processing

Process engineering, capability and efficiency development

Control systems

System engineering/integration

Human machine interface

[1] Note: not commonly referred to in this way in Food.

Pharma/Biopharma sector[1]

Challenges

- Intensified manufacturing, digital design and sustainable analysis of new and existing pharmaceuticals: pulling new products through development into UK rather than overseas manufacture (ᵂ) (≡) (@)
- Medicine stratification both in small molecule and bio/advanced therapies to optimise existing medicines and support rapid introduction of new drugs (ᵂ) (Ⓟ)
- Stratified medicine for 'Cinderella diseases' not treatable by generic drugs, applying artificial intelligence and 'formulation on demand' to establish continuous flow through the value chain to the patient (ᵂ) (Ⓟ)
- Manufacture of new testing systems for antibiotic resistance using technologies often from outside the sector to develop alternative ways to prevent or combat antibiotic resistance (ᵂᵂ)
- Point-of-care production delivering tailored pharmaceuticals to individual patients, supporting cost-effective care given pressures on ageing population, primary care and rising energy and transport costs (ᵂ) (≡) (Ⓟ) (@)
- Medicine stratification both in small molecule and bio/advanced therapies to optimise existing medicines and support rapid introduction of new drugs (ᵂ)
- Flexible, low cost manufacture of advanced therapies, exploiting new investment routes to ensure new cell therapy products are manufactured in UK (ᵂ)
- Intelligent systems for real-time distributed manufacture of new therapies, exploiting parametric testing to allow real-time release of products delivered directly to the patient (ᵂ) (@)
- Developing maintenance-free facilities using modular design and improved monitoring and control to allow 24/7/12/1 operation (ᵂ)
- Sourcing drug development knowledge, using leading data management and analysis techniques to accelerate product market introduction despite limited and shrinking cadre of experts (ᵂ) (≡)
- Develop UK supply chain, using data analysis and prediction algorithms to capture value from novel biopharma therapies (ᵂ) (≡)
- Enhancing innovation in pharmaceutical product development, integrating process development and market exploitation to reduce pre-competitive development costs (ᵂ) (≡)

Key[2] (ᵂ) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(Ⓟ) Challenge identified at industrial consultation dinner(s)
(@) Challenge reinforced by HVM CTO review

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1. **Sources** a) BIS Strategy for UK Life Sciences; Health KTN – The Future of HVM in the UK Pharma, BioPharma and Medical Device Industry; MMIP and BIA Publications; 8 Great Technologies: Regenerative Medicine; 8 Great Technologies: Synthetic Biology; ABPI Annual Review; Health KTN; 8 Great Technologies: Life Sciences; Genomics and Synthetic Biology. b) Landscaping workshops 26th Feb and 6th March 2015. c) Industry Consultation Dinners May – July 2015.
2. (ᵂᵂ) Supporting detail of workshop outputs is available separately.
   (≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
   (Ⓟ) Challenges identified in industrial consultation dinners have limited supporting detail.

Other business capabilities identified in sector documentation and by the HVMC CTOs, but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Smart packaging
- New business models
- Integrated supply chain
- Getting the regulator and the regulatory system to be able to deal with distributed manufacture
- Intelligent production and packaging

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Electronics, photonics and power electronics
Sensor technologies
Advanced and autonomous robotic technologies
Packaging
Other product technology competencies[1]
Materials
Other new materials and materials science
Biomaterials
Enabling technology
Big data management and analytics
Autonomy
Measurement, metrology, assurance and standards
Management/operational/supply chain
Supply chain and business model innovation
Production technology
Tooling and fixtures
Biological and synthetic biology processing
Formulation
Process engineering, capability and efficiency development
Post processing
Control systems
System engineering/integration
Integrated design and manufacture
Systems modelling and simulation

[1] Product technology competencies only relevant to the sector

Medtech sector[1]

Challenges

- Improving the acceptance of and UK innovation for smart and wearable devices, including through enhanced validation and regulation, including in healthcare (ʬ) (≡) (ʭ) (@)
- Medtech product verification (ʭ) (@)

Key[2]
(ʬ) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(ʭ) Challenge identified at industrial consultation dinner(s)
(@) Challenge reinforced by HVM CTO review

Other business capabilities identified in sector documentation, and through HVMC CTO review but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Drug delivery with compliance and combination devices
- Tools for patient safety, quality and efficacy including specialised teaching training validation
- User-led digital design tools (patient, clinician, surgeon)
- Nano-film manufacture
- Data storage, management and analysis
- Smart software algorithms that allow decision making
- Digital health devices, and healthcare app developments
- Producing and verifying metal additive manufactured medical parts

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Electronics, photonics and power electronics
Sensor technologies
Other product technology competencies[3]
Materials
Nanomaterials and nanotechnology

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1. **Sources** a) TSB Stratified Medicine Roadmap; BIS Strategy for UK Life Sciences; Health KTN – The Future of HVM in the UK Pharma, BioPharma and Medical Device Industry; 8 Great Technologies: Regenerative Medicine; 8 Great Technologies: Regenerative Medicine; 8 Great Technologies: Life Sciences, Genomics and Synthetic Biology. b) Landscaping workshops 26th Feb and 6th March 2015. c) Industry Consultation Dinners May – July 2015
2. (ʬ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(ʭ) Challenges identified in industrial consultation dinners have limited supporting detail.

3 Product technology competencies only relevant to the sector.

Management/operational/supply chain
Supply chain and business model innovation
Enabling technology
Software development and management
Autonomy
Measurement, metrology, assurance and standards
Internet of things
Production technology
*Additive manufacturing/*3D printing
Advanced assembly
Tooling and fixtures
Other novel cutting, shaping and machining processes
Control systems
System engineering/integration
Integrated design and manufacture
Systems modelling and simulation

Defence and security sector[1]

Challenges

- Smart reconfigurable factories, driven by simulation and modelling, to cost effectively manufacture complex and difficult high value products and components (ᵂ)
  The development of such 'smart' manufacturing for be operation in deployed locations is an area of particular interest*.
- Improving the acceptance of and UK innovation for smart and wearable devices through enhanced validation and regulation (ᵂ) (≡) (Ⓐ)
  Acceptance and validation is new technologies is applicable across all defence equipment. Within the term 'acceptance' there is quite a range of topics that enable their uptake. MOD needs a body of evidence that proves the new technology fulfills the requirement. (*)
- New approaches to defence innovation using open innovation and business models to drive technology import from other sectors (ᵂ) (≡).
  This is something that the MOD (and DE&S Technology Office in particular) has been persuing recently. Work to date with Additive Manufacturing would suggest that a lot could be gained from working more effectively with other nations, in addition to other sectors. There are some relationships with the Defence and Aero and Motorsports industries (for example), which produce some benefit, but there is certainly duplication of effort at best. (*)
- Building new models of innovation across the supply/value chain (including SMEs), sharing innovation responsibility across tiers to increase the speed of introduction and uptake (ᵂ) (≡)
  In the more immediate term this may focus on e.g.: air capabilities and intelligent systems (Ⓐ); advanced systems development for hostile environments (Ⓐ; improved fuel efficiency (Ⓐ);tailored composite and lightweight structures (Ⓐ); front line materials specification(Ⓐ); front-line mechanical manufacturing to reduce burden on logistics (Ⓐ); front-line biomanufacturing (e.g. fuels) (Ⓐ;, interoperability (Ⓐ) Security impact of the introduction of smart technologies – e.g. the increased difficulty to identify counterfeited parts (*)).
- Maximising HVM development pipeline synergies with the defence sector, maintaining a pipeline of new technologies continuing selectively to exploit the strong UK science base (ᵂ).(i)
  This supports defence exports, and builds understanding of defence needs in the context of influence and support for adjacent and non-traditional sectors such that defence can better and subsequently spin-in technology and capability from the market place
- Through-life capability development, exploiting, for example performance prediction and degradation assessment to drive cost reduction and affordability (ᵂ) (≡)

Key[2] (ᵂ) HVM challenge as identified in landscaping workshops February/March 2015

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1 **Sources** a) Defence Growth Partnership: Securing Prosperity; DSTL Technology Strategy; DGP Roadmapping; UK SDSR 2010; RUSI: Options for Britain's Defence and Security; 8 Great Technologies: The Big Data Revolution and Energy-Efficient Computing; 8 Great Technologies: Robotics and Autonomous Systems. b) Landscaping workshops 26th Feb and 6th March 2015. c) Industry Consultation Dinners May – July 2015.

2. (ᵂ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(Ⓐ) Challenges identified in industrial consultation dinners have limited supporting detail.

(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(⍈) Challenge identified at industrial consultation dinner(s)
(*) Added by Tom Barker, DSTL Technology Office)

Other business capabilities not highlighted elsewhere in the process, which may require an additional HVM challenge to address for the longer term:

- Agile toolkits relating to Robotics; Automation & Autonomy*
- Space-related technologies, including affordable access*
- Compressing development cycles, SWAP and cost*
- Nurturing the supply chain for Quantum 2.0 technologies linked to precision timing and navigation, sensing with gravity*
- Synthetic Biology supporting manufacture/exploitation of nano(structured) materials, multi-function materials, coatings and structures', sustainability and sustainable access

Note (*) identified by Prof Ian Youngs, FInstP, FIET, CPhys
Job title: Dstl Fellow and Advisor to Dstl's Knowledge Innovation and Future Enterprise (KnIFE) and Dstl's Materials And Structures Technology Science and Technology Centre (MAST STC)

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology

Plastic and silicon electronic technologies
Sensor technologies
Other product technology competencies[1]

Materials

Other new materials and materials science
Biomaterials

Management/operational/supply chain

Product and service integration
Supply chain and business model innovation

Enabling technology

Software development and management[2]
Big data management and analytics
Autonomy
Internet of things
Measurement, metrology, assurance and standards

Production technology

Additive manufacturing/3D printing
Advanced assembly
Tooling and fixtures
Remanufacturing
Biological and synthetic biology processing

1

System engineering/integration

Integrated design and manufacture

Systems modelling and simulation[2]

Human machine interface

Further Notes:

(1): Product technology competencies only relevant to the sector.

(2): Includes Multi-scale, multi-physics, whole life simulation and design (see US Materials Genome Initiative)

(3): "Electromagnetic" technologies are important but have not featured in other sector reviews to date and hence are not covered by competence themes so far identified. They link to communications and remote sensing/surveillance in other sectors. It covers a broad range across the RF, microwave (terahertz) infrared and optical parts of the spectrum linking to coatings, devices, sub-systems, systems, and emerging S&T areas such as metamaterials and nanophotonics/plasmonics.

Aerospace sector[1]

Challenges

- Smart reconfigurable factories (including automation and for new product proving), driven by simulation and modelling, to cost effectively manufacture complex and difficult high value products and components (🜨)(≡)
- Building new models of innovation across the supply/value chain (including SMEs), sharing innovation responsibility across tiers to increase the speed of introduction and uptake (🜨) (≡) *(May focus on e.g.: improved fuel efficiency (♖); reduced noise (♖)); increased production rate (particularly for composites and other lightweight structures and materials) (♖); high production rate SPF (♖); efficient and reliable electrical actuation (♖); digital data support to supply chain and design and build process from concept (♖); LEP panes replacing windows (♖);repairability of advanced composites (♖); manufacturing advanced and specialist metallics (♖); decreased component count/subassembly optimisation (♖);part to part assembly(♖)); Laminar flow wing (@); geared fan engine (@); Lower cost, higher efficiency planes (@), new fuel and lubricants(@))*
- Coatings and surface optimisation finding alternative chemicals in response to REACH to maintain or replace current manufacturing processes otherwise forced to close (🜨)
- Application of leading through-life principles, automatic repair and remanufacturing in developing low maintenance aircraft to reduce the overall cost of ownership (🜨)

Key[2] **(🜨)** HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(♖) Challenge identified at industrial consultation dinner(s)
(@) Additional challenge identified by HVM CTO review

Other business capabilities identified in sector documentation but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Rapid, cost effective materials/process validation

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology

Electronics, photonics and power electronics
Power generation technologies
Fuels and lubricants
Other product technology competencies[1]

[1] **Sources** a) Lifting Off: Implementing the Strategic Vision for UK Aerospace; UK SDSR 2010; NATEP publications; 8 Great Technologies: The Big Data Revolution and Energy-Efficient Computing; 8 Great Technologies: Robotics and Autonomous Systems; ATI documents. b) Landscaping workshops 26th Feb and 6th March 2015 c) Industry Consultation Dinners May – July 2015.

[2] (🜨) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(♖) Challenges identified in industrial consultation dinners have limited supporting detail

Materials
New composites
Lightweight materials
Other new materials and materials science
Management/operational/supply chain
Product and service integration
Supply chain and business model innovation
Enabling technology
Software development and management
Big data management and analytics
Internet of things
Measurement, metrology, assurance and standards
Production technology
Primary processes (casting, forging including alloying)
Laser processing
Additive manufacturing/3D printing
Powder metallurgy
Advanced assembly
Tooling and fixtures
Surface engineering (finishing and coating)
Remanufacturing
Volume composite manufacture
Process engineering, capability and efficiency development
Formulation
Control systems
System engineering/integration
Integrated/hybrid technologies
Integrated design and manufacture
Systems modelling and simulation
Human machine interface

[3] Product technology competencies only relevant to the sector

Space sector[1]

Challenges

- Developing new propulsion systems through investment in design, build and test facilities to secure UK share of the global small launchers market (ᵂ) (≡)
- Developing new materials such as new composites to establish world-leading competitiveness in space applications (ᵂ) (≡)
- Cost-effective launch capability (≡)
- Obsolescence and availability improvement (≡)

Key[2] (ᵂ) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy

Other business capabilities identified in sector documentation and through HVMC CTO review but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Miniaturised payloads
- New, large platforms
- Satellite data service and exploitation
- Space debris detection
- Manufacture of fuel tanks
- New business models

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Materials
New composites
Other new materials and materials science
Management/operational/supply chain
Supply chain and business model innovation
Enabling technology
Measurement, metrology, assurance and standards
Production technology
Joining
Additive manufacturing/3D printing
Advanced assembly

1. **Sources** a) Satellite Applications Catapult Documents; 8 Great Technologies: Satellites and Commercial Applications of Space; AMSCII documents b) Landscaping workshops 26th Feb and 6th March 2015
2. (ᵂ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(⍈) Challenges identified in industrial consultation dinners are not applicable in this sector.

System engineering/integration

Integrated design and manufacture

Systems modelling and integration

Automotive sector[1]

Challenges

- Smart reconfigurable factories, driven by simulation and modelling, to cost effectively manufacture complex and difficult high value products and components (ᵂᵂ)
- Integrating design for manufacturing and new manufacturing processes across the automotive supply chain, strengthening the potential for value capture by UK manufacturers (ᵂᵂ) (≡) (@)
- Advanced, fuel-efficient vehicle power units, exploiting new materials and coatings and smart technology to exploit manufacture of emission reduction and efficiency demands (ᵂᵂ) (≡) (Π) (@)
- Automotive supply chain skills enhancement, particularly in electric traction and hybrid drives to exploit and sustain innovation and attract inward investment (ᵂᵂ) (≡)
- Flexible and adaptable 'personalised' vehicle ranges, exploiting a wide range of new technologies to support rapid changes in vehicle fleet and model refresh (ᵂᵂ)
- Unmanned automotive vehicles building in sensing, autonomy data analysis and modelling to reduce congestion and emissions (ᵂᵂ) (≡) (Π)
- Advances in manufacturing/joining technologies for advanced low weight materials to achieve automotive scale and cost requirements (Including composites and advanced high-strength steel) (≡)

Key[2] (ᵂᵂ) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(Π) Challenge identified at industrial consultation dinner(s)
(@) Challenge reinforced by HVM CTO review

Other business capabilities identified in sector documentation and through HVMC CTO review but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Improved human machine interface
- Component supply and integrated
- Smart supply chain
- General drive for lower cost and higher efficiency

1. **Sources** a) Automotive Council; Growing the Automotive Supply Chain 2014; BIS National Strategy Document - Driving Success; AutoCRC Roadmap. b) Landscaping workshops 26th Feb and 6th March 2015.
2. (ᵂᵂ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(Π) Challenges identified in industrial consultation dinners have limited supporting detail.

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Electronics, photonics and power electronics
Sensor technologies
Advanced and autonomous robotic technologies
Power generation technologies
Energy storage technologies
Hydrogen fuel cells
Fuels and lubricants
Other product technology competencies[1]
Materials
Nanomaterials and nanotechnology
New composites
Lightweight materials
Other new materials and materials science
Management/operational/supply chain
Product and service integration
Supply chain and business model innovation
Enabling technology
Software development and management
Big data management and analytics
Autonomy
Internet of things
Production technology
Primary processes (casting, forging including alloying)
Joining
Powder metallurgy
Additive manufacturing/3D printing
Advanced assembly
Remanufacturing
Volume composite manufacture
Component manufacturing and processing using polymeric materials (plastics)
Process engineering, capability and efficiency development
Formulation
Control systems
System engineering/integration
Integrated design and manufacture
Systems modelling and simulation
Human machine interface

[1] Product technologies relevant only to the sector

Rail sector[1]

Challenges

- New railways including lightweight mobility, infrastructure and network optimisation to minimise environmental impact and drive cost and resource efficiency (ww) (≡) (@)

Key[2] (ww) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(@) Challenge reinforced by HVM CTO review

Other business capabilities identified in sector documentation and through HVMC CTO review but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- High speed track maintenance/repair and inspection
- Integrated smart supply chain

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Plastic and silicon electronic technologies
Electronics, photonics and power electronics
Sensor technologies
Power generation technologies
Energy storage technologies
Fuels and lubricants
Other product technology competencies[3]
Materials
New composites
Lightweight materials
Other new materials and materials science
Management/operational/supply chain
Product and service integration
Supply chain and business model innovation

1 **Sources** a) National Rail Strategy Document; RSSB Strategy 2010; RTS 2012 – The Future Railway; EIT – Railway Capability Roadmapping Phase B Report. b) Landscaping workshops 26th Feb and 6th March 2015

2 (ww) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(Ⓝ) Challenges identified in industrial consultation dinners are not applicable in this sector.

3 Product technologies relevant only to the sector.

Enabling technology
Software development and management
Big data management and analytics
Autonomy
Internet of things
Measurement, metrology, assurance and standards
Production technology
Surface engineering (finishing and coating)
Remanufacturing
Volume composite manufacture
Formulation
Control systems
System engineering/integration
Systems modelling and simulation
Human machine interface

Marine sector[1]

Challenges

- Under sea equipment and infrastructure (🍷)

Key[2] (🍷) Challenge identified at industrial consultation dinner(s)

Other business capabilities identified in sector documentation but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- New anti-fouling and other coatings
- Sensors and monitoring
- Improved production capability
- Improved human machine interface
- Intelligent and autonomous systems
- Microbial clean-up
- New product molecules

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Sensor technologies
Fuels and lubricants
Materials
Nanomaterials and nanotechnology
New composites
Lightweight materials
Other new materials and materials science
Enabling technology
Big data management and analytics
Autonomy
Measurement, metrology, assurance and standards
Production technology
Advanced assembly
Tooling and fixtures
Surface engineering (finishing and coating)
Volume composite manufacture
Process engineering, capability and efficiency development
Formulation

1. **Sources** a) BIS TSB UK Marine Roadmap 2012; Innovate UK Marine Roadmap 2015 (unpublished).
2. (ᵂᵂ) Supporting detail of workshop outputs is available separately.
   (≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
   (🍷) Challenges identified in industrial consultation dinners have limited supporting detail.

System engineering/integration

Integrated design and manufacture

Systems modelling and simulation

Human machine interface

Energy sector[1]

Challenges

- New energy storage devices for power grid smoothing as demands for security and sustainability of supply increase (W) (Ω)
- Localised energy generation, storage and trading integrating, for example, PV generation and new business models to optimise sustainable energy generation (W) (≡)
- Manufacture and replacement of components for offshore wind turbines to ensure investment in renewables benefits the UK value chain (W)
- Development of industrially focused advanced materials and materials processing expertise (≡)
- Development of 'real-world' test and characterisation facilities/techniques (≡)

Key[2] (W) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(Ω) Challenge identified at industrial consultation dinner(s)

Other business capabilities identified in sector documentation and through HVMC CTO review but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Fuel cells for distributed generation
- Integrated, localised PV to H2 storage (incl. reversible fuel cells)
- Fast, flexible thermal power plants
- Biofuels
- New business models

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Electronics, photonics and power electronics
Sensor technologies
Power generation technologies
Energy storage technologies
Hydrogen fuel cells
Other product technologies[2]
Materials
New composites

1. **Sources** a) BIS Offshore Wind Industrial Strategy; 8 Great Technologies: Energy and its Storage; HVM Energy Deep Dive. b) Landscaping workshops 26th Feb and 6th March 2015.
2. (W) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(Ω) Challenges identified in industrial consultation dinners have limited supporting detail.

2 Product technologies relevant only to the sector.

Graphene
Lightweight materials
Other new materials and materials science
Management/operational/supply chain
Supply chain and business model innovation
Enabling technology
Measurement, metrology, assurance and standards
Production technology
Additive manufacturing/3D printing
Surface engineering (finishing and coating)
Volume composite manufacture
Component manufacturing and processing using polymeric materials (plastics)
Biological and synthetic biology processing
Formulation
System engineering/integration competencies
Systems modelling and simulation

Nuclear sector[1]

Challenges

- Exploit the UK nuclear decommissioning programme (ᵂ*) (≡)
- Strengthening the UK value capture in small and medium nuclear reactor design and build (ᵂ*) (Ⓡ)
- Increasing UK supply chain contribution to nuclear new build associated equipment (ᵂ*)(@)
- Exploiting the value available in existing fleet life extension (ᵂ*) (≡) (@)
- Quick and reliable routes to certification of new technologies (≡)
- Business model management to reduce impact of up-front expenses (≡)

Key[2] (ᵂ*) HVM challenge as identified in written submission post landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(Ⓡ) Challenge identified at industrial consultation dinner(s)
(@) Challenge reinforced by HVM CTO review

Other business capabilities identified in sector documentation but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Power output management: grid security and balancing

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Other product technology competencies[3]
Materials
Other new materials and materials science
Enabling technology
Measurement, metrology, assurance and standards
Production technology
Primary processes (Casting, forging incl. alloying)
Joining
Laser processing
Other novel cutting, shaping and machining processes
Advanced assembly
Powder metallurgy
Additive manufacturing/3D printing
Remanufacturing

1 **Sources** a) Nuclear AMRC Publications; 8 Great Technologies: Energy and its Storage; Sharing in Growth documents. b) Interview with Mike Tynan, CEO NAMRC, May 2015

2 (ᵂ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(Ⓡ) Challenges identified in industrial consultation dinners have limited supporting detail.

3 Product technologies relevant only to the sector.

System engineering/integration competencies

Integrated design and manufacture

Systems modelling and simulation

Oil & gas sector[1]

Challenges

- Major subsea equipment manufacture (ᵂ*)
- Manufacturing in composite material (ᵂ*)
- Repair using composite materials (ᵂ*)
- Harnessing robotics and automated systems (≡)
- Driving down supply chain costs (≡)

Key[2] (ᵂ*) HVM challenge as identified in written submission post landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy

Other business capabilities identified in sector documentation but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Transportation of chemicals to oilfields
- Continuity of supply

Manufacturing competencies required for challenges

Product technology

Electronics, photonics and power electronics
Sensor technologies
Other product technology competencies[3]

Materials

Nanomaterials and nanotechnology
New composites

Management/operational/supply chain

Supply chain and business model innovation

Enabling technology

Software development and management
Big data management and analytics
Autonomy
Measurement, metrology, assurance and standards

Production technology

Additive manufacturing/3D printing
Surface engineering (finishing and coating)
Volume composite manufacture
Process engineering, capability and efficiency development

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1 **Sources** a) BIS UK Oil & Gas Industrial Strategy; UK HVM 2012 – Oil and Gas. b) Written Submission by Ian Phillips CEO OGIC.

2 (ᵂ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(Ⓡ) Challenges identified in industrial consultation dinners are not applicable in this sector.

3 Product technologies relevant only to the sector.

System engineering/integration competencies

Integrated design and manufacture

Systems modelling and simulation

Built environment sector[1]

Challenges

- 'Active buildings' with energy capture, storage and control, to improve environmental efficiency (ᵂᵂ) (≡)
- Off-site manufacturing and associated 'through-process' control to reduce cost and increase speed of building (ᵂᵂ) (≡)

Key[2] (ᵂᵂ) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy

Other business capabilities identified in sector documentation but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- On-site 'printing' of materials and structures

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Sensor technologies
Advanced and autonomous robotic technologies
Other product technology competencies[3]
Materials
Lightweight materials
Other new materials and materials science
Management/operational/supply chain
Supply chain and business model innovation
Enabling technology
Autonomy
Measurement, metrology, assurance and standards
Production technology
Additive manufacturing/3D printing
Remanufacturing
Volume composite manufacture
Control systems

1 **Sources** a) BIS Construction 2025 Industrial Strategy; Foresight SEMBE Roadmap; CSIC Roadmap; HVM Roadmap.
b) Landscaping workshops 26th Feb and 6th March 2015.

2 (ᵂᵂ) Supporting detail of workshop outputs is available separately.
(≡) Other cchallenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(Ⲙ) Challenges identified in industrial consultation dinners are not applicable in this sector.

3 Product technologies relevant only to the sector.

System engineering/integration competencies

Integrated design and manufacture

Systems modelling and simulation

Chemicals sector[1]

Challenges

- Process and business modelling, using models to reduce the need for physical trials to optimise current and new processes and drive process intensification (ᵂ) (≡)
- Circular economy and sustainable supply chains which use new feed stocks and waste streams to meet market demand with lower resource consumption (ᵂ) (≡) (@)
- Robust processes for scale up/scale down, enhancing the flexibility of operations to respond more rapidly to local market needs (ᵂ) (≡)
- Regenerating existing assets, enhancing monitoring and control to run new processes on existing assets, reducing the need for investment (ᵂ) (≡)
- Ambient-condition sustainable chemical processes, using new catalysis and synthetic biology and alternative energy sources to reduce energy consumption (ᵂ)
- Creating innovative products, through the integration of new chemicals, materials, coatings (≡)

Key[2] (ᵂ) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(@) Challenge reinforced by HVM CTO review

Other business capabilities identified in sector documentation and through HVMC CTO review but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Develop improved process analysis and control (intelligent systems) capability
- Smaller more efficient lower cost more flexible plant
- Scale-out (i.e. how do you build a lot distributed manufacturing plants and give them the ability to act collectively)
- Process intensification (batch to continuous or intensification of known processes)

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology

Sensor technologies

Power generation technologies

1. **Sources** a) Chemistry Growth Partnership; BIS Strategy for UK Life Sciences; Chemistry Growth Strategy Group: Strategy for delivering chemistry-fuelled growth of the UK economy; CPI/KTN: A Strategy for Innovation in the UK chemistry-using industries; SCI: Chemistry: we mean business. b) Landscaping workshops 26th Feb and 6th March 2015.
2. (ᵂ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(Ⓟ) Challenges identified in industrial consultation dinners are not applicable in this sector.

Materials
Nanomaterials and nanotechnology
Other new materials and materials science
Biomaterials
Management/operational/supply chain
Product and service integration
Supply chain and business model innovation
Enabling technology
Autonomy
Measurement, metrology, assurance and standards
Production technology
Surface engineering (finishing and coating, including alloying)
Remanufacturing
Biological and synthetic biology processing
Formulation
Process engineering, capability and efficiency development
Post processing
Control systems
System engineering/integration competencies
Integrated/hybrid technologies
Integrated design and manufacture
Systems modelling and simulation

Industrial biotechnology (IB) sector[1]

Challenges

- Scale-up of industrial biotechnology processes for bio-renewables (ᵂ*) (≡)
- Understanding techno-economics of biotech processes (ᵂ*) (≡)
- Transforming the chemicals industry with bio processes (ᵂ*) (@)
- Extracting value from waste (fuels from waste biorefining) (Ⓡ)

Key[2] (ᵂ*) HVM challenge as identified in written submission post landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(Ⓡ) Challenge identified at industrial consultation dinner(s)
(@) Challenge reinforced by HVM CTO review

Other business capabilities identified in sector documentation and through HVMC CTO review but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Feed stock supply, waste and bio feed stocks
- Integrate conventional processes with bio process at low temperature (e.g. fermentation and AD) and also high temperature (e.g. gasification)
- C1 fermentation and sugar processing
- Integration of a range of processes into a bio refinery that is capable of handling many feedstocks and produces many products
- Smaller, more efficient, lower cost, more flexible plant
- Scale-out (i.e. how do you build a lot distributed manufacturing plants and give them the ability to act collectively)

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology

Plastic and silicon electronic technologies
Sensor technologies
Packaging
Other product technology competencies[3]

Materials

Other new materials and materials science
Biomaterials

1. **Sources** a) Chemistry Growth Partnership; BIS Strategy for UK Life Sciences. b) Written Submission, Alex Amey + Colleagues BBSRC April 2015.
2. (ᵂ) Supporting detail of workshop outputs is available separately.
   (≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
   (Ⓡ) Challenges identified in industrial consultation dinners have limited supporting detail.
3. Product technologies relevant only to the sector.

Enabling technology

Big data management and analytics

Autonomy

Production technology

Remanufacturing

Biological and synthetic biology processing

Formulation

Process engineering, capability and efficiency development

System engineering/integration competencies

Integrated design and manufacture

Systems modelling and simulation

Textiles sector[1]

Challenges

- Multifunctional and superperforming textiles with functionality through physical properties and built-in sensing and intelligence, to create high added value and offset downward pressures on the traditional sector (ʬ) (≡) (⊓)
- Separation and re-processing of fabrics (≡)
- Rapid in-line identification of polymers (≡)
- Re-invigorating sustainable textiles industry (⊓)

Key[2] (ʬ) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(⊓) Challenge identified at industrial consultation dinner(s)

Other business capabilities identified in sector documentation but not highlighted elsewhere in the process, which may require an additional HVM challenge to address: none

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Materials
Other new materials and materials science
Enabling technology
Autonomy
Measurement, metrology, assurance and standards
Production technology
Additive manufacturing/3D printing
Surface engineering (finishing and coating)
Remanufacturing
Process engineering, capability and efficiency development
Control systems

1. **Sources** a) UKFT Guide to UK Performance Textiles. b) Landscaping workshops 26th Feb and 6th March 2015.
2. (ʬ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(⊓) Challenges identified in industrial consultation dinners have limited supporting detail.

Electronics and ICT sector [1]

Challenges

- Exploitation of ICT in increased flexibility of product manufacturing to deliver product customisation, new product introduction and end of life management (🌐) (≡) (🏛)
- Exploiting the various routes to 3D manufacture of printed electronics to integrate functionality into a new breed of smart devices (🌐) (≡) (🏛)
- Support digital manufacture with high bandwidth communications, exploiting real-time software and high frequency and microwave hardware to build UK sovereign capability in 1–60GHz radio essential for 4G LTE and 5G (🌐)
- Processor, sensing and energy harvesting integration for the Internet of Things, developing a common hardware platform to allow 3D devices to connect to the Internet (🌐)
- Electronics for harsh applications using design and simulation tools to create cost-effective extension of electronics applications into more 'real-world' situations (🌐)
- Developing manufacturing design tools accessible for SMEs to ensure they can compete with larger, and international competition (🌐) (≡)
- Quality and reliability in electronics manufacture (🏛)

Key[2] (🌐) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(🏛) Challenge identified at industrial consultation dinner(s)

Other business capabilities identified in sector documentation and through HVMC CTO review, but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Security
- Power electronics with high thermal density
- Power electronics with high switching speed; High mix low volume production
- Emerging electronics (the hybrid systems of conventional and printed electronics- making the devices small and cheap enough to become ubiquitous)

1 **Sources** a) ESCO Report 2013; Power Electronics 2013; Printed Electronics Roadmap (KTN); OLAE Roadmap; EPSRC Annual Report 2014; PETEC Roadmap for Printable Electronics; Electronics HVM roadmap. b) Landscaping workshops 26th Feb and 6th March 2015.

2 (🌐) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(🏛) Challenges identified in industrial consultation dinners have limited supporting detail.

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Plastic and silicon electronic technologies
Electronics, photonics and power electronics
Sensor technologies
Advanced and autonomous robotic technologies
Other product technology competencies[1]
Materials
Graphene
Other new materials and materials science
Management/operational/supply chain
Supply chain and business model innovation
Enabling technology
Software development and management
Big data management and analytics
Autonomy
Internet of things
Cloud computing
Measurement, metrology, assurance and standards
Production technology
Laser processing
Additive manufacturing/3D printing
Surface engineering (finishing and coating)
Process engineering, capability and efficiency development
Formulation
System engineering/integration competencies
Integrated/hybrid technologies
Integrated design and manufacture
Systems modelling and simulation

[1] Product technologies relevant only to the sector.

Materials sector[1]

Challenges

- New materials design, qualification and integration, connecting the innovation chain from lab to market to capture value for the UK from new materials development (ᵂ) (≡) (@)
- International collaboration in advanced materials and additive manufacture (AM) development, exploiting UK research strengths to make the UK the 'go-to' country for partnership in these areas and maintain the high ground as they are exploited (ᵂ)
- Design for sustainable use of materials integrating sustainable practice in manufacturing to drive efficient use of world resources (ᵂ) (≡)
- New supply chain development, exploiting new business models to co-fund industrial capacity in new materials (ᵂ) (≡) (@)

Key[2] (ᵂ) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(@) Challenge reinforced by HVM CTO review

Other business capabilities identified in sector documentation but not highlighted elsewhere in the process, which may require an additional HVM challenge to address: none

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Materials
Nanomaterials and nanotechnology
Graphene
Other new materials and materials science
Management/operational/supply chain
Supply chain and business model innovation
Enabling technology
Big data management and analytics
Autonomy
Measurement, metrology, assurance and standards
Production technology
Primary processes (casting, forging (incl. alloying)
Additive manufacturing/3D printing
Process engineering, capability and efficiency development

1. **Sources** a) UK Materials Roadmap; BPF Roadmap 2015; Elastomer Roadmap 2014; AMLC KTN Polymer Strategy Document; 8 Great Technologies: Advanced Materials and Nano-Technology. b) Landscaping workshops 26th Feb and 6th March 2015.
2. (ᵂ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(Ⓡ) Challenges identified in industrial consultation dinners are not applicable in this sector.

System engineering/integration competencies

Integrated design and manufacture

Systems modelling and simulation

Cross-sector themes

Robotics and automation[1]

Challenges

- Building new cross-discipline collaborations in robotics and automation to increase UK investment in fully automated and robot-assisted manufacture (ᴡ)

Key[2] (ᴡ) HVM challenge as identified in landscaping workshops February/March 2015

Other business capabilities identified in sector documentation and through HVMC CTO review, but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Reconfigurable and flexible systems
- Flexible handling
- Autonomous systems

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Sensor technologies
Advanced and autonomous robotic technologies
Other product technology competencies[3]
Enabling technology
Big data management and analytics
Autonomy
Internet of things
Control systems
System engineering/integration competencies
Integrated design and manufacture
Systems modelling and simulation
Human machine interface

1 **Sources** a) 8 Great Technologies: Robotics and Autonomous Systems; 8 Great Technologies: The Big Data Revolution and Energy-Efficient Computing. b) Landscaping workshops 26th Feb and 6th March 2015

2 (ᴡ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(ᴨ) Challenges identified in industrial consultation dinners are not applicable in this sector.

3 Product technologies relevant only to the sector.

Flexible manufacturing[1]

Challenges

- Smart reconfigurable factories, driven by simulation and modelling for example in Aerospace/Defence/Automotive to cost effectively manufacture complex and difficult high value products and components (ʬ) (≡) (ᄆ) (@)
- Automated systems with remote monitoring and control through establishing better visibility of new and existing technologies to allow manufacture of increasingly complex products (ʬ) (≡)

Key[2]
(ʬ) HVM challenge as identified in landscaping workshops February/March 2015
(≡) Relevant challenges referred to in sector documentation, including BIS strategy
(ᄆ) Challenge identified at industrial consultation dinner(s)
(@) Challenge reinforced by HVM CTO review

Other business capabilities identified in sector documentation and through HVMC CTO review but not highlighted elsewhere in the process, which may require an additional HVM challenge to address:

- Supply chain visibility to tier 3 and lower
- Logistics
- Materials handling and processing
- Sensors integration
- Quality and remedial processing
- Contribution to 'Industry 4.0' in general (small capital-efficient plants with flexible outputs tailored to local customised and personalised markets)
- Flexible manufacturing in large plants also important e.g. automotive

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Product technology
Sensor technologies
Materials
Other new materials and materials science
Management/operational/supply chain
Product and service integration
Supply chain and business model innovation

1. **Sources** a) Flexible Manufacturing SIG; b) Landscaping workshops 26th Feb and 6th March 2015.
2. (ʬ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(ᄆ) Challenges identified in industrial consultation dinners have limited supporting detail.

Enabling technology
Software development and management
Autonomy
Big data management and analytics
Internet of things
Mobile internet
Measurement, metrology, assurance and standards
Production technology
Advanced assembly
Remanufacturing
System engineering/integration competencies
Integrated design and manufacture
Systems modelling and simulation
Human machine interface

Design[1]

Challenges

- Integration of design with early stage innovation activity with new business models encouraging collaboration between designers, supply chain players, innovators and end users to create user need and associated market pull (ᵂᵂ) (Ⓡ) (@)

Key[2] (ᵂᵂ) HVM challenge as identified in landscaping workshops February/March 2015
(Ⓡ) Challenge identified at industrial consultation dinner(s)
(@) Challenge reinforced by HVM CTO review

Other business capabilities identified in sector documentation but not highlighted elsewhere in the process, which may require an additional HVM challenge to address: none

Manufacturing competencies identified in sector strategy documentation and landscaping workshops (these may not be linked explicitly to identified challenges)

Enabling technology
Big data management and analytics
Measurement, metrology, assurance and standards
Management/operational/supply chain
Supply chain and business model innovation
System engineering/integration competencies
Systems modelling and simulation
Integrated design and manufacture
Human machine interface

1. **Sources** a) UK Design Council – Leading Business by Design: High Value Manufacturing; Design in Britain; Innovation by Design. b) Landscaping workshops 26th Feb and 6th March 2015.
2. (ᵂᵂ) Supporting detail of workshop outputs is available separately.
(≡) Other challenges mentioned in BIS strategy and other documentation may not meet HVM challenge definition.
(Ⓡ) Challenges identified in industrial consultation dinners have limited supporting detail.