15th Anniversary HVM 2017 & 4th Graphene New Materials Conference
2-3 November 2017 Cambridge, UK
www.cir-strategy.com/events

HVM and Industrial Digitalisation: Are we undergoing a '4th Industrial Revolution'?

Professor Tim Minshall
Dr John C Taylor Professor of Innovation
Head of Institute for Manufacturing

IfM MANAGEMENT TECHNOLOGY POLICY

UNIVERSITY OF CAMBRIDGE
Department of Engineering

www.ifm.eng.cam.ac.uk

IfM MANAGEMENT TECHNOLOGY POLICY

UNIVERSITY OF CAMBRIDGE
Department of Engineering

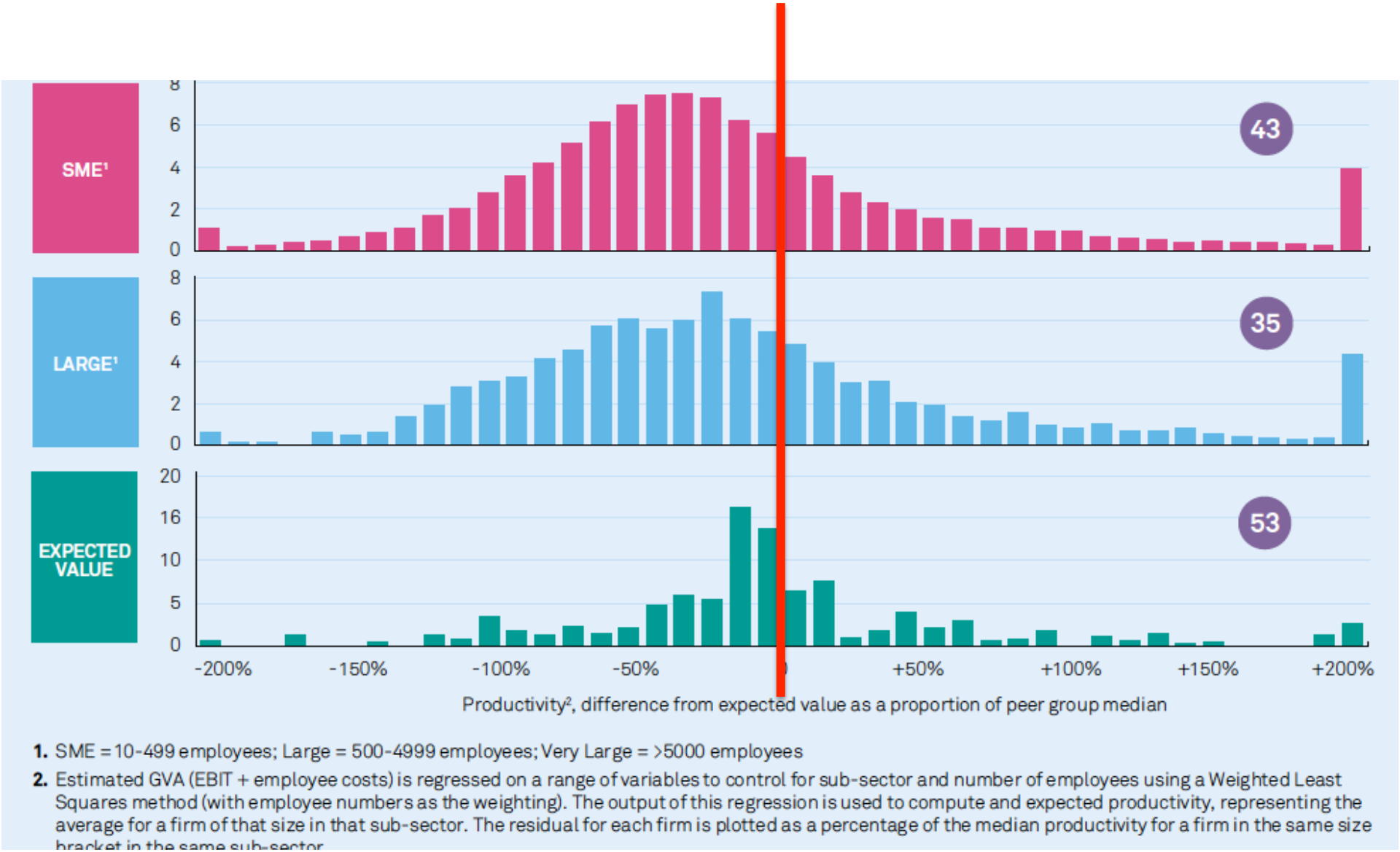
IfM at a glance…

IfM MANAGEMENT TECHNOLOGY POLICY

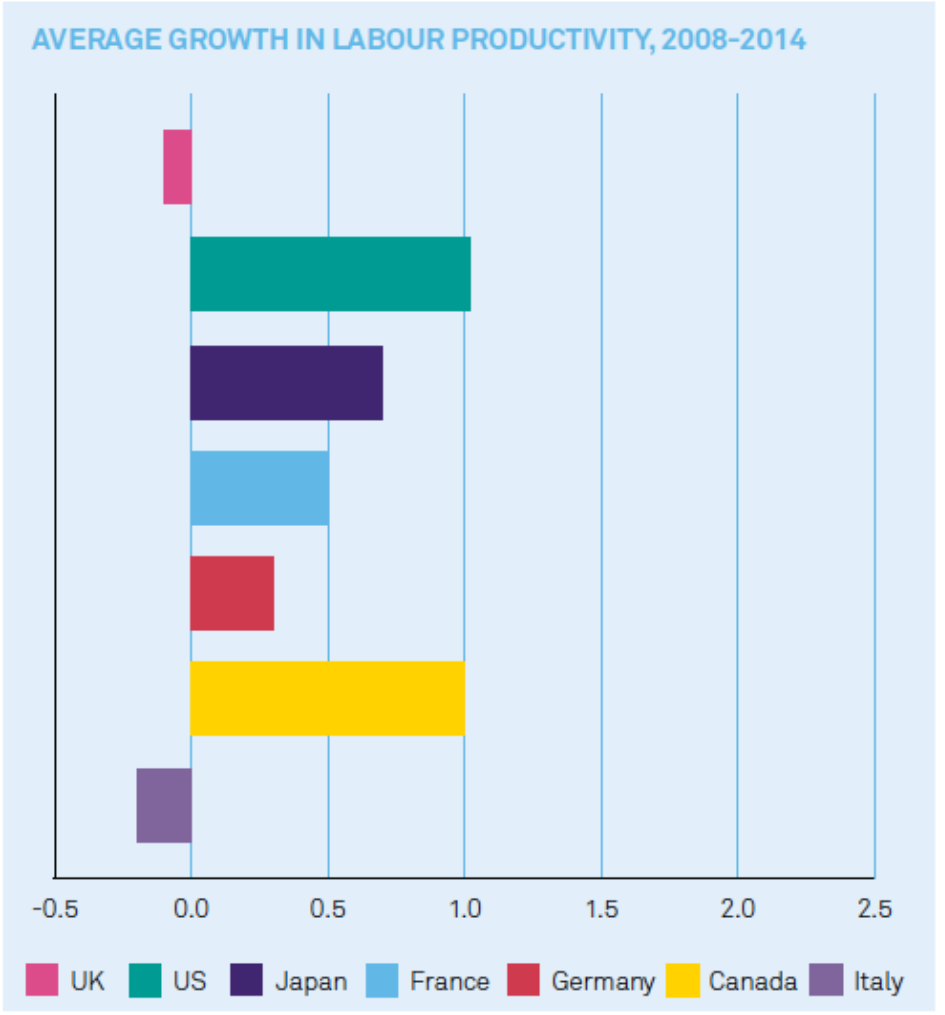
UNIVERSITY OF CAMBRIDGE
Department of Engineering

Key context

- ‘Healthy’ economy requires increased productivity



1. SME = 10-499 employees; Large = 500-4999 employees; Very Large = >5000 employees
2. Estimated GVA (EBIT + employee costs) is regressed on a range of variables to control for sub-sector and number of employees using a Weighted Least Squares method (with employee numbers as the weighting). The output of this regression is used to compute and expected productivity, representing the average for a firm of that size in that sub-sector. The residual for each firm is plotted as a percentage of the median productivity for a firm in the same size bracket in the same sub-sector



IfM MANAGEMENT TECHNOLOGY POLICY

http://industrialdigitalisation.org.uk/

UNIVERSITY OF CAMBRIDGE
Department of Engineering

Key context

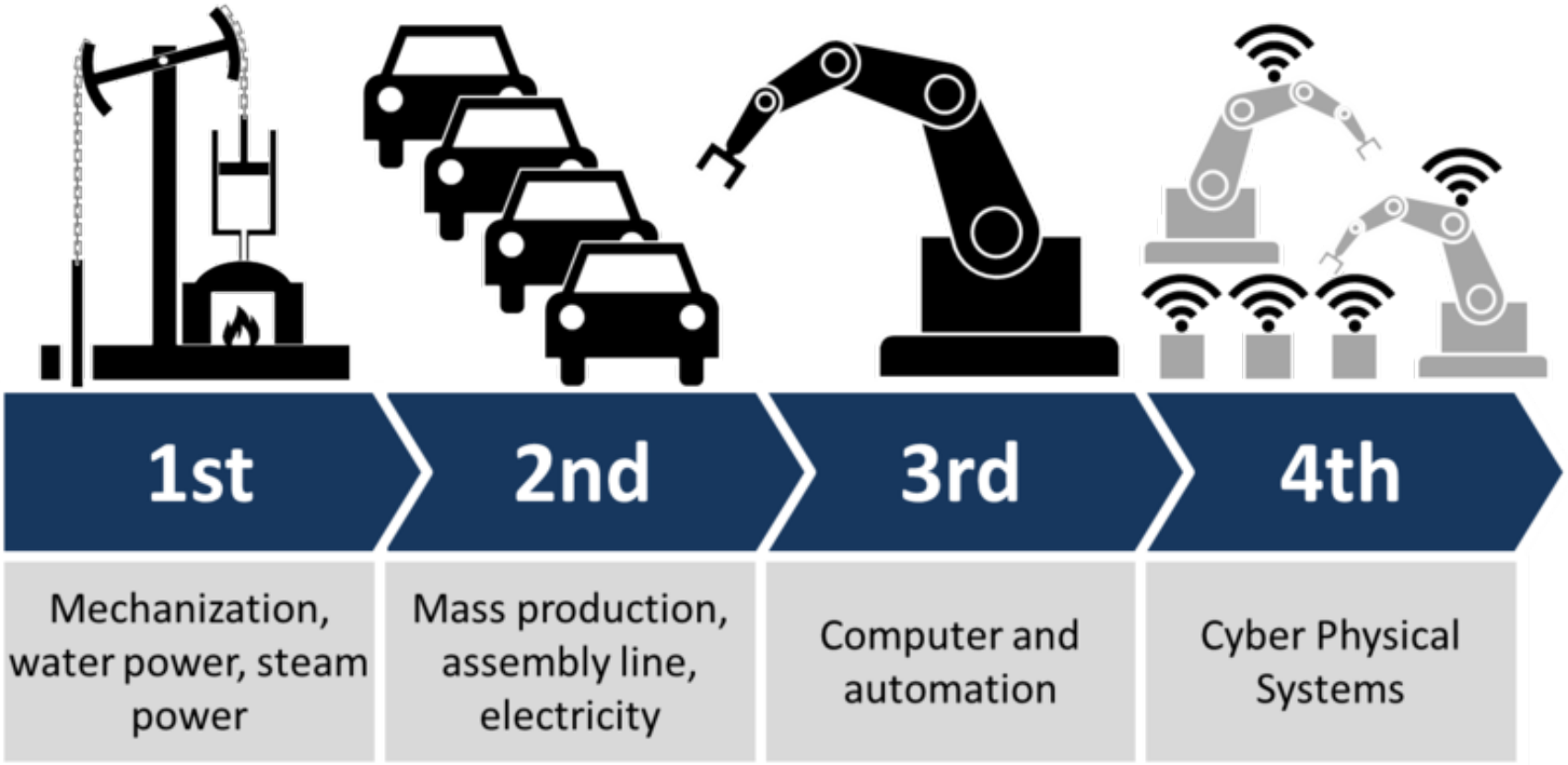
- ‘Healthy’ economy requires increased productivity
- Technology is long-term driver of productivity growth
- Technological innovation is critical but difficult

Image: State Library of South Australia


Image: www.portcities.co.uk

Image: www.containersforsale.co.uk

Image: www.portofelixstowe.co.uk



IfM MANAGEMENT TECHNOLOGY POLICY

Image: Christoph Roser at AllAboutLean.com"

UNIVERSITY OF CAMBRIDGE
Department of Engineering

UK Industrial Strategy

The 10 pillars

- Investing in science, research & innovation
- Developing skills
- Upgrading infrastructure
- Supporting businesses to start and grow
- Improving procurement
- Encouraging trade & inward investment
- Delivering affordable energy & clean growth
- Cultivating world-leading sectors
- Driving growth across the whole country
- Creating the right institutions to bring together sectors & places

https://www.gov.uk/government/policies/industrial-strategy

2017 Industrial Digitalisation Review

IfM MANAGEMENT TECHNOLOGY POLICY

http://industrialdigitalisation.org.uk/

UNIVERSITY OF CAMBRIDGE
Department of Engineering

t

Industrial Digitalisation

IfM MANAGEMENT TECHNOLOGY POLICY

Source: BBC Tomorrow's World archive on YouTube

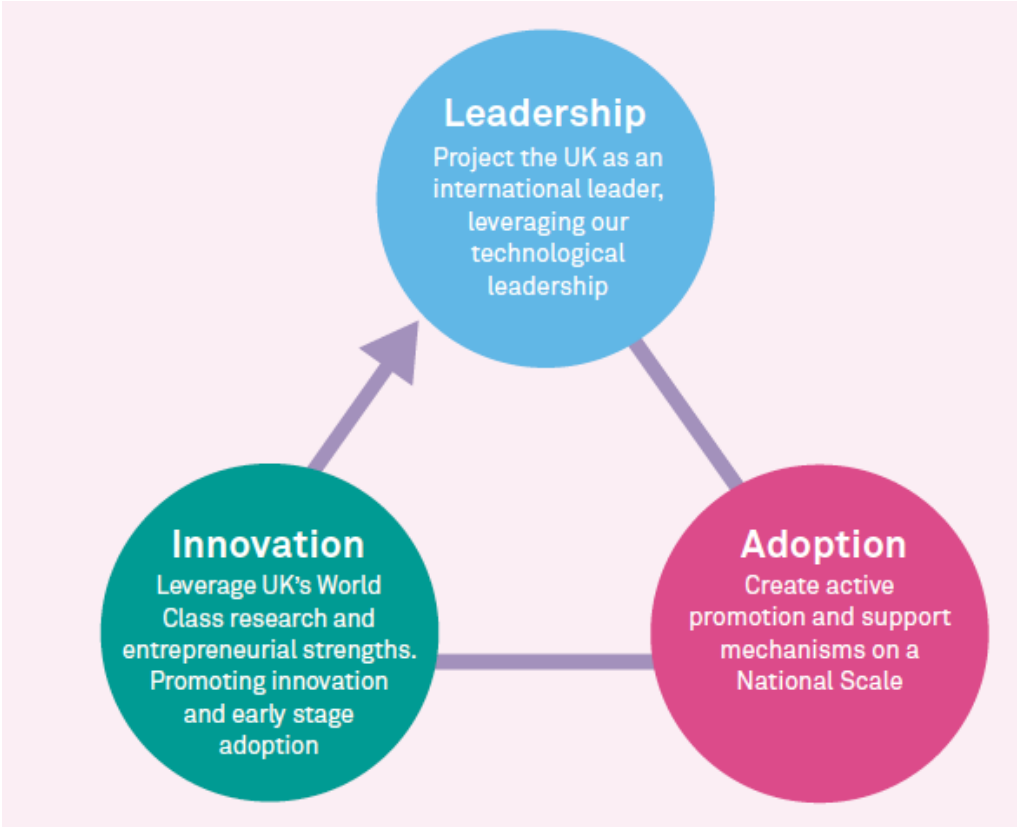
UNIVERSITY OF CAMBRIDGE
Department of Engineering

IfM MANAGEMENT TECHNOLOGY POLICY

Source: BBC Tomorrow's World archive on YouTube

UNIVERSITY OF CAMBRIDGE
Department of Engineering

2017 Industrial Digitalisation Review



IfM MANAGEMENT TECHNOLOGY POLICY

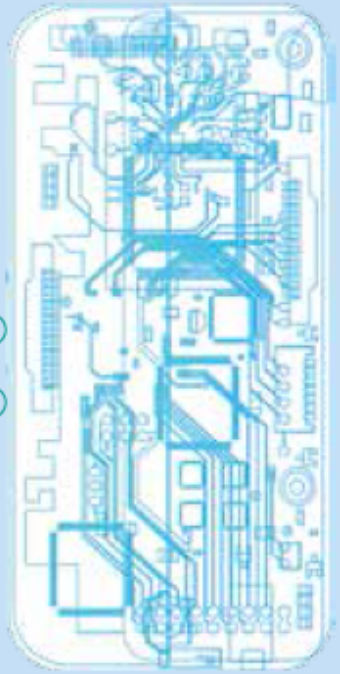
http://industrialdigitalisation.org.uk/

UNIVERSITY OF CAMBRIDGE
Department of Engineering

PHYSICAL PRODUCTS IN PHYSICAL SPACE

DIGITAL PRODUCTS IN VIRTUAL SPACE

E.G. SENSORS & BIG DATA

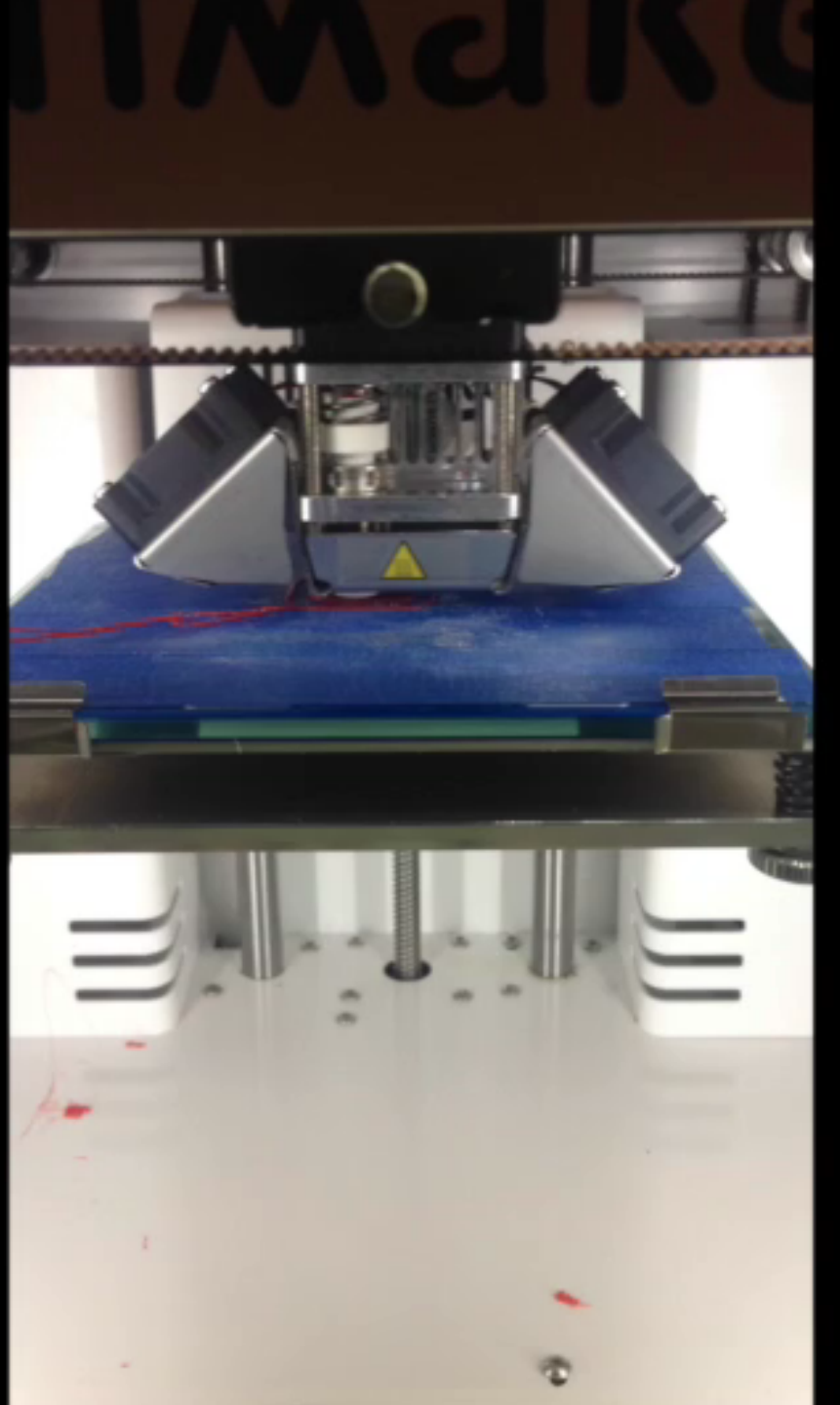


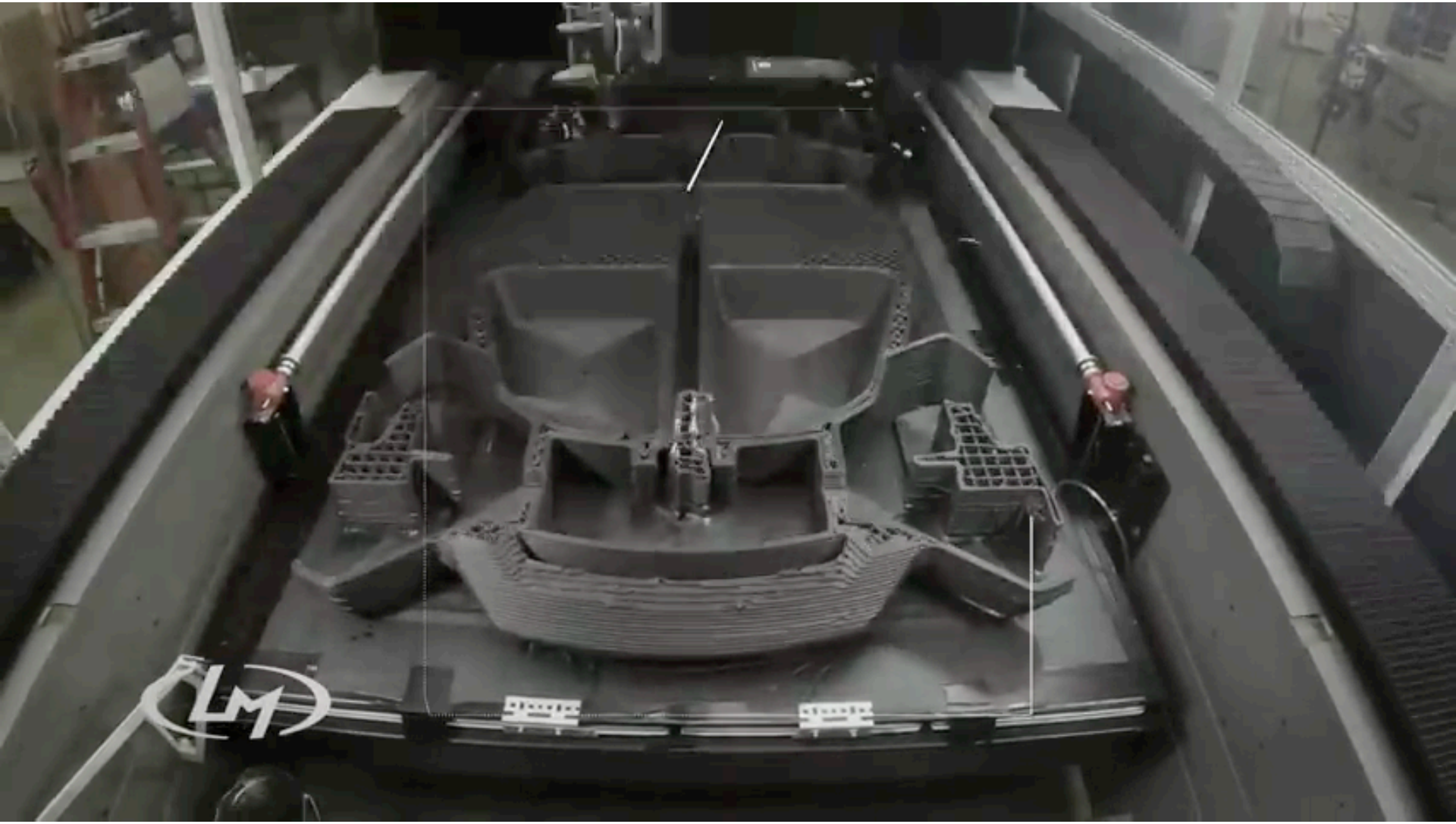
E.G. ADDITIVE MANUFACTURE & AUGMENTED REALITY

IfM MANAGEMENT TECHNOLOGY POLICY

http://industrialdigitalisation.org.uk/

UNIVERSITY OF CAMBRIDGE
Department of Engineering

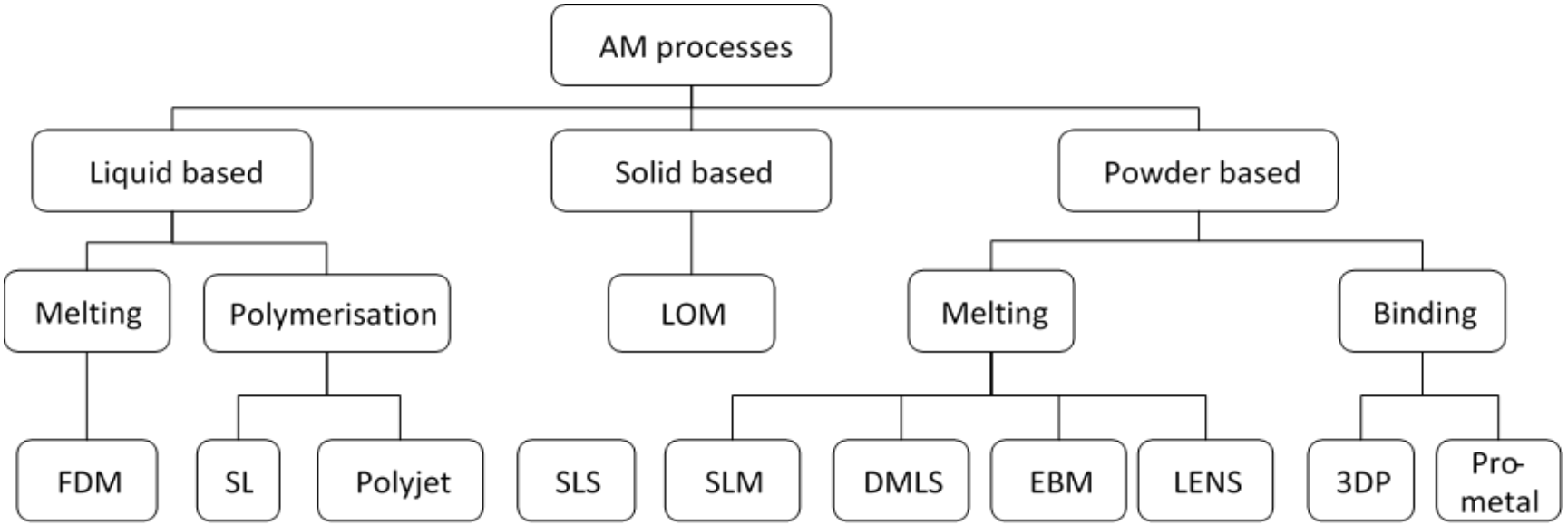




IfM MANAGEMENT TECHNOLOGY POLICY

UNIVERSITY OF CAMBRIDGE
Department of Engineering

https://www.carbon3d.com/stories/adidas/

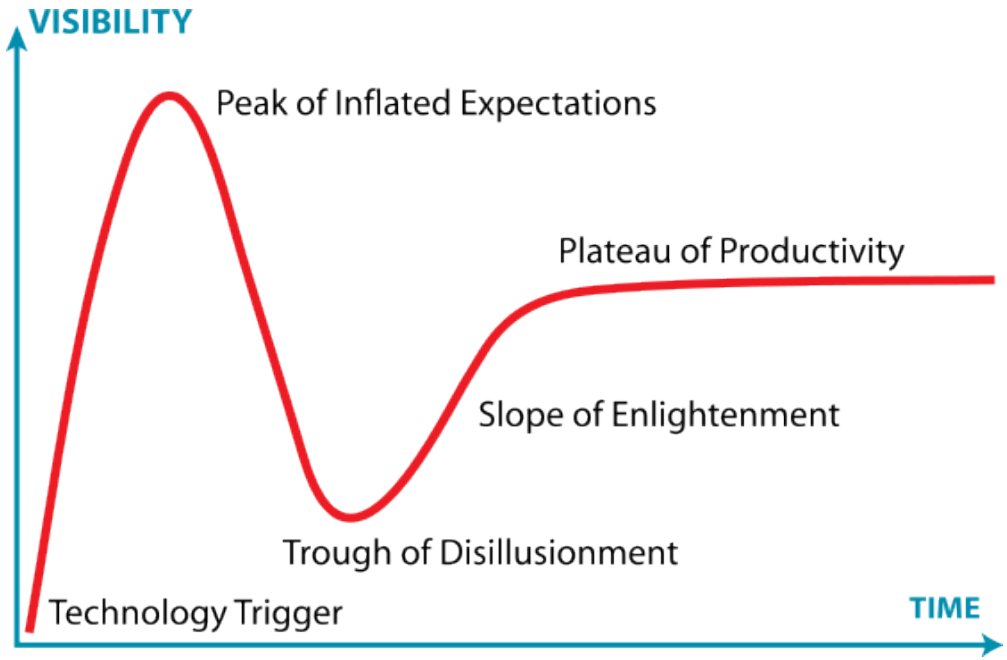


Rapid Prototyping → **Rapid Tooling** → **Direct Manufacturing**

Wong, K. V. and A. Hernandez (2012). "A Review of Additive Manufacturing." ISRN Mechanical Engineering Article ID 208760.
Deradjat, D. and T. Minshall (2017). "Implementation of Rapid Manufacturing for Mass Customisation." Journal of Manufacturing Technology Management **28**(1).

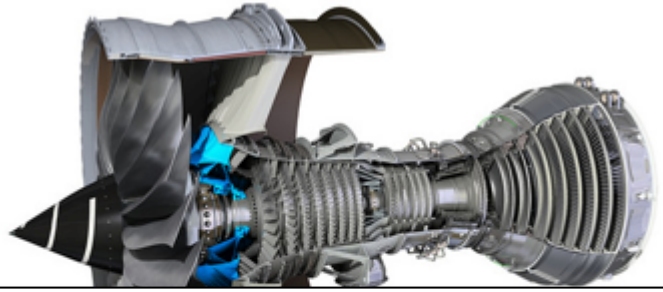
‘3D printing [..] has the potential to revolutionize the way we make almost everything’

President Obama, State of the Union Address 2013



http://www.gartner.com/

IfM MANAGEMENT TECHNOLOGY POLICY

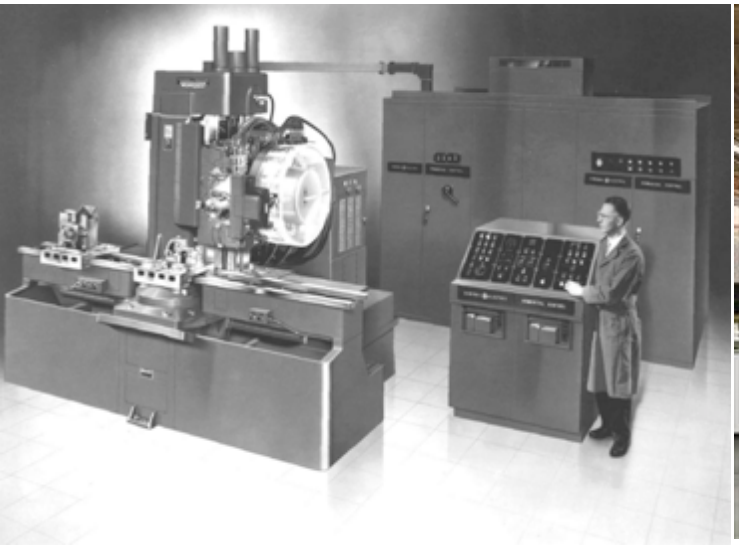


"It is estimated that the UK can win up to 8% or £5bn of this rapidly growing global market for AM products and services, forecast to reach £69bn by 2025 and this will have a strong effect on protecting existing jobs (63,000 by 2020) while also generating new employment".

Additive Manufacturing UK 2016.

Images: www.rolls-royce.com

Is this ‘just another production technology’?



Images: Ramesh Pathania/Mint; www.used-robots.com; www.ifm.eng.cam.ac.uk; news.cision.com

IfM MANAGEMENT TECHNOLOGY POLICY

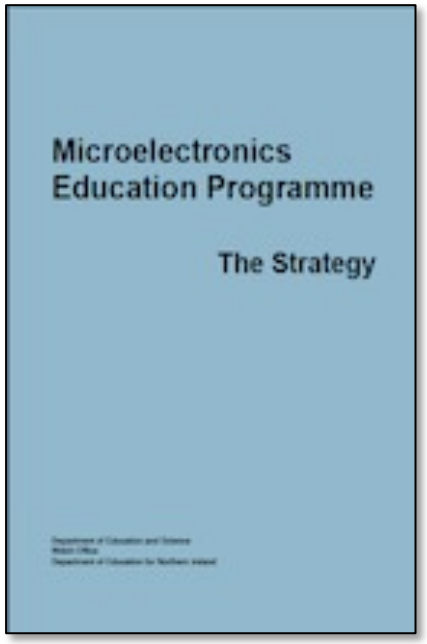
UNIVERSITY OF CAMBRIDGE
Department of Engineering

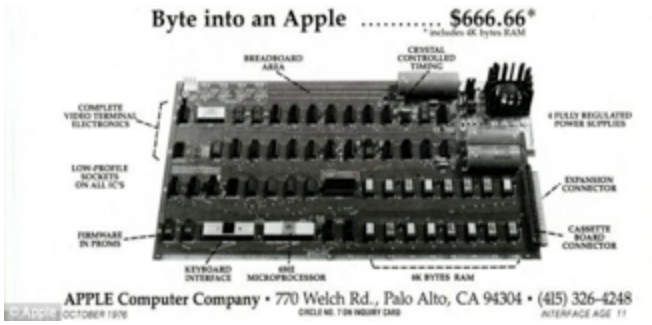
Industry 4.0

Is this a ‘digital’ thing?

‘*3D printing: The PC all over again?*’
Economist 1.12.12

‘A 3D printer for every school would encourage innovation’
The Week 19.6.14





Images: http://www.computerhistory.org/; oldcomputers.net; Konstantin Lanzet; Evan-Amos; Apple Inc.

IfM MANAGEMENT TECHNOLOGY POLICY

UNIVERSITY OF CAMBRIDGE
Department of Engineering

How to improve our ability to commercialise emerging production technologies?

i. What are the actual and potential impacts of the adoption of AM-3DP on business models?

EPSRC
Pioneering research and skills

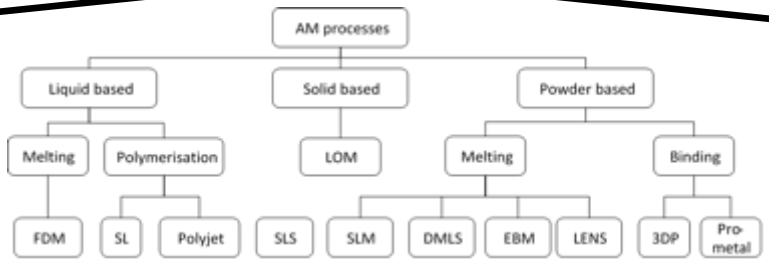
Research Councils UK
Digital Economy
Transforming Business and Society

E·S·R·C
ECONOMIC & SOCIAL RESEARCH COUNCIL

IfM MANAGEMENT TECHNOLOGY POLICY

UNIVERSITY OF CAMBRIDGE
Department of Engineering

time

Value **context**	ASTM International – Standards Worldwide; WIPO World Intellectual Property Organization; mtc Manufacturing Technology Centre
Value **capture**	    Ultimaker; eos e-Manufacturing Solutions; GKN HOEGANAES; shapeways
Value **creation**	

Phaal, R., E. O'Sullivan, M. Routley, S. Ford and D. Probert (2011). "A framework for mapping industrial emergence." Technological Forecasting and Social Change 78(2): 217-230.

Potential for mass customisation

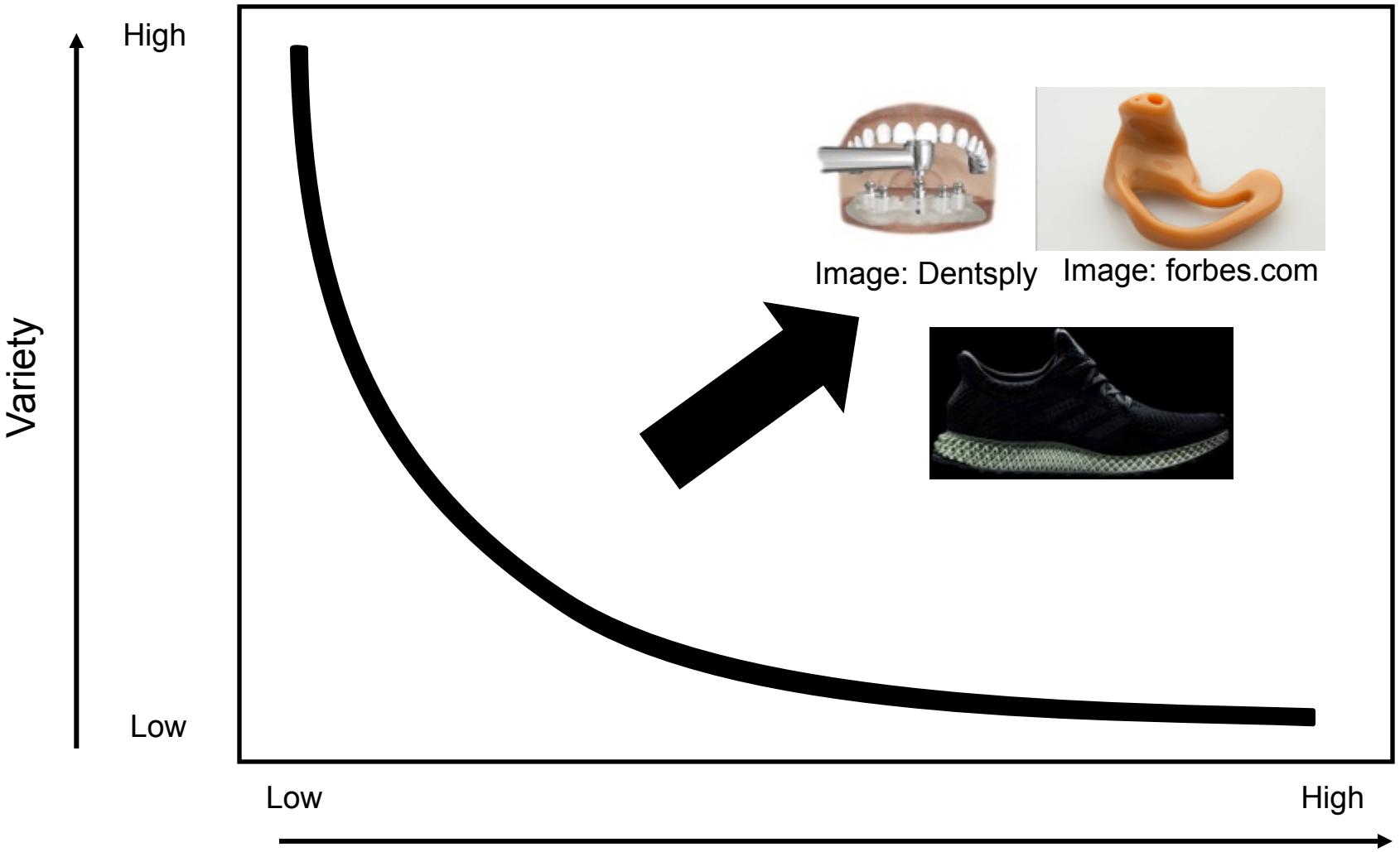


Image: Dentsply

Image: forbes.com

With thanks to Dominik Deradjat

IfM MANAGEMENT TECHNOLOGY POLICY

UNIVERSITY OF CAMBRIDGE
Department of Engineering

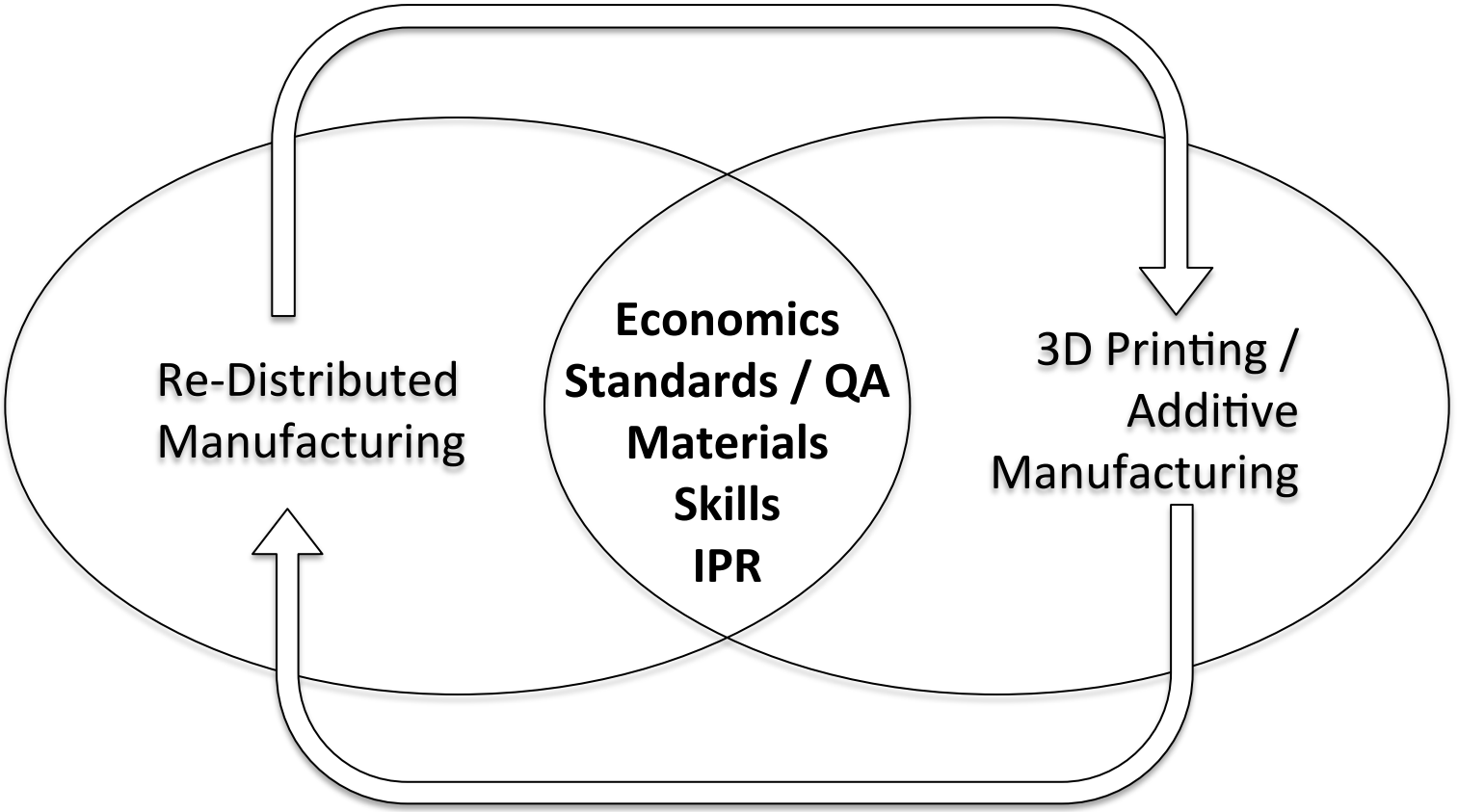
How to improve our ability to commercialise emerging production technologies?

i. What are the actual and potential impacts of the adoption of AM-3DP on business models?

ii. How is the adoption of AM-3DP linked to the location of production activities?

3D printing-enabled re-distributed manufacturing

Provides opportunities for



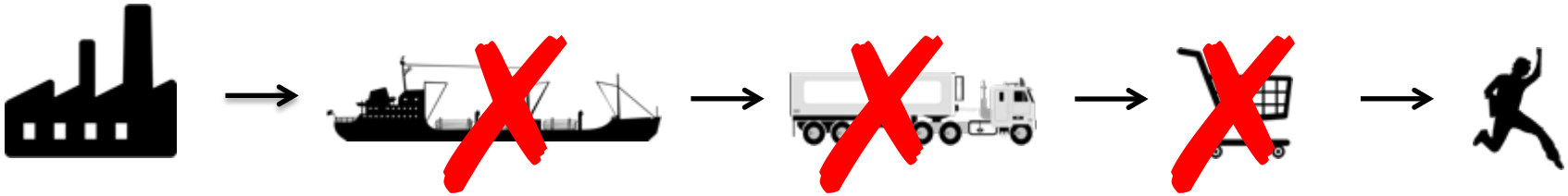
Enables

Ford, S. and T. Minshall (2015). Defining the research agenda for 3D printing-enabled re-distributed manufacturing. Advances in Production Management Systems 2015, 5-9 September. Tokyo.

IfM MANAGEMENT TECHNOLOGY POLICY

UNIVERSITY OF CAMBRIDGE
Department of Engineering

Production **Consumption**



Production + Consumption

IfM MANAGEMENT TECHNOLOGY POLICY

UNIVERSITY OF CAMBRIDGE

https://openclipart.org/

Image: NASA


Image: NASA

Production + Consumption

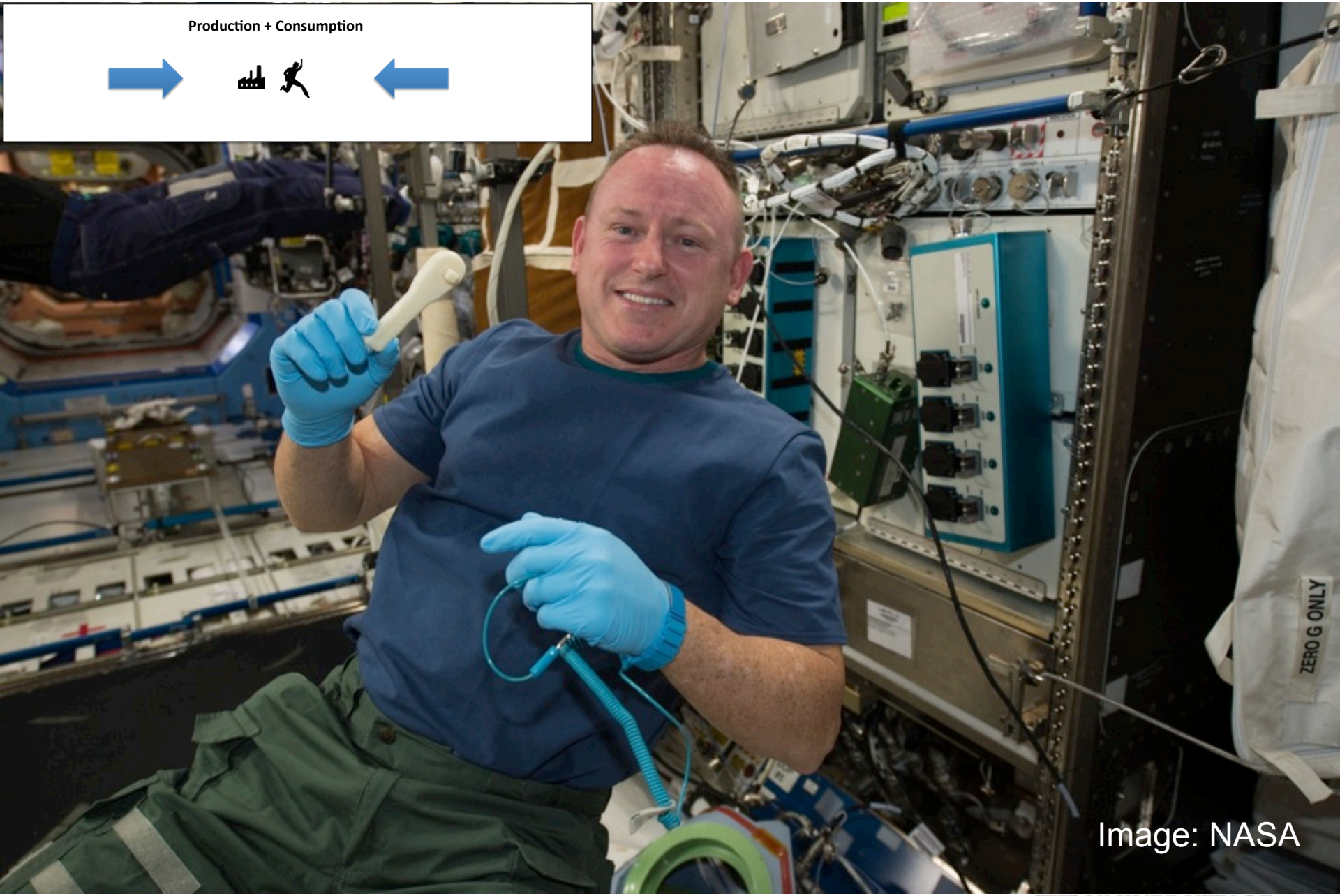


Image: NASA


Production + Consumption
Image: www.fieldready.org

RENISHAW
apply innovation™

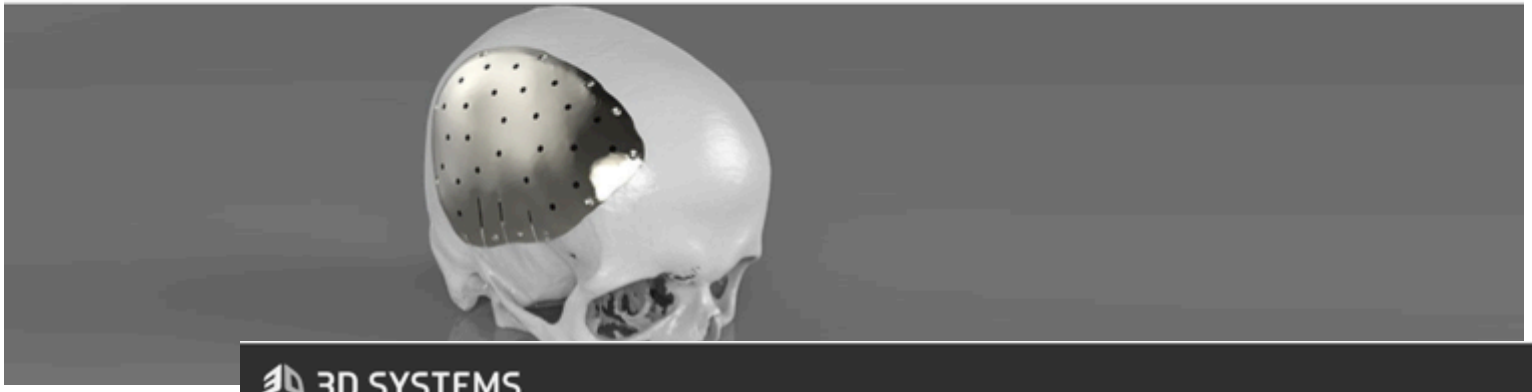
Search

Products Industries Support News Our company Contact us

Home - Metal 3D printing - Additive manufacturing systems - Industries - **Healthcare**

Metal 3D printing for healthcare

3D printing, also known as additive manufacturing, is an exciting technology whose benefits are being readily embraced with real life applications being developed daily.



3D SYSTEMS

English

Solutions | Quickparts – On Demand Manufacturing | Resources | Support | How to Buy | Contact Us

Medical Device Design & Manufacturing

ACCELERATE PRODUCT INNOVATION

Comprehensive additive manufacturing solutions to advance new medical products from concept to commercialization with 3D Systems

IfM MANAGEMENT TECHNOLOGY POLICY

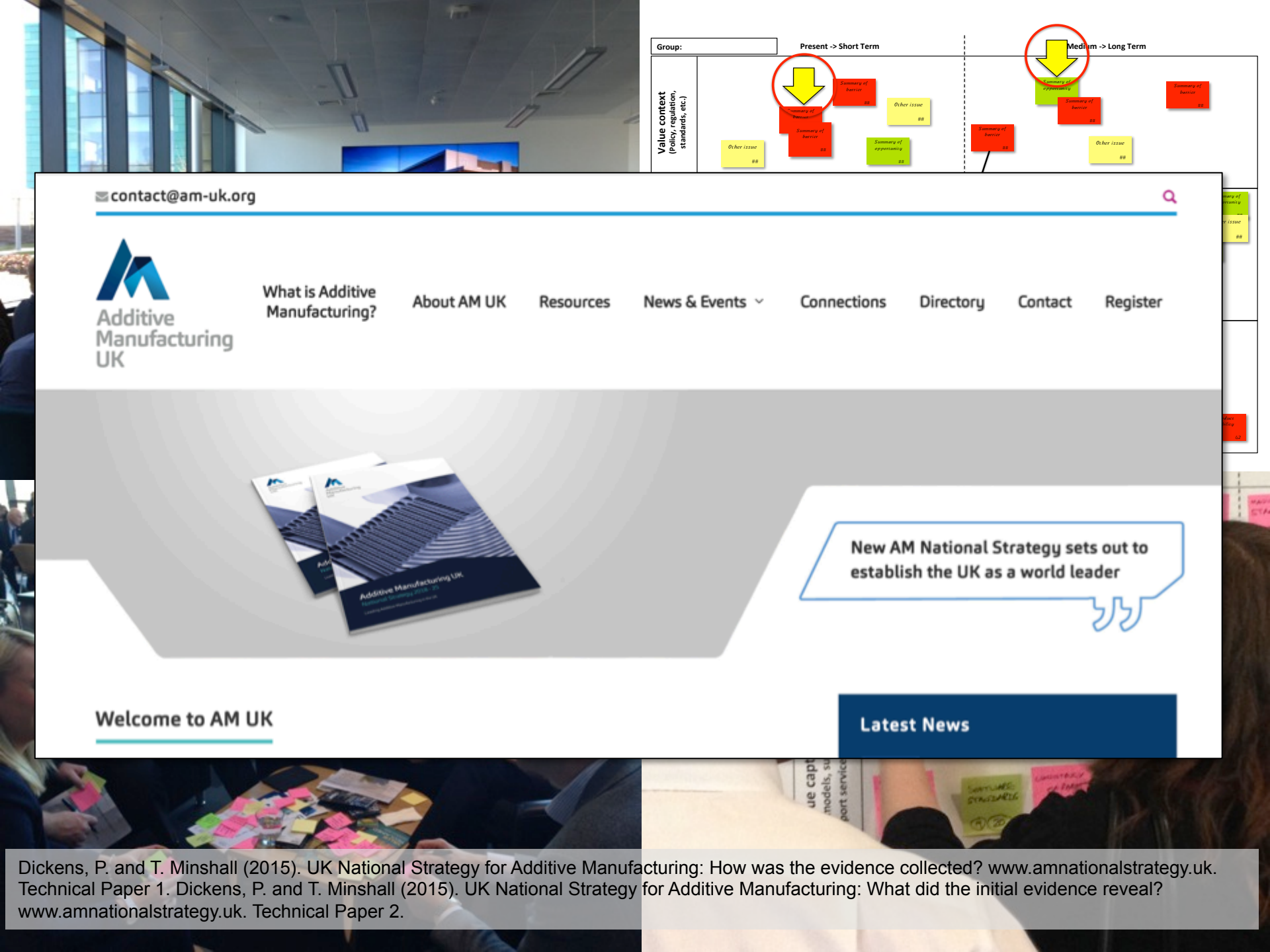
UNIVERSITY OF CAMBRIDGE
Department of Engineering

How to improve our ability to commercialise emerging production technologies?

i. What are the actual and potential impacts of the adoption of AM-3DP on business models?

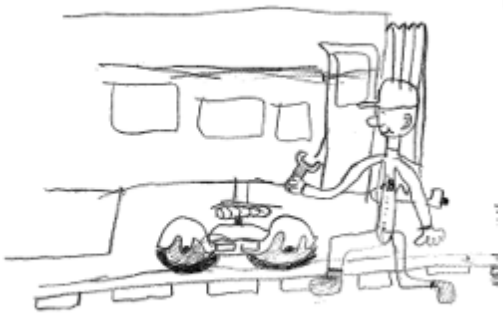
ii. How is the adoption of AM-3DP linked to the location of production activities?

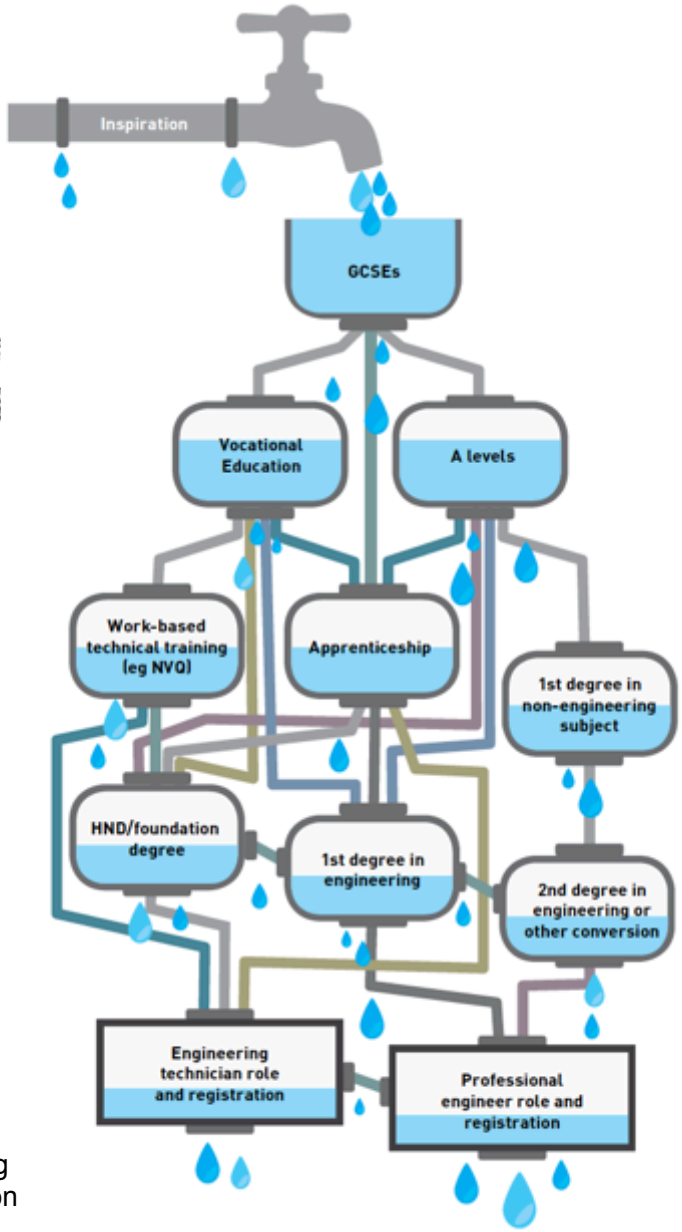
iii. What are skills and capabilities required for value to be created & captured from adopting AM-3DP?

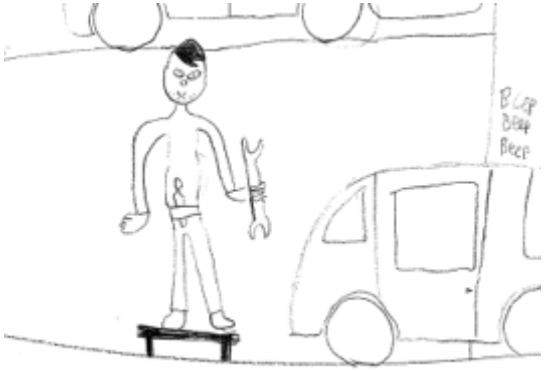


Dickens, P. and T. Minshall (2015). UK National Strategy for Additive Manufacturing: How was the evidence collected? www.amnationalstrategy.uk. Technical Paper 1. Dickens, P. and T. Minshall (2015). UK National Strategy for Additive Manufacturing: What did the initial evidence reveal? www.amnationalstrategy.uk. Technical Paper 2.

Issue	Summary of common perceived barriers
Materials	Understanding properties in different processes / machines / applications, QA, costs, availability (IP constraints, independent suppliers), use of mixed materials, recyclability, biocompatibility.
Design	Need for guides and education programmes on design for AM – better understanding of design for AM constraints, availability of AM-skilled designers, security of design data.
Skills / Education	Lack of appropriate skills (design, production, materials, testing) preventing adoption, up-skilling current workforce vs. training of next generation, education of consumers, awareness in schools.
Cost / Investment / Financing	Funding to increase awareness and reduce risk of adoption (testing, scale-up, machine purchase) – especially for SMEs, understanding of full costs (including post-processing, testing), cost of materials.
Standards / Regulation	Perceived or actual lack of standards – all sectors / sector specific (especially aero / health / motorsport), for processes / materials / software / products / applications.
Measurement / Inspection / Testing	Need data libraries, standards for tests (general and sector specific), materials/ in-process / final part, tests for higher volumes, non-destructive testing, QA through lock-in *c.f.* open access to data.
IP / Protection / Secrecy	Balancing need for openness to share knowledge with need for commercial protection to capture value from investments, enforcement of IP rights.







Perkins, J. (2013). Review of Engineering Skills, Department of Business, Innovation and Skills.

IfM MANAGEMENT TECHNOLOGY POLICY

UNIVERSITY OF CAMBRIDGE
Department of Engineering

How to improve our ability to commercialise emerging production technologies?

i. What are the actual and potential impacts of the adoption of AM-3DP on business models?

ii. How is the adoption of AM-3DP linked to the location of production activities?

iii. What are skills and capabilities required for value to be created & captured from adopting AM-3DP?

Key context

- 'Healthy' economy requires increased productivity
- Technology is long-term driver of productivity growth
- Technological innovation is critical but difficult

Is this a '4th Industrial Revolution'?

What is going to slow the uptake of new production technologies?

15th Anniversary HVM 2017 & 4th Graphene New Materials Conference
2-3 November 2017 Cambridge, UK
www.cir-strategy.com/events

HVM and Industrial Digitalisation: Are we undergoing a '4th Industrial Revolution'?

Professor Tim Minshall
Dr John C Taylor Professor of Innovation
Head of Institute for Manufacturing

IfM MANAGEMENT TECHNOLOGY POLICY

UNIVERSITY OF CAMBRIDGE
Department of Engineering